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TeamAware

TEAM AWARENESS ENHANCED WITH ARTIFICIAL INTELLIGENCE AND AUGMENTED REALITY

Deliverable D2.4

Scenarios for System Validation

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Abstract:	Identification and description of the scenarios that will be addressed in the validation and demonstration activities in WP13, matching needs, requirements and functionalities.
Keyword List:	TeamAware, Systems, Validation, Demonstration Scenarios
Licensing information:	The document itself is delivered as a description for the European Commission about the demonstration activities of TeamAware, so it is not public.
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Document Description

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v0.4	23/12/2021	KPIs incorporated	TREE
v0.6	21/01/2022	Sections 1 and 2 updated, and solution selection for both scenarios incorporated.	TREE, RAN
v0.8	24/01/2022	Integrated preliminary scenario and solution descriptions from partners	TREE
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v0.91	30/03/2022	Format corrections	TREE
v1.0	26/05/2022	Final version to be released to the EC	TREE

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Terms and abbreviations

ADS	Acoustic Detection System
AI	Artificial Intelligence
AMS	Activity Monitoring System
AR	Augmented Reality
ARMI	Augmented Reality and Mobile Interfaces
AWI	Awareness Increase
C2	Command and Control
CBRN	Chemical, Biological, Radiological and Nuclear (Operations Specialists)
CCTV	Close Circuit TeleVision
CDM	Chemical Dispersion Model
CDS	Chemical Detection System
CICIS	Citizen Involvement and City Integration System
COILS	Continuous Outdoor-Indoor Localisation System
CSAP	Common Situational Awareness Picture
CSV	Comma Separated Variable
DoA	Direction of Action
DKI	Downstream Knowledge Increase
EC	European Commission
EoU	Ease of Use
FR	First Responder
GDPR	General Data Protection Regulations
GNSS	Global Navigation Satellite System
GPU	Graphics Processing Unit
GSM	Global System for Mobile Communications
GUI	Graphical User Interface
HMD	Human-Made Disaster
ICS	Incident Command System
IMS	Infrastructure Monitoring System
IMU	Inertial Measurement Unit
IoT	Internet of Things
IR	InfraRed
IT	Information Technology
KPI	Key Performance Indicator
LEA	Law Enforcement Agency
LORA	LOng RAnge (Network)
NATO	North Atlantic Treaty Organization
ND	Natural Disaster
OUS	Overall user satisfaction
PR	Preparation Readiness
SMART	Specific, Measurable, Achievable, Reasonable, Time-bound
SSCN	Secure and Standardised Communication Network
TEI	Time Efficiency Increase
TGM	Trial Guidance Methodology
TMS	Team Monitoring System
TP	TeamAware Platform
UKI	Upstream Knowledge Increase
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle

UI	User Interface
US	Usefulness
UX	User Experience
VSAS	Visual Scene Analysis System
WCDS	Wearable Chemical Detection System
WiFi	Wireless Fidelity (Network)
WP	Work Package

Executive Summary

This deliverable provides a general description of TeamAware's demonstration scenarios following accepted trial description methodologies, and helps to link users' needs, TeamAware's functionalities, and requirements. This deliverable puts into the single version document the results of several rounds of interaction between the technical partners and the end users from the TeamAware consortium.

During the preparation of this deliverable, not only the scenarios but also the end user needs were collected from each end user participating in this consortium during the dedicated requirements collection phase of the project. The lists of needs corresponding to the scenarios were analysed in successive workshops participated by the coordinators, technical work package leaders and the end users in the consortium. In the end of those workshops both functional and technical requirements, consistent with the scenarios, were built for the TeamAware components as well as the overall TeamAware system. In detail, a concrete technical baseline agreed by the whole consortium was achieved so that each technical partner can focus on their research and innovation activities in technical work packages (WP3-WP12) according to the requirements and the final demonstration and validation can be built accordingly in WP13.The organisation of the deliverable is as follows:

- Section 1: context of this deliverable into the overall project;
- Section 2: description of the methodology followed;
- Section 3: description of the natural disaster scenario;
- Section 4: description of the human-made disaster scenario;
- Section 5: main conclusions of the document;
- Appendix 0: the background information and nomenclature for requirements;
- Appendix 1: operational and functional needs gathered from end users for natural disaster scenario;
- Appendix 2: operational and functional needs gathered from end users for human-made disaster scenario;
- Appendix 3: the overall technical requirements for each TeamAware component and overall TeamAware system.

1 Introduction

This deliverable presents the preparation of the demonstration scenarios that will be featured in WP13 (*Demonstration and Validation*) at a later stage of TeamAware. This presentation paves the way for both the intermediate and the final demonstrations of the TeamAware project, which will take place by month 36 and will evaluate and validate all the work achieved in the project. Each validation and demonstration through the project life will end up with analysis and lessons learned, which will be taken into account later.

The main motivation of this deliverable is to give a structured view of the arrangements which will be put in place in the demonstration, as well as to anticipate the needs emanating from the associated research. It is worth mentioning that two demonstrations are foreseen in TeamAware. In month 18, a mid-term demonstration will take place focused on evaluating the individual TeamAware components. Later, by month 36, the final demonstration will involve the whole TeamAware ecosystem. This document addresses identification and description of the scenarios that will be showcased in the final validation and demonstration activities in WP13, as well as operational needs, requirements and functionalities.

Two demonstration scenarios have been considered, providing a good representation of the complexities found in real life:

- The first scenario features a natural disaster leading to a technological disaster. It will involve damaged buildings, human victims, gas leakage, and fire and smoke in an underground.
- The second scenario involves (simulation of) a terrorist attack with further incidents (e.g., explosions, toxic chemical attacks). SPP will be LEA for this scenario and will ensure protection and countermeasures to the risks detected. This scenario will include planning and preparation phase.

Both scenarios adhere to the general schema depicted in Figure 1.

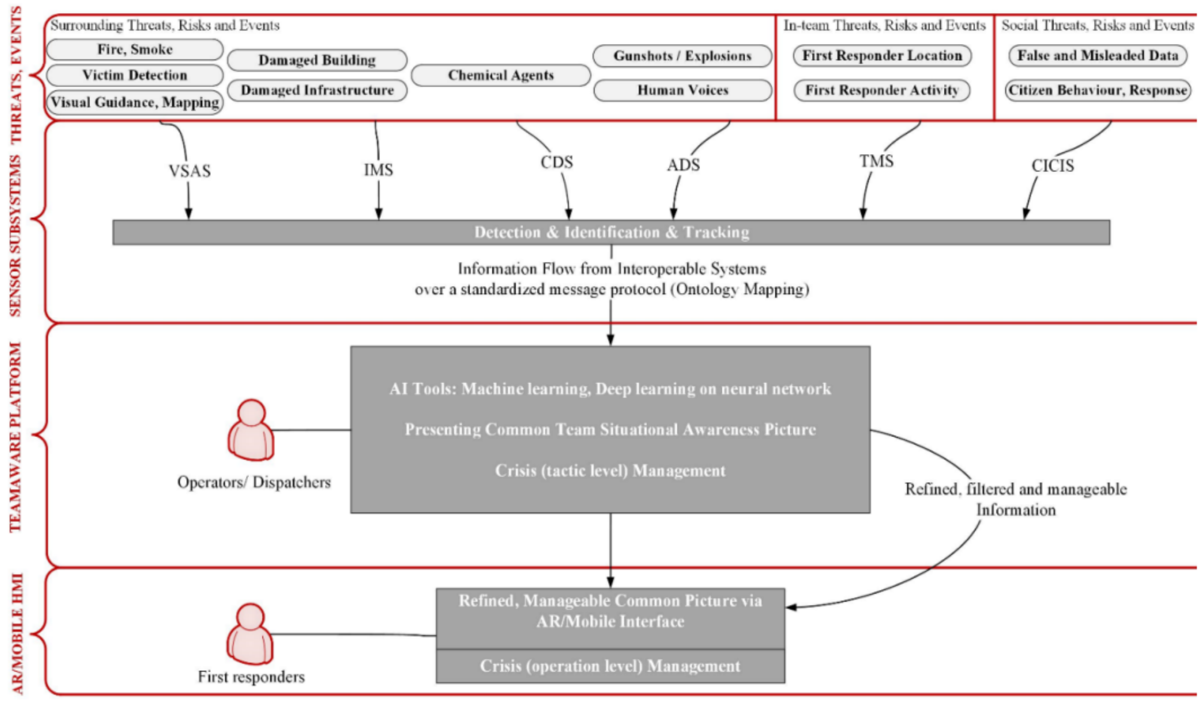

Figure 1. End-users' operation in demonstration scenarios.

Given the complexity of the scenarios, it has been necessary to describe them in a systematic way so that no arrangements will remain uncovered by the time the demonstrations take place within WP13. This has been achieved by relying on the Trial Guidance Methodology (TGM) developed by the DRIVER+ project [1]. The TGM provides step-by-step guidelines to perform a trial through a clear, structured, and co-creative approach.

The benefits of this are two-fold. On the one hand, the preparation of the scenario is as detailed as possible, leading to a productive and efficient execution and evaluation of results. On the other hand, due to the previous point, if one of the scenarios needed some adjustments to evolve their design it will be easier to decide which modifications are needed to fit the needs of the project.

1.1 About this Deliverable

Task 2.2 ("*End-users' needs, requirements, constraints and scenarios*") targets a better understanding of the needs from end-users. Ultimately, this entails identifying the most relevant scenarios for severe disasters together with the end-users of the TeamAware consortium and the partners providing the technological solutions to support the goals of the project.

Leveraging a user-centred co-design process involving end-users and technical partners, WP2 managed to outline a rigorous approach and design of the demonstration scenarios while at the same time converging the end-users' expectations and needs with the technical developments of the project.

For the solution providers, this document also clarities how their solutions will be validated during the final demonstrations.

This document is the fundament for the subsequent demonstration and validation activities within WP13. This deliverable only has one iteration (final), the current D2.4 due for month 9, covering the full demonstration and validation to be conducted under WP13 by month 36.

Refinements will be made in WP13, where the trail methodology will be further detailed, as well as based on the mid-term trials (interim demonstrations) with the individual TeamAware components.

1.2 Document Structure

This document is structured as follows. The current Section 1 helps to contextualise the deliverable inside the activities of the project.

Section 2 introduces the methodology followed in this document for describing TeamAware's demonstration scenarios, which mirrors the one to be used in WP13 (*Demonstration and Validation*).

Sections 3 and 4 describe both demonstration scenarios following the methodology presented in Section 2. They are dedicated respectively to the natural disaster scenario and the human-made disaster scenario. For each of them, the following aspects are covered:

- context for the scenario;
- gaps identified by end-users;
- research questions to be answered;
- formulation of the scenario;
- solutions used;
- data collection plan;
- evaluation plan;
- overall scenario objective.

Section 5 concludes the main document with some conclusions.

Finally, three appendices list the operational needs per scenario and technical requirements derived from each scenario, and how they are linked to the specific gaps identified by the end-users for each specific scenarios. Nevertheless, the motivation behind the TeamAware project covers a general aspects involving the gap-analysis published by "The International Forum to Advance First Responder Innovation" (IFAFRI), common global capability-gaps listed in Table 1. Hence, the requirement lists in the appendices involve not only the requirements corresponding to the scenarios but also the objectives corresponding to the four main gaps published by IFAFRI.

Table 1 IFAFRI common global capability gaps. [2]

Capability Gap 1 [3]	The ability to know the location of responders and their proximity to risks and hazards in real time
Capability Gap 2 [4]	The ability to detect, monitor, and analyse passive and active threats and hazards at incident scenes in real time
Capability Gap 3 [5]	The ability to rapidly identify hazardous agents and contaminants
Capability Gap 4 [6]	The ability to incorporate information from multiple and non-traditional sources to the incident command operations

1.3 Relation with Other Tasks and Deliverables

The current document is directly related to the following work packages:

- WP1 – Project Management and Coordination (T1.4 – Data management);
- WP3 – Visual Scene Analysis System;
- WP4 – Infrastructure Monitoring System;
- WP5 – Chemical Detection System;
- WP6 – Acoustic Detection System;
- WP7 – Team Monitoring System;
- WP8 – Citizen Involvement and City Integration System;
- WP9 – Secure and Standardised Communication Network;
- WP10 – TeamAware AI Platform Software;
- WP11 – TeamAware AR/Mobile Interfaces;
- WP13 – Demonstration and Validation.

A list of deliverables that are closely related to the current document and encapsulate the biggest dependencies is provided below. While other deliverables may show some links with D2.4,they are subsumed by the ones in the following list:

- D1.3, D1.8 – Data Management Plan v1, v2;
- D1.4, D1.7 – Legal, Ethical and Societal Issues Handbook v1, v2;
- D2.1 – Conceptual Analysis and System Requirements;
- D2.2, D2.6 – Conceptual Platform Software Architecture and Design v1, v2;
- D2.3, D2.7 – Conceptual System Architecture and Design v1, v2;
- D2.5 – Legal and Ethical Principles and Guidelines;
- D3.11 – Validated Visual Scene Analysis System (VSAS);

- D4.11 – Validated Infrastructure Monitoring System (IMS);
- D5.10 – Validated Chemical Detection System (CDS);
- D6.9 – Validated Acoustic Detection System (ADS);
- D7.9 – Validated Team Monitoring System (TMS);
- D8.15 – Validated Citizen Involvement and City Integration System (CICIS);
- D9.1 – Network Architecture and Domain Ontology Report;
- D9.8 – Validated Secure Cloud Network;
- D10.6 – Validated TeamAware Platform;
- D11.10 – Validated TeamAware Interface;
- D13.1, D13.6 – TeamAware Demonstration Plan Report v1, v2;
- D13.4 – Evaluation of Individual TeamAware Components Demonstration;
- D13.10 – Evaluation of Final TeamAware System Report.

There is a specific relationship between this deliverable and the work of the demonstrations as both the interim and final demonstrations will use the scenarios outlined in this deliverable.

The **interim demonstrations** will feature deployment of components of each of the technical providers work on a stand-alone basis. In other words, they will be structured around seven separate mini demonstrations. The technical detail of each will be developed through Work Packages 3 to 9 (the small red circle in Figure 2 below).

Moving onto the final demonstrations towards the end of the project, these same seven technical solutions (Work Packages 3 to 9) will be demonstrated within the capabilities developed through Work Packages 10 to 12 – The AI Platform Software, the Mobile Interface and the integrating and testing environment, respectively.

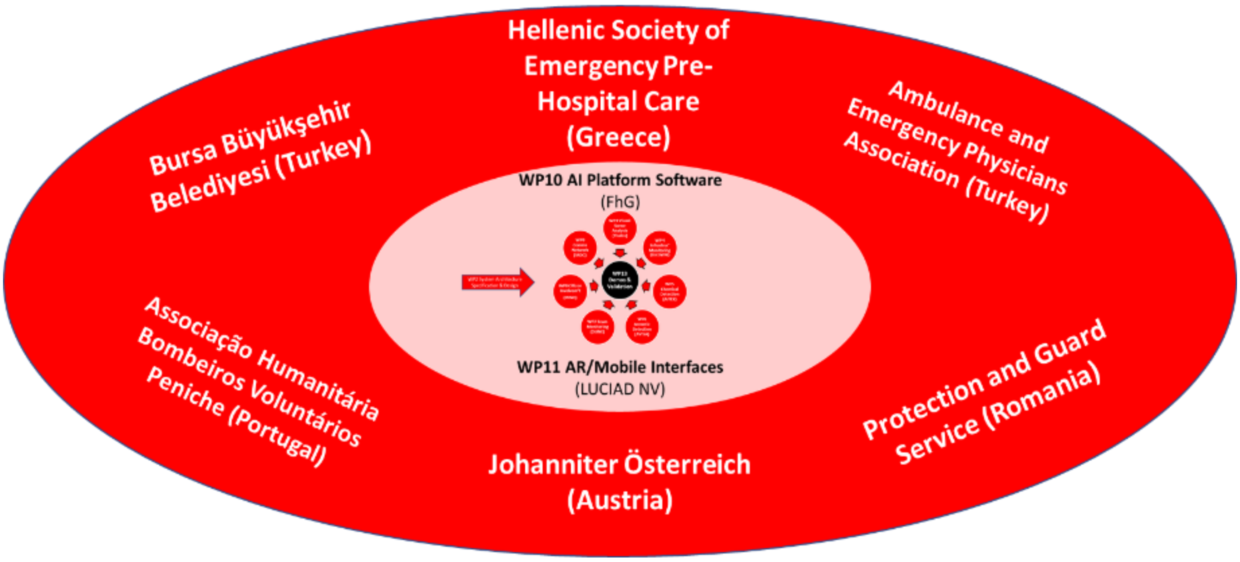

Figure 2**. Structure of the demonstrations.**

All demonstration and validation activities will need to be undertaken in a solid and well-defined operational context as agreed by the users (the six organisations shown in the outer ellipse in Figure 2) to provide a clear understanding of the user benefit and perceived desirability of each solution.

The starting point for creating a context within which this can happen are the two detailed scenarios, the outlines of which this deliverable presents.

The interim demonstrations are anticipated to be based upon agreed sub-sets of the two overall scenarios whereas the final demonstrations will be based upon further detailed versions of the full scenarios outlined in this deliverable.

It can now be understood that aspects of this deliverable create a foundation for the activities of the demonstrations (WP13). For this reason, the management teams from TREE and RAN have stayed closely and aligned throughout the process of creating a clear understanding of precisely *how* the deliverables from this WP will inform the early activities of the demonstrations.

As an example, D2.1 ("*Conceptual Analysis and System Requirements*") provides a contextual description of the circumstances under which the project runs. D2.4 (this document) provides sufficient information to enable the scenarios to be further developed for system validation as the demonstrations progress. D2.5 ("*Legal and Ethical Principles and Guidelines*") provide the legal and ethical principles and guidelines within which the demonstrations will take place.

2 Methodology Used

The current document aims to provide a systematic and comprehensive description of the demonstration scenarios that will be covered in TeamAware. For the sake of achieving meaningful results, as well as using the European funding in the most productive and efficient manner, it is instrumental that they have a robust design and a clear goal.

For the sake of not re-inventing the wheel, and instead of coming up with an ad-hoc methodology tailored for the characteristics and purposes of TeamAware, the descriptions are built upon within a methodology that has gained broad traction and acceptance among the community.

The adopted methodology (of which the scenarios form a part) is based on the Trial Guidance Methodology (TGM), resulting from the FP7 DRIVER+ project and documented in [1]. It is worth mentioning that, for the purposes of this deliverable, the TGM will not be strictly applied due to constraints of resources and time. The TGM itself, in fact, underlines that the guide is just an adaptable framework and encourages projects to adapt its application to the particular needs of the trial.

2.1 The Trial Guidance Methodology

For the sake of improving the understanding of the rest of the document, the summary of the TGM is provided below. The reader is encouraged to read the original source for more details.

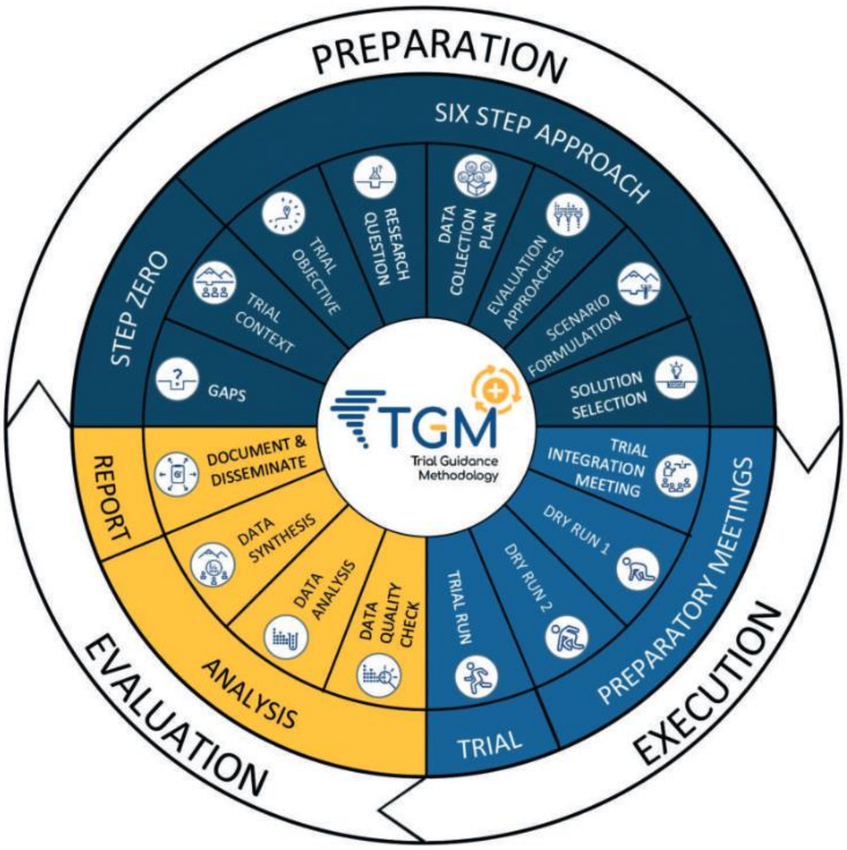

Figure 3. DRIVER+'s TGM at a glance [1].

The TGM is composed by three consecutive phases:

- Preparation;
- Execution;
- Evaluation.

The **Preparation phase** is all about understanding what considerations need to be taking into account and setting up the experiment. The result of this phase is a formalised contextualisation of the gaps and the different arrangements that surround the validation scenario.

The **Execution phase** comes next. The ultimate goal of this phase is to capture relevant data for further analysis. It consists of a preparatory trial integration meeting to have all expectations and roles clear and aligned, two rehearsals to test the data collection and where technical tests and adjustments to the scenario can be made, and finally the trial itself where the data is finally collected.

The last stage is the **Evaluation phase**. The data collected during the previous phase is cleaned and processed to make sense of the metrics and verify if the research questions have been answered. In addition, the lessons are documented, and the knowledge base is updated.

In the current deliverable only the scenarios and context components of the Preparation phase of the demonstrations are addressed. In turn, the Execution and Evaluation phases will be covered later on in TeamAware within WP13 (*Demonstration and Validation*).

2.2 Adapted Methodology

Taking advantage of the versatility of the TGM, the current document will address relevant aspects of the Preparation phase consisting of the exact same steps, but in a slightly different order to that in Figure 3. The final arrangement of steps of this phase is depicted in Figure 4:

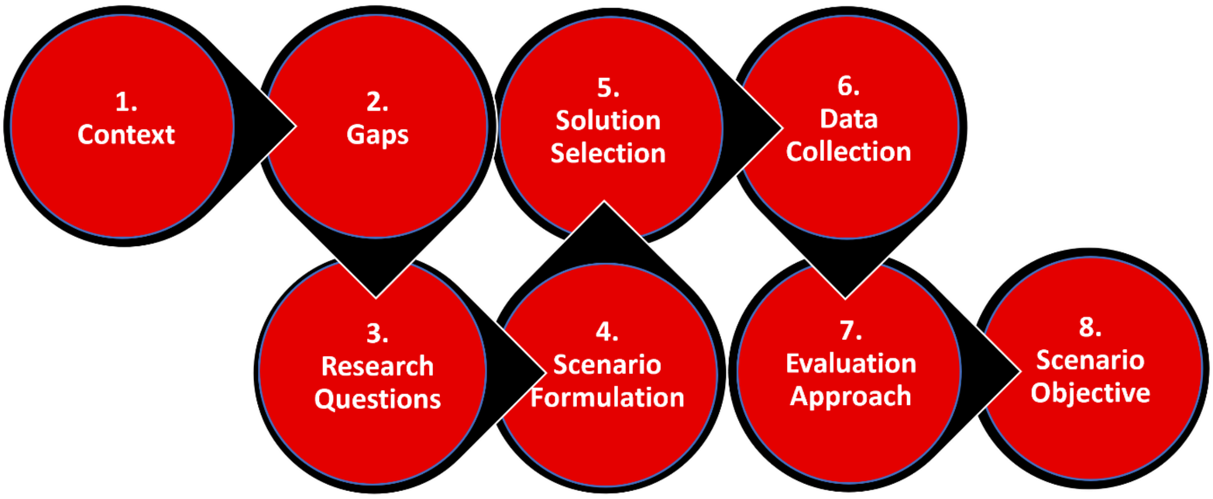

Figure 4. Preparation phase's steps.

