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Autonomous Indoor Outdoor Safety Tracking system

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### Deliverable D2.1 Scenarios and User Requirements

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1 Executive Summary

The present document constitutes the first issue of Deliverable D2.1 “Scenarios and User Requirements” in the framework of the Project titled “Autonomous Indoor Outdoor Safety Tracking system” (Project Acronym: AIOSAT; Grant Agreement No 776425).

This document has been prepared to give insight in the way fire brigades in Europe work. The document clarifies the differences that have been observed between the firefighter brigades among the countries participating in the project and even within countries, among the regions. With such differences, three representative scenarios are presented and the end user requirements are described for them.

The user requirements described in the current document are input data for the technical requirements and system design to be presented in [4].
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# Abbreviations and acronyms

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<thead>
<tr>
<th>Abbreviation / Acronyms</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACP</td>
<td>Advanced Control Post</td>
</tr>
<tr>
<td>AVL</td>
<td>Automatic Vehicle Location</td>
</tr>
<tr>
<td>DMO</td>
<td>Direct Mode</td>
</tr>
<tr>
<td>eDMR</td>
<td>extended Digital Mobile Radio</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographical Information System</td>
</tr>
<tr>
<td>ICP</td>
<td>Incident Command Post</td>
</tr>
<tr>
<td>FRS Centrum</td>
<td>Fire Rescue Service Centrum (Belgium)</td>
</tr>
<tr>
<td>MRC</td>
<td>Media Reception Center</td>
</tr>
<tr>
<td>TSC</td>
<td>Twente Safety Campus (Netherlands)</td>
</tr>
<tr>
<td>TETRA</td>
<td>Trans European Trunked Radio Access</td>
</tr>
</tbody>
</table>
4 Background and Current Practice

This section presents the diversity of organizations, team compositions, communications and operational facts that have been described by the end users in different countries. From these descriptions it is clear that there is no common procedure among the countries of Europe and this is a reality even among the regions of the same country. The generic facts are presented for Belgium, Spain, and the Netherlands. Furthermore, inside Spain, the differing specificities of rural and urban firefighter units are listed to widen the focus of the background and current practices.

4.1 Organization of the rescue zones in Belgium

The number of firefighters (volunteers and professionals) that is needed in the different rescue zones in Belgium is determined by the rescue zones themselves. Therefore, they use parameters such as population, surface of the zone, and risk analysis (industrial, civil).

A rescue zone is an independent entity that is managed by the zone council. This is a board of directors composed of the mayors of the townships that belong to the rescue zone. A federal law from 2007 regulates the operation of the rescue zones.

There is even a law that regulates the crew on a standard fire truck. A fire truck is only activated in the dispatching system when the vehicle is staffed with 4 firemen, one fireman-truck driver and one fire chief. If the crew is not complete (available in the system) then the fire truck can’t be dispatched. In this case the computer searches for another, nearest fire truck that has a complete crew.

Firefighters in Belgium still use military grades: fireman / corporal / sergeant / master sergeant / lieutenant / captain / major / colonel.

4.1.1 Operational facts

At this moment there is no registration of the location of the individual firefighter during an incident. The following list shows the few safety precautions that are integrated in the standard operations:

- Monitoring of the time a fireman is using his breathing apparatus (Dräger board).
- Each breathing apparatus is equipped with a Personal Alert Safety System.
- Each fire truck is equipped with an evacuation horn.

When the emergency call centre receives a call, the incident is translated into an incident type. There is a list of more than 100 incident types. Each incident type is linked with a proposal for response on the incident. This proposal is submitted to the local dispatching and is an advice for the local fire brigade. The proposal consists of vehicles and personnel that should be activated and sent to the incident.

4.1.2 Equipment

Each fireman is equipped with a portable radio that uses the TETRA network. Every fire truck has his mobile TETRA radio on board. The communication is organised in a fleet map (i.e., a structure of communication groups).
When the fireman goes underground, the communication with the TETRA-network has a lower reach. In these cases, they can use the Direct Mode Operation (DMO) for local communication. DMO mode allows portable radios that are in a certain range to communicate directly, without relying on infrastructure such as cell towers. Despite a lot of effort there is still no reliable communication from indoor or underground locations to the TETRA-network.

Most of the fire trucks are equipped with an Automatic Vehicle Location-module (AVL). The position of the fire truck is visible in the local dispatching. The AVL is also provided by the TETRA network.

Another standard equipment is the infrared-thermal (IR) camera. All first-line fire trucks are equipped with an IR-Thermal camera.

### 4.2 Organization of firefighters in Spain

The Spanish government does not fix the team composition of the firefighter teams nor does it specify the specific procedures to be applied in case of emergencies. Each municipality and region has to compose their shifts depending on their records and needs.

The ranges of the team members in Spain are:

* Bombero / Cabo / Sargento / Suboficial / Subinspector / Oficial / Inspector,*

which could be translated to:

* Firefighter / corporal / sergeant / deputy officer / deputy inspector / officer / inspector.*

However, in Spain there are different kinds of firefighters:

- Firefighters in cities with more than 20,000 inhabitants.
- Provincial firefighters for small cities and towns, who operate in urban areas or in rural but not forest areas.
- UME (firefighters of the military emergency unit).
- BRIF Brigades of the Ministry of the Environment. These are the largest brigades (about 17 members). There is a brigade leader and there may also be an observer or foreman.

