SEVENTH FRAMEWORK PROGRAMME

System and Actions for VEHicles and transportation hubs to support Disaster Mitigation and Evacuation

Grant Agreement No. 234027

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List of abbreviations

AOA         Angle-Of-Arrival
CCTV        Closed Circuit Television
CRM         Crew Resource Management method
DR          Dead Reckoning
DSA         Decision Support Agents
EC          Evacuation Calculator
GNSS        Global Navigation Satellite System
GPRS        General Packet Radio Service
GPS         Global Positioning System
GSN         Global System for Mobile communications
HGV         Heavy Goods Vehicle
LCD         Liquid Crystal Display
LED         Light Emitting Diode
NLOS        NonLine Of Sight
PAVA        Evacuation Public Address Systems
PDA         Personal Digital Assistant
PT          Public Transport
RFID        Radio Frequency Identification
SDSS        Spatial Decision Support Systems
SPH         Smoothed Particle Hydrodynamics
TDG         Tactical Decision Game
TDOA        Time Difference Of Arrival
TfL         Transport for London
UI          User Interface
UWB         Ultra WideBand
WiFi        Wireless Fidelity
WP          Workpackage
WSN         Wireless Sensor Network
Executive Summary

This Deliverable presents the SAVE ME project concept and objectives, as well as its expected results, providing an overview of the planned work throughout the project’s three year duration. The first chapter of the Deliverable (Chapter 1) is the introduction, presenting the general overview of the problem and giving the project data. Chapter 2 describes the aims and objectives and defines the target user groups and application areas considered and supported by the SAVE ME Consortium. In Chapter 3, a description of the technical approach of the project is included, starting with the users’ needs, the scenarios of use and the background technologies, and following with the plans for each technological aspect in the project. Chapter 4 presents the expected achievements and Chapter 5 the foreseen impacts. Chapter 6 gives the concluding remarks of the Deliverable.

In Annex A, the list of SAVE ME beneficiaries is provided, as well as the Project Coordinator’s contact details. A short project presentation (2 pages) is provided in Annex B.
1. Introduction

Many areas in the world have been, and are likely to be affected by severe physical disasters, such as earthquakes, tsunamis, hurricanes, etc; whereas fire and floods usually occur as immediate results of these incidents. Natural disasters are becoming more frequent and have obvious impacts on transport operations and infrastructure. One major difficulty that is imposed on the planning of the logistics of private and public transport is the effect of a catastrophic earthquake. On the other hand, fires with the most serious consequences (such as those involving injuries, fatalities or extensive material damage) have mostly been the result of tunnel accidents. Over 200 people have died in Europe as result of tunnel fires in the last decade, 16 fire accidents occurred in road tunnels in Europe from 1986 until 2006. Unfortunately, public transportation fire is also not a rare phenomenon.

In addition to the above, a great menace of our time is terrorism. Transportation infrastructure, hubs and stations are often targets of terrorist attacks because of the easy access and escape for the terrorists and congregations of strangers guarantee the attacker a high degree of anonymity. Crowds in contained environments are also vulnerable to both conventional explosives and unconventional weapons. Moreover, terrorist attacks cause alarm and great disruption; previous attacks have caused the deaths of many innocent people.

Physical disasters and terrorism constitute a great and escalating menace to transportation networks, infrastructure and hubs, with increasing emphasis on areas with high concentrations of people, such as Public Transport terminals/stations and tunnels.

1.1 Project data

The following table summarises the project data:

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<td>Web site</td>
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Table 1: Summary of project data.

The Project Coordinator contact details are listed in Annex A. The SAVE ME Consortium consists of 11 contractors from seven countries (Annex A) with high competence related to the SAVE ME objectives, with respect to the various scientific, technological and application areas. The reason for such an extended partnership is the effort to unite the different expertise on SAVE ME related activities, but also a
pan-European approach, in order to realise the project challenge. Thus, the geographic spread of the Consortium and the Pilot sites is well balanced to cover the different priorities, transport and disaster environments and expertise available across Europe.

Through its User Forum initiative, the project intends to involve organisations from other European countries.
2. What is SAVE ME

SAVE ME aims to develop a system that detects disaster events in public transport terminals / vehicles and critical infrastructures (i.e. tunnels and bridges) and supports quick and optimal mass evacuation guidance, to save the lives of the general public and the rescuers, giving particular emphasis to the most vulnerable travellers.

The application areas of SAVE ME are the following:

- Metro terminal (wide area).
- Metro platform (confined area).
- Metro vehicle.
- Tunnel (especially for the long ones, both highway and urban tunnels are considered).

However, the project’s target application areas cover any PT vehicles, stations, hub and critical transportation infrastructures (e.g. tunnels and bridges).