The reason for the rearrangement is based on the fact that some of the steps are conditioned to the arrangements already found in TeamAware's Description of Action. This implies that some information about the Context is available, and from that it is possible to derive some gaps and not the other way round. The same applies too for the Solution Selection step, which is influenced by the systems developed in the project.

Either way, the Preparation phase consists of the eight steps below, which are also featured broadly in the TGM. That methodology divides them into two different parts. The first part (which they name step zero) spans the first two steps in the following list and deals with the boundary conditions of the experiment and the motivation why it is being conducted. The second part includes the last six steps and allows to formalise aspects of the preparation itself such as what will be done in the demonstration, what data are sought for, and how they will be analysed afterwards. However, this division is more conceptual than operational, and does not introduce additional requirements or dependencies into the application of the individual steps.

The purpose of each of the steps depicted in Figure 4 is as follows.

1. **Context**: a particular situation in which end users usually find difficulties, including the roles, equipment, and the test environment.
2. **Gaps**: this is understood as the identification of what can be improved in the current capabilities to cover adequately the needs imposed by the given context, both within the project proposal phase and the demonstration scenarios. This is an aspect that must be discussed with the end-users, as suggested by the TGM.
3. **Research questions**: concretisation of the objectives into the specific questions that the consortium is interested in answering. Among other recommendations pointed out in the TGM [1], it is recommended that they have a simple formulation, they can be answered by the trial, and they refer to the previously identified gaps. Every gap should be covered by one or multiple research questions.
4. **Scenario formulation**: situation in which the gaps are noticeable. The storyline is detailed, and all the relevant roles, equipment, and restrictions are listed.
5. **Solution selection**: description of the tools that enable to close the gaps. These tools can exist, or refer to missing pieces of hardware, software, or expertise that is still to be covered by the time the Execution phase starts.
6. **Data collection**: description of what data will be collected in order to answer the research questions including a set of key performance indicators (KPIs), how, when, and by whom.
7. **Evaluation approach**: techniques and tools that will be used both to collect the raw data and to analyse them in order to answer the research questions. At this stage it may not be clear the format and amount of data to be analysed, and so the TGM suggests evaluating different options for that matter.
8. **Scenario objective**: description of the motivations behind conducting the demonstration scenario and the objectives expected to be achieved. They should be formulated in such a way that they can be expressed in a SMART (Specific, Measurable, Achievable, Reasonable, Time-bound) way for maximum utilisation of the demonstration.

2.3 Scenarios' Co-Design Process

Since the early stages of the project, it became clear that the whole portfolio of activities in TeamAware should have active involvement of end users (scenario owners and other participating end users). Indeed, targeting a set of objectives that are not in line with their overarching needs would have important negative implications for the success of TeamAware as a package. This, too, applies to the coarse design of the demonstration scenarios, which is the scope of the current deliverable.

The following stakeholders have played a key role in the design of the demonstrations as described in this document:

- WP13, represented by its coordinator (RAN), as the group in TeamAware which will develop and execute the general arrangements in the current D2.4.
- The coordinators of both scenarios, BBB and SPP.
- The rest of the end-users in the consortium.
- The technical work packages in the project (WP3 to WP11) and their coordinators, as representatives of the hardware and software subsystems comprising all together the entire software family, products and services of the TeamAware project.

This document is the result of the cooperation among all the above. Nevertheless, they share the understanding that the current document just represents a baseline for describing the demonstration scenarios, which will be expanded and refined under the umbrella of WP13.

The underlying design principle has been that "the work should build around the existing capability of technical solution providers and the needs identified by the end users". From their record of activities in their respective fields they have come across several repeating difficulties (gaps) which might be improved by the solutions under development as part of the TeamAware project. These gaps have been the starting point of the discussions. The demonstration scenarios will be arranged to assess the usability and desirability of TeamAware in mitigating those gaps. This will be published in two deliverables, the first immediately following the interim demonstration (D13.3) in month 18 and a fully populated version following the final demonstration (D13.8) in month 36.

WP2 has enabled a dialogue among all the stakeholders listed above. The goal has been to let end-users present their gaps and discuss with the technological partners the best use of the TeamAware solutions to mitigate them. The use case was made clear to the greatest possible extent and expressed in a set of functional requirements (gaps). This has allowed technical partners to derive a set of coarse technical requirements to steer their work in upcoming months.

A detailed description of how the requirements have been derived is given in Section 2.4. However, the key takeaway is:

- **End-users have defined operational needs**.
- **Technical partners have defined functional and technical requirements**.

This process will continue throughout the project as a fundamental output of the demonstrations. The iterative process of the design is important and will enable an incremental growth in understanding of both solution providers and users. Providing this handshake and clear separation between end-users and technical partners have been one of the major driving forces of WP2. The relation among work packages is summarised in Figure 5 and Figure 6.

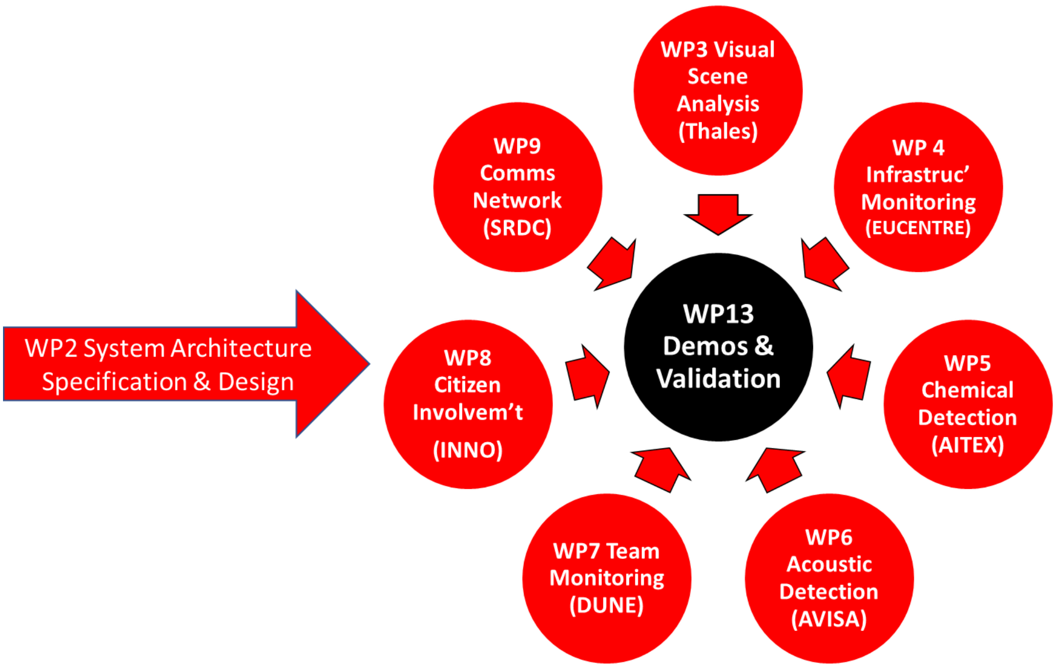

Figure 5. Relation among work packages (1/2).

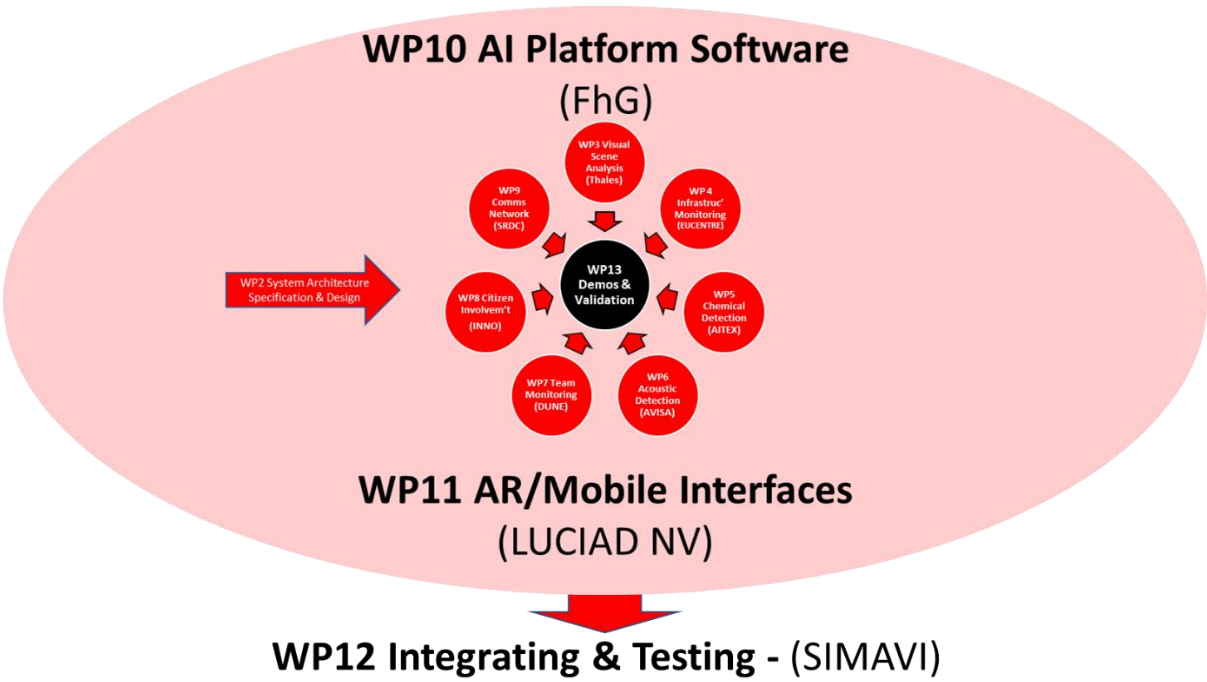

Figure 6. Relation among work packages (2/2).

The refinement of both the demonstration scenarios and the technical specifications of the TeamAware systems and components will be made in upcoming months. On the one hand, WP13 will iterate the definition of the demonstrations based on the preliminary capabilities of the TeamAware systems and components and the end-users involved in each scenario. On the other hand, WP3-11 will carry on the design and development task with a fundamental knowledge of the activities to be performed in the demonstrations.

An important milestone for the convergence of both lines of work will take place in M18 with the mid-term demonstrations. Their main goal is to demonstrate and evaluate the TeamAware developments in a standalone way (i.e., by individual tests), replicating (but limiting in complexity) their intended use in the final demonstration. The preliminary conclusions from the mid-term evaluation will be fed back into the technical work packages and used for further improving the solutions.

Detailed use of the scenarios (i.e., how they will be deployed in each of the demonstrations) is yet to be clarified and will be developed by all partners throughout the demonstration planning period to come. In principle:

- The interim demonstrations will be based upon a specific component of each of the scenarios, relevant to the technical application being demonstrated. For example, a solution deploying drones will be demonstrated within the context of a sub aspect of the scenario benefiting from aerial operations. This will be determined in partnership between the users themselves and the solution developer.
- The final demonstrations will use the further developed scenarios in full.

It is too early to predict the impact of the pandemic on the demonstrations. In fact, the consortium has already established a risk mitigation plan for pandemic related restrictions on travelling, physical meetings. The risk will be mitigated by setting online meetings and by conducting individual module integration before the main system integration. The main system integration and demonstration will be postponed to an appropriate time. Nevertheless, on the basis that it is easier to 'virtualise' a well-developed demonstration plan, the planning assumption is that the events will take place in person, in the real world. Arrangements are currently being made to facilitate this. Full contingencies will be developed to enable the demonstrations to take place in a virtual environment using the facilities of the technical developers themselves.

2.4 Analysis of the End-User Need and Derivation of Requirements

The formal definition of the demonstration scenarios has not been the only result derived from the conversations among all the partners at this stage. Another result has been the obtaining of a formal set of functional and technical requirements for all the TeamAware components.

The process consisted of the following stages:

1. An initial consultation was made to the end-users in relation to the operational functionalities they would like the TeamAware components to feature. The following information was collected:
    a. the TeamAware component they relate to,
    b. the demonstration scenario in which those functionalities would make an impact,
    c. the level of importance for an end-user to see that functionality implemented, in a scale from 0 to 10.
2. Those functionalities were shared with the technical partners, giving them the opportunity to evaluate them and correlate them with their research activities in TeamAware. This allowed them to append the following information.
    a. A rating from 0 to 10 indicating how implementable those functionalities would be, given the starting TRL of that system and the technical and financial limitations imposed by TeamAware's Grant Agreement. *(The expected outcome is TRL6 in TeamAware)*

   b. Additional clarifications and comments to steer the discussions.
3. In parallel, the level of compliance of those functionalities with the Grant Agreement was assessed. Each of them was assigned one of the following four values:
   a. *TeamAware*: potentially implementable in TeamAware.
   b. *Product*: to be taken into account in TeamAware's sustainability plan, and (or) for a future project after TeamAware.
   c. *Demo*: user-need is transferred to WP13 for future decision. (Demo specific implementation)
   d. *Out of scope*: not in the scope of TeamAware's DoA.
4. With all the above information, several rounds of discussions were conducted yielding to a final decision. For this final stage, only those functionalities with their compliance marked as *TeamAware* in the previous steps were considered. The final decision about those functionalities was chosen among three different values:
   - *Yes*: to be supported in TeamAware.
   - *Yes, with restrictions*: to be supported in TeamAware, but with some technological restrictions to be decided by the technical partners.
   - *No*: not to be supported in TeamAware.

Figure 7 shows a small fragment of the complete list of functionalities under analysis.

END USERS **Related TeamAware component (e.g. ADS, ARMI, Platform, SSCN)**	**END USERS** **Description of user need**	**END USERS** **Priority (0: lowest, 10: highest)**	**TECHNICAL PARTNERS** **Feasibility (0: lowest, 10: highest)?**	**TECHNICAL PARTNERS** **Clarifications from technical partner**	**Final Decision**	**Status** **TeamAware: To be implemented in TeamAware** **Product: To be implemented in product phase after TeamAware RIA as a new project** **Demo: To be concerned for WP13**
CDS	**Execution phase**: Based on the footages from the CCTV at the entrance to the venue, the CDS decision support functionality will be able to predict the type of the chemical agent based on the symptoms shown by victims and the hazardous chemical dispersion model.	10	0	HAVELSAN: We cannot integrate with a camera to detect symptoms, first responders need to detect them.	N	TeamAware
TMS	**Execution phase**: Automatic classifications must be performed by the system to determine the correct position of an individual and also predict the next position based on the detected gestures (e.g. currently walking but according to sensor readings it is expected to fall/faint)	10		HAVELSAN: It is not clear. If the content is fatigue analysis then it is OK.	Y (with restrictions)	TeamAware
TMS	Execution phase: As part of Task 7.2, the system must have the goal to monitor the health of an officer and the body posture in an operational context. Intuitive and relevant alerts must be generated automatically by the system, with a minimum number of fake positives.	9	8?	FHG: Some of the false positives will be mittigated by the data fusion process (although we of course can't guarantee 100% accuracy). This of course only speaks to the reduction of false alarms. We cannot speak to the requirements for WP7.	Y	TeamAware
ARMI	Execution phase: As part of Task 11.2, the users will also have a feedback option through which they will be able to accept or reject an information/command from the command centre. Gestures will be used for this activity.	8	8	Way to make FR aware of a new command, could be vibration & white screen flashes on the mobile application	Y	TeamAware
ARMI	**Execution phase**: AR glasses need to have a compact format, to be lightweight and not block the line of sight	9	5	We are going to use the HoloLens 2 for this project. However, since our application will use OpenXR, if a more suitable device is released during the project (and the budget allows it) we might consider changing the device for the demonstrations.	Y (with restrictions)	TeamAware

Figure 7. Excerpt from the list of functionalities analysed.

Overall, more than 150 operational needs and functionalities have been analysed. The functionalities with *TeamAware* compliance values and with a final decision of "*Yes*" or "*Yes, with restrictions"* (spanning a subset of more than 110 items) have been agreed by the whole consortium, becoming the *operational need and functional requirements* that the TeamAware components must adhere to.

These frozen operational needs have fuelled the work of the technical partners. Based on the operational needs and functional requirements they have decided the technical requirements of their respective TeamAware components, in such a way that eventually they will support the agreed functionalities. In the particular case of those functional requirements accepted with restrictions, technical partners have also studied the conditions (e.g., operational temperature range, supported light conditions) in which they will be met.

TeamAware's final functional and technical requirements are derived from the operational needs of the end users by the technical partners are compiled in the appendices of this document. The analysis procedure for end user needs and derivation of technical requirements are illustrated in the diagram below.

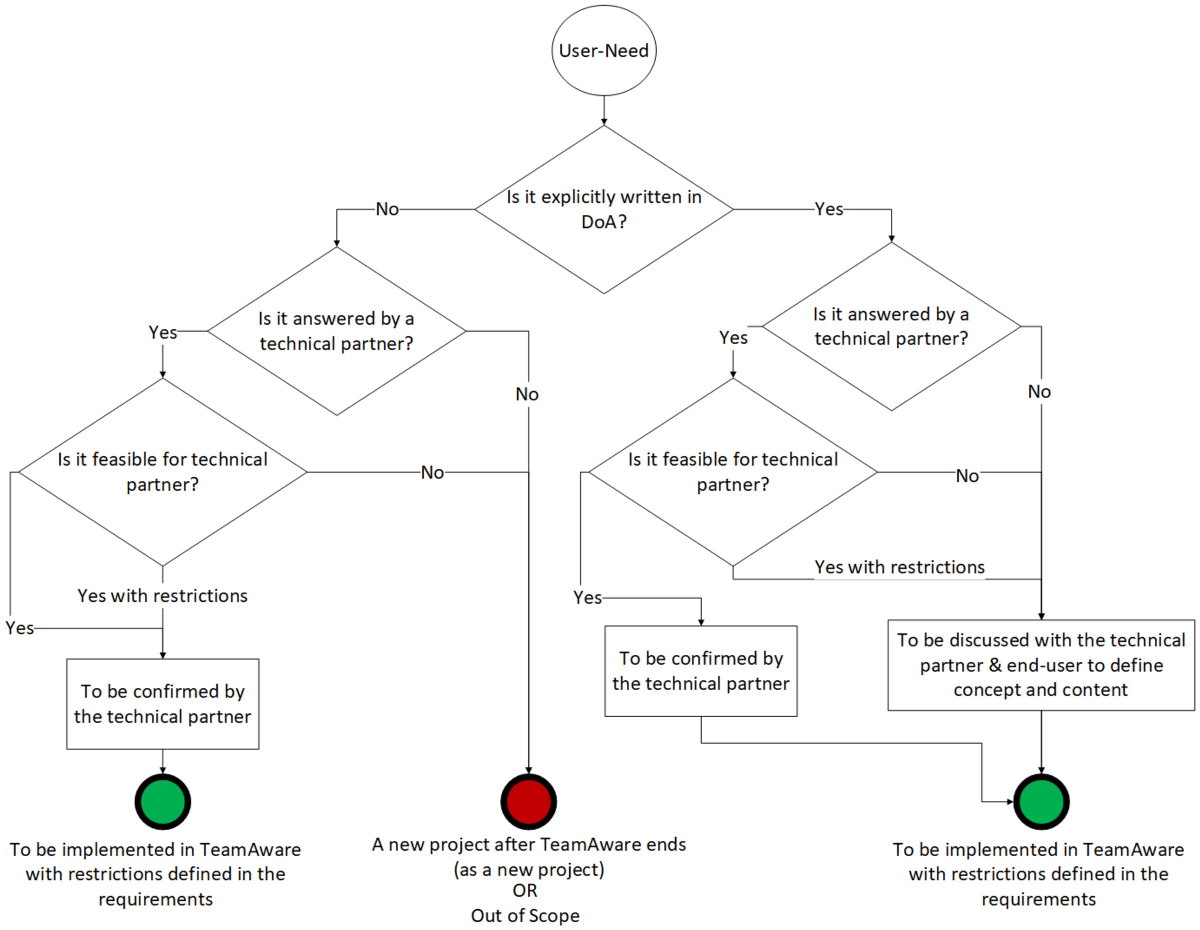

Figure 8 The flow chart of the method for analysis of end users' needs and derivation of end users.

3 Natural Disaster Demonstration Scenario

This scenario will be a NaTech (a natural disaster leading to a technological disaster) one affecting surface buildings and underground. There will be multiple types of incidents such as fire and smoke in a subway, victims, human screams, etc. There will be damaged buildings due to the natural disaster. TeamAware system will provide complete situational awareness picture for the first responders in the affected area.

Context

The scenario is planned in the BursaRay metro line, which is an important means of transport in Bursa city. The 39-km-long line is used by 250.000 passengers on a daily basis. Overall, the tunnel is 900 meters long.

In this scenario, its assumed that an explosion has taken place at the 530th meter of the tunnel's entrance, and the emergency exits are located at the 450th meter of the tunnel. The main goal of the scenario is, therefore, to rescue the citizens trapped in the tunnel by the first responders and save and rescue teams.

Since this demonstration scenario assumes an explosion and certain destructions of the metro infrastructure, the assumed physical outcomes of the explosion and destructions will be described in a configuration-type prerequisite (initial conditions) for the demonstration operation. It should also include application of corresponding safety procedures for potentially possible cases of hazardous materials, broken electrical power lines, posterior and potential risks implied by damages to the infrastructure and so on.

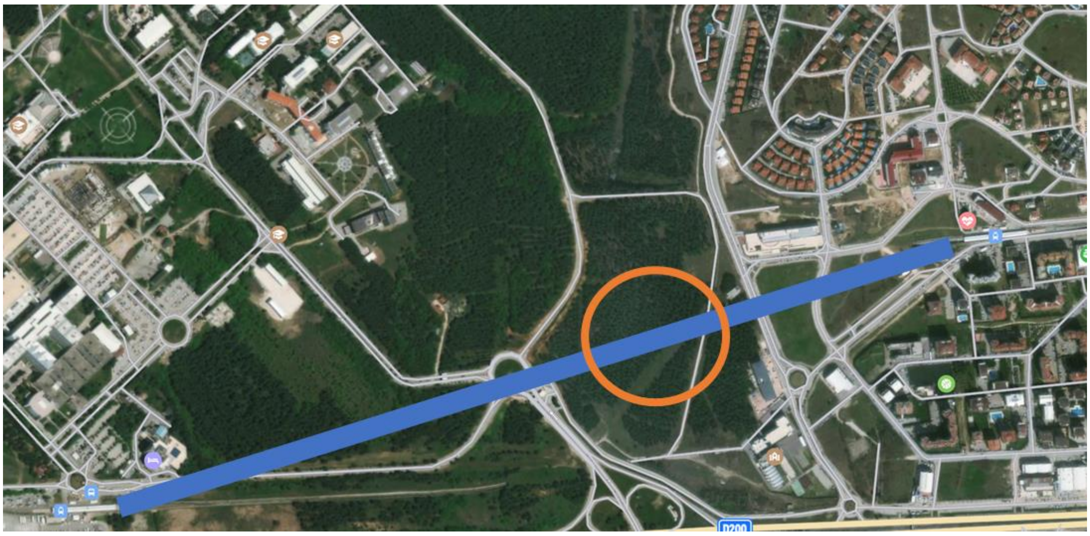

Figure 9. Aerial view of the BursaRay metro line and the area affected by the explosion.