Moreover, there are volunteer firefighters except in the autonomous community of *Catalonia* and *Levante*, where they collect money from guards and interventions. Professionals and volunteers need to be qualified by the training centres. The most of these training centres for urban firefighters are public (e.g., Jovellanos centre). Training for forest firefighters depends on each region. There are state recommendations but they are not mandatory.

#### 4.2.1 General considerations for communications

A pair of PMR (Private Mobile Radio) radio channels is allocated for the licensed bands. One channel is used in "direct" mode in the operations area and the other in "infrastructure" mode to communicate with central services. There are five licensed bands available in Spain and they are distributed by provinces. Repeaters can be used but they are not usually seen very well because they involve a logistical burden and because they create shadows of coverage.
The mobile phone is widely used, taking advantage of the fact that the operators contracted to provide service to the regional administration (predominant operator) are committed to providing very good coverage throughout the territory. The incumbent operator may be required to put a repeater in the fire zone to ensure coverage.

The larger brigades can have an exclusive radio channel; the rest use the general channels.

4.2.2 General considerations for operational facts

This paragraph presents the description of a command post for a wide area intervention and some relevant data for the operations on field which complements the information of the previous paragraph.

4.2.2.1 Incident Command Post

The Incident Command Post (ICP) is always located in a place with sufficient coverage for communication. In the case of Andalusia, for example, there is a main ICP and then smaller ones per province.

The meteorology data, maps (Google Earth, IGN, GVSIG), and orthophotos are available and these “static” data are preloaded in the ICP.

In the ICP there are several roles (for example chief of operations, director of extingishment, head of logistics, etc.) who normally speak loudly. Each one communicates with his team in the field through a specific radio channel. In general, each of them listens and speaks on several radio channels.

In case of air intervention, the air operation coordinator would be on-board an aircraft with two pilots and two technicians.

4.2.2.2 Operations on field

The positions of the brigade chiefs in control are:

- the chief of operations
- the chief of security
- the head of monitoring
- the head of the central headquarters (barracks)

It would be interesting to know the position not only of each brigade chief, but of each member to monitor, assess and help during the intervention (change of circumstances and progresses done).

Moreover, it would also be interesting for the brigade commanders to know the location of other brigades and media commanders (e.g. air). In any case, it is known that due to stress factors, a single person can only attend to three or four things at a time. In the same way, in any situation, each person has a maximum of four direct persons in charge during an intervention, no matter the size and nature (fire, rescue, services, etc.) of the intervention.

There is usually a specific radio channel between the head of the brigade (normally close to the truck) and all the members of their team, specially with the fireman spearhead to regulate the flow of water. For each truck-pump there is usually only one spearhead. There can be two spearheads and it is very rare that there are three.
In small or medium brigades, the brigade chief normally does not have a device with a screen to continuously see the position of his team. However, it may make sense to be given the option to consult it eventually.

4.2.3 Organization in Extremadura Region – Spain

This paragraph presents the specific data for rural intervention in the Autonomous Community of Extremadura, one of the most devastated regions by fire in Spain.

These data are based on the forest fire fighting plan of Extremadura (Plan INFOEX) that establishes the organization and procedures for action of the media and services owned by the Junta de Extremadura and those that are assigned by other Public Administrations and Entities or Organizations of a public or private nature, in order to deal with forest fires that occur in the territory of the Autonomous Community. The picture below shows the infrastructure deployed in Extremadura by INFOEX Plan to cover the entire region.

![Figure 1: Infrastructure in Autonomous Community of Extremadura](image)

4.2.3.1 Operational facts

Currently, each brigade consists of five members; four firefighters and a brigade leader. The brigade leader is the only member located from the brigade group and his position is reported to the Advanced Control Post (ACP; see the next section for a description).

During the action, the members of the brigade have a maximum distance of 30 meters among them.
4.2.3.2 Equipment

In terms of equipment, the Advanced Control Post (ACP) is a van with internet connection via Satellite or LTE. The main applications in the control station are based on Geographic Information Systems (GIS).

The firefighters have a communication network based on an DMR (Digital Mobile Radio) technology of TP Systems [1]:

- 3 simultaneous communications paths within a 12.5 kHz channel spacing, one of them dedicated to data.
- Available in VHF frequencies (30-50 MHz, 66-88 MHz, 146-174 MHz).
- The links between base stations are connected using 5 GHz band (unlicensed).
- Terminals can work also in Mode Simplex (Direct Mode), but in this mode there is no position feedback to the Advanced Control Post.

4.2.4 Organization in San Sebastian – Spain

This paragraph presents the specific data of an urban firefighter station in San Sebastian, in Spain.

The average values of the shifts for several fire stations connected with San Sebastian are:

- 16 firefighters / shift in San Sebastian
- 4 firefighters / shift in smaller fire stations in Guipuzkoa
- 6 firefighters / shift in small fire stations in Bizkaia

And the team composition for the San Sebastian station is:

- 4 firefighters for a small intervention
- 9 firefighters for an average intervention
- Up to 30 firefighters for big interventions

4.2.4.1 Operational facts

There are no records of the firefighters’ positions, neither inside a building nor outside. But there is a role informally called “tabla” (that could be translated by “board” in English) which is in charge of supervising the quantity of air left in everybody’s breathe-aid system. In addition to that, the tabla annotates the movements of the firefighters deployed taken into consideration the communications transmitted among them during the intervention. This person is always located outside the building, if the intervention is indoor.