The primary user groups of this proposal are all passengers, including elderly, disabled, children, and, in general the most vulnerable traveller groups.

The major innovation points of SAVE ME are as follows:

- Development of standardised ontologies for rapid and reliable non-verbal communication between all stakeholders in case of emergency.
- Development of standardised icons/earcons/haptic elements for intuitive and language-free crowd herding in case of emergency.
- Accurate user localisation inside the PT vehicle/station/platform or the tunnel, using low-cost and power and high autonomy local sensors (e.g. those belonging to the smart dust family such as MOTES).
- Dynamic monitoring of the position and movements of humans in case of an emergency event.
- Distributed sensor units with partial decision capability in case of communication outage/failure and lack of human interaction.
- Improved simulation models, taking into account the specific characteristics of vulnerable travellers (i.e. behaviour and speed/agility of children, elderly, disabled, etc.).
- Real time dynamic emergency support models, fusing simulation models with real time data.
- Development of a Decision Support System based upon the real time emergency support models and the estimation/calculation of human behaviour after they are informed/guided (closed loop system).
- Personalised route guidance of travellers inside the tunnel or station, through their mobile phones.
- Generic route guidance of non-equipped users, through situated public displays / announcements.
- Route guidance and decision support system, guiding the emergency units (dynamically, through PDA) to respond optimally to the needs of the trapped humans.
- Integrated monitoring and emergency support system, dynamic and with accurate localisation, covering the needs of all key actors involved.
- Use of successful escape routes as patterns to guide other users.
- Handling of panic reactions by appropriate HMI and modelling.
- Holistic approach, encompassing appropriate design guidelines, event detection, disaster mitigation and training actions.
Thus, the SAVE ME main objectives are:

1. To identify the actual problems and needs of all travellers and stakeholders in dealing with various physical disaster or terrorism events.
2. To devise specific use cases and application scenarios, covering all the project application areas (metro terminal, platform, vehicle and tunnel) for all types of emergencies considered (earthquake, fire and terrorist attack).
3. To develop a holistic system architecture, that will allow inclusion of different elements and modules, as well as a common ontological architecture for hazards recognition, cause, severity and mitigation.
4. To specify the systems and their modules for detection and to develop the required sensors (for detection, localisation, and situation awareness), as well as the appropriate telecommunication infrastructure.
5. To investigate all users’ behaviour (including emotions and stress) during panic situations, leading to the development of appropriate interfaces to inform the public, avoiding the causes of havoc and stress (including vulnerable travellers).
6. To develop algorithms, based on intelligent agents, for personalisation of the information provision to the needs of each user (e.g. simple visual information for elderly users, or sound notification for visually-impaired users).
7. To develop a Decision Support System (DSS), based upon dynamic and closed-loop simulation and modelling tools, with real time data.
8. To offer support to the infrastructure operators.
9. To offer guidance to the rescue crew through PDAs.
10. To offer guidance to the public through their mobile devices, as well as through public terminals and announcements.
11. To develop training programmes (methodology, curricula and tools) for the infrastructure operators, the emergency unit personnel and the general public, to optimise their performance during emergencies.
12. To install and test the SAVE ME system in two Pilot sites (in the underground station and metro vehicles of Nexus in Newcastle-upon-Tyne, UK, and the Gotthard tunnel in Switzerland), in order to evaluate its reliability, usability, usefulness, efficiency and market viability.
13. To develop concise exploitation and dissemination plans for the successful and efficient adoption of SAVE ME products.
14. To contribute to the standardisation activities that are being undertaken by National, European and International bodies, on infrastructure properties and evacuation aids.

The SAVE ME objectives are divided among 9 workpackages (WPs), as listed below:

- WP1 Problem definition, clustering and use cases
- WP2 System Architecture specification and common ontological framework
- WP 3 Algorithms, interfaces and intelligent agents
- WP 4 Detection system
- WP 5 Decision support system
- WP 6 Emergency support measures
- WP 7 Training measures
- WP 8 Pilot testing
- WP 9 Dissemination, guidelines, standards and exploitation

In addition to these WPs, a management WP exists (WP10).
3. Technical approach

3.1 Needs

3.1.1 The needs of vulnerable users in emergencies

When planning for large scale emergency situations, it is easy to forget that some segments of the population have additional needs that go beyond those of the average user, requiring more than a survival kit and an evacuation plan. During emergencies, the elderly are slow to react, slow in their movements and can get easily disoriented. There are also a number of situations requiring a different approach by emergency planners (Disaster Handbook, 1998). In detail, the groups of people for which special, specific emergency planning is needed, are composed of:

1. Individuals who require special attention (including the elderly, children, and non-native language speakers).
2. Visually impaired, who need information in a media accessible to them.
3. Hearing impaired, who need special help to receive messages.
4. People who use wheelchairs, or are otherwise mobility impaired, and who need special rescue techniques and transportation that is accessible for them.
5. Mentally impaired, who need training and constant reinforcement to learn steps to save themselves.