The following end users will participate in this demonstration scenario:

- Bursa Buyuksehir Belediyesi (BBB);
- Resilience Advisors (RAN);
- Acil Afet Ambulans Hekimleri Dernegi (AAHD).

Throughout the scenario, the data collected from the demonstration participants should always comply with the corresponding GDPR regulations.

As for the technical side, the partners participating in the following technical work packages will take part in the trial:

- WP3 – Visual Scene Analysis System. Technology provider: THALES;
- WP4 – Infrastructure Monitoring System. Technology provider: EUCENTRE;
- WP5 – Chemical Detection System. Technology providers: AITEX, HAVELSAN;
- WP6 – Acoustic Detection System. Technology provider: AVISA;
- WP7 – Team Monitoring System. Technology provider: DUNE, HAVELSAN;
- WP8 - Citizen Involvement and City Integration System. Technology provider: INNOVA;
- WP9 – Secure and Standardised Communication Network. Technology provider: SRDC;
- WP10 – TeamAware AI Platform Software. Technology provider: Fraunhofer;
- WP11 – TeamAware AR/Mobile Interfaces. Technology provider: LUCIAD.

Finally, ETICAS will participate by watching for the application of ethical principles during and after the execution of the scenario.

3.2 Scenario Specific Gaps

The following gaps in emergency situations have been recognised by the scenario coordinator (BBB) and the partners involved in it, and their mitigation will be studied in the demonstration scenario:

- **ND-GAP-1**. Actionable intelligence based on information from heterogeneous sources;
- **ND-GAP-2**. Preparedness for large scale evacuation;
- **ND-GAP-3**. Adequate Common Situational Awareness Picture (CSAP) environment;
- **ND-GAP-4**. Obtaining of the critical information remotely about the incident;
- **ND-GAP-5**. Monitoring the physiological signs of emergency responders;
- **ND-GAP-6**. Adequate communication technology for crisis management.

3.3 Research Questions

The answers to the following Research Questions, formulated when applying the TGM methodology to the TeamAware project, will shed some light over the gaps considered under the natural disaster scenario and listed in the section above.

- **ND-RQ-1**. How beneficial can the TeamAware ecosystem be for improving the efficiency of the operations performed by first responders and LEAs in emergency scenarios?
- **ND-RQ-2**. Is it possible to use augmented reality to enhance preparedness for large scale evacuation?
- **ND-RQ-3.1**. Can the status of first responders be effectively monitored with easy-to-use equipment?
- **ND-RQ-3.2**. Is it possible to come up with innovative systems and components for first responders with respect to the current state of the art?
- **ND-RQ-4**. What is the level of integration between the TeamAware systems and the platform into a unified ecosystem?

3.4 Scenario Formulation

The scenario is planned in BursaRay metro line, which is an important component of Bursa city in the field of transportation. The 39 km long line is used by 250.000 passengers daily.

In this context, there is an explosion at the 530th meter of the 900-meter-long tunnel between the University-Batıkent stops on the University-Kestel line of the BursaRay metro line located in the city centre of Bursa, and a related fire broke out. The scenario is formulated on basis of an assumption that a given event (explosion of given magnitude at given location) has happened, and that it has caused a given list of consequences (destruction of metro tunnel, etc).

The firefighters, who receive the necessary information from the officers on the subway line, head to the emergency exit door at the 450th meter of the tunnel with four separate teams (two firefighting teams and two rescue teams).

When the firefighters arrive at the emergency exit door at the 450th meter of the tunnel, they realise that the door is closed from the outside and open the door with the help of a sledgehammer and enter the tunnel. The firefighters also observe signs of infrastructural damage around the emergency exit and need TeamAware system to help them with expertise from the IMS System, as well as check the damaged area for possible gas and smoke leaks with CDS.

With the instruction of the authorised chief, the fire extinguishing team and the rescue team are divided into two separate teams:

- While one firefighting team proceeds to the scene by establishing a waterway (100 meters and five hoses), the other firefighting team starts to work for smoke evacuation.
- While one rescue team proceeds to the scene for the stranded passengers, the other rescue team starts to work on scene-lighting and scanning activities.

The teams that arrive at the scene see that there was a fire in the front of the second wagon of the four-wagon-long metro, and that the passengers escaped to the back of the wagon and are stranded in that area.

The fire extinguishing team starts the extinguishing works by processing water from the waterway that they had prepared beforehand. Meanwhile, the rescue team opens the wagon doors with the rescue equipment and starts the evacuation process of the stranded passengers. Optionally, some of the passengers inside the tunnel may communicate symptoms for possible suffer from a gas leak or smoke (which could be used to test the CDS gas diagnostic algorithms based on victim symptoms).

While the team that has responded to the fire in the wagon continues its work, the other three teams evacuate people standing and people on stretchers.

While the rescue and extinguishing works continue, it is noticed that a firefighter is lying motionless on the ground at the 525th meter of the tunnel by using the TMS. The coordination team, who receives the necessary data from the TeamAware platform, immediately shares the information with the rescue teams who continue their evacuation work in the tunnel. Rescue teams, who immediately take head to the specific location of the firefighter after receiving the commands and information from the coordination chief, reach their colleague lying motionless on the ground between the two wagons. The colleague lost consciousness during the rescue efforts for an unknown reason, and he was trapped in a place where the other teammates could not notice him. They take the trapped firefighter out of the tunnel on a stretcher and hand him over to the medical teams.

3.5 Solution Selection

Almost all the TeamAware systems (except CDS/WP5 and CICIS/WP8) will be used within this demonstration scenario as part of the trial by the end users involved.

3.5.1 Visual Scene Analysis System (WP3)

The VSAS is made up by two main components: a drone and a helmet. The drone is equipped with GPS, RGB-D camera, VCSEL lidars, wireless connectivity, and on-board computing power.

Figure 10. VSAS drone.

The helmet is equipped with grey scale camera, an IR camera, IMU, wireless connectivity, and possibly with on-board computing power (and optionally with the link to the AR glasses).

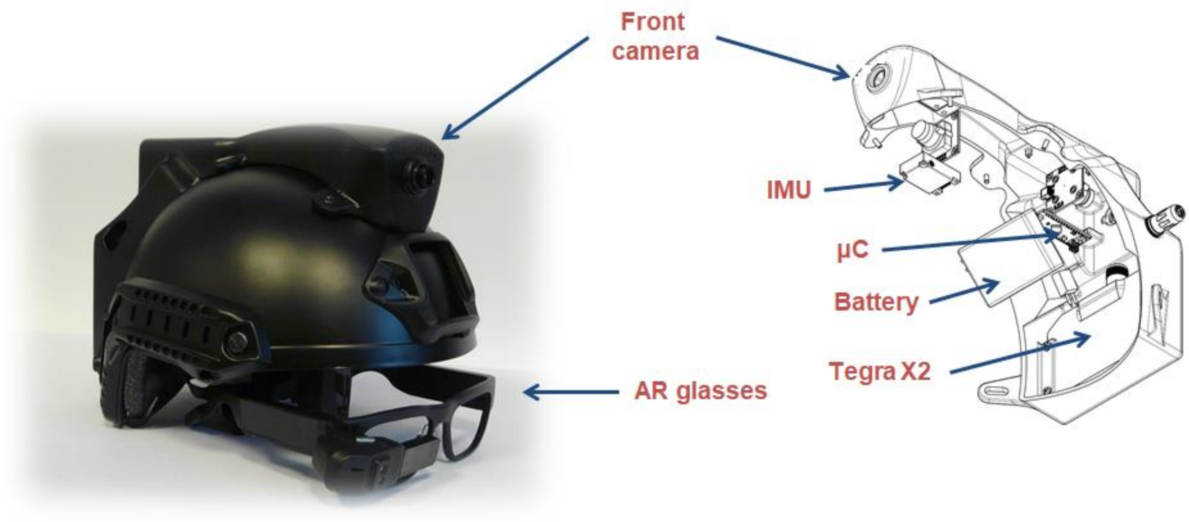

Figure 11. VSAS helmet.

For the purposes of the natural disaster scenario, first responders will take the drone on site in order to create a map of the area and locate trapped civilians. Once safety procedures are complete, firefighters can get to the subway train. They will be helped with guiding instructions generated thanks to the helmet, which approximate their position.

Before first responders can reach the disaster zone, they must create a safe path or a waterway, and possible clean out the smoke. During this time, the drone will head directly to the danger zone and thus, generate a map. The map will be updated at runtime and streamed wirelessly to the main ground station. There, it can be visualised (2D / 3D) easing and improving the decision-making process.

When the drone arrives at the disaster zone, the operator starts to look for stranded passengers while the map keeps being updated. The video stream can be analysed and annotated to help the operator finding victims (e.g., human detection algorithms, contrast/luminosity enhancements).

After firefighters finish preliminary procedures, they have to move to the disaster zone. The helmet will record their path and estimate their relative position. These positions will be sent automatically and wirelessly to the ground station for a global understanding of the operation. When needed, any helmet can guide its wearer along the reversed path to get back to the entrance.

3.5.2 Infrastructure Monitoring System (WP4)

In general terms, the inspection of the affected area by the IMS greatly benefits from having maps from before the incident. At the current stage it is being analysed if a map of inside the tunnel will be available. Therefore, there are two possible scenarios:

1. The map of the tunnel **is** available: the IMS will be used to inspect the area surrounding the explosion inside the tunnel, checking the integrity of the wall, ceilings, and other infrastructure elements.
2. The map of the tunnel **is not** available: the natural event which led to the explosion may have damaged buildings and infrastructures in the overall area. The IMS will be used to guarantee the safety of the rescue team coordinating the operations that is based at the two exits of the tunnel.

Either way, the system will output a human-readable report for human experts (i.e., structural engineers) with information about the faults identified in the inspected area. The report will also include a classification of the different faults with visual annotations. Although the operators will have been trained by the TeamAware platform, the analysis of the IMS outcome should be conducted by an expert for more realistic and effective results.

3.5.3 Chemical Detection System (WP5)

The use of the CDS System within this scenario is restricted by the fact that CDS is supposed to function in the open area, in this case, outside the tunnel and not inside. On the other side, internal infrastructure damages (in tunnels, parking lots, inside buildings) frequently may lead to break up of water and gas supply tubes. Even if the source of a gas leak and/or smoke may be in the interior area, possible cracks in the building walls may be the gateways for gas and smoke to exit outside and constitute danger for the people around the building. Such interpretation allows to test CDS System within the scenario despite of its restriction in the interior areas.

In particular, signs of an infrastructure damage around the emergency exit from the tunnel will trigger activation of the CDS System to check the area around the emergency exit. Either invisible gas or smoke from internal fire, or both, can be detected.

The compounds the system will detect can be categorised under two groups:

- Threats:
    - Toxic industrial gases, mostly accidentally released as a consequence of the disaster.
    - Flammable organic gases.
    - Vapours emanated from concealed explosives or other threats to be detonated by purpose (i.e., by terrorists) on purpose upon first the arrival of LEAs and first responders.
    - Chemical Warfare Agents
        - Such toxic substances, namely Ammonia (NH3), Sulphur Dioxide (SO2), Chlorine (Cl), Hydrogen Cyanide (HCN), Phosphine (PH3) and Carbon Monoxide (CO).
- Other type of indicators: Oxygen (O2), Florine (F2), Hydrogen (H2) which can be required measured for the operational teams on the field.

The CDS is composed by the Wearable Chemical Detection System (WCDS) and the Chemical Dispersion Model (CDM) that will consider simulations that will evaluate the information provided by the sensors, combining information on the meteorological situation as well as conditions of the terrain or holography.

The WCDS platform is based on two modules. The first one, the sensor module is an electronic base that can manage some types of electrochemical sensors. Basically, this module works as a base to supply power and manage the communications of the sensors. This component is compact to facilitate its placement on a garment. It can be located on the shoulder, on the sleeve, in a pocket. The location will depend on the type of activity and uniform to be worn by the user. This module will be integrated with a 4G/5G communications module to send the information continuously to the platform. In addition, a Galileo GNSS module and accelerometer are included to complement with location information.

All the information provided by the WCDS will be complemented with location and timestamp. This data will be transmitted via 4G/5G communication network and stored in a server database where will be post-processed.

At the server the data provided by the sensors will be stored and analysed. CDM will be considered for the simulation and analysis. CDM will be applied to Ammonia (NH3), Sulphur Dioxide (SO2), Chlorine (Cl), Hydrogen Cyanide (HCN), Phosphine (PH3), Carbon Monoxide (CO) to obtain simulation for the dispersion. This system will be running in a Linux server consuming the data produced by the sensors. The system should calculate two separate pollution zones according to the user's selection. In order to calculate the pollution zone, user can provide some inputs or setting depending on the selected model and preferences. With those inputs, the interface service should be called. The interface service will receive the sensor data over the database defined in the system.

CDS also provides a symptom based chemical detection, it is used by first responders entering some text-based symptoms of a victim and the system gives an output of the possible gases that could have affected the victim.

Eventually, that information will be transmitted to the TeamAware Platform, which will display all the relevant data in such a way that the mission commander can have a situational awareness and take the appropriate actions (e.g., deploy units, restrict access, move civilians, etc.).

3.5.4 Acoustic Detection System (WP6)

The ADS can help the rescue team in scanning the affected area. Since the situation in the tunnel after the explosion is unknown, a UAV equipped with ADS, multispectral and IR-camera is a good option for scanning the area. The ADS can detect any sound sources such as people screaming, asking for help, any later explosions or fire blasts.

The advantage ADS has over other technologies in this case is that it is not affected by light conditions or if there are obstacles between the victims and the rescue team, or even when there is smoke in the air, while these conditions can make it challenging for the visual-based technologies. Possible fusion of acoustic data with information from camera and IR-cameras (in case of no light), which are deployed in Visual Scene Analysis System (see WP3 VSAS section above), can help in finding the location of the real sound sources and this will help the rescue team find the location of victims. The ADS can speed up initial scanning of the scene before even the light is provided. Fusing visual and acoustic data can provide a more accurate estimation of the location of the sound sources, and this can be used to control the position of the UAV accordingly by directing the UAV to fly toward the area that more urgent help is needed. By being closer to the area with higher priorities for help, more accurate information with better resolution can be obtained. Fusion of data in this case is important because the environment in the tunnel would be very reverberant and several reflections of different sound sources from different surfaces will be received by the acoustic array. Fusion of data can help to find the location of the sources of interest.

Therefore, in this scenario, ADS can be used for scene scanning by detection and localization of sound events/activities such as (conscious) passengers asking for help, human screaming, explosions or glass breaking in the tunnel.

3.5.5 Team Monitoring System – Activity Monitoring System (WP7)

In the scope of this scenario, a set of wearable AMS (10 motion units + 1 health unit + 1 gateway) will be equipped by all the members of the rescue team. Motion units will be placed on upper legs, lower legs, upper arms, lower arms, head, trunk (1 for each limb); health unit will be placed on wrist and gateway will be placed on the waist. Each set will send quaternion data carries the posture information of the rescue team member who wears it for each limb. The limbs that AMS modules will be attached are shown in Figure 12 and Figure 13, these modules will be placed on body by using reusable elastic bands, one by one, it can be both worn by the rescuer himself/herself or it can be worn by the aid of another rescuer. There will be a total of 12 wearable modules 10 for posture, 1 for health and 1 for gateway units. Posture information and anomaly detection for each user that wears the AMS set can be monitored on request by other users. List of the classified movements or anomalies will be constructed with collaboration between end-users and technical team, according to that list, training data will be collected for the listed movements. AMS will operate continuously during a 10h of operation.

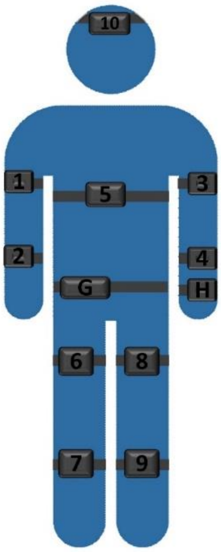

Figure 12. AMS module placement with respect to limbs (G indicating the gateway, H indicating the health sensor module).

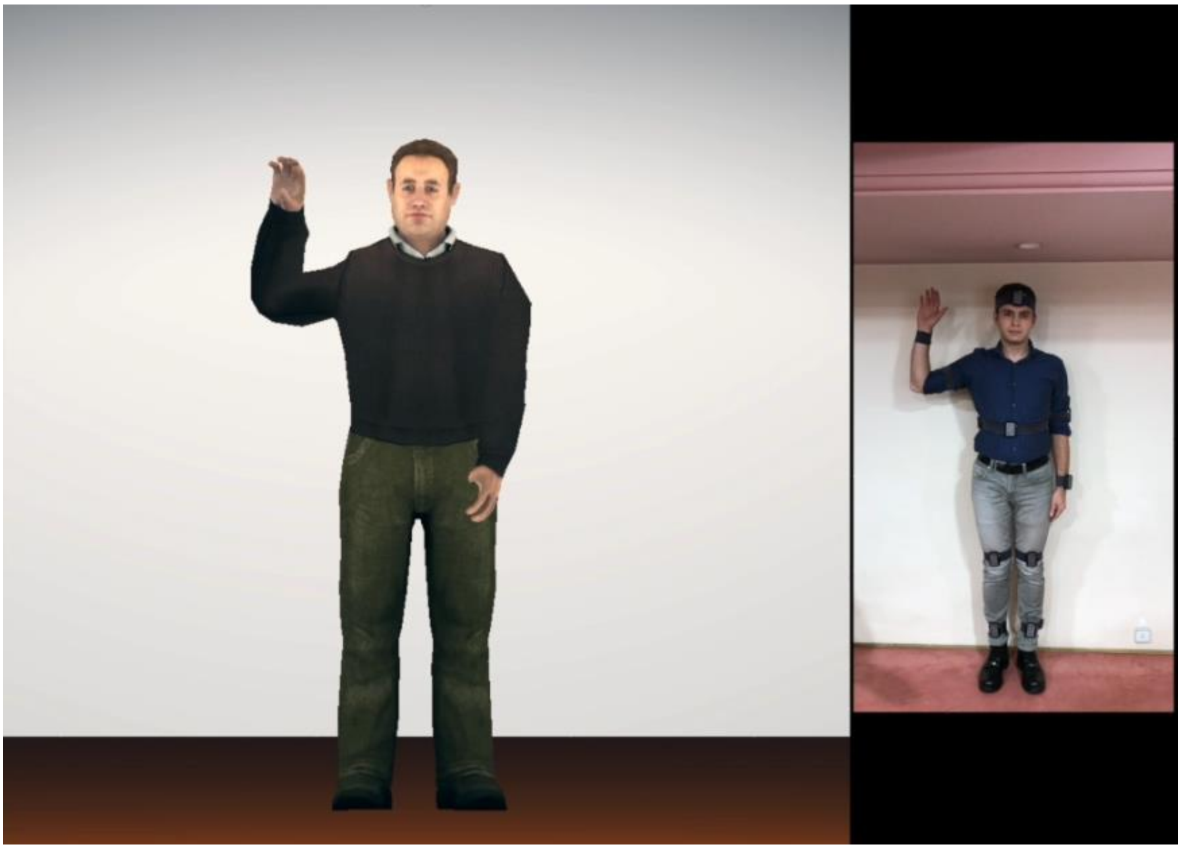

Figure 13. AMS placement and modelling.

The AMS will play its major role by providing the posture and anomaly (if there is) information of each first responder. Anomalies that will be detected is stumbling, faint, tiredness, fallen or laying rescuers and detected actions (such as walking, sitting etc.). This information will be delivered to the coordination chief, who will send a number of rescuers. The joint knowledge of the positions (in 3D) and condition of both the unconscious firefighters and his/her colleagues will be the enabling tool to: 1) detect the risky event (unconscious operator) almost instantaneously; 2) precisely and timely drive the rescue action.

3.5.6 Team Monitoring System – Continuous Outdoor Indoor Localisation System (WP7)

In this scenario, the COILS will be equipped by all the members of the rescue team entering the tunnel and their position will be delivered to the TeamAware platform with 1 Hz position refresh rate (tuneable). At the TeamAware platform the current position is displayed, along with the walked path history (tuneable past display time). The COILS will also let the operator of TeamAware platform operate track refinement techniques (automatic and manual). The COILS will be operative from the very beginning to the end of the demonstration.

The COILS will play its major role by providing the location information of the collapsed, unconscious firefighter (the unconscious state itself can be detected by AMS and COILS). This information will be delivered to the coordination chief, who will send the rescuer teams, whose position is provided by the COILS. The joint knowledge of the positions (in 3D) of both the unconscious firefighters and his/her colleagues will be the enabling tool to: 1) detect the risky event (unconscious operator) almost instantaneously; 2) precisely and timely drive the rescue action. Figure 14 and Figure 15 show the segments of COILS applicable to both scenarios.

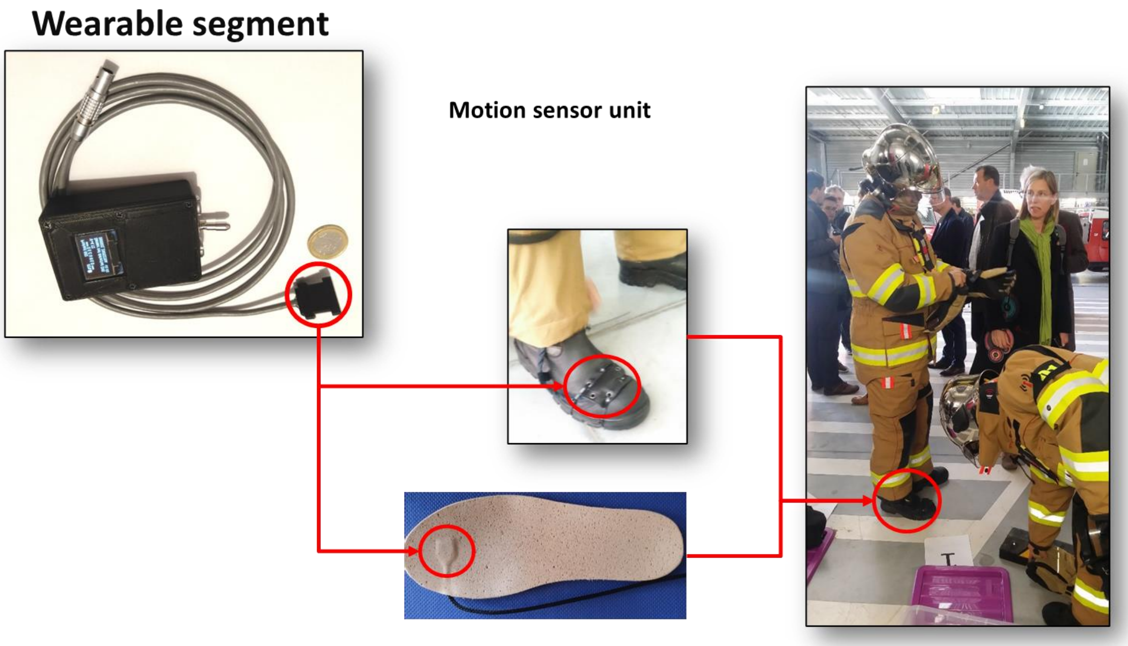

Figure 14. Wearable segment of COILS in the context of both scenarios.