In case of intervention underground, the voice communication needs to be guaranteed. If needed, one of the roles of the brigade members is to have one firefighter landed in a secure spot (normally the stair case) for communication, acting as a bridge. The experience of the
end users contacted from that urban station is that the communications are easily attenuated inside the buildings. Therefore, their main concern is to have a strong communication even if the data transmitted/received are less (in case any data sent).

The coordination with other agencies related to emergency (112, medical services, police, traffic, weather predictions, etc.) is guaranteed by the sharing of a common framework with internal timeline information and interactive text messaging (data on the screen of every coordination centre). Every step is annotated, with its time stamp and with a real time visualization by means of a Geographical Information System (GIS). The locations are refreshed every 20 seconds, approximately and it could be replied with the storage data.

If the intervention inside a building is due to a fire, the firefighters will act on their knees to avoid the extreme hot temperatures closer to the ceiling.

4.2.4.2 Equipment

The voice system equipment is PMR based, but the need of encryption could force a shift to DMR in the next years.

Basque government has also a TETRA system deployed for voice and positioning for all the emergency services. However, for operations in the city, the firefighters of San Sebastian prefer to use their PMR equipment. They use TETRA for the location of the trucks in movement, as part of the centralized emergency service.

The clothing and equipment is different depending on the kind of intervention. In case of fire, they must use a breathe-aid system with one or two air bottles (depending on the location of the fire) and an ICU device. This motion-sensitive device detects firefighter motion without responding to false alarms. It senses the pressure of the air inside the bottles (digital and analogue), the time remaining with a safe air condition, the temperature and the status of the batteries (9 V). This modular system is maintained and checked every time it has been used, so it seems a good place to integrate any other device we could propose.

The average weight carried out by a firefighter is 30 kg.
4.3 Organization of Fire Services in The Netherlands

There are about 17 million people in the Netherlands and there are 350 cities. Every city or municipality has at least one fire station and at least one fire truck. Some fire stations also have a rescue tender and/or a ladder truck (see Figure 5 and [2]¹). In the Netherlands, fire brigades (Dutch: Brandweer) are organized in 25 safety regions as shown in Figure 3. The response time is 8 minutes.

Figure 3: Safety Regions in the Netherlands (Twente is marked)

In total, there are 4000 professional fire-fighters and 24000 volunteer fire-fighters in the Netherlands. Both professional and volunteer firefighters follow the same education, training,

¹ Pictures and information were made available by TSC from a Brandweeracademie Presentation by Jaap Molenaar.
and the same tasks in firefighting and rescue. In the Netherlands there approximately 12000 fires per year with 100 deaths and 1000 injuries. The costs of the fires is 1.2 billion euro in damage.

A basic unit in the Netherlands consists of 6 firemen that are addressed by numbers. A basic unit is led by a sub-officer. The sub-officer (B-110) of the first team is called 110, of the second team 120, etc. There is one driver (P-119) who stays with the truck and controls the pumps. The other 4 members form the attack team (1 and 2: 111 and 112) and the water team (3 and 4: 113 and 114). Individual team members are called by their number during an incident [3].

![A Basic Unit in the Netherlands](image)

Figure 4: A Basic Unit in the Netherlands

A middle size team consists of two basic units with an additional ladder truck and an officer.

<table>
<thead>
<tr>
<th>Size of Incident</th>
<th>Description</th>
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<tr>
<td>Small</td>
<td>1 fire struck (basic unit)</td>
</tr>
<tr>
<td>Medium</td>
<td>2 fire trucks with a commander</td>
</tr>
<tr>
<td>Large</td>
<td>3 fire trucks with a commander</td>
</tr>
<tr>
<td>Very large</td>
<td>4 fire trucks with a commander and a head officer (Hoofd Officier van Dienst) This is called a platoon</td>
</tr>
<tr>
<td>Even larger</td>
<td>Commandant van Dienst in command</td>
</tr>
</tbody>
</table>

Ranks, in increasing order: Fireman, Sub-officer (Dutch: Bevelvoerder), Officer (Officier van Dienst, Hoofd Officier van Dienst, Commandant van Dienst)

4.3.1 Equipment

Every fire station has at least one basic fire truck (Dutch: Tankautospuit). A basic truck can transport 6 to 9 persons; it has a tank for 1500 litres of water, a water pump, 60-90 meters of high pressure hoses, 600 meters of low pressure hoses, foam, and all kind of rescue equipment and ladders. Some fire stations also have rescue tenders or ladder trucks.
To communicate between the crew in the fire truck and the dispatch / telephone operators, the Twente Safety Region uses an application called LiveOP. This application is an advanced mobile operational intelligence platform for public safety services and government agencies. LiveOP supports first responders with real-time incident information, instructions, visual guidance and connects to IoT-devices for optimal monitoring.

The app provides the crew real-time information on every location. In a basic unit, there are tablets in the fire truck (see Figure 7 and Figure 8) and only the sub-officer has an app. All other crew members do not use tablets or phones during an operation.