The elderly are among the most frequent users of public transport. In Scotland, over a quarter of adults held a concessionary travel pass, including over four-fifths of those who were aged 65 and over. In 2005, 15% of people aged 60+ used a concessionary travel pass every day or almost every day, and 40% used one at least once a week (44% of women and 32% of men) (Scottish Executive news, 2007). Also, British figures report that 20% of men and nearly 30% of women aged 70 or more use the local bus service for their daily trips (OECD, 2001).

Children, also fall under the vulnerable users group. Care and protection for children in emergencies is among the primary concerns in such events. Children may become separated from their families in many different ways; armed conflict, mass population displacement, natural disasters, and other crises can all cause children to become separated from their families or other adults responsible for them. Separation can also occur accidentally, such as when families are fleeing from attacks without warning.

Given their vulnerable position generally and the fact that their principle carers may be missing, killed or seriously injured, children are at increased risk of harm in accidents within the transportation environment. For this reason, it is essential to ensure that measures are put in place to protect children, and to ensure that the effect of the trauma itself and any further consequences are minimised. Children under 18 usually constitute at least 50 per cent of the population affected by an emergency. Therefore, any response which does not take into account children’s issues fails a substantial proportion of the affected population (Toms & MacLeod, 2007).

Thus, the specific needs of the most vulnerable users, such as elderly, disabled and children, need to be incorporated into any disaster mitigation system from its initial design phase and, furthermore, their specific behaviour, speed of movement and mobility limitations are to be included in any human behaviour models.
3.1.2 The needs of the rescue personnel in emergencies

Over the last decade, urban disasters have shown that even in the most developed economies, catastrophic events can overwhelm communications grids. In fact, in these scenarios the sheer variety and complexity of network infrastructure and the far greater needs and expectations of victims and responders increases the likelihood that any single system may fail. Communications failures in New York City on September 11th 2001 contributed directly to the loss of the lives of at least 300 firefighters.

A correctly selected and implemented method of a continuous communication system can save a considerable amount of time during a rescue operation in confined spaces. Instantaneous communication between the rescuers and rescue personnel on the outside of the incident place can dramatically improve the success of the entire rescue operation. Rescuers inside an incident space can immediately call for the specific equipment needed to extricate a victim or for additional support. They can also relay medical information or direct line hauling operations to make the operation to proceed much more smoothly. Reliable communication between the attendant and rescue entrants has a calming effect on rescuers and reduces the likelihood of additional accidents caused by misunderstandings, confusion or panic. Communication between team members is primarily for the safety of the rescuers. However, other advantages to a correctly deployed communication system include: higher levels of "perceived" safety, better training, a reduction in the stress experienced by rescuers due to claustrophobia or panic, a more efficient use of manpower, and ultimately, faster rescues. Another characteristic of proper communication that is commonly overlooked is the ability of rescuers to communicate with a victim or assess their condition prior to actual rescuer entry into a confined space.

Figure 1: Tunnel Evacuation (Llangollen District, UK).
Another important tool for rescuers is their proper guidance to the location of people needing help. This effectively eliminates the need for rescue crews to both find and authenticate the isolated person and greatly reduces the risk to rescue crews, thus helping to take the ‘search’ out of ‘search and rescue’. Also, environmental monitoring is of crucial importance, as an accurate assessment of all hazards may not be possible because they may not be immediately obvious or identifiable. Rescue personnel may be selecting erroneous protective measures due to limited information available to them.

To conclude, rescuers need precise information on the situation, seamless communication means between them and the operations centre and proper guidance to the trapped travellers.

3.2 Scenarios of use

The priority Use Cases for the project will be issued based on the selected travel groups and environments, as well as the stakeholders and traveller needs. Each use case will be composed of several application scenarios. Since the proposal phase of the project, the main SAVE ME Use Cases have been identified and are presented below.

Use Case 1: Emergency Detection
Using the WSN sensors of WP4, any sign of emergency (i.e. smoke, water, humidity) will be reported to the operator’s centre and will be fed to the DSS to suggest actions. A “green” or “yellow” phase action plan will be initiated, following the relevant adaptive interfaces strategy for travellers’ guidance.

Use Case 2: Disaster Mitigation Operation
In the situation where a disaster has occurred, the simulation model (static) of the DSS will run for the specific infrastructure. Then, as real time data starts coming-in from the sensors (WP4), the model will be constantly re-calculating and providing data to the DSS to take decisions. Emergency support measures (WP6) will then be realised, in accordance to DSS actual plan (always of course under human supervision and responsibility), which may adapt the plan according to new incoming data. The position and movements of the trapped travellers will