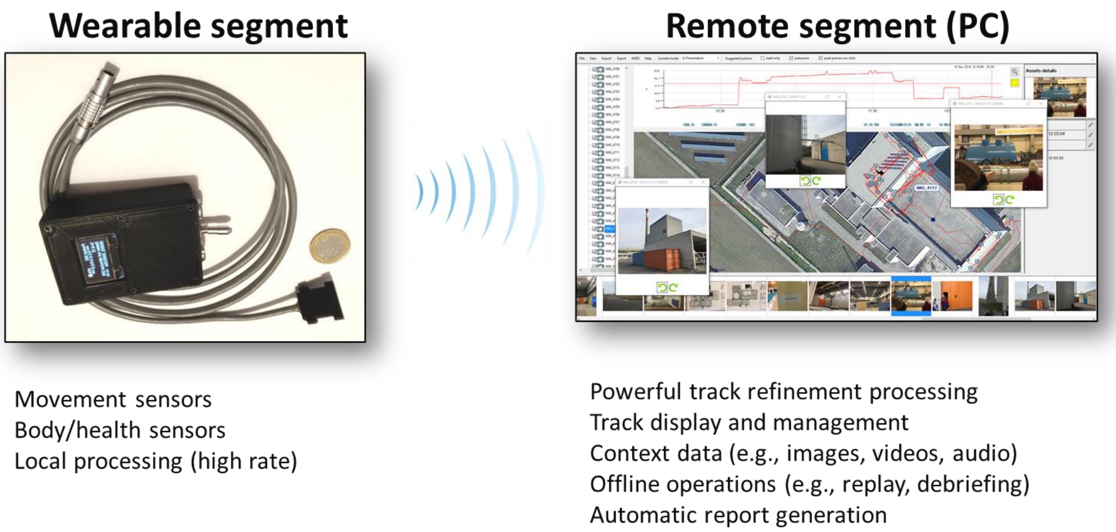

Figure 15. Wearable and remote segment of COILS in the context of both scenarios.

3.5.7 Citizen Involvement and City Integration System (WP8)

The expected use of the CICIS system in the test scenario comprises the following cases:

- Social media data gathering in order to gather information provided from persons stuck inside the tunnel environment as well as from citizens that notice evidence of the incident outside of the tunnel (e.g., smoke). The data expected to be generated will consist of citizen report text and photos with coarse geo-location of events for data gathered outside of the tunnel.
- The CICIS system and app will be used to identify citizens in need of assistance (via self-report) and to guide citizens away from dangerous situations. For this particular scenario, the Citizen App will be used by a person inside the tunnel in order to report relevant information about the number of persons in need of help and their injury status including photos of the location on the train where the persons are trapped in order to help with locating them. The Citizen App will also be demonstrated as an alternative to mass messaging for the purpose of directing citizens away from areas of danger and intensive rescue activities in the affected area.

The gathered data via CICIS will be presented via the overall TeamAware Platform.

3.5.8 Secure and Standardised Communication Network (WP9)

The Secure and Standardized Communication Network will be the backbone of the communication. The communication infrastructure is aimed at running on a public cloud. During the pilot it will be able to be running in a private cloud and, due to the use of Kubernetes (https://en.wikipedia.org/wiki/Kubernetes), new IT hardware can be added easily and dynamically should the demonstration required so. Optionally, if hardware is provided by the end-users, the mirror image of the cloud infrastructure can be installed in the end-user premises. The cloud infrastructure is based on Kubernetes and the current version of the system is presented in Figure 16(copied here from D9.1 document).

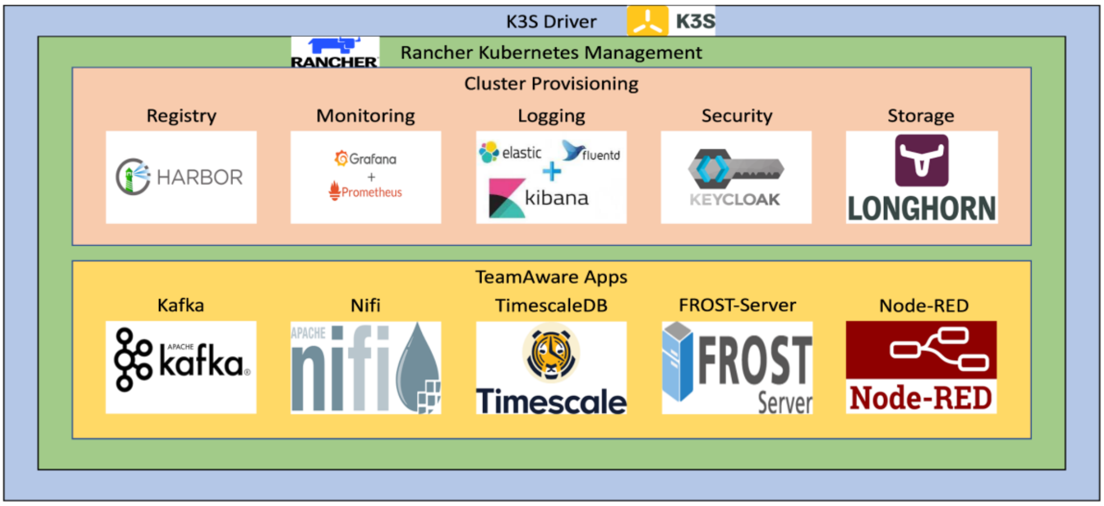

Figure 16. Current TeamAware cloud infrastructure (D9.1).

More detailed information will be available in deliverable D9.1 ("*Network Architecture and Domain Ontology Report*").

For each of the systems used in the pilot, necessary data adapters will be implemented through standardised interfaces. Conversely, the available data can be queried through standardised interfaces as well.

Considering the communication technology, direct interviews between the technical partners and the pilot coordinator BBB have been conducted. BBB will be able to provide WiFi, LORA (https://en.wikipedia.org/wiki/LoRa) and GSM (3G/4G) networks in their premises. Albeit, in case of a communication failure it is planned to establish an ad-hoc mesh network through Raspberry Pis Model 3 or 4 B+ (https://en.wikipedia.org/wiki/Raspberry_Pi). The intended architecture is shown in Figure 17.

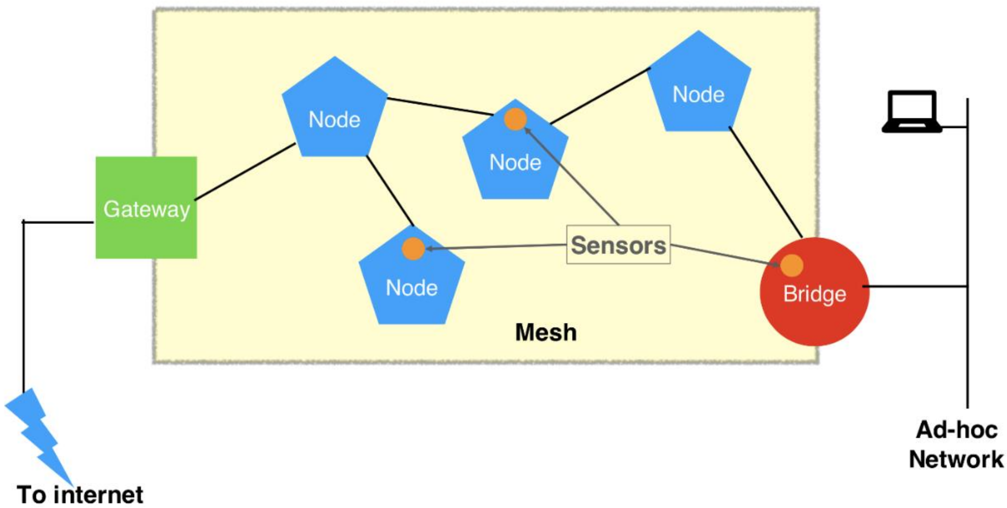

Figure 17. TeamAware ad-hoc mesh network.

3.5.9 TeamAware Platform (WP10)

In the natural disaster scenario the role of the TeamAware platform is twofold from the end-user perspective. On the one hand, the data management part (data storage and data fusion) is responsible for the data handling, cataloguing, and storing for all connected edge systems and software modules, as well as providing this information to all edge systems and software modules which need to access this data. The data management part of the software platform will provide this functionality in a high-level software way, so the actual network transmission components and layers are not to be taken into account. The data fusion section is, from user perspective, part of the backend software platform and is mainly responsible to combine different information generated by the edge systems where possible to generate an additional benefit in terms of data reliability and information potential. The gathered and fused data will be used to build the "Common Situational Awareness Picture".

On the other hand, the second part of the software, from user perspective, is the deployable operator front end. This is a high-level front end intended for on-site team leaders and coordinators, which will be presented with the in-situ information provided by the TeamAware systems. For example, these include the current location of the first responders at the tunnel equipped with location sensors in relation to each other and (if accessible) in relation to other objects (map view). This user interface (GUI) will be able to display all relevant information available to the system as specified by the other included TeamAware systems in an intelligent manner. In detail, the refined and manageable "Common Situational Awareness Picture" will be presented to the operators in the operational centre and first responders in the field as well.

3.5.10 Augmented Reality and Mobile Interfaces (WP11)

The goal of the Augmented Reality and Mobile Interfaces (ARMI) is to give the first responders the critical data they need to enhance their spatial awareness via well-defined user interface and user experiences (UI/UX) designs. At the same time, they provide a direct way for the command-and-control centre to give specific information to the first responders on a time sensitive and non-obstructive way.

In this regard, in the natural disaster scenario AR and mobile UI's will provide data regarding the safety of the areas to the first responders, combining their location with the known damaged areas reported from the sensors. This will allow operational team to keep each first responder updated on the safety information of the area they are in without intervention from the command-and-control centre.

In addition to improving the first responders' safety UI will also provide information to enhance their performance. In this scenario UI will mark in real time the victims that have been located and the first responder that is lying on the ground and, if available, the navigation data the team needs to get them to their objectives.

When a significant hazard on the field has been identified at the TeamAware Platform, it will send a notification to the ARMI. With this notification, the AR will show an icon indicating that more details are available in the mobile UI (maybe related to the type of danger details given by the Platform). The mobile UI will dynamically switch to the related view, showing to the end-user the details of the hazard.

3.6 Data Collection

The current section gives a glimpse to the data that will be collected during the scenario to answer the research questions. Even though it is just a first approach which will be later refined in WP13, it will provide a close description that will provide a base line for future discussions.

At the high level, the collected data will pass through the following collection and processing stages:

1. Raw data collected by systems (sensors).
2. Cleaned and parsed data fed into the data analysis platform.
3. Reconstructed data and derived by AI and machine learning algorithms.

4. Data fused among systems, interpreted data (alarms) and mapped into Common Situational Awareness Picture (CSAP).
5. KPI data at level of the entire emergency situation and its risk factors.

The following table summarises which data will pass through the above-mentioned processing stages per each sensor system.

Table 2. Collection and processing stages for each TeamAware sensor system.

Sensor System	Raw data	Cleaned data	Reconstructed data	Fused and interpreted data (VIS = visualisation CSAP = Alerts)	KPI data on given emergency situation
VSAS	Images & video of fire, smoke, human victims	Areas of interest identified, noise & background subtracted	Fire data object, smoke cloud data objects, debris data objects, human victims data objects, etc.	VIS: Fire & smoke locations. CSAP: Alerts on victim images	Risks from fire, smoke and victims within the global situation
IMS	Images & video of tunnel and/or external damages	Areas of damage identified, areas without damage (bg.) cut out	Infrastructure damage data objects reconstructed and classified	VIS: location of damages CSAP: alerts on damages and their consequences	Risks from infrastructure damages within the global situation
ADS	Explosion sound Human voices	Acoustic noise subtracted	Acoustic signals reconstructed and classified	VIS: location and time of explosions and voices CSAP: Alerts on explosion and victim voice sound	Risks from explosions and victims within the global situation
TMS	Agent health, locations and movement sensor data	Agent health, position, location and move types are identified	Trajectories of agents reconstructed, agent positions classified, health data analysed	VIS: agent positions and trajectories CSAP: Alerts on agent position and health	Risks from team state & victims within the global situation

ARMI				VIS: global 3D view of the scene with all data types CSAP: 3D map of alert events	Risks from (in)completeness of global picture and relations of factors in 3D + time space

Having collected the raw, cleaned, reconstructed, and fused data mentioned above and having interpreted it in the sense of risks within the global emergency situation, the efficiency of the TeamAware platform and the entire project from the stakeholders' perspective can be measured based on the project-level KPIs.

In the following, a list of the metrics and measures (KPIs) to be collected is provided. For each of them, it is described who collects the data, who are they collected from, at what point of the trial, and how it is obtained:

- **Awareness increase (AWI)**: the perceived increase in the awareness of the circumstances involving the emergency scenario due to the use of the TeamAware platform, as perceived by the staff at the command centre. In other words, it refers to the quality of the fused data.
    - Collected by: Resilience Advisors.
    - Collected from: BBB staff at the command centre.
    - When: After the trial.
    - How: By means of questionnaires representing AWI in a numerical scale.

- **Upstream knowledge increase (UKI)**: the increase in the usefulness of the information about the incident as obtained by the TeamAware sensors and sent to the command centre. In other words, it refers to the usefulness of the raw data as collected by the TeamAware systems. This metric may be measured individually at system level.
    - Collected by: Resilience Advisors.
    - Collected from: Affected end-users.
    - When: After the trial.
    - How: By means of questionnaires representing UKI in a numerical scale.

- **Downstream knowledge increase (DKI)**: the increase in the usefulness of the information about the incident fused at the TeamAware platform and sent to the end-users on the field, and the way it is presented to them.
    - Collected by: Resilience Advisors.
    - Collected from: Affected end-users.
    - When: After the trial.
    - How: By means of questionnaires representing DKI in a numerical scale.

- **Usefulness (US)**: the perceived level of utility of the solutions used in the demonstration scenario for assisting first responders, and the potential perceived for future use. This metric may be measured individually at component level.
    - Collected by: Resilience Advisors.
    - Collected from: Affected end-users.
    - When: Before and after the trial.
    - How: By means of questionnaires representing US in a numerical scale.

- **Time efficiency increase (TEI)**: the perceived increase in the agility to perform the rescue operations, compared to similar operations conducted in the past without the assistance of the TeamAware systems. This metric may be measured individually at component level.
    - Collected by: Resilience Advisors.
    - Collected from: Affected end-users.
    - When: After the trial.
    - How: By means of questionnaires representing TEI in a numerical scale.

- **Ease of use (EoU)**: the level of ergonomics of the solutions as perceived from end users involved in the trial. This metric may be measured individually at component level.
    - Collected by: Resilience Advisors.
    - Collected from: Affected end-users.
    - When: Before and after the trial.
    - How: By means of questionnaires representing EU in a numerical scale.

- **Overall user satisfaction (OUS)**: a measure of how the expectations of the different components have been met. This metric may be measured individually at component level.
    - Collected by: Resilience Advisors.
    - Collected from: Affected end-users.
    - When: Before and after the trial.
    - How: By means of questionnaires representing OUS in a numerical scale.

The following table links each KPI mentioned above to the related TeamAware sensor systems, indicating if they apply. Components like the Platform and the SSCN are applied to all of them, and are therefore intentionally omitted:

Table 3. Applicability of KPIs for each TeamAware sensor system.

		VSAS	ADS	IMS	TMS	ARMI
KPI	Data \ Improvement question	Images of fire, victims smoke	Audio of explosions, victim voices	Image analysis of infrastruct. damage	Team health and activity metrics	Virtual 3D visualisations
AWI	How much does it increase awareness?	X	X	X	X	X

UKI	How much does it improve Upstream Knowledge?	X	X	X	X	
DKI	How much does it improve Downstream Knowledge?					X
US	How much does it help to minimise injuries, to better allocate resources?	X	X	X	X	X
TEI	How much does it reduce time of reaction?	X	X	X	X	X
EoU	How easy is it to use?	X	X	X	X	X
OUS	How much does it satisfy users?	X	X	X	X	X

The collection of data will adhere to the considerations and protocols for personal data management that have been described in D1.3 (Data Management Plan v1), and which will be expanded in D1.8 (Data Management Plan v2) due by month 30.

The trial will involve the collection of personal data from human participants (e.g. video footage, vital signs) after providing informed consent, and will be collected and processed appropriately under GDPR. Data collection and storage practices, regardless of the format, will be adequately secured to safeguard confidentiality. The project will retain only records or data that have been pseudonymised or anonymised.

For further information about the handling of collected data, the reader is encouraged to check D1.3 for more details.

3.7 Evaluation Approach

This section provides a first approach to the evaluation phase. However, this should not be understood as a final version but as a baseline in which WP13 will base its work and build the final strategy towards evaluation.

Based on the KPI-related questionnaires, the KPI metrics are calculated. Various TeamAware sensor systems contribute to such KPI valuation, as described in Section 3.6. Then, based on the KPIs, the research questions are answered, which in turn are aimed to decide whether TeamAware can fill in the gaps identified by the end-users.

The following table provides a first approach to how the KPI values are calculated (when applicable, KPI contributions per system could be sum up using a weighting technique). This forms a baseline for the obtention of meaningful evaluation information that will be refined by WP13 later on in the project. All the KPIs are calculated in the similar manner: the difference of a measured KPI metric value between the scenarios "with" and "without" TeamAware platform, is normalized to the value "without" the platform, and weighted by 100 to express it in percent.

Table 4. Procedure to calculate the different KPIs.

KPI	KPI evaluation questions to users: "How would you estimate …"	KPI without TeamAware	KPI with TeamAware	KPI value calculation
AWI	... your awareness from 1 to 10	AW1	AW2	AWI = 100 * (AW2 - AW1) / AW1
UKI	... upstream knowledge from 1 to 10	UK1	UK2	UKI = 100 * (UK2 - UK1) / UK1
DKI	… downstream knowledge from 1 to 10	DK1	DK2	DKI = 100 * (DK2 – DK1) / DK1
US	… usefulness of TeamAware platform and its components (subsystems), from 1 to 10	US1 = 1	US2	US = 100 * (US2 – US1) / US1
TEI	… time efficiency (e.g. mean time of reaction per event type), in minutes	T1sys T1tot = max(T1sys)	T2sys T2tot = max(T2sys)	TEI = 100 * (T2 – T1) / T1, Either for Tsys or for Ttot
EoU	… ease of use from 1 to 10	EoU1 = 1	EoU2	EoU = 100 * (EoU2 – EoU1) / EoU1
OUS	… overall satisfaction from 1 to 10	OUS1 = 1	OUS2	OUS = 100 * (OUS2 – OUS1) / OUS1

The following table shows the relationship (marked as "X" in case when related and empty when not) between the research questions presented in Section 3.3 with the KPIs defined in Section 3.6:

Table 5. KPIs used in answering each research question.

	ND-RQ-1	ND-RQ-2	ND-RQ-3.1	ND-RQ-3.2	ND-RQ-4
AWI	X				
UKI			X	X	
DKI		X			
US	X	X	X	X	X
TEI	X	X			X
EoU	X	X	X	X	
OUS	X	X	X	X	X

For example, to answer ND-RQ-1 the following KPIs are related: AWI, US, TEI EoU and OUS. Finally, the following table presents some quantitative and qualitative relations between the KPI values and the Research Questions defined in Section 3.6. Again, these relations will be refined in WP13.

Table 6. Answers to Research Questions based on KPIs.

Research Question	Answer based on KPI	Comments and/or conditions
ND-RQ-1	= AWI + TEI + US + EoU + OUS	All KPIs contribute here, may be sum up with or without weights
ND-RQ-2	YES	Given that DKI, US, TEI, EoU and OUS of the ARMI system are reasonably good, i.e. DKI_ARMI > 0 & US_ARMI > 0 & TEI_ARMI > 0 & EoU_ARMI > 0 & OUS_ARMI > 0
ND-RQ-3.1	YES	Given that UKI, US, EoU and OUS of the TMS system are reasonably good, i.e. UKI_TMS > 0 & US_TMS > 0 & EoU_TMS > 0 & OUS_TMS > 0
ND-RQ-3.2	YES	Given that overall UKI, US, EoU and OUS are reasonably good, i.e. UKI > 0 & US > 0 & EoU > 0 & OUS > 0
ND-RQ-4	= TEI_SSCN + US_SSCN + OUS_SSCN	Given that US, TEI and OUS of SSCN system are reasonably good, i.e. US_SSCN > 0 & TEI_SSCN > 0 & OUS_SSCN > 0

The formulas presented here are example guidelines, while the real ones to be applied can be revised and adjusted during the demo preparation works under coordination of WP13. If needed, the KPIs contributing to ND-RQ-1 and ND-RQ-4 may be combined with a weighted sum reflecting their relative importance (this depends on real KPI values obtained after the demo scenario, for example if KPI A changes from 5% to 10% and KPI B changes from 50% to 100%, both doubling, it may be useful to weight KPI A with a factor 10). For questions ND-RQ-2, ND-RQ-3.1 and ND-RQ-3.2, various threshold values (e.g., 25%, 50%, 75%, 100%) may be applied to conclude the satisfaction of the affirmative answer conditions (this may also depend on the real KPI values obtained during the demo).

3.8 Scenario Objective

The disaster scenario portrayed in this chapter is of a mixed nature, in the sense that a natural disaster leads to some failures of human infrastructures which worsens the consequences and inherits danger of the situation. The disaster is unforeseen, and first responders must react to the circumstances on the basis of their training and expertise. **The specific details concerning the execution of the scenario will be developed in WP13**.

The TeamAware systems involved will be used to facilitate the search and rescue operations of the end users and increase their safety in doing so. The TeamAware platform will combine the information coming from all the sensors and fuse it to provide increased situational awareness to the operators on the field. The SSCN will provide a transparent harmonisation layer thanks to which both the platform and the systems can establish bi-directional communication regardless of specific data formats.

In general, apart from the TeamAware platform and the SSCN, the TeamAware systems can be classified into two separated groups:

1. Systems that **send** raw data to the platform to increase situational awareness.
2. Systems that **receive** fused data from the platform to assist the first responders on the field.

The scenario is characterised by the low visibility and the presence of smoke and fire inside a closed environment. These characteristics entail some specific requirements to the TeamAware's systems and components. For the sake of readability, these requirements have been compiled in Appendix 1.

4 Human-Made Disaster Demonstration Scenario

The second scenario will be about terrorist related event(s). During the development of this scenario there might be multiple types of incidents (i.e., an explosion or toxic chemical attack, etc.). SPP is working on detailed scenario script and preparation plans, which will be documented later on (under WP13).

4.1 Context

The scenario is planned in the city centre of Bucharest, in a crowded area with high volumes of traffic, near offices and residential areas. On the same day of an international summit, several threats will be detected at some points of that area. The great variety of buildings surrounding the venue (e.g., from older with a high degree of degradation to newer buildings, from one level houses to 20-storey apartment buildings, from local stores to factories, etc.) is also a factor to take into consideration. Potential risks of incidents involving hazardous materials (gases, liquids, etc.) should trigger application of corresponding security policies and procedures. Data about all the civilians and the rescue workers involved in the demonstration must comply with legal regulations (GDPR).

Figure 18 depicts the venue area at the centre (the Palace of the Parliament) and three different locations of interest nearby (a gas station, a factory, and an abandoned building).