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2 https://www.liveop.net
Figure 7: Back seats of the fire truck with display (top right) and charging equipment

Figure 8: Front Seats with Tablet (left), charging equipment (right)
4.4 Conclusion

Table 1 summarizes the different organization parameters of firefighting services in Belgium, Spain, and The Netherlands. In order to have a common ground for the test scenarios, it is important to also look for similarities. For example, the minimum number of dispatched firefighters in Belgium, Spain, and The Netherlands is 10, 4, and 4, respectively. For larger fires, the teams will be larger, so if our scenarios offer a basic setup for ten firefighters, it could be applied to a team from any of these three countries. The test scenarios will be explained in detail in the next chapter.
<table>
<thead>
<tr>
<th>Organizational entity name</th>
<th>Belgium</th>
<th>Spain (Extremadura)</th>
<th>Spain (San Sebastian)</th>
<th>Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety region</td>
<td>Rescue zone</td>
<td>Plan INFOEX</td>
<td>SPEIS (Servicio de Prevención, Extinción de Incendios y Salvamentos)</td>
<td>Safety region</td>
</tr>
<tr>
<td>Standard unit size (minimum)</td>
<td>5 vehicles, 20 people including 10 firefighters</td>
<td>5 people, including 4 firefighters</td>
<td>4 firefighters</td>
<td>1 truck with 6 people, including 4 firefighters</td>
</tr>
<tr>
<td>Currently available personal equipment</td>
<td>Breathing apparatus (Dräger board) with Personal Alert Safety System; Portable radio: TETRA or DMO</td>
<td>Digital Mobile Radio (TP Systems), several frequency bands</td>
<td>PMR voice system; ICU device for movement detection, air tank pressure, temperature, etc.</td>
<td>TETRA voice system; LiveOP (tablet for subofficer only)</td>
</tr>
<tr>
<td>Currently available equipment in fire truck</td>
<td>Evacuation horn; Automatic Vehicle Location; IR-thermal camera</td>
<td>Advanced Control Post (ACP): internet connection via satellite or LTE; GIS-based applications</td>
<td>“Tabla” recording firefighters’ movements and remaining air; common framework for coordination with other agencies, using GIS; TETRA system for truck positioning</td>
<td>Additional tablets with LiveOP application for visual guidance, connections to IoT devices, etc.</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td>Response time 8 minutes</td>
</tr>
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</table>
5 Scenarios

The AIOSAT project aims for a platform that can be applied in a wide range of firefighting situations. This includes variance in settings (e.g., rural vs urban) and variance in firefighting procedures in different countries. In order to design, develop, and evaluate the AIOSAT platform, we will use three main scenarios. Two of these are urban and the third one is a rural scenario. The urban scenarios are divided in complex buildings above and underground level. As stated by the final users, for simpler buildings, it is usually not a problem to localize a small firefighting team; the scenarios for the more complex structures would automatically cover simpler buildings anyway.

With end users and testing facilities in three partner countries, we also aim to test the presented scenarios in three different locations, under conditions that are typical for the respective scenarios in each country.

5.1 Forest Scenario – Mixed Conditions for Open Sky

The first scenario that we describe here is a rural scenario. This scenario exemplifies a typical firefighting operation conducted by INFOEX in a rural area.

Several brigades of firefighters are deployed to combat a fire detected in a far rural scenario that has alerted and mobilized a medium-level operations plan in the firefighting agency and other supporting agencies. All the firefighter brigades will establish an AIOSAT safety communication link between them and the ICP so that their location and other relevant sensor data can be tracked. Using the location data provided by the AIOSAT system the ICP staff make sure all the firefighters operate safely and are able to optimize the operations. In the example here presented, at a certain time during the firefighting operations, the fire moves to a critical-protection zone with access difficulties, so the firefighter arrives to the zone using aerial vehicles.

The location scenario is located in the Tentudia Sierra. This place is a region in the south of Badajoz (Extremadura – Spain) next to the foothills of Sierra Morena and the provinces of Seville and Huelva (Andalusia). Its highest point is the peak of Tentudia. This place is where the event of fire is triggered (time t0) and contains the following municipalities: Bienvenida, Bodonal de la Sierra, Cabeza la Vaca, Calera de León, Fuente de Cantos, Fuentes de León, Monesterio, Montemolín, and Segura de León.
The scenario step-by-step is here presented even if the exact location of each element is not foreseen in such a wide area intervention.

**STEP 0. Time= t0.**

A guard post watches smoke rising from the Tentudia Sierra and, immediately, warns to the ICP through the channel radio. The ICP warns to the closer brigade to act immediately.

**STEP 1. Time= t0 + 1h.**

The first brigade (one brigade chief and four firefighters in this case) arrives at the incident location in a truck equipped with two water pumps (see Figure 11. The brigade activates the AIOSAT system and the local communication links are set between brigade chief and the firefighters. The chief brigade gets the location and other information from sensors of each member through the AIOSAT communication system and publishes through the backhaul network.
STEP 2. Time= $t_0 + 1h15min$

Each pair of firefighters operates a fire hose (Figure 12). The separation between the members is up to 200 meters.

**Figure 12: Firefighters operating a fire hose**

STEP 3. Time= $t_0 + 3h$.