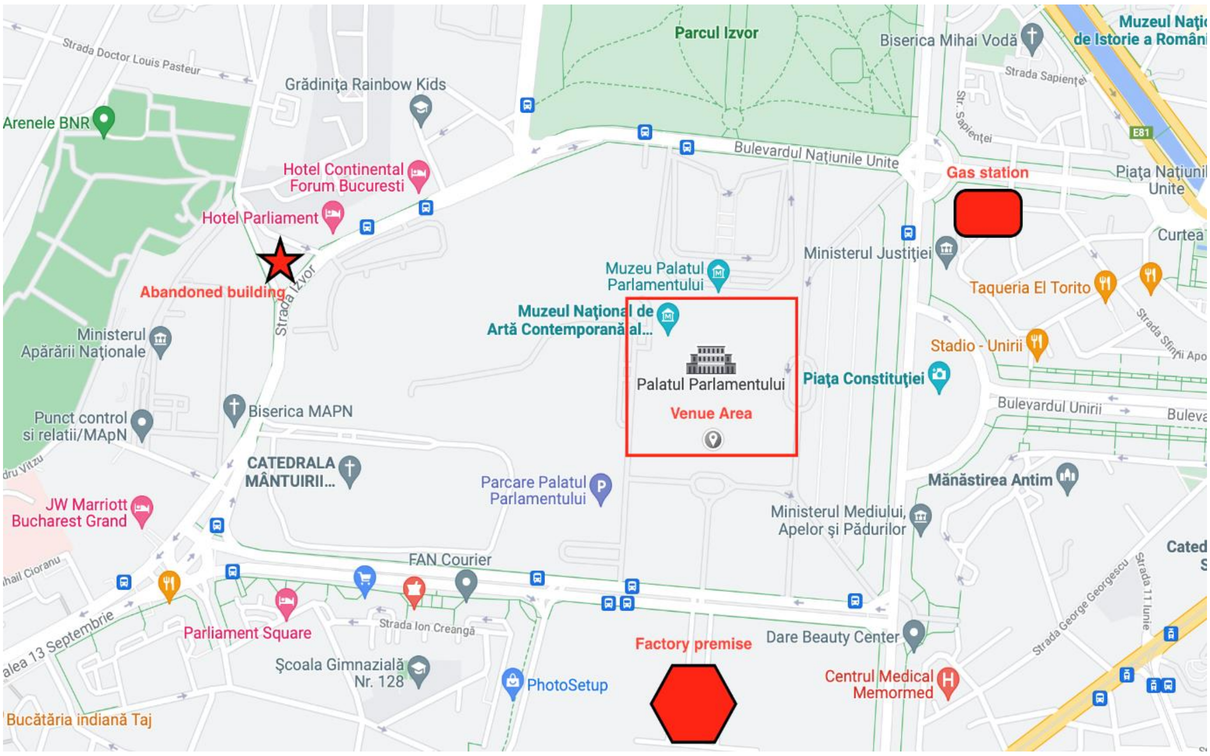

Figure 18. Aerial view of Bucharest's Palace of the Parliament and the area affected by the attack.

The following end-users will participate in this demonstration scenario:

- Serviciul de Protectie Si Paza (SPP);

- Resilience Advisors (RAN);
- Associaçao Humanitaria dos Bombeiros Voluntarios de Peniche (AHBVP);
- Johanniter Osterreich Ausbildung und Forschung Gemeinnutzige Gmbh (JOAFG);
- Elliniki Etaireia Epeigousas Pronosokomeiakis Frontidas (HSEPC).

As for the technical side, the partners participating in the following technical work packages will take part in the trial:

- WP3 – Visual Scene Analysis System. Technology provider: THALES;
- WP4 – Infrastructure Monitoring System. Technology provider: EUCENTRE;
- WP5 – Chemical Detection System. Technology providers: AITEX, HAVELSAN;
- WP6 – Acoustic Detection System. Technology provider: AVISA;
- WP7 – Team Monitoring System. Technology providers: DUNE, HAVELSAN;
- WP8 – Citizen Involvement and City Integration System. Technology provider: INNOVA;
- WP9 – Secure and Standardised Communication Network. Technology provider: SRDC;
- WP10 – TeamAware AI Platform Software. Technology provider: FRAUNHOFER;
- WP11 – TeamAware AR/Mobile Interfaces. Technology provider: LUCIAD.

Finally, ETICAS will participate by watching for the application of ethical principles during and after the execution of the scenario.

4.2 Scenario Specific Gaps

Existing gaps in emergency situations, whose mitigation will be studied in the demonstration scenario.

- **HMD-GAP-1**. Availability of devices capable of evaluating the infrastructure and producing visual outputs that can be easily interpreted by users without prior knowledge or skills.
- **HMD-GAP-2**. Availability of systems capable of detecting a variety of chemical substances from fixed position or mounted on devices/persons taking into account environmental conditions (e.g., wind, humidity, temperature) and generate a report on the risk level and mitigation strategies.
- **HMD-GAP-3**. Availability of systems for detecting and distinguishing different kinds of blasts (e.g., explosions, debris, gunshots, fire blasts) and generating alerts accordingly.
- **HMD-GAP-4**. Monitoring of vital signs, position, and movement of the staff on the field in real time without affecting their movement, generate custom alerts, and accurately detect the type of activity that is performed.
- **HMD-GAP-5**. Increase of situational awareness by the use of augmented reality devices.
- **HMD-GAP-6**. Generation of automatic alerts based on identified events.
- **HMD-GAP-7**. Deployment of an on-premise private network, with no internet connection, to connect all the required hardware devices for the intervention.
- **HMD-GAP-8**. Plan the mission and deploy all assets on the map to have situational awareness for the venue area.

4.3 Research Questions

The answer to the following questions, combined, will shed some light over the gaps considered under the human-made disaster scenario and listed in the previous section:

- **HMD-RQ-1**. How helpful is the TeamAware ecosystem to automate visual analysis of possible infrastructure damages?
- **HMD-RQ-2**. To which extent does the TeamAware ecosystem deal with airborne risks?
- **HMD-RQ-3**. How helpful is TeamAware software in detecting and triggering alerts based on the analysis of sounds (explosions, gun shots, victim calls, etc)?
- **HMD-RQ-4.1**. How much does TeamAware help in monitoring real-time physical state and health of rescue team members?
- **HMD-RQ-4.2**. What is the cost-to-benefit ratio of the TeamAware wearable team monitoring devices ("cost" in sense of possible inconveniences which may arise from wearing on those devices)?
- **HMD-RQ-5**. How much do ARMI contribute to increase situational awareness?
- **HMD-RQ-6**. How helpful are the automatic alerts delivered by the TeamAware platform?
- **HMD-RQ-7**. How well do the TeamAware platform and devices work in an on-premise network?
- **HMD-RQ-8**. How much does the TeamAware ecosystem contribute to preparing for a human-made disaster?

4.4 Scenario Formulation

Assuming that there is a summit participating VIP attendees in Bucharest. This has attracted attention of terrorist individuals and groups, which consider this as a great opportunity to draw attention to their agenda. The general public will have access in the vicinity of the venue, but not at the actual premises. After making an analysis of the location, several risks have been identified in the surrounding area:

- A factory is about 1 km far and its main attribute is the use of chemical compounds with a high degree of toxicity. For this reason, a risk assessment is simulated by TeamAware to determine if these can represent a risk for the summit. The location of the factory is depicted with a red hexagon.
- A gas station is 200 meters far (depicted with a red rectangle with rounded corners in the top right corner of Figure 18) and TeamAware platform will be used to simulate an explosion (having in mind an intel of an attack that will target the specific gas station) and determine an area in which people will not be allowed to have access to in order to prevent any harm in case of an incident.
- An abandoned building with an increased level of degradation and with a high risk of collapsing is in the area near the venue of the summit (the red star in the left side of Figure 18).

The general public will have the access to these three potentially dangerous locations forbidden during the summit. Instead, these facilities will be monitored using TeamAware systems.

As part of the usual procedure followed by Law Enforcement Agencies (LEAs), missions are most of the times planned in advance and are not spontaneous as most incidents that first responders (FR) deal with. For this reason, a lot of work made by officers reside in the operation planning part. As a result, several days before the summit a complex operation planning is made in advance to take into account all forces, all specific conditions of the environment where the mission will unfold, and all the threats and vulnerabilities associated to the event. TeamAware systems will be used to plan the mission in the safest and most efficient way.

The day of the event, the deployed systems monitor the designated area to detect threats. The presence of a hazardous chemical gas is detected at the operational area. As a result, an alarm is raised and live feed from cameras is offered from the area where the alarm was raised. Not far away from that particular area, a (simulated) fire and smoke in a garbage can is detected as well, which also triggers an alarm and informs the mission commander about the situation. Finally, an explosion is detected (either as a real explosion of a blank cartridge or simulated with a laud pre-recorded sound of a real explosion occurred in the past somewhere else), and officers are deployed on the field to contain the risk. Citizens are informed about the incident and are gathered in a safe place. All the available information, including the alarms, the location and health status of the officers on the field, and the live data from the TeamAware systems, is forwarded to the Command Centre.

4.5 Solution Selection

All the TeamAware systems will be used as part of the scenario by the end-users involved. Their use within the scenario is described below.

4.5.1 Visual Scene Analysis System (WP3)

The same two VSAS subsystems (drone and helmet) mentioned in the first scenario will also be used in this scenario. Drones will be ready to fly to the area (e.g., building) that triggered an alarm and analyse the situation, in particular when an explosion is detected. They will create a map of the situation, and the operator will figure out if it is safe for officers to go in. The video stream can be analysed and annotated to help the operator make a decision (e.g., human detection algorithms, contrast/luminosity enhancements).

4.5.2 Infrastructure Monitoring System (WP4)

The IMS can be used to inspect structures around the critical area in order to make a fast screening and detect near-to-collapse or dangerous structures to establish areas in which access should be forbidden, or to plan safer emergency rescue paths. Indeed, the system is intended for the identification of risks and threats surrounding the first responders based on the visual detection of damages on structures and infrastructures within the critical event area, using drone surveillance.

The main output produced by the system, intended as the output of the onsite inference module, will be a human-readable report describing the results of the screening process. More precisely, the report will contain sufficient information for human experts about where possible structural faults have been detected in the input video, in the format of time intervals. A classification of the fault type will also be provided, together with specific video frames with visual annotations.

Although the operators will have been trained by the TeamAware platform, the analysis of the IMS outcome should be conducted by an expert for more realistic and effective results. In fact, result output from the tool is human-readable and intended to be used by experts such as structural engineers, both onsite and at the command centre, in order to evaluate structural danger situations.

4.5.3 Chemical Detection System (WP5)

The Chemical Detection System will be also used in the demonstration scenario to ensure that the environment is risk-free from any chemical that may put the life of a person in jeopardy. From an operational point of view, the CDS must be able to detect a wide variety of substances that can pose a threat to the life of a person.

The same as in the ND scenario, the compounds the system will detect in HMD scenario can be categorised under two groups:

- Threats:
    - Toxic industrial gases, mostly accidentally released as a consequence of the disaster.
    - Flammable organic gases.
    - Vapours emanated from concealed explosives or other threats to be detonated by purpose (i.e., by terrorists) on purpose upon first the arrival of LEAs and first responders.
    - Chemical Warfare Agents
        - Such toxic substances, namely Ammonia (NH3), Sulphur Dioxide (SO2), Chlorine (Cl), Hydrogen Cyanide (HCN), Phosphine (PH3) and Carbon Monoxide (CO).
- Other type of indicators: Oxygen (O2), Florine (F2), Hydrogen (H2) which can be required measured for the operational teams on the field.

The CDS is composed by the Wearable Chemical Detection System (WCDS), the Chemical Dispersion Model (CDM) and the CDS server platform. Please see detailed description of CDS components in Section 3.5 above.

4.5.4 Acoustic Detection System (WP6)

ADS can be used for detection and location of sound events when they happen, such as gunshots, explosions, fire blasts, building collapses, or human speech (asking for help) or human screams.

Since for this scenario the map of the place is known in prior, the best surveillance performance is achieved by having a UAV equipped with ADS that can fly/hover and land in different places. This UAV equipped with the ADS can be used for scanning the area of interest to detect and locate sound events of interest such as gunshots, explosions, fire blasts, and building collapse. Fusion of the ADS data with other information such as map and camera information is also important to provide more accurate detection and localization of sound events.

4.5.5 Team Monitoring System – Activity Monitoring System (WP7)

The operation of the AMS is similar to that in the natural disaster scenario. A set of wearable AMS (10 motion units, 1 health unit, and 1 gateway) will be equipped by all the members of the rescue team. Motion units will be placed on upper legs, lower legs, upper arms, lower arms, head, trunk (1 for each limb); health unit will be placed on wrist and gateway will be placed on the waist. Each set will send quaternion data carrying the posture information of the rescue team member who wears it for each limb. The limbs that AMS modules will be attached are shown in Figure 12 and Figure 13, these modules will be placed on body by using reusable elastic bands, one by one, it can be both worn by the rescuer himself/herself or it can be worn by the aid of another rescuer. There will be a total of 12 wearable modules (10 for posture, 1 for health, and 1 for gateway units). Posture information and anomaly detection for each user that wears the AMS set can be monitored on request by other users. List of the classified movements or anomalies will be constructed with collaboration between end-users and technical team, according to that list, training data will be collected for the listed movements. AMS will operate continuously during a 10h of operation.

The AMS will play its major role by providing the posture and anomaly (if there is) information of each rescuer. Anomalies that will be detected are stumbling, faint, tiredness, fallen or laying officers and detected actions (such as walking, sitting etc.). This information will be delivered to the coordination chief.

4.5.6 Team Monitoring System – Continuous Outdoor Indoor Localisation System (WP7)

In this scenario, the COILS will be equipped by all the active members in the field and their position will be delivered to the ICS with 1 Hz position refresh rate (tuneable). At the ICS the current position is displayed, along with the walked path history (tuneable past display time). The COILS will also let the operator at the ICS operate track refinement techniques (automatic and manual). The COILS will be operative from the very beginning to the end of the demonstration.

The COILS will be used to coordinate the field officers and monitor their activity and health state (alerts are automatically generated if the situation imposes it). The configuration of the system is the same as in the other demonstration scenario and is depicted in Figure 14 and Figure 15.

4.5.7 Citizen Involvement and City Integration System (WP8)

The expected use of the CICIS system in the test scenario comprises the following cases:

- City IoT sensor integration of city air quality sensors and a building control system as well as of generic IoT infrastructure for the purpose of identifying power failures during the event. All these IoT sensors could generate data which could be used e.g., for chemical dispersion through the air, for monitoring the state of building systems within a building of concern (e.g., factory in the scenario) and data on an area affected by the explosion in the simulation scenario (via detection of power failure of generic IoT components).
- Social media data gathering in order to collect information on types and locations of events occurring within and close to the operational area in the scenario. The data is expected to consist of citizen report text and photos with coarse geo-location of events.
- The CICIS system and app will be used to identify citizens in need of assistance (via self-report) and to guide citizens away from dangerous situations. For this particular scenario, it will be demonstrated how to use a different operational mode for guiding citizens in order to reduce the chance of abusing the CICIS app in order to increase the number of human casualties.

The gathered data via CICIS will be presented via the overall TeamAware Platform.

4.5.8 Secure and Standardised Communication Network (WP9)

The use of the Secure and Standardised Communication Network in the human-made disaster scenario is very similar to that in the natural disaster scenario, given its cross-cutting and scenario-agnostic nature.

Nevertheless, there are two main differences worth noting:

1. For security reasons, the internet connection for the human-made demonstration scenario may not be available. Therefore, the SSCN shall support the operation in a local private network.
2. All the TeamAware ecosystem will be used simultaneously, with the resulting increase in computational power and input and output bandwidth. In other words, this scenario can be regarded as the stress test of the SSCN.

With these two specificities in mind, the operation of the network will be very similar to the other scenario. The reader is encouraged to check the internal components of the network depicted in Figure 16.

4.5.9 TeamAware Platform (WP10)

Given the cross-cutting nature of the TeamAware Platform, its role within this scenario is similar to that in the natural disaster scenario featuring a twofold nature from end-user perspective. In detail, the main objective of TeamAware platform is to build the “Common Situational Awareness Picture” for the operational teams in the field and operators in the operation centre.

On the one hand, the data management part will deal with the tasks of storage and data fusion and is, ultimately, the responsible for combining the data coming from the different sources to generate augmented information and increase data reliability.

On the other hand, a deployable operator front end will also be put in place. This is a high-level front end intended for on-site team leaders and coordinators, which will be presented with the in-situ information provided by the TeamAware systems. These include for example the current location of the officers equipped with location sensors in relation to each other. This GUI will be able to display all relevant information available to the system as specified by the other included TeamAware systems in an intelligent manner.

4.5.10 Augmented Reality and Mobile Interfaces (WP11)

In this scenario the ARMI will present to the end users the data regarding the damaged areas and the critical infrastructures on the surrounding area via well-defined UI/UX interfaces. For instance, it will alert the first responders and LEA’s of the explosions and gunshots detected on the area beside many other threats on the operational field.

Different heterogeneous information will be prioritised for each type of end-user. For example, operators might want to show gunshots to the LEAs from some distance but not to the medical end-users, so that the LEAs can respond to that threat while the victims nearby are being looked after by the medical staff.

Similar to the other scenario, when a significant hazard on the field has been identified at the TeamAware Platform, a notification to the ARMI will be sent. With this notification, the AR will show a universally understandable generic icon indicating that more details are available in the mobile UI (maybe related to the type of danger details given by the Platform). The mobile UI will dynamically switch to the related view, showing to the end-user the details of the hazard.

4.6 Data Collection

The data collection and data flow within the TeamAware platform for this disaster scenario is very similar to the one described in Section 3. Therefore, the majority of data, KPIs and their metrics are similar as well. The specificities of this scenario are the use of the CDS and the CICIS, and a few specific KPIs defined below. For completeness of this Section, both the common KPIs and the scenario-specific KPIs together are presented.

Table 7. Example of possible collection and processing stages for each TeamAware sensor system.

Sensor System	Raw data	Cleaned data	Reconstructed data	Fused and interpreted data (VIS = visualisation, CSAP = alerts)	KPI data on given emergency situation
VSAS	Images & video of fire, smoke, human victims	Areas of interest identified, noise & background subtracted	Fire data object, smoke cloud obj., human victims data objects	VIS: Fire & smoke locations. CSAP: Alerts on victim images	Risks from fire, smoke and victims within the global situation
IMS	Images & video of buildings and damages	Areas of damage identified, areas without damage (bg.) cut out	Infrastructure damage data objects reconstructed and classified	VIS: location of damages CSAP: alerts on damages and their consequences	Risks from infrastructure damages within the global situation
CDS	Smoke density, locations, gas components	Background data subtracted	Chemical data objects located and classified	VIS: gas location areas CSAP: Alerts on air pollution and their move prediction	Risks from air pollution within the global situation
ADS	Explosion, gunshot sounds, etc.? Human voices	Acoustic noise subtracted	Acoustic signals reconstructed and classified	VIS: location and time of explosions and voices CSAP: Alerts on explosion and victim voice sound	Risks from explosions and victims within the global situation
TMS	Agent health data, locations, movement data, etc.	Agent health, position, location and move types are identified	Trajectories of agents reconstructed, agent positions classified, health data analysed	VIS: agent positions and trajectories CSAP: Alerts on agent position and health	Risks from team state & victims within the global situation

CICIS	Text and images/video from citizens	“Background” / “noise” / fake messages suppressed	Important messages classified	VIS: show text & media from citizens CSAP: alerts on fake or extra information	Risks from presence of fake or lack of useful information within the global situation
ARMI				VIS: global 3-d view of the scene with all data types CSAP: 3-d map of alert events	Risks from (in)completeness of global picture and relations of factors in 3-d + time space

Still, and for the sake of completeness, the preliminary list of the KPIs measured in order to answer the research questions is provided below. As in the case of the natural disaster scenario, this list will be later refined in WP13, although in the current form it provides a base line for future discussions. End-users and pilot coordinators will have the objective to define the KPIs used in the pilots in WP13 and evaluate the platform based on these KPIs. This initial list is only the foundation and the number and complexity of these requirements are expected to grow at later stages of the project.

- **Awareness (AW)**: the perceived increase in the awareness of the circumstances involving the emergency scenario due to the use of the TeamAware platform, as perceived by the staff at the command centre.
  - Collected by: Resilience Advisors.
  - Collected from: SPP staff at the command centre.
  - When: after the trial.
  - How: by means of questionnaires featuring a numerical scale.

- **Upstream knowledge (UK)**: the usefulness of the information about the incident as obtained by the TeamAware sensors and sent to the command centre. This metric may be measured individually at component level.
  - Collected by: Resilience Advisors.
  - Collected from: affected end-users.
  - When: after the trial.
  - How: by means of questionnaires featuring a numerical scale.

- **Downstream knowledge (DK)**: the usefulness of the information about the incident fused at the TeamAware platform and sent to the end users on the field, and the way it is presented to them.
  - Collected by: Resilience Advisors.
  - Collected from: affected end-users.
  - When: after the trial.
  - How: by means of questionnaires featuring a numerical scale.

- **Usefulness (US)**: the perceived level of utility of the solutions used in the demonstration scenario for assisting first responders, and the potential perceived for future use. This metric may be measured individually at component level.
  - Collected by: Resilience Advisors.
  - Collected from: affected end-users.
  - When: before and after the trial.
  - How: by means of questionnaires featuring a numerical scale.

- **Time efficiency increase (TEI)**: the perceived increase in the agility to perform the rescue operations, compared to similar operations conducted in the past without the assistance of the TeamAware systems. This metric may be measured individually at component level.
  - Collected by: Resilience Advisors.
  - Collected from: affected end-users.
  - When: after the trial.
  - How: by means of questionnaires featuring a numerical scale.

- **Ease of use (EoU)**: the level of ergonomics of the solutions as perceived from end users involved in the trial. This metric may be measured individually at component level.
  - Collected by: Resilience Advisors.
  - Collected from: affected end-users.
  - When: before and after the trial.
  - How: by means of questionnaires featuring a numerical scale.

- **Overall user satisfaction (OUS)**: a measure of how the expectations of the different components have been met. This metric may be measured individually at component level.
  - Collected by: Resilience Advisors.
  - Collected from: affected end-users.
  - When: before and after the trial.
  - How: by means of questionnaires featuring a numerical scale.

- **Preparation readiness (PR)**: a measure of how thorough the preparation procedures have been and to which extent the rescue teams are ready for a human-made disaster event. This metric may be measured individually at component level.
  - Collected by: Resilience Advisors.
  - Collected from: affected end-users.
  - When: before and after the trial.
  - How: by means of questionnaires featuring a numerical scale.

The Table 8 links the related TeamAware sensor systems for each KPI. The Platform and the SSCN are omitted, as all the KPIs listed above apply to them:

Table 8. Applicability of KPIs for each TeamAware component.

		VSAS	ADS	CDS	IMS	TMS	ARMI	CICIS
KPI	Data \ Improvement question	Images of fire, victims smoke	Audio of blasts, victim voices	Airborne substances	Image analysis of infrastruct. damage	Team health and activity metrics	Virtual 3D visualisations	Text & media from citizens
AWI	How much does it increase awareness?	X	X	X	X	X	X	X
UKI	How much does it improve Upstream Knowledge?	X	X	X	X	X		X
DKI	How much does it improve Downstream Knowledge?						X	X
US	How much does it help to minimise injuries to better allocate resources?	X	X	X	X	X	X	X
TEI	How much does it help reduce reaction time?	X	X	X	X	X	X	X
EoU	How easy is it to use?	X	X	X	X	X	X	X
OUS	How much does it satisfy users?	X	X	X	X	X	X	X
PR	How thorough has the preparation phase been?	X	X	X	X	X	X	X

The same considerations of the previous demonstration scenario in relation to the ethical treatment of data are of application here as well. The entire life cycle of the data collected in the trial will abide to the management plan described in D1.3 (Data Management Plan v1), and which will be expanded in D1.8 (Data Management Plan v2) due by month 30. GDPR will be also of application in relation to the collection and processing of personal data from human participants.

4.7 Evaluation Approach

At a high level, the evaluation approach for this disaster scenario is the same as the one described for the natural disaster scenario as described in Section 3.6. Based on the KPI-related questionnaires, the KPI metrics are calculated. Various TeamAware sensor systems contribute to such KPI valuation (as described in previous Section 3.6). Then based on the KPIs, the research questions are answered, which in turn are aimed to resolve the project gaps.

The Table 9 summarises how the scenario-specific KPI values are calculated for this scenario.

Table 9. Procedure to calculate the different KPIs.

KPI	KPI evaluation questions to users: "How would you estimate …"	KPI without TeamAware	KPI with TeamAware	KPI value calculation
AWI	... your awareness from 1 to 10	AW1	AW2	AWI = 100 * (AW2 - AW1) / AW1
UKI	... upstream knowledge from 1 to 10	UK1	UK2	UKI = 100 * (UK2 - UK1) / UK1
DKI	… downstream knowledge from 1 to 10	DK1	DK2	DKI = 100 * (DK2 – DK1) / DK1
US	… usefulness of TeamAware platform and its components (subsystems), from 1 to 10	US1 = 1	US2	US = 100 * (US2 – US1) / US1
TEI	… time efficiency (e.g., mean time of reaction per event type), in minutes	T1sys T1tot = max(T1sys)	T2sys T2tot = max(T2sys)	TEI = 100 * (T2 – T1) / T1
EoU	… ease of use from 1 to 10	EoU1 = 1	EoU2	EoU = 100 * (EoU2 – EoU1) / EoU1
OUS	… overall satisfaction from 1 to 10	OUS1 = 1	OUS2	OUS = 100 * (OUS2 – OUS1) / OUS1
PR	… your readiness after the preparation phase, from 1 to 10	PR1	PR2	PR = 100 * (PR2 – PR1) / PR1

The Table 10 shows the research questions presented in Section 4.3 and their relationship with the KPIs defined in Section 4.6:

Table 10. KPIs used in answering each research question.

	HMD-RQ-1	HMD-RQ-2	HMD-RQ-3	HMD-RQ-4.1	HMD-RQ-4.2	HMD-RQ-5	HMD-RQ-6	HMD-RQ-7	HMD-RQ-8
AWI	X	X	X	X	X	X	X	X	X
UKI	X	X	X	X	X	X	X	X	X
DKI						X	X	X	X
US	X	X	X	X	X	X	X	X	X
TEI						X	X	X	X
EoU				X	X	X	X		
OUS				X	X	X	X		X
PR						X			X

Finally, the Table 11 presents some quantitative and qualitative relations between the KPI's values and the Research Questions defined in Section 4.3. Again, these relations will be refined in WP13.

Table 11. Answers to Research Questions based on KPIs.

Research Question	Answer based on KPI	Comments and/or conditions
HMD-RQ-1	= AWI + UKI + US	For VSAS + IMS systems
HMD-RQ-2	= AWI + UKI + US	For CDS
HMD-RQ-3	= AWI + UKI + US	For ADS
HMD-RQ-4.1	= AWI + UKI + US + EoU + OUS	For TMS
HMD-RQ-4.2	= AWI + UKI + US + EoU + OUS	For TMS
HMD-RQ-5	= AWI + UKI + DKI + US + TEI + EoU + OUS + PR	For ARMI
HMD-RQ-6	= AWI + UKI + DKI + US + TEI + EoU + OUS	For TP
HMD-RQ-7	= AWI + UKI + DKI + US + TEI	For SSCN
HMD-RQ-8	= AWI + UKI + DKI + US + TEI + OUS + PR	For all systems

4.8 Scenario Objective

The disaster scenario portrayed in this chapter has a purely human origin, targeting the damage to both the infrastructures around the summit and the people in it. A fundamental difference with the natural disaster scenario is that the possibility of a threat is foreseen, and the response of the team is planned with anticipation, to allow the summit to be organised ensuring the highest levels of safety and the most efficient response by the LEAs. **The specific details of how the preparation and execution phases will unfold will be developed in WP13**.

The TeamAware systems involved will be used to facilitate the preparation of the scenario and, when in execution, to detect the threats as swiftly and accurately as possible to ensure the safety of the people attending the summit. The TeamAware Platform, using the SSCN to achieve data interoperability, will fuse all the data coming from the systems to provide the end-users on the field with a complete and useful picture of the different threats.

The same distinction made in the natural disaster scenario between systems that send raw data and receive fused data applies here. The difference in this case is that all the systems in the project will be involved in the human-made disaster scenario. For the sake of readability, their requirements have been compiled in Appendix 2.

5 Conclusions

This report presents the different demonstration scenarios that will be executed in TeamAware. The current description will be subsequently discussed and serve as a baseline for further refinements in WP13 (*Demonstration and Validation*).

The description of both scenarios has followed a systematic approach based on well-known and accepted practises. Only few modifications have been made over the order in which the aspects of the scenario description are presented, based on the expertise of the partners of the consortium with previous involvement in demonstration activities. As a result, these changes facilitate the presentation and understanding of the scenario.

Moreover, an additional analysis of the coarse technical requirements introduced by each scenario is provided in the appendices. Their purpose is to provide a link between the needs expressed by end-users and the requirements of the different TeamAware systems and components. In addition, Sections 3.5 and 4.5 describe their functionalities in relation to the needs of the users and the scenario scripts prepared in accordance. In other words, **this deliverable allows to link needs, functionalities, and requirements**.

The outputs of this deliverable are instrumental for the overall project, as it lays the foundations of the conversations to be held within WP13 and provides a context to all the work performed in the rest of technical work packages.

6 References

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[3] «IFAFRI Capability Gap 1 "Deep Dive" Analysis Synopsis,» International Forum to Advance First Responder Innovation, 2018.

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[5] «IFAFRI Capability Gap 3 "Deep Dive" Analysis Synopsis,» International Forum to Advance First Responder Innovation, 2017.

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7 APPENDICES

7.1 APPENDIX 0: Background Information and Nomenclature for Requirements

This appendix is documented to be a guideline to understand and analyse the operational end user needs collected for each scenario and the corresponding technical requirements given in the appendices. In detail, appendix 1 and appendix 2 correspond to the operational and functional needs collected from the end users for the natural disaster and human-made disaster scenarios, respectively. Appendix 3 is the list of technical requirements derived from the operational needs of the end users in the scenario descriptions. Some of the requirements may perhaps be fulfilled with certain restrictions because at the moment of the requirements formulation the analysis works within all the systems are still being carried out.

The following nomenclature is used for labelling the user needs and requirements.

ADS : Acronym for subsystem (WP 6) named Acoustic Detection System.

ARMI : Acronym for TeamAware AR mobile UI (WP 11)

CDS : Acronym for subsystem (WP 5) named Chemical Detection System.

CICIS : Acronym for subsystem (WP 8) named Citizen Involvement City Integration System

HMD : Acronym for human made disaster scenario. This acronym is used in end-user need labelling for the scenario classification.

IMS : Acronym for subsystem (WP 4) named Infrastructure Monitoring System.

ND : Acronym for natural disaster scenario. This acronym is used in end-user need labelling for the scenario classification.

NEED : Acronym for end users' operational and functional needs. This acronym is used for labelling the end-user operational needs.

REQ : Acronym for the requirements. This acronym is used for labelling the functional and non-functional technical requirements for TeamAware components and overall system.

SSCN : Acronym for subsystem (WP 9) named Secure and Standardised Communication Network

TMS : Acronym for subsystem (WP 7) named Team Monitoring System.

TP : Acronym for TeamAware platform software (WP 10)

VSAS : Acronym for subsystem (WP 3) named Visual Scene Analysis System.

Need ID:

<ScenarioAcronym>-NEED-<WPAcronym1>_<WPAcronym2>-##

ND-NEED-TMS-## (End used need for a scenario for a single subsystem)

ND-NEED-TMS_VSAS-## (End used need for a scenario for multiple subsystems)

Requirement ID:

REQ-<WPAcronym>-##

REQ-TMS-## (Technical requirement for a subsystem.)

7.2 APPENDIX 1: Operational Needs for the Natural Disaster Scenario

This appendix involves the operational and functional end users' needs corresponding to natural disaster scenario which will be demonstrated and assessed in the Natech demonstration. These user needs have been analysed by the whole consortium and will be applied to TeamAware components and overall system with restrictions defined in the technical requirements in Appendix 3.

7.2.1 Visual Scene Analysis System (WP3)

- **ND-NEED-VSAS-01:** The Helmet shall guide the First Responder and feature a homing function (return to base)
- **ND-NEED-VSAS-02:** The drone system shell take into account the safety and security of the area and rise warnings of potential dangers or alerts of collisions.
- **ND-NEED-VSAS-03:** The VSAS shall be permanently monitoring and patrolling to keep the information up to date.
- **ND-NEED-VSAS-04**: The VSAS shall support the on-demand scanning of areas.
- **ND-NEED-VSAS-05**: The helmet cameras shall be used as input streams for victim detection in the environment.

Table 12. Mapping of VSAS requirements to gaps (natural disaster scenario).

	ND-GAP-1	ND-GAP-2	ND-GAP-3	ND-GAP-4	ND-GAP-5	ND-GAP-6
ND-NEED-VSAS-01						
ND-NEED-VSAS-02	X	X	X	X		
ND-NEED-VSAS-03			X	X		
ND-NEED-VSAS-04			X	X		
ND-NEED-VSAS-05	X		X	X		

7.2.2 Infrastructure Monitoring System (WP4)

- **ND-NEED-IMS-01**: The IMS shall be able to identify if a structure is sufficiently safe for the emergency services
- **ND-NEED-IMS-02:** The IMS shall be able to analyse images in different wavelengths.
- **ND-NEED-IMS-03**: The IMS shall be able to capture clear and stable images.

Table 13. Mapping of IMS requirements to gaps (natural disaster scenario).

	ND-GAP-1	ND-GAP-2	ND-GAP-3	ND-GAP-4	ND-GAP-5	ND-GAP-6
ND-NEED-IMS-01	X	X	X	X		
ND-NEED-IMS-02	X		X			
ND-NEED-IMS-03			X			

7.2.3 Chemical Detection System (WP5)

- **ND-NEED-CDS-01:** The CDS needs to be lightweight in order to be mountable on a device (UAV or UGV) or on the officer that will enter the area of interest for scanning prior the mission.
- **ND-NEED-CDS-02**: The final product needs to be hardened to work in a variety of conditions (e.g., inside and outside, low temperature to below -25 degrees Celsius, high temperature to beyond 60 degrees Celsius, rain, snow, fog, wind, shock, vibe, sand, dust, salt), without affecting the performance of the system in any way. In TeamAware this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **ND-NEED-CDS-03**: The CDS will have to tackle with threats (toxic industrial gases, flammable organic gases, vapours emanated from concealed explosives or other threats to be detonated on purpose, chemical warfare agents) and human presence markers (ammonia, 2-3 butanedione, and acetonitrile).
- **ND-NEED-CDS-04**: The CDS shall be able to scan and detect the presence of all the above chemicals at the same time.
- **ND-NEED-CDS-05**: The CDS decision support functionality will be able to predict the type of the chemical agent based on the symptoms shown by victims and the hazardous chemical dispersion model.
- **ND-NEED-CDS-06**: A comprehensive analysis and simulation shall be done to determine what are the risks associated with a leak or explosion from such a facility (e.g., the dispersion model of chemicals, the trajectory, the estimated time to reach the venue, the concentration and associated risk for the detected chemicals). When creating such a simulation, a variety of parameters will be considered (e.g., type of and amount of agent container(s), wind, terrain composition, type of surface(s), vegetation(s), air stability, surface air temperature, relative humidity, rain, snow, fog, clouds and real-time changes of any of these factors with an update to the risk assessment).
- **ND-NEED-CDS-07**: The environment conditions (wind speed, direction, humidity, temperature and other parameters of interest that can influence the spread) shall be correlated by the CDS and shall be displayed on a map information on the dispersion model including time of detection and the affected areas with different colours and gradients based on the substances, concentration.
- **ND-NEED-CDS-08**: A UAV or UGV with a CDS mounted on it shall be deployed in the area to get information from the core of the cloud and extract more data that may be missed initially by the sensor from the surrounding area.
- **ND-NEED-CDS-09**: The CDS will offer predictions (e.g., amount of time estimated for the chemical to reach the venue based on trajectory, environment conditions and type of chemical, the area on the map from the venue location that will be affected and to what extent with differentiated colours depending on the amount of substance or risk).
- **ND-NEED-CDS-TP-01**: Information related to the chemicals detected shall be transmitted in real-time with accurate metadata (e.g., timestamp, location, substance, thresholds) to the command centre with a visual representation on the map related to where the detection occurred. Each substance will be depicted with a different colour and the intensity of the colour will be varied in accordance with the dispersion model and strength of the substance, so that particular areas that are more affected will be highlighted.

Table 14. Mapping of CDS requirements to gaps (human-made disaster scenario).

	ND-GAP-1	ND-GAP-2	ND-GAP-3	ND-GAP-4	ND-GAP-5	ND-GAP-6
ND-NEED-CDS-01						

ND-NEED-CDS-02						
ND-NEED-CDS-03	**X**		**X**			
ND-NEED-CDS-04	**X**		**X**			
ND-NEED-CDS-05	**X**		**X**			
ND-NEED-CDS-06	**X**		**X**			
ND-NEED-CDS-07	**X**		**X**			
ND-NEED-CDS-08				**X**		
ND-NEED-CDS-09	**X**		**X**			
ND-NEED-CDS-TP-01	**X**		**X**			**X**

7.2.4 Acoustic Detection System (WP6)

- **ND-NEED-ADS-01:** The ADS shall differentiate between human voice and shouting, and environmental sounds.

Table 15. Mapping of ADS requirements to gaps (natural disaster scenario).

	ND-GAP-1	ND-GAP-2	ND-GAP-3	ND-GAP-4	ND-GAP-5	ND-GAP-6
ND-NEED-ADS-01	X		X	X		

7.2.5 Team Monitoring System (WP7)

- **ND-NEED-TMS-01:** The TMS shall feature geo-referencing. In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **ND-NEED-TMS-02**: The TMS shall trigger alarms for critical health values. In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **ND-NEED-TMS-03**: The TMS shall provide the victims' and Emergency Medical Teams' vital signs to the command centre. In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **ND-NEED-TMS-04**: The TMS shall provide knowledge of the team members' position and location (both indoors and outdoors). In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.

Table 16. Mapping of TMS requirements to gaps (natural disaster scenario).

	ND-GAP-1	ND-GAP-2	ND-GAP-3	ND-GAP-4	ND-GAP-5	ND-GAP-6
ND-NEED-TMS-01			X	X	X	
ND-NEED-TMS-02	X		X		X	
ND-NEED-TMS-03			X	X	X	
ND-NEED-TMS-04		X	X	X	X	

7.2.6 Citizen Involvement and City Integration System (WP8)

- **ND-NEED-CICIS-01:** Related to social media fetching, the CICIS shall be appropriately calibrated in terms of the frequency at which data is extracted and for how data is filtered to support operations on text data; support for multimedia content (e.g., image, audio, video content) should be considered if feasible within the scope of the project and its ethical and legal framework.
- **ND-NEED-CICIS-02**: The CICIS shall provide answers to general questions that citizens may request when an event unveiled.
- **ND-NEED-CICIS-03**: The CICIS shall support data retrieval from multiple social network services and shall demonstrate fetching information from at least one such source in the project.
- **ND-NEED-CICIS-04**: The CICIS shall apply location-based and classification filters to the social media content. Moreover, spam data and other irrelevant data must be automatically excluded in order to keep only relevant data at hand.
- **ND-NEED-CICIS-05**: A post incident module will include feedback acquisition based on questionnaires and interviews to determine how and to what extent certain citizens were affected.

Table 17. Mapping of CICIS requirements to gaps (human-made disaster scenario).

	ND-GAP-1	ND-GAP-2	ND-GAP-3	ND-GAP-4	ND-GAP-5	ND-GAP-6
ND-NEED-CICIS-01	X					X
ND-NEED-CICIS-02	X	X	X	X		
ND-NEED-CICIS-03	X		X	X		X
ND-NEED-CICIS-04	X		X	X		
ND-NEED-CICIS-05				X		

7.2.7 Secure and Standardized Communication Network (WP9)

No specific functional requirements have been identified specifically for this scenario for the Secure and Standardised Communication Network. Some required functionalities have been identified, but they have been mapped to actions to be solved during the preparation of the demo (transferred to WP13) or to future activities beyond TeamAware.

7.2.8 TeamAware Platform (WP10)

- **ND-NEED-ARMI-TP-01:** The system shall support the use of tactical signs.
- **ND-NEED-ARMI-TP-02**: The system shall be able to provide live feedback about the situation in the selected area of interest.
- **ND-NEED-ARMI-TP-03**: The system shall feature a flat hierarchy and a reduced number of clicks.
- **ND-NEED-ARMI-TP-04**: The staff from the Emergency Medical Services deployed in the field shall be able to receive commands and intel about suspicious events and activities identified or triggered in their vicinity to analyse them.
- **ND-NEED-ARMI-TP-05**: The system shall display call signs and tactical signs on a map.
- **ND-NEED-TP-01**: The platform shall provide a quick way of displaying the information and a quick interpretation of the available data.
- **ND-NEED-TP-02**: The platform shall provide the Emergency Medical Team with the necessary information and dangers (vital signs etc.).
- **ND-NEED-TP-03**: The platform shall provide fast imaging and geo referenced pictures.
- **ND-NEED-TP-04**: The platform shall feature export functions to CSV (securing transferability of data to third systems).

Table 18. Mapping of TeamAware Platform requirements to gaps (natural disaster scenario).

	ND-GAP-1	ND-GAP-2	ND-GAP-3	ND-GAP-4	ND-GAP-5	ND-GAP-6
ND-NEED-ARMI-TP-01			X	X		
ND-NEED-ARMI-TP-02		X	X	X		X
ND-NEED-ARMI-TP-03			X			
ND-NEED-ARMI-TP-04	X	X	X	X		
ND-NEED-ARMI-TP-05			X			
ND-NEED-TP-01			X			
ND-NEED-TP-02	X		X	X	X	X
ND-NEED-TP-03			X			
ND-NEED-TP-04			X			

7.2.9 Augmented Reality and Mobile Interfaces (WP11)

- **ND-NEED-ARMI-TP-01:** The system shall support the use of tactical signs.
- **ND-NEED-ARMI-TP-02**: The system shall be able to provide live feedback about the situation in the selected area of interest.
- **ND-NEED-ARMI-TP-03**: The system shall feature a flat hierarchy and a reduced number of clicks.
- **ND-NEED-ARMI-TP-04**: The staff from the Emergency Medical Services deployed in the field shall be able to receive commands and intel about suspicious events, activities identified or triggered in their vicinity in order to analyse.
- **ND-NEED-ARMI-TP-05**: The system shall display call signs and tactical signs on a map.

Table 19. Mapping of ARMI requirements to gaps (natural disaster scenario).

	ND-GAP-1	ND-GAP-2	ND-GAP-3	ND-GAP-4	ND-GAP-5	ND-GAP-6
ND-NEED-ARMI-TP-01			X			
ND-NEED-ARMI-TP-02		X	X	X		X
ND-NEED-ARMI-TP-03			X			
ND-NEED-ARMI-TP-04	X	X	X	X		
ND-NEED-ARMI-TP-05			X			

7.3 APPENDIX 2: Operational Needs for the Human-Made Disaster Scenario

This appendix involves the operational and functional end users' needs corresponding to human-made disaster scenario which will be demonstrated and assessed in the HMD demonstration. These user needs have been analysed by the whole consortium and will be applied to TeamAware components and overall system with restrictions defined in the technical requirements in Appendix 3.

7.3.1 Visual Scene Analysis System (WP3)

- **HMD-NEED-VSAS-01:** Helmet cameras and the drone camera shall be used as input streams, for victim detection in the environment.
- **HMD-NEED-VSAS-02**: The VSAS shall detect debris, smoke, dust, damaged cars, and injured people from the demolished abandoned building.
- **HMD-NEED-VSAS-03**: The VSAS shall detect cars, garbage cans and trees on fire near the gas station due to the explosion, along to smoke generated by the objects on fire from the surrounding area.
- **HMD-NEED-VSAS-04**: The VSAS shall detect a dense cloud of substances approaching from the south, where the chemical factory is placed.
- **HMD-NEED-VSAS-05**: The VSAS shall apply object detection feature on 5 simultaneous CCTV streams without the need of human intervention.
- **HMD-NEED-VSAS-06**: An UAV with a camera shall be deployed in the air for victim detection getting to certain areas hard to reach by foot, thus helping officers. In the command centre, the mission commander will have displayed telemetry data from the UAV, the video stream, the correct position on the map, the direction in which the device is flying, the speed.
- **HMD-NEED-VSAS-07:** With the aid of VSAS, officers will also be detected on the 2D and 3D maps to determine their position, estimate their trajectory and have a situational awareness from the field directly in the C2. In this manner, it will be easier to guide officers through the building or send other forces to extract or back-up the existing unit previously deployed even in GNSS-denied environments.
- **HMD-NEED-VSAS-08:** With the aid of VSAS different activities must be automatically detected from video footages from field officers, UAV, CCTV and raise alarms when these are detected (e.g., fire, flood, debris, smoke, dust, etc.). All the systems must be operational in any of these environments and offer reliable and accurate alarms, with very limited false positives.
- **HMD-NEED-VSAS-09:** With the aid of a helmet with an IR camera mounted on it, officers are able to train in advance how they would intervene in case of an incident (find the nearest exist of the building or send back-up forces to the officer in danger). In the end, a 3D model is generated of the environment to use first-level semantic data for environment characterisation (detection of obstacles, dangerous items and ways out).
- **HMD-NEED-VSAS-10:** VSAS is able to offer an accurate automatic object detection feature during daytime and night-time, without affecting results in any way, as part of Task 3.3 (e.g., tree, rocks, cars, roads, signs, buildings, window, door, hatch, big cracks) that will help LEAs determine the vulnerabilities of the environment. It will be able to detect the windows from where a sniper may target a protected figure, a door that may be used to enter/exit a restricted area, a hatch/crack that may be used to hide guns/explosives.
- **HMD-NEED-VSAS-11:** VSAS can be used to determine the risks/vulnerabilities from the surrounding area (e.g., for outdoor by analysing the building and objects from near the venue and for indoor by analysing the interior and objects within the venue area).
- **HMD-NEED-VSAS-12:** The object detection feature from Task 3.3 will support a variety of objects and the list must fit the needs/requirements of end users (e.g., the list of objects will be provided by end users during the project lifetime to help technical partners enrich their

algorithms and train the system to detect all objects that officers consider of interest in the operational environment).

- **HMD-NEED-VSAS-13:** Lidar will be able to also map the outdoor environment of the building and detect elements of interest for the LEA (e.g., windows, big cracks, doors, etc.).
- **HMD-NEED-VSAS-14:** CCTV camera footage (several streams) can be used as input for the analysis in case a specific area is not accessible for officers with helmets and all the processing will be done as in the previous case (3D model of environment with environment characterization).
- **HMD-NEED-VSAS-15:** Another applicability of VSAS as part of Task 3.4 is to detect persons in the environment. This feature can be used by SPP officers to try and detect perpetrators that may try to hide in restricted areas before the event.
- **HMD-NEED-VSAS-16:** A 3D model must then be generated with the results from the indoor and outdoor environment, to help LEAs understand the venue, its vulnerabilities and limitations and plan the mission accordingly.
- **HMD-NEED-ADS-TP-VSAS-01**: Images from the VSAS shall be correlated with sounds from ADS and a complete image is given to the officers.
- **HMD-NEED-ARMI-TMS-TP-VSAS-01**: Execution phase: provide added value to the system by support for 3D-enabled output (with possible restrictions).
- **HMD-NEED-ALL-01**: A complete report of the incidents, with a timeline of events shall be generated to have a clear understanding of what was identified, in a user-friendly format.