Due to fire size, more firefighters arrive and an ACP is deployed (see Figure 13). The ACP configures the AIOSAT communication network connected to the brigade chiefs and receives data from the sensors of all the brigade chiefs and the fire fighters that are involved in the operation. The locations of the brigade chiefs would being controlled by the chief of operations, the chief of security, the head of monitoring and the central headquarters by means of the AIOSAT system.
STEP 4. Time= t0 + 4h.

The ICP prepares an action plan using the data about the fire (perimeter, intensity), the information provided by the air unit and the weather conditions. Some of this data, such as escape routes, is sent to the brigade chiefs. The ICP/ACP may also distribute the location of every brigade chief to all of them.

STEP 5. Time= t0 + 8h.

More fire trucks arrive at the incident and prepare the equipment and water pump (Figure 14). The AIOSAT system on board makes a self-checkout before activating and joining the existing AIOSAT communication network.

STEP 6. Time=t0+10h.

Due to wind (Figure 15), the fire changes its direction, so the ICP coordinates a re-position of the brigades using their communication system. The AIOSAT communication system would be useful here to send urgent graphical instructions to the chief brigades by means of the AIOSAT applications.
STEP 7. Time=t0+12h.

The ICP team decides to act in an area with no access for fire trucks due to orography. In these conditions, they will be deployed using a helicopter (Figure 16). Due to the fact that the brigade is far from the ACP, only an AIOSAT local network is established between firefighters and the brigade chief, but the brigade chief provides a backhaul connection to share the data with the ACP.
5.2 Underground Carpark Scenario

The second scenario is a fire in an underground carpark in the old city centre of Ghent in Belgium, see Figure 17.

![Map of the underground parking in the city centre of Ghent](image1.png)

**Figure 17:** Map of the underground parking in the city centre of Ghent

![Ghent city centre](image2.png)

**Figure 18:** Ghent city centre

The carpark is situated under a traffic-free market square called Vrijdagmarkt, pictured in Figure 18. It consists of three underground levels and a small building above ground level (Figure 19) which is used for ticket sales, pedestrian access to the underground carpark, and for surveillance purposes. An overview map of access stair cases for pedestrians and access ramps for cars is shown in Figure 20.
Figure 19: Underground level and carpark access building

Figure 20: Overview of carpark access stairs and ramps
The scenario focuses on a car fire happening at level –3 and consists of the following major elements:

- Car fire at level –3
- A vehicle fire produces a large amount of smoke. On floor –3 limited visibility can be expected.
- Major elements of the response of the fire brigade.
  - Evacuate all three floors.
  - Localize and combat the fire.
  - Ventilate all three floors.
- Normal response:
  - One standard unit (see Section 4) supplemented with at least one fire truck (i.e., two extra teams of two firemen).
  - Officer on scene decides if additional support is needed.
- Response for the test scenario:
  - One standard unit.
  - Only the firemen of the two fire trucks (4x2) and the sub-officers (2x1) are involved in the test scenario, see also Figure 22.
Table 2 presents a course timeline of the main events and actions of the underground carpark scenario. The abbreviations used are explained in Figure 23. Situation sketches are illustrated in Figure 24 to Figure 29.

Figure 23: Labelling used in the scenario timeline
The AIOSAT system would be useful during this intervention locating the people involved. That would enhance the safety of the firefighters and help in case of change in the conditions of the fire and place.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Location</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Level -3</td>
<td>Start of the fire</td>
</tr>
<tr>
<td>1</td>
<td>Level -3</td>
<td>Driver from another car notices the smoke</td>
</tr>
<tr>
<td>2</td>
<td>Level -3</td>
<td>Automatic fire alarm activated</td>
</tr>
<tr>
<td>3</td>
<td>Security building</td>
<td>Parking guard calls 112 and evacuation alarm is activated.</td>
</tr>
<tr>
<td>4</td>
<td>112</td>
<td>Call is processed bij 112</td>
</tr>
<tr>
<td>5</td>
<td>112 / Dispatch FR5 Centrum</td>
<td>HTML reaches dispatch FR5 Centrum</td>
</tr>
<tr>
<td>7</td>
<td>Fire station</td>
<td>Firetrucks leave the firestation (2 firestations)</td>
</tr>
<tr>
<td>11</td>
<td>Square above parking</td>
<td>Arrival of firetrucks nearest firestation (FT1)</td>
</tr>
<tr>
<td>12</td>
<td>Square above parking</td>
<td>First exploration of the scene &amp; consultation of the parking guard (location of the fire)</td>
</tr>
<tr>
<td>13</td>
<td>Square above parking</td>
<td>Activation of the smoke extraction installation is ordered bij U1</td>
</tr>
<tr>
<td>13</td>
<td>Firetruck 1 / Staircase 3</td>
<td>Preparation T1 + T2 for fireattack using dry column at staircase 3</td>
</tr>
<tr>
<td>15</td>
<td>Firetruck 2 / Staircase 2</td>
<td>Preparation T3 + T4 for fireattack using dry column at staircase 2</td>
</tr>
<tr>
<td>16</td>
<td>Level -3</td>
<td>T1 starts the search for the fire. T2 is backup/standby in staircase 3 at level -3, U1 stays near T1 + T2 and/or firetruck</td>
</tr>
<tr>
<td>19</td>
<td>Level -3</td>
<td>T3 starts the search for the fire. T4 is backup/standby in staircase 3 at level -3, U2 stays near T3 + T4 and/or firetruck</td>
</tr>
<tr>
<td>20</td>
<td>Level -3</td>
<td>T1 reaches the fire and starts the extinguish of the carfire.</td>
</tr>
<tr>
<td>22</td>
<td>Level -3</td>
<td>T1 communicates to U1 that the fire is under controle</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>U2 communicates to T3 + T4 that they can stop the fireattack and that they have to start the sweeping of the 3 levels.</td>
</tr>
<tr>
<td>23</td>
<td>Level -3</td>
<td>T3 starts the sweeping of level -3 (limited visibility - takes some time to complete the sweep +/-10 minutes)</td>
</tr>
<tr>
<td>24</td>
<td>Level -2</td>
<td>T4 starts the sweeping of level -2 (+/- 5 minutes)</td>
</tr>
<tr>
<td>25</td>
<td>Level -3</td>
<td>T1 communicates to U1 that fire is extinguished</td>
</tr>
<tr>
<td>26</td>
<td>Level -3</td>
<td>U1 communicates to T2 that they have to do a sweeping on Level -1 (+/- 5)</td>
</tr>
<tr>
<td>29</td>
<td>Level -2</td>
<td>T4 communicates to U2 that Level -2 is clear.</td>
</tr>
<tr>
<td>31</td>
<td>Level -1</td>
<td>T2 communicates to U1 that level -1 is clear.</td>
</tr>
<tr>
<td>33</td>
<td>Level -3</td>
<td>T3 communicates to U2 that the level -3 is clear.</td>
</tr>
<tr>
<td>35</td>
<td>FT1</td>
<td>U1 and U2 order to all teams to meet at FT1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All teams present at FT1</td>
</tr>
</tbody>
</table>
Figure 24: Situation from $t = 0$ minutes to $t = 16$ minutes.