Table 20. Mapping of VSAS requirements to gaps (human-made disaster scenario).

	HMD-GAP-1	HMD-GAP-2	HMD-GAP-3	HMD-GAP-4	HMD-GAP-5	HMD-GAP-6	HMD-GAP-7	HMD-GAP-8
HMD-NEED-VSAS-01	X							
HMD-NEED-VSAS-02	X					X		
HMD-NEED-VSAS-03	X	X				X		
HMD-NEED-VSAS-04	X	X				X		
HMD-NEED-VSAS-05	X					X		
HMD-NEED-VSAS-06	X					X		X
HMD-NEED-VSAS-07	X			X				
HMD-NEED-VSAS-08	X					X		
HMD-NEED-VSAS-09	X			X				X
HMD-NEED-VSAS-10	X					X		
HMD-NEED-VSAS-11	X					X		
HMD-NEED-VSAS-12	X							X
HMD-NEED-VSAS-13	X							
HMD-NEED-VSAS-14	X							

HMD-NEED-VSAS-15	**X**							**X**
HMD-NEED-VSAS-16	**X**					**X**		**X**
HMD-NEED-ADS-TP-VSAS-01	**X**		**X**			**X**		
HMD-NEED-ARMI-TMS-TP-VSAS-01	**X**				**X**			**X**
HMD-NEED-ALL-01	**X**					**X**		**X**

7.3.2 Infrastructure Monitoring System (WP4)

- **HMD-NEED-IMS-01:** The system needs to analyse the content in a short period of time (4x to 8x the real time of video playing) and obtain a high precision rate of above 80% or even 90% if the conditions are good (e.g., good quality video, with proper lighting and comprehensive analysis of the building from all angles).
- **HMD-NEED-IMS-02**: The system shall not have any restrictions or limitations related to light conditions, weather conditions (e.g., fog, rain, snow) or environment conditions (e.g., dust, salt, sand). In our scenario the building is abandoned, not connected to electricity and the windows and doors are reinforced for securing the building. As a result, the structural indoor analysis shall be performed even in poor light conditions, given that most abandoned buildings have the same format.
- **HMD-NEED-IMS-03**: The output format shall be easily interpreted by the users (e.g., user-friendly GUI, export format) and with no need for other tools or applications to render the generated output. The report should be exported in different formats (document or image), which can be printed at needs in different formats (A4, A3, A2, etc.). A full report with views from different angles and various colours depicting the level of danger needs to be generated at the end.
- **HMD-NEED-IMS-04**: The final product needs to be hardened to work in a variety of conditions (e.g., inside or outside, low temperature to below -25 degrees Celsius, high temperature to beyond 60 degrees Celsius, rain, snow, fog, wind, shock, vibe, sand, dust, salt), without affecting the performance of the system in any way. In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **HMD-NEED-IMS-05**: The IMS shall take into account different structural elements and the associated and identified damage when generating the simulation for the building and the associated report (e.g., a wooden floor is affected in a different way by cracks than a concrete floor).
- **HMD-NEED-IMS-06**: The IMS will help officers check the integrity and impact of surrounding buildings near the venue location.
- **HMD-NEED-IMS-07**: The IMS shall detect damaged structure, critical situations and make an analysis to the integrity of a building for officers to understand the risk associated with a specific building.
- **HMD-NEED-IMS-08**: The IMS shall work with input data from cameras mounted on UAVs, but also with video streams from CCTV, body camera, helmet camera, AR glasses camera, as well as images and videos uploaded to the system for analysis from offline sources.
- **HMD-NEED-IMS-09**: A structural engineer can access a specific area of the report generated by IMS where detailed information will be revealed (e.g., in text and visual format).
- **HMD-NEED-IMS-10**: Video streams from helmet cameras and body cameras shall be used to analyse rooms and walls and determine if there is a risk for a fall and if lives are in danger.
- **HMD-NEED-IMS-11**: The weather outside is a bit foggy, a bit after the sunset and there is a lot of dust in the area for which the analysis will be made. This will not affect the analysis and an UAV will be deployed to scan and determine the risks.
- **HMD-NEED-ALL-01**: A complete report of the incidents, with a timeline of events shall be generated to have a clear understanding of what was identified, in a user-friendly format.

Table 21. Mapping of IMS requirements to gaps (human-made disaster scenario).

	HMD-GAP-1	HMD-GAP-2	HMD-GAP-3	HMD-GAP-4	HMD-GAP-5	HMD-GAP-6	HMD-GAP-7	HMD-GAP-8
HMD-NEED-IMS-01	X					X		

HMD-NEED-IMS-02	**X**							
HMD-NEED-IMS-03	**X**							
HMD-NEED-IMS-04	**X**					**X**		
HMD-NEED-IMS-05	**X**							
HMD-NEED-IMS-06	**X**							**X**
HMD-NEED-IMS-07	**X**							
HMD-NEED-IMS-08	**X**							**X**
HMD-NEED-IMS-09	**X**							
HMD-NEED-IMS-10	**X**							
HMD-NEED-IMS-11	**X**							
HMD-NEED-ALL-01	**X**					**X**		

7.3.3 Chemical Detection System (WP5)

- **HMD-NEED-CDS-01:** The CDS needs to be lightweight in order to be mountable on a device (UAV or UGV) or on the officer that will enter the area of interest for scanning prior the mission.
- **HMD-NEED-CDS-02**: The final product needs to be hardened to work in a variety of conditions (e.g., inside and outside, low temperature to below -25 degrees Celsius, high temperature to beyond 60 degrees Celsius, rain, snow, fog, wind, shock, vibe, sand, dust, salt), without affecting the performance of the system in any way. In TeamAware this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **HMD-NEED-CDS-03**: The CDS will have to tackle with threats (toxic industrial gases, flammable organic gases, vapours emanated from concealed explosives or other threats to be detonated on purpose, chemical warfare agents) and human presence markers (ammonia, 2-3 butanedione, and acetonitrile).
- **HMD-NEED-CDS-04**: The CDS shall be able to scan and detect the presence of all the above chemicals at the same time.
- **HMD-NEED-CDS-05**: The CDS decision support functionality will be able to predict the type of the chemical agent based on the symptoms shown by victims and the hazardous chemical dispersion model.
- **HMD-NEED-CDS-06**: A comprehensive analysis and simulation shall be done to determine what are the risks associated with a leak or explosion from such a facility (e.g., the dispersion model of chemicals, the trajectory, the estimated time to reach the venue, the concentration and associated risk for the detected chemicals). When creating such a simulation, a variety of parameters will be considered (e.g., type of and amount of agent container(s), wind, terrain composition, type of surface(s), vegetation(s), air stability, surface air temperature, relative humidity, rain, snow, fog, clouds and real-time changes of any of these factors with an update to the risk assessment).
- **HMD-NEED-CDS-07**: The environment conditions (wind speed, direction, humidity, temperature and other parameters of interest that can influence the spread) shall be correlated by the CDS and shall be displayed on a map information on the dispersion model including time of detection and the affected areas with different colours and gradients based on the substances, concentration.
- **HMD-NEED-CDS-08**: A UAV or UGV with a CDS mounted on it shall be deployed in the area to get information from the core of the cloud and extract more data that may be missed initially by the sensor from the surrounding area.
- **HMD-NEED-CDS-09**: The CDS will offer predictions (e.g., amount of time estimated for the chemical to reach the venue based on trajectory, environment conditions and type of chemical, the area on the map from the venue location that will be affected and to what extent with differentiated colours depending on the amount of substance or risk).
- **HMD-NEED-CDS-TP-01**: Information related to the chemicals detected shall be transmitted in real-time with accurate metadata (e.g., timestamp, location, substance, thresholds) to the command centre with a visual representation on the map related to where the detection occurred. Each substance will be depicted with a different colour and the intensity of the colour will be varied in accordance with the dispersion model and strength of the substance, so that particular areas that are more affected will be highlighted.
- **HMD-NEED-ALL-01**: A complete report of the incidents, with a timeline of events shall be generated to have a clear understanding of what was identified, in a user-friendly format

Table 22. Mapping of CDS requirements to gaps (human-made disaster scenario).

	HMD-GAP-1	HMD-GAP-2	HMD-GAP-3	HMD-GAP-4	HMD-GAP-5	HMD-GAP-6	HMD-GAP-7	HMD-GAP-8
HMD-NEED-CDS-01		X						X
HMD-NEED-CDS-02		X						
HMD-NEED-CDS-03		X				X		
HMD-NEED-CDS-04		X				X		
HMD-NEED-CDS-05		X				X		
HMD-NEED-CDS-06		X				X		X
HMD-NEED-CDS-07		X				X		X
HMD-NEED-CDS-08		X				X		
HMD-NEED-CDS-09		X				X		X
HMD-NEED-CDS-TP-01		X				X		
HMD-NEED-ALL-01		X				X		

7.3.4 Acoustic Detection System (WP6)

- **HMD-NEED-ADS-01:** The final product needs to be hardened to work in a variety of conditions (e.g., inside or outside, low temperature to below -25 degrees Celsius, high temperature to beyond 60 degrees Celsius, rain, snow, fog, wind, shock, vibe, sand, dust, salt), without affecting the performance of the system in any way. In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **HMD-NEED-ADS-02**: The design of the ADS needs to be compact and light-weight in order for it to be mounted on a UAV.
- **HMD-NEED-ADS-03**: The ADS will limit to minimum number of false alarms generated by natural events (e.g., thunder, rain, wind), by the device that is used for transportation (e.g., UAV). All these sounds will not influence the analysis and will be ruled out of the detections.
- **HMD-NEED-ADS-04**: The ADS shall be able to identify accurately overlapping sound events to detect and correctly and accurately identify different categories of sounds (e.g., speech masked by car horn, voice masked by gunshot, whistle masked by explosion).
- **HMD-NEED-ADS-05**: All sounds need to be differentiated, correctly timestamped and categorized automatically in order to have a clear timeline of events in case of an audit.
- **HMD-NEED-ADS-06**: Alerts shall be classified based on the type of the sound and associated a weight depending on the severity (e.g., explosion is more dangerous than gunshot which is more important than speech which is more important than whistle).
- **HMD-NEED-ADS-07**: The ADS will listen at all times and make alerts in the correct timeline of the events.
- **HMD-NEED-ADS-08**: The ADS shall be able to identify well-defined pattern with the aid of Machine Learning (i.e., screaming after an explosion). Such patterns are vital to identify threats and take the appropriate countermeasures.
- **HMD-NEED-ADS-09**: The ADS will be able to detect a variety of acoustic events: gunshots (muzzle blast and shockwave), explosions (blast), human whistling (tonal sound), debris (from buildings) and human speech.
- **HMD-NEED-ADS-10**: On site also an UAV with ADS shall be deployed that has the goal to detect victims in the ruins from remote locations, hard accessible. It is important that false alarms are limited, that the functionality is not affected by the sound generated by the UAV and the functionality focuses on victim identification.
- **HMD-NEED-ADS-TP-01**: Sounds shall be displayed on the map, categorised by type, without overlapping, in such a manner that it is clear what events have been detected in the specific area.
- **HMD-NEED-ADS-TP-VSAS-01**: Images from the VSAS shall be correlated with sounds from ADS and a complete image is given to the officers.
- **HMD-NEED-ALL-01**: A complete report of the incidents, with a timeline of events shall be generated to have a clear understanding of what was identified, in a user-friendly format.

Table 23. Mapping of ADS requirements to gaps (human-made disaster scenario).

	HMD-GAP-1	HMD-GAP- 2	HMD-GAP-3	HMD-GAP-4	HMD-GAP-5	HMD-GAP-6	HMD-GAP-7	HMD-GAP-8
HMD-NEED-ADS-01			X					
HMD-NEED-ADS-02			X					

HMD-NEED-ADS-03			**X**			**X**		
HMD-NEED-ADS-04			**X**			**X**		
HMD-NEED-ADS-05			**X**			**X**		
HMD-NEED-ADS-06			**X**			**X**		
HMD-NEED-ADS-07			**X**			**X**		
HMD-NEED-ADS-08			**X**			**X**		
HMD-NEED-ADS-09			**X**			**X**		
HMD-NEED-ADS-10			**X**			**X**		
HMD-NEED-ADS-TP-01			**X**			**X**		
HMD-NEED-ADS-TP-VSAS-01	**X**		**X**			**X**		
HMD-NEED-ALL-01			**X**			**X**		

7.3.5 Team Monitoring System (WP7)

- **HMD-NEED-TMS-01:** The TMS shall offer high level of accuracy and fault tolerance. Redundant technologies must be used to ensure that the system is operational even in environments with restrictions or limitations. In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **HMD-NEED-TMS-02**: The TMS shall cover a variety of physiological parameters like heartbeat, temperature, oxygen level, respiration rate, stress level, body posture with various sensors that work simultaneously and offer a complete picture of the situation, with predictions and accurate evaluation.
- **HMD-NEED-TMS-03**: The TMS shall detect the floor at which a specific officer is at in order to determine its accurate position in case of an event (e.g., simply depicting the position on a map for multiple floor buildings is not relevant in time critical situations). In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **HMD-NEED-TMS-04**: The mission commander shall have the capability to see all officers in the field equipped with dedicated equipment on a pre-existing GIS solution (integration with existing infrastructure) and determine their health status and position with accuracy defined in the technical requirements.
- **HMD-NEED-TMS-05**: Under no circumstances shall the TMS influence the movement of officers or other activities specific for their line of work.
- **HMD-NEED-TMS-06**: Specific attention shall be needed to the security features of such devices, given the fact that sensible information related to personal data shall be handled (e.g., health monitoring). All devices need to ensure anonymization of collected data. In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **HMD-NEED-TMS-07**: The TMS shall be flexible and work in different weather and environmental conditions (e.g., rain, snow, fog, water, dust, salty, water, sand). In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements. In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **HMD-NEED-TMS-08**: Automatic classifications shall be performed by the system to detect the anomalies (i.e., fatigue analysis). In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **HMD-NEED-TMS-09**: The TMS shall monitor the health of an officer and the body posture in an operational context. Intuitive and relevant alerts must be generated automatically by the TMS, with a minimum number of fake positives. In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **HMD-NEED-TMS-10**: The TMS shall support for both indoor and outdoor localization. Outdoor and indoor environments need to be analysed separately and the TMS shall offer technologies and mitigations specific for each environment: robustness against obstacles; better resilience against environmental elements (e.g., dense smoke, humidity, absorption), minimising the possible interference, etc. In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **HMD-NEED-TMS-11**: A variety of activities shall be detected automatically by the TMS and with accuracy (e.g., walking, running, crawling, dragging, holding a gun, lifting items, restraining, climbing, etc.). In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.
- **HMD-NEED-ARMI-TMS-TP-VSAS-01**: Provide added value to the system by support for 3D-enabled output (with possible restrictions). In TeamAware, this need should be compatible with TRL-6 and with the restrictions defined in the requirements.

- **HMD-NEED-ALL-01**: A complete report of the incidents, with a timeline of events shall be generated to have a clear understanding of what was identified, in a user-friendly format.

Table 24. Mapping of TMS requirements to gaps (human-made disaster scenario).

	HMD-GAP-1	HMD-GAP-2	HMD-GAP-3	HMD-GAP-4	HMD-GAP-5	HMD-GAP-6	HMD-GAP-7	HMD-GAP-8
HMD-NEED-TMS-01				X				
HMD-NEED-TMS-02				X				
HMD-NEED-TMS-03				X		X		
HMD-NEED-TMS-04				X		X		
HMD-NEED-TMS-05				X				
HMD-NEED-TMS-06				X				
HMD-NEED-TMS-07				X				
HMD-NEED-TMS-08				X		X		
HMD-NEED-TMS-09				X		X		
HMD-NEED-TMS-10				X				
HMD-NEED-TMS-11				X				
HMD-NEED-ARMI-TMS-TP-VSAS-01				X	X	X		
HMD-NEED-ALL-01				X				

7.3.6 Citizen Involvement and City Integration System (WP8)

- **HMD-NEED-CICIS-01:** Related to social media fetching, the CICIS shall be appropriately calibrated in terms of the frequency at which data is extracted and for how data is filtered to support operations on text data; support for multimedia content (e.g., image, audio, video content) should be considered if feasible within the scope of the project and its ethical and legal framework.
- **HMD-NEED-CICIS-02**: The CICIS shall provide answers to general questions that citizens may request when an event unveiled.
- **HMD-NEED-CICIS-03**: The CICIS shall support data retrieval from multiple social network services and shall demonstrate fetching information from at least one such source in the project.
- **HMD-NEED-CICIS-04**: The CICIS shall apply location-based and classification filters to the social media content. Moreover, spam data and other irrelevant data must be automatically excluded in order to keep only relevant data at hand.
- **HMD-NEED-CICIS-05**: A post incident module will include feedback acquisition based on questionnaires and interviews to determine how and to what extent certain citizens were affected.
- **HMD-NEED-ALL-01**: A complete report of the incidents, with a timeline of events shall be generated to have a clear understanding of what was identified, in a user-friendly format

Table 25. Mapping of CICIS requirements to gaps (human-made disaster scenario).

	HMD-GAP-1	HMD-GAP-2	HMD-GAP-3	HMD-GAP-4	HMD-GAP-5	HMD-GAP-6	HMD-GAP-7	HMD-GAP-8
HMD-NEED-CICIS-01						X		X
HMD-NEED-CICIS-02						X		
HMD-NEED-CICIS-03						X		
HMD-NEED-CICIS-04						X		X
HMD-NEED-CICIS-05								X
HMD-NEED-ALL-01						X		

7.3.7 Secure and Standardised Communication Network (WP9)

- **HMD-NEED-SSCN-01:** device lifetime and battery lifetime need to also be considered when selecting specific equipment (e.g., in operational environments a mission cannot be stopped to change batteries to a sensor deployed in the field at a specific height, mounted on the building or tree).
- **HMD-NEED-SSCN-02**: The system shall check the sensors health.
- **HMD-NEED-SSCN-03**: The system shall check connection quality indicators.
- **HMD-NEED-SSCN-04**: The content needs to comply with the need-to-know principle and offer a hierarchical access to data.
- **HMD-NEED-SSCN-TP-01**: The system shall display the health status to the operator on a secondary screen.
- **HMD-NEED-ALL-01**: A complete report of the incidents, with a timeline of events shall be generated to have a clear understanding of what was identified, in a user-friendly format.

Table 26. Mapping of SSCN requirements to gaps (human-made disaster scenario).

	HMD-GAP-1	HMD-GAP-2	HMD-GAP-3	HMD-GAP-4	HMD-GAP-5	HMD-GAP-6	HMD-GAP-7	HMD-GAP-8
HMD-NEED-SSCN-01							X	X
HMD-NEED-SSCN-02							X	X
HMD-NEED-SSCN-03							X	X
HMD-NEED-SSCN-04							X	
HMD-NEED-SSCN-TP-01						X	X	
HMD-NEED-ALL-01							X	

7.3.8 TeamAware Platform (WP10)

- **HMD-NEED-ADS-TP-01:** Location of detected and categorized sounds by ADS shall be displayed on the map without overlapping, in such a manner that it is clear what events have been detected in the specific area.
- **HMD-NEED-ARMI-TP-01**: information shall be displayed on a map in the TeamAware system in a desktop or web application in order for the mission commander to have a situational awareness and take the appropriate actions and also in the operational field on a smartphone application. Moreover, the simulation evolution or prediction will also be animated on the map to offer a clear understanding for the mission commander on what is expected.
- **HMD-NEED-ARMI-TP-02**: The Mission Commander shall have the possibility to send directions to follow to a certain area of interest.
- **HMD-NEED-ARMI-TP-03**: The Mission Commander shall have the possibility to send alerts from the operation centre to field officers. The latter can see the information in their AR glasses. Information may be in the form of text, photos, maps or directions to follow to a certain area of interest.
- **HMD-NEED-ARMI-TP-04**: Different types of alerts need to be generated, according to the severity of the threat. A classification provided by the end users will help to differentiate between different types of alerts. The alerts shall be displayed in UI's.
- **HMD-NEED-ARMI-TP-05**: Alerts need to be short and clear for officers in order to shorten the reaction time.
- **HMD-NEED-CDS-TP-01**: Information related to the chemicals detected shall be transmitted in real-time with accurate metadata (e.g., timestamp, location, substance, thresholds) to the command centre with a visual representation on the map related to where the detection occurred. Each substance will be depicted with a different colour and the intensity of the colour will be varied in accordance with the dispersion model and strength of the substance, so that particular areas that are more affected will be highlighted.
- **HMD-NEED-CDS-TP-02:** CDS will offer predictions (e.g., amount of time estimated for the chemical to reach the venue based on trajectory, environment conditions and type of chemical, the area on the map from the venue location that will be affected and to what extent with differentiated colours depending on the amount of substance/risk).
- **HMD-NEED-SSCN-TP-01**: The system shall display health status to operator.
- **HMD-NEED-ADS-VSAS-TP-01**: Images from the VSAS shall be correlated with sounds from ADS and a complete image is given to the officers.
- **HMD-NEED-ARMI-TMS-TP-VSAS-01**: Provide added value to the system by support for 3D-enabled output (with possible restrictions).
- **HMD-NEED-TP-01**: After each sound detection, a pinpoint is made on the map with the accurate location and the nearest available CCTV camera, helmet camera, body camera, UAV camera, or any other input type will automatically extract features of the detected objects and set bounding boxed of the target. Correlations and classification results from the input video and audio will be fused to increase the accuracy of the detection, if possible.
- **HMD-NEED-TP-02**: Preparation phase: the system shall allow users to place markers corresponding to the TeamAware subsystems on the map from an existing library that was previously defined by the users.
- **HMD-NEED-TP-03**: The administrators need to have a GUI where they can check the status of all hardware and software modules and installed equipment to ensure no flaws are detected. The connections need to be depicted with different colours to underline issue (e.g., red for offline or disconnected devices, yellow for weak signal, and green for good connectivity).
- **HMD-NEED-ALL-01**: A complete report of the incidents, with a timeline of events shall be generated to have a clear understanding of what was identified, in a user-friendly format.

Table 27. Mapping of TeamAware Platform requirements to gaps (human-made disaster scenario).