Figure 25: Situation from $t = 17$ minutes to $t = 22$ minutes.
Figure 26: Situation on level –3 from \( t = 23 \) minutes to \( t = 33 \) minutes.

Figure 27: Situation on level –2 from \( t = 23 \) minutes to \( t = 33 \) minutes.
Figure 28: Situation on level –1 from $t = 23$ minutes to $t = 33$ minutes.

Figure 29: Situation at $t = 35$ minutes.
5.3 Driving with Firetruck and Complex Building Scenario

The third scenario that we describe here actually contains two subscenarios in an urban setting. One is a fire in a multistoried residential building such as a home for the elderly, and the other one is in a large industrial building. Included in the scenario is the travelling route from the fire station to the location of the fire. We aim for a complex scenario, because tactical information is important in such a situation. Therefore, the scenarios will be done with at least two teams. Each team has a commander (*bevelvoerder* in Dutch). For every two teams, there is one officer (*Officier van Dienst, OvD*) who coordinates the two teams. For very large operations, there is an additional head officer, who coordinates the whole operation.

5.3.1 Residential building subscenario

At the Twente Safety Campus there are multiple buildings available for real-life fire testing. One of these is a complex building basically consisting of two separate houses that have indoor connections on each floor, see Figure 30.

![Complex building at the Twente Safety Campus facility.](image)

In our scenario, we assume that this is a home for the elderly, which makes a more complex than a regular residential building, because it will be necessary to evacuate people who are less likely able to get out of the building by themselves.

The scenario focuses on a kitchen fire starting on the ground floor, escalating to the first floor. It consists of the following major elements:

- Complex building (e.g., elderly home)
- Kitchen fire on ground floor
- Escalation to first floor
- Multiple victims
- Evacuation of multiple residents
- Normal response for a complex residential building:
  - Two standard units (each consisting of a fire engine with a chief, a driver, and two teams of two firefighters)
  - One officer (in a separate car)
- Additional response for a home for the elderly:
  - One more unit including a rescue vehicle.

Situation sketches for the normal response are shown in Figure 31 to Figure 33. The first team is labelled “110” and follows the thick/red arrows, the second team is “120” and follows the thin/white arrows. The officer is labelled “OvD 100”.

![Figure 31: Situation on the ground floor.](image-url)
Figure 32: Situation on the first floor.

Figure 33: Situation on the second floor.
5.3.2 Industrial building subscenario

The second complex building subscenario is based on an incident that took place in the village of De Punt in the Netherlands in 2008. In the actual incident three firefighters lost their lives. The firefighters were trapped inside a burning building after the entrance had been blocked by a smoke explosion. Investigation of the incident revealed that the unconscious firefighters might have been rescued if their colleagues would have known their locations at the time of the accident.

The scenario in the AIOSAT project describes a similar large fire in a complex industrial building with a large floor area. The fire produces large amounts of toxic smoke due to exposed insulation material and eventually causes a smoke explosion. The scenario contains the following major elements:

- Complex industrial building
  - Large floor area
- Big fire
  - Large amounts of toxic smoke due to insulation material
  - Smoke explosion / Flashover
- Critical moment
  - Where is everybody?
  - Change of tactic
- Response:
  - Four fire engines (TS) and two rescue vehicles (HW)
  - Two officers (OvD) on scene
  - One head officer (COPI) on scene

Figure 34 illustrates the situation before and during the smoke explosion.

A more detailed timeline of the events follows in Table 3.

Table 3: Timeline of the industrial building scenario.

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:05</td>
<td>Emergency services receive a phone call reporting an indoor fire in an industrial building.</td>
</tr>
<tr>
<td>11:12</td>
<td>The first fire truck arrives at the scene. The fire fighters see heavy smoke coming out of the building, but at the time of arrival, the firefighters see no flames.</td>
</tr>
<tr>
<td>11:13</td>
<td>The commander decides to scale up the operation, so another fire truck turns out to the scene, along with a separate officer.</td>
</tr>
<tr>
<td>11:13</td>
<td>Meanwhile, a team of two firefighters enters the building to inspect the situation and to see if there are people inside. Both firefighters wear compressed air breathing apparatus. Moreover, they carry a fire hose and a thermographic camera. The commander in the truck sees their position in the building on the display in the truck, while the firefighters report their findings using the radio.</td>
</tr>
<tr>
<td>11:17</td>
<td>Suddenly, there is an explosion caused by smoke that had been building up under the roof. Now, flames are coming out of the side of the building.</td>
</tr>
</tbody>
</table>

---

3 See https://en.wikipedia.org/wiki/De_Punt_fire

4 See e.g. https://www.youtube.com/watch?v=qmNEdWjIRoM
<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:18</td>
<td>Two firefighters are trapped in the building. There is no voice communication with them anymore. However, the display in fire truck shows their last known locations in the building. The officer scales up the operation again, so another fire truck is sent out.</td>
</tr>
<tr>
<td>11:20</td>
<td>The second fire truck arrives with additional equipment. The first thing the new firefighters do is to gain access to the room where their colleagues were when the explosion occurred by breaking down a wall.</td>
</tr>
<tr>
<td>11:26</td>
<td>The unconscious colleagues are taken out of the building. The officer decides to scale up again.</td>
</tr>
<tr>
<td>11:32</td>
<td>Two more fire trucks, two rescue vehicles, with another (sub)officer and a head officer arrive at the scene.</td>
</tr>
<tr>
<td>11:46</td>
<td>The whole company is now operational.</td>
</tr>
<tr>
<td>14:50</td>
<td>The fire is contained.</td>
</tr>
</tbody>
</table>

**Figure 34: Situation sketch**
6 User Requirements

This section describes requirements that have been collected from various end user groups in the different participating countries. These user requirements will form the base for the system requirements and the architecture of the AIOSAT platform to be described in deliverable D2.2 [4].

6.1 Meetings with end users

To discuss the end user requirements, five working groups have been organized with the partners of AIOSAT and some of the members of the advisory board.

a) FRS representatives with other FRS members
b) SAXION and INERTIA with TSC
c) CEIT with San Sebastian firefighters
d) INTEGRASYS with INFOEX
e) INTEGRASYS and CEIT with FAASA

For case a), FRS established a small workgroup with the following members on 11-jan-2018 (first meeting):

- Jurgen Verlinden – lieutenant – adjunct director operations – end-user in the smart@fire project
- Brecht Vandeburie – lieutenant – operations – end-user in the smart@fire project
- Alain Dhaemers – lieutenant – operations – new technologies (project with drones)
- Yves Pieters – major – director logistics

After a brief introduction to the project it was clear that the AIOSAT project has a link with the EU-project smart@fire (2017)⁵. Jurgen and Brecht had the pleasure to participate in this project as testers of the prototype (an intelligent fire suit). As a result, section 4.1 has been written down.

For case b) Berend Jan van der Zwaag, Raluca Marin-Perianu and Mihai Marin-Perianu from Inertia, and Wilco Bonestroo from Saxion met with Ymco Attema and Gerke Spaling from Veiligheidsregio Twente / Twente Safety Campus. Sections 4.3 and 5.3 are results of two meetings of this workgroup.

For case c) Iñigo Adin met Imanol Andonegui at San Sebastian Fire station on 4-jan-2018. As part of the advisory board, Imanol will be receiving the information generated during the project. Section 4.2.4 has been written down with the information obtained during this meeting.

For case d) Jose Manuel Sanchez and Iñigo Adin met Domingo Villalba (FAASA-SEILAF) in Madrid on 15-feb-2018. Sections 4.2.1 and 4.2.2 have been described based on this conversation.

⁵ See http://www.smartatfire.eu
Case e) has been the input for Section 4.2.3 after a meeting between Jose Manuel Sanchez and the responsible of INFOEX at Extremadura, on 16-feb-2018.

6.2 Positioning

The end users have identified the following points and values for the positioning data:

- **Horizontal accuracy**: It is important to make a difference between the indoor accuracy and the outdoor accuracy. Indoor it has to be clear in which compartment or room the firefighter is located. If the accuracy is not good enough, the information could be false and a search and rescue could be directed to the wrong compartment or room. For the outdoor accuracy, an accuracy of 5 to 10 meters should be sufficient.
- **Vertical accuracy**: Indoor the accuracy has to be sufficient to determine the floor level on which the firefighter is located.
- **Integrity level assessment**: A system has to work in at least 9 of the 10 cases. If the reliability is less the system will not be used because the users will not have faith in the system.
- **Tracking system update frequency**: Potential end users indicated that the update rate should be as fast as possible. However, an update of the position of the firefighter every 10 seconds should be sufficient for the most of the applications and scenarios described in this document. In the case of rural interventions, the end users have specified values about 1 minute.

6.3 Communications

The end users have listed the following characteristics which would be more detailed in [4]:

- Robust, reliable, long range links, even in harsh indoor environments and rubble
- Automatic configuration (easy and fast deployment) of the radio network.

For the rural scenarios, the main problem is when the brigade needs to go to a no coverage area of DMR, because the van/truck cannot get there and the firefighters have to go using a helicopter. The brigade has to work in Simplex mode; one person has the role of link between the area and where he has DMR coverage. If the above is not possible, the mission is cancelled.

One of the ideas from INFOEX is that they would like that in this situation the positions will automatically arrive at the link or, even better, that the brigade device optionally had a satellite messaging modem (e.g., Iridium) which would free the need for the human link (which can then be dedicated to other tasks). That would be considered as a third party element to the AIOSAT system.

Landmarking for communication repeater is not ideal but could be taken into consideration. In this case, it must avoid any configuration by the firefighters.

6.4 Applications and integration of the system

For the application, AIOSAT partners must keep in mind that the requirements of the applications and the data to be shared among every player are different for the systems for the (sub)officers, those for the team commanders, and those for the firefighters themselves.
Integration into existing equipment, if any, is an important aspect. For example, in the Netherlands, different fire brigades use different information systems. However, there is a reference architecture that prescribes how to share information between the systems. The architecture is called VeRa (Veiligheidsregios Referentie Architectuur)\(^6\).

Some interesting ideas have been declared by some of the end users for the different applications. All of them are here listed and they will be taken into consideration for the final implementation of the AIOSAT system, even if they will not be all covered for every single scenario:

- The system could perform a self-check on arrival at the MRC (Media Reception Centre) or at the firefighter stations to see battery status and possible failures.
- The brigade chief could report the entry and exit routes and make sure that he has not chosen a “no exit” route.
- On the other way around, the different escape strategies can be communicated via data, for example, between the application of the ICP and the application that the brigade leader consults.
- The brigade leader could be informed if there are firefighters that are arriving to a “deadman zone” or moving away from the safety zone or the planned escape routes.
- That every X time the brigade leader validates the time it has been working and its location (North-South etc.)
- That if a firefighter takes more than X time stopped, that it is explicitly asked to recognize that it is OK by pressing for example a button. This “counting” procedure can also be done on demand or on a scheduled basis, if the procedures declare so.
- The application could be used for reconstruction of incidents and training purposes.
- If you do not receive data from a firefighter during X time (e.g., due to lack of coverage but it may be for another reason), activate alarms in the ICP, and locally, put the device in "radio beacon" mode, activate a light or audible signal so that the companions can locate the fireman.
- The information should be displayed on a ruggedized tablet. The use of the tablet should be possible in ‘all weather’ conditions. A wet screen should have no implication for the use of the tablet.
- The tablet is mobile. It can be stored in the commando vehicle but when necessary it can be used ‘stand-alone’ on the scene.
- It should be possible to send the image from the tablet to a second screen for example in the ICP, if any.
- The autonomy of the brigade leader application support should be more than 4 hours.
- The battery of the ICP application support might be changed without a shutdown of the overall system.
- The role of “tabla”, declared by San Sebastian firefighters could be covered by the deployed application, if the data of the breathing monitoring systems could be sent.

### 6.5 Requirements for the portable sensor

The end users have also specified certain requirements for portable sensors:

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\(^6\) See [https://www.noraonline.nl/wiki/VeRa_(Veiligheidsregios_Reference_Architectuur)](https://www.noraonline.nl/wiki/VeRa_(Veiligheidsregios_Reference_Architectuur)}
The weight of the sensor should be as low as possible (1 kg declared by San Sebastian Firefighters)
The sensor should be as small as possible, so as to not disturb the normal motion of the firefighter
The autonomy must be more than 12h (missing in action, victim of a collapse, etc.)
The working temperature of the sensor should be between -10°C and +100°C.
The sensor can resist a fall of 10 meter. The visibility during the interventions may be very poor, so the system should be robust enough to handle hits and shocks.
7 Conclusions

The aim of this document is to describe the operational settings where the AIOSAT system will be used. It presents the background and the state of the art of the positioning and communication technologies during the interventions in different countries and different regions. From that starting point, the scenarios that are relevant for all the end users involved in the project have been presented. The last section summarized desirable highlevel requirements from the end users.

The scenarios and user requirements are input for the technical requirements that will be more detailed and specified in [4] and that will drive the development of the AIOSAT system. In all the cases described in that document, AIOSAT system would benefit for the safety of the firefighters involved in the intervention. The people in command could monitor, assess and help the teams deployed during the operation on the field and the position data could be used for training and continuous improvement, afterwards.
8 References

[3] Stichting Brandweeropleidingen BOGO. Leergang Manschap A Les 2 Oriëntatie brandbestrijding. (internal presentation)
[4] AIOSAT Deliverable D2.2: Architecture and system requirements