	HMD-GAP-1	HMD-GAP-2	HMD-GAP-3	HMD-GAP-4	HMD-GAP-5	HMD-GAP-6	HMD-GAP-7	HMD-GAP-8
HMD-NEED-ADS-TP-01	X					X		
HMD-NEED-ARMI-TP-01					X	X		X
HMD-NEED-ARMI-TP-02					X	X		
HMD-NEED-ARMI-TP-03					X	X		
HMD-NEED-ARMI-TP-04					X	X		
HMD-NEED-ARMI-TP-05					X	X		
HMD-NEED-CDS-TP-01		X			X	X		
HMD-NEED-CDS-TP-02		X				X		X
HMD-NEED-SSCN-TP-01						X	X	X
HMD-NEED-ADS-VSAS-TP-01	X	X	X			X		
HMD-NEED-ARMI-TMS-TP-VSAS-01	X	X			X	X		
HMD-NEED-TP-01			X		X	X		
HMD-NEED-TP-02					X	X		X
HMD-NEED-TP-03						X		X
HMD-NEED-ALL-01						X		

7.3.9 Augmented Reality and Mobile Interfaces (WP11)

- **HMD-NEED-ARMI-01**: The ARMI shall be able to transmit video in good quality, to have a battery life of several hours of transmission and reception, and to have storage capability in case connectivity issues appear to store on the local device.
- **HMD-NEED-ARMI-02**: The ARMI shall display health status in mobile app.
- **HMD-NEED-ARMI-03**: The ARMI shall support both major operating systems (Android and iOS), given the fact that both are used by officers on the field, and they need to have the possibility to communicate with all smartphones deployed.
- **HMD-NEED-ARMI-04**: Officers on the field shall receive on the smartphone information about the readings from the CDS with statistics, dispersion model and data of the substances identified in order to take the proper measures.
- **HMD-NEED-ARMI-05**: Mobile applications will offer proactive guidance to the team.
- **HMD-NEED-ARMI-06**: Mobile applications become a back-up tool in terms of communication between the C2 and the field.
- **HMD-NEED-ARMI-07**: The ARMI shall support login on mobile and generate a QR code for AR.
- **HMD-NEED-ARMI-08**: The ARMI shall provide access to the required essential information for the teams under extreme conditions (stress, visibility, accessibility, speed, etc.) in a simple, quick, and intuitive format.
- **HMD-NEED-ARMI-09**: The users shall have a feedback option through which they will be able to accept or reject an information or command from the command centre. Gestures will be used for this activity.
- **HMD-NEED-ARMI-10**: AR glasses need to have a compact format, be lightweight, and not block the line of sight.
- **HMD-NEED-ARMI-11**: Alerts can be generated on a smartphone application regardless of the operating system.
- **HMD-NEED-ARMI-12**: Mobile applications shall provide access to multimedia information in the form of maps, images, videos, plans, or documents that can help officer in the field better understand the situation where they will intervene.
- **HMD-NEED-ARMI-TP-01:** Information shall be displayed on a map in the TeamAware system in a desktop or web application in order for the mission commander to have a situational awareness and take the appropriate actions and also in the operational field on a smartphone application. Moreover, the simulation evolution or prediction will also be animated on the map to offer a clear understanding for the mission commander on what is expected.
- **HMD-NEED-ARMI-TP-02**: The Mission Commander must have the possibility to send directions to follow to a certain area of interest.
- **HMD-NEED-ARMI-TP-03**: The Mission Commander must have the possibility to send alerts from the operation centre to field officers. The latter can see the information in their AR glasses. Information may be in the form of text, photos, maps or directions to follow to a certain area of interest.
- **HMD-NEED-ARMI-TP-04**: Different types of alerts need to be generated, according to the severity of the threat. A classification provided by the end users will help to differentiate between different types of alerts. The alerts shall be displayed in UI's.
- **HMD-NEED-ARMI-TP-05**: Alerts need to be short and clear for officers in order to shorten the reaction time.
- **HMD-NEED-ARMI-TMS-TP-VSAS-01**: Provide added value to the system by support for 3D-enabled output (with possible restrictions).
- **HMD-NEED-ALL-01**: A complete report of the incidents, with a timeline of events shall be generated to have a clear understanding of what was identified, in a user-friendly format.

Table 28. Mapping of ARMI requirements to gaps (human-made disaster scenario).

	HMD-GAP-1	HMD-GAP-2	HMD-GAP-3	HMD-GAP-4	HMD-GAP-5	HMD-GAP-6	HMD-GAP-7	HMD-GAP-8
HMD-NEED-ARMI-01					X		X	
HMD-NEED-ARMI-02					X			
HMD-NEED-ARMI-03					X		X	
HMD-NEED-ARMI-04		X			X			
HMD-NEED-ARMI-05				X	X			X
HMD-NEED-ARMI-06					X		X	
HMD-NEED-ARMI-07					X		X	
HMD-NEED-ARMI-08					X	X		
HMD-NEED-ARMI-09					X		X	
HMD-NEED-ARMI-10					X			
HMD-NEED-ARMI-11					X	X		
HMD-NEED-ARMI-12					X	X		
HMD-NEED-ARMI-TP-01					X	X		X
HMD-NEED-ARMI-TP-02						X	X	
HMD-NEED-ARMI-TP-03				X	X	X		
HMD-NEED-ARMI-TP-04					X	X		
HMD-NEED-ARMI-TP-05					X	X		
HMD-NEED-ARMI-TMS-TP-VSAS-01	X			X	X			X
HMD-NEED-ALL-01					X	X		

7.4 APPENDIX 3: The requirements for TeamAware System and Components

The requirement list in this section has been derived from the operational/ functional needs and objectives defined in TeamAware DoA. These requirements are the baseline of the research activities performed in each WP's to implement a robust TeamAware system. Although these are the concrete baselines for the overall TeamAware system and corresponding components, there may be minor restrictions and constraints on the requirements as the research activities goes on under the work packages.

7.4.1 Visual Scene Analysis System (WP3)

- **REQ-VSAS-01:** The drone shall operate with a minimum network bandwidth of at least 10 Mbits/s.
- **REQ-VSAS-02**: The drone shall comply with relevant legislations and have a human drone pilot.
- **REQ-VSAS-03**: the drone shall allow a payload of up to 200 g.
- **REQ-VSAS-04**: If a new payload is forecasted it shall be computationally and battery standalone.
- **REQ-VSAS-05**: The drone shall be reduced in size to be able to explore areas of at least 80cm wide.
- **REQ-VSAS-06**: The drone shall operate and rely on existing radio and network links. They shall be available at any time and without perturbation during the mission.
- **REQ-VSAS-07**: The helmet shall operate and rely on existing radio and network links. They shall be available at any time and without perturbation during the mission.
- **REQ-VSAS-08**: The helmet shall operate with a minimum network bandwidth of at least 15 Mbits/s.
- **REQ-VSAS-09**: The helmet shall facilitate the path realignment.
- **REQ-VSAS-10**: The VSAS shall use two high-end GPUs to run the AI Algorithms.
- **REQ-VSAS-11**: The system shall be trained on the training datasets provided by the end users.
- **REQ-VSAS-12**: The ground station shall operate with a minimum network bandwidth of at least 8 Mbits/s per output video stream.
- **REQ-VSAS-13:** The VSAS shall guide the first responders with respect to the environment modelling above 90% accuracy
- **REQ-VSAS-14:** The VSAS shall characterise the surrounding objects, victims (i.e., human or animal) by their thermal footprints above 90% accuracy.
- **REQ-VSAS-15:** The system shall detect the suspicious elements above 90% accuracy by analysing the visual scene.

7.4.2 Infrastructure Monitoring System (WP4)

- **REQ-IMS-01**: The UAV camera shall have enough image resolution to detect the level of damage expected in the demo and work with sufficient visibility conditions to obtain sufficiently clear footage.
- **REQ-IMS-02**: The IMS shall be able to provide indications to an expert about which infrastructure or building around the demo site shows evidence of structural damage as the result of the main demo event.
- **REQ-IMS-03**: The UAV shall have enough reach to explore the relevant buildings in the surrounding area.
- **REQ-IMS-04**: The UAV shall have enough battery to complete the exploration of a standard building.
- **REQ-IMS-05**: The UAV's batteries shall be quickly rechargeable or swappable to resume the operation as quick as possible.

- **REQ-IMS-06**: The workstation or laptop on which the monitoring system is processing the data shall have hardware components with minimum specifications concerning the capability to resist to harsh environment or weather conditions.
- **REQ-IMS-07**: The monitoring system shall process input data from cameras mounted on UAVs, but also with video streams from CCTV, body camera, helmet camera, provided that the minimum image resolution and clearness are sufficient to detect damages.
- **REQ-IMS-08**: The monitoring system shall need to analyse the content in a minimum period of time and obtain the target level of accuracy (above 90%).
- **REQ-IMS-09**: The output of IMS shall be provided in a format readable and interpretable by an expert user (structural engineer), possibly at least in the form of report.

7.4.3 Chemical Detection System (WP5)

- **REQ-CDS-01**: The CDM server shall have enough CPU, memory, and storage resources for analysing the incoming raw data.
- **REQ-CDS-02**: The CDM shall use weather forecast information for calculating the particle dispersion area in pre-specified format to produce a dispersion of a specific chemical.
- **REQ-CDS-03**: The CDM shall prepare CBRN measurement messages (Chemical 4) using the measurements available by drone mounted and wearable chemical detection sensory system.
- **REQ-CDS-04**: The CDM shall calculate Chemical 5 (CBRN-polluted zone) dispersion using Chemical 4 messages from different points.
- **REQ-CDS-05**: The Lagrange dispersion model shall produce particle-based dispersion considering 3D topology.
- **REQ-CDS-06**: The AEP dispersion model shall produce warning area-based dispersion considering 2D topology in NATO standard.
- **REQ-CDS-07**: The CDM shall predict the time of contamination started for a specific location.
- **REQ-CDS-08**: The CDM Lagrangian Model shall produce concentration for a specific location on contamination area.
- **REQ-CDS-09**: The CDM shall be able to output the results from the dispersion model for the analysis of an operator.
- **REQ-CDS-10**: The CDM shall receive configuration information as input using a specific API for more accurate results in a given scenario.
- **REQ-CDS-11**: The CDM shall calculate particle distribution periodically.
- **REQ-CDS-12**: The CDM shall provide multiple dispersion measurements for multiple points.
- **REQ-CDS-13**: The AEP dispersion model shall calculate dispersion for chemical list Ammonia (NH_3), Sulphur Dioxide (SO_2), Chlorine (Cl), Hydrogen Cyanide (HCN), Phosphine (PH_3), Carbon Monoxide (CO).
- **REQ-CDS-14**: The Lagrange dispersion model shall calculate dispersion for chemical list Ammonia (NH_3) and Sulphur Dioxide (SO_2).
- **REQ-CDS-15**: The dispersion model shall calculate the contamination of chemicals covering a 100-meter radius zone.
- **REQ-CDS-16**: The CDS shall provide prediction for the possible type(s) of the chemical(s) (which are pre-defined in CDS chemical library) by entering the text-based symptoms shown by victims to the model.
- **REQ-CDS-17**: The symptom-based chemical detection shall work with accuracy above 90%.
- **REQ-CDS-18**: The CDM shall produce a dispersion output to be used by TeamAware.
- **REQ-CDS-19**: The CDM shall define a different colour for each substance to be used by TeamAware.
- **REQ-CDS-20**: The CDM shall receive detection information for specifying a detection with substance, detection time, detection location and detection value.

- **REQ-CDS-21**: The CDM shall work with no access to internet in case the weather and topology data is supplied to system by the user.
- **REQ-CDS-22**: The drone-mounted and wearable CDS shall detect and measure different toxic substances, namely Ammonia (NH3), Sulphur Dioxide (SO2), Chlorine (Cl), Hydrogen Cyanide (HCN), Phosphine (PH3) and Carbon Monoxide (CO). Also, another type of indicators is required like Oxygen (O2), Florine (F2), Hydrogen (H2) which can be required measured for the operational teams on the field.
- **REQ-CDS-23**: The CDS module will be lightweight to be wearable and mountable on UAV or UGV.
- **REQ-CDS-24**: The chemical detection sensory system components will be hardened to work in a variety of conditions.
- **REQ-CDS-25**: The drone-mounted and wearable CDS will be able to detect some substances at the same time with accuracy above 90% in the range of 10-20 meters.
- **REQ-CDS-26**: The CDS shall prepare the list of detections for a specific time interval (if it is available) of different locations consisting of the substance, detection location and detection value.
- **REQ-CDS-27:** The CDS shall prepare the list of detections for a specific location or area (if it is available) of different times consisting of the substance, detection time and detection value.

7.4.4 Acoustic Detection System (WP6)

- **REQ-ADS-01**: The ADS shall be able to detect a sound source despite the obstacles between the victims and the sensors in the tunnel (while visual sensors may fail), when the UAV is hovering or landed in the tunnel.
- **REQ-ADS-02**: Since the ADS is not performing speech recognition, it will perform audio classification on human screams and the word “help” from the civilian test members that are frequent in real life disaster scenarios.
- **REQ-ADS-03**: The UAV carrying the ADS should be able to fly within a narrow section like a tunnel.
- **REQ-ADS-04**: The ADS shall be able to detect human scream, human presence, explosions, fire blasts, gunshots or break of glasses.
- **REQ-ADS-05**: UAV’s batteries shall be quickly recharged or swapped to resume the operation as quick as possible.
- **REQ-ADS-06**: The ADS shall be able to detect a small number of people who might stand opposite each other, at the initial stage.
- **REQ-ADS-07**: The ADS’s acoustic array shall have a sufficiently wide angle of reception, so that it can catch sounds coming from different locations while the UAV is hovering or landed, depending on the characteristics of the scenario.
- **REQ-ADS-08:** The ADS shall detect and localise gunshots, explosions, in the range of 200 m with the localisation accuracy of 10 meter and direction accuracy within ±5 degrees.
- **REQ-ADS-09:** The ADS shall detect and localize people whistling, and human speech in the range of 50 meter, with the localisation accuracy of 10 meters

7.4.5 Team Monitoring System (WP7)

- **REQ-TMS-01**: The TMS shall monitor the health condition and movements of whomever the sensors are placed on correctly, either the victims or end users.
- **REQ-TMS-02**: The TMS will provide the position and location of each member of the team equipped with the COILS, with different levels of accuracy, depending on the magnetic pollution level and the GNSS availability and reliability.

- **REQ-TMS-03**: The system can provide geo-referencing of the whole trach of each user, when the GNSS fixes are available and reliable, at least in a fragmented and sporadic way.
- **REQ-TMS-04**: The system shall provide vital signs data and alarm for critical values for vital signs with an accuracy of at least 85%.
- **REQ-TMS-05**: The AMS and COILS shall operate normally at the temperature underneath the protective suit of the operator.
- **REQ-TMS-06**: The AMS shall provide a variety of physiological parameters such as heartbeat, body temperature, oxygen level in blood, respiration rate, and stress level and body posture using various sensors working simultaneously.
- **REQ-TMS-07**: The COILS implements both inertial altitude drift compensation and barometer and inertial fusion. The automatic floor discrimination is achievable for mission times < 1 hour; longer missions are managed by operator-assisted vertical position drift compensation at the ICS side.
- **REQ-TMS-08**: AMS and COILS shall not interfere with the movements of the end user.
- **REQ-TMS-09**: The output data of COILS supports the 3D representation.
- **REQ-TMS-10**: The system shall anonymise data to provide the security of the critical data of the end users.
- **REQ-TMS-11**: The system shall classify a list of movements, defined by both end-users and technical partner and not conflicting with the operational requirements, with an accuracy larger than 85%.
- **REQ-TMS-12**: The COILS can provide, if necessary, DLLs and libraries to generate automatic reporting of the whole mission.
- **REQ-TMS-13**: The system shall work under environmental conditions that is supported by at least IP34 degree internal protection.
- **REQ-TMS-14**: The system shall operate in full performance between in minimum range of 0°C and 50°C.
- **REQ-TMS-15**: The system shall be able to resist occasional sprays of water from the hoses of the firefighters.
- **REQ-TMS-16**: If there is slight (spot or distributed) magnetic interference the AMS and COILS shall be able to minimise its effects with recoverable performance decrease, else AMS should either perform with an unrecoverable decrease or fail.
- **REQ-TMS-17**: The system shall provide anomaly detection defined within a list by the technical partner.
- **REQ-TMS-18**: All the activities, unless it conflicts with the operational requirements, should be tracked, including running, crouching, grovelling on the ground, and standing still.
- **REQ-TMS-19**: The AMS shall monitor heart rate between 0-250 bpm (beats per minute) range with accuracy of ±3%.
- **REQ-TMS-20**: The AMS shall monitor blood oxygen saturation level between 0-100% range with accuracy of ±3%.
- **REQ-TMS-21**: The AMS shall monitor body temperature between 0°C and 50°C range with accuracy of 0.2°C between 37°C and 39°C.
- **REQ-TMS-22**: The AMS shall monitor body movements with an accuracy of at least ±2° in static mode and ±4° in dynamic mode.
- **REQ-TMS-23**: Both AMS and COILS shall provide all the outcomes with timestamp.
- **REQ-TMS-24**: The AMS modules shall work with rechargeable battery and battery shall last for 5h of operations while all networks are used actively.
- **REQ-TMS-25**: The system shall give the health status as an output.
- **REQ-TMS-26**: The COILS shall provide localisation accuracy of 3-5 meters indoor and 1-5 meter outdoor.

7.4.6 Citizen Involvement and City Integration System (WP8)

- **REQ-CICIS-01:** CICIS shall include functionalities for citizens to self-register skill proficiencies that can be used by the system in order to select recommendations for citizen actions in emergency situations. Informed consent will specify the exact use of any data voluntarily and optionally provided by citizens to specify this.
- **REQ-CICIS-02:** CICIS shall gather information relevant to the crisis situation at hand from social networks and provide relevant information to the TeamAware platform.
- **REQ-CICIS-03:** CICIS shall integrate city IoT sensor data and metadata in order to extend the types and/or coverage area of available sensor data.
- **REQ-CICIS-04:** CICIS shall gather and identify as relevant or not relevant social media messages that are potentially relevant for the current emergency.
- **REQ-CICIS-05:** CICIS shall analyze the data gathered via social media in order to extract information that is relevant for the current emergency situation.
- **REQ-CICIS-06:** CICIS shall estimate the confidence it has into the validity and truthfulness of social media analysis output.
- **REQ-CICIS-07:** CICIS shall assist citizens by providing them with guidance in emergency situations.
- **REQ-CICIS-08:** CICIS shall enable sending messages for upcoming events to citizens who are identified as being active in the area of concern via self-registration
- **REQ-CICIS-09:** CICIS shall gather information relevant to the crisis situation at hand from social networks and provide relevant information to the TeamAware platform.
- **REQ-CICIS-10:** CICIS shall provide methods for post-incident data gathering and evaluation including surveys and interviews.
- **REQ-CICIS-11:** CICIS shall take measures in order to prevent and/or reduce the effect of manipulation of the system through deliberately falsified data.
- **REQ-CICIS-12:** CICIS shall ascertain that intermittent or complete loss of Internet connectivity is handled gracefully and operations are resumed from the last request that was successfully processed when Internet connectivity is re-established.

7.4.7 Secure and Standardised Communication Network (WP9)

- **REQ-SSCN-01**: TeamAware SSCN will have an interoperable architecture and it will be scalable and optimised to connect different types and numbers of wearable, portable, and drone-borne sensors.
- **REQ-SSCN-02**: TeamAware SSCN will provide the necessary data models and data format translation mechanism among the TeamAware components to achieve interoperability.
- **REQ-SSCN-03**: TeamAware SSCN shall be able to process large amounts of data.
- **REQ-SSCN-04**: An ad hoc mesh communication network shall be deployed.
- **REQ-SSCN-05**: TeamAware SSCN shall provide the necessary security and privacy mechanisms for both end-to-end communication and among TeamAware internal components by considering aspects such as authentication, authorisation, confidentiality, integrity, auditability, and non-repudiation.
- **REQ-SSCN-06**: TeamAware SSCN cloud infrastructure shall be deployed on any bare metal server.
- **REQ-SSCN-07**: The sensors' gateways will expose health data to TeamAware Platform so that their status can be displayed on the GUI.
- **REQ-SSCN-08**: The TeamAware platform will constantly monitor connection quality indicators.
- **REQ-SSCN-09**: TeamAware will implement role-based access control on the data provided to TeamAware platform.

7.4.8 TeamAware Platform (WP10)

- **REQ-TP-01**: The platform will be able to digest external data in an offline fashion.
- **REQ-TP-02**: The platform displays operational forces with an applicable subset of DV102 signs for the scenario.
- **REQ-TP-03**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end and include all available information from the system to provide a quick evaluation of the situation.
- **REQ-TP-04**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end and include all available information from the system to provide both the teams on the field and the dispatch centre with the necessary information.
- **REQ-TP-05**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end and include all available information from the system to display live information about an area of interest.
- **REQ-TP-06**: The platform's user interface will display all georeferenced information available at a georeferenced map.
- **REQ-TP-07**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end and include all available information from the system with a simple hierarchy of menus.
- **REQ-TP-08**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end and include all available information from the system with appropriate geo-referencing.
- **REQ-TP-09**: The platform will be able to write the collected data into transferable documents in a human readable format.
- **REQ-TP-10**: The platform will be able to share all its information with ARMI.
- **REQ-TP-11**: The platform shall display operational forces with an applicable subset of DV102 signs for the scenario.
- **REQ-TP-12**: The platform will have the capabilities to set thresholds for numerical sensor values at which alarms can be triggered.
- **REQ-TP-13**: The platform will include all available information from the system.
- **REQ-TP-14**: The platform will provide guidance for the user based on automated recognition of key features and the appropriate response based on first responders' SOPs and knowledge.
- **REQ-TP-15**: The platform's user interface will display all georeferenced information available on a georeferenced map.
- **REQ-TP-16**: The platform implementation process and technology stack will be developed according to the project structure.
- **REQ-TP-17**: The platform's user interface will provide limited functionality to visualise 3D data (the GUI will not provide high level rendering functionality like e.g. physics-Based Rendering, Physics-Based Animation, Physics-Based Simulation, Mesh Editing, Skinning, Rigging, and so on).
- **REQ-TP-18**: The platform's GUI will provide additional functionality for planning and execution (placing predefined markers, marking areas from a set of predefined options, sending information in form of predefined message types to ARMI).
- **REQ-TP-19**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end and include all available information from the systems.
- **REQ-TP-20**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end and include all available information from the systems in a user-friendly way.
- **REQ-TP-21**: The platform will be able to digest external data in an offline fashion.
- **REQ-TP-22**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end to depict different chemical substances in different colours.
- **REQ-TP-23**: The platform's GUI will offer limited animation support for predefined data.
- **REQ-TP-24**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end to display the results of the chemical dispersion model.

- **REQ-TP-25**: The platform's user interface will display all geo-referenced information available on a geo-referenced map.
- **REQ-TP-26**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end to display the health status to the operator.
- **REQ-TP-27**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end to display the status of all hardware and software modules.
- **REQ-TP-28**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end to display all detected sound sources.
- **REQ-TP-29**: The platform will be able to share information with the ARMI.
- **REQ-TP-30**: The platform will offer some navigation guidance for the mobile interface user, if sufficient data is available.
- **REQ-TP-31**: The platform will adhere to DIN EN ISO 9241-12 for the operator front-end to display clear and short alerts.

7.4.9 Augmented Reality and Mobile Interfaces (WP11)

- **REQ-ARMI-01**: The system shall avoid using external services to be able to work without internet as long as end user provides the required infrastructure for SSCN.
- **REQ-ARMI-02**: The system shall implement tactical signs.
- **REQ-ARMI-03**: The system shall enable the user to provide feedback.
- **REQ-ARMI-04**: The system shall keep a flat hierarchy of menus.
- **REQ-ARMI-05**: The system shall display real-time notifications.
- **REQ-ARMI-06**: The system shall work with reduced functionality if the network connection is lost or intermittent.
- **REQ-ARMI-07**: The system shall be able to provide feedback to the C2.
- **REQ-ARMI-08**: The AR application shall be able to display 3D data.
- **REQ-ARMI-09**: the mobile application shall display the result of time-dependent simulations provided by TP.
- **REQ-ARMI-10**: The mobile application shall show readings, statistic, and simulations.
- **REQ-ARMI-11**: The mobile application shall show the status of the sensors.
- **REQ-ARMI-12**: The system shall receive real-time notifications from the C2.
- **REQ-ARMI-13**: The mobile application shall be available for iOS and Android.
- **REQ-ARMI-14**: Colour codes shall be used to properly identify the severity of the alerts.
- **REQ-ARMI-15**: The AR glasses shall minimise obstruction of the line of sight.
- **REQ-ARMI-16**: Mobile devices shall display multimedia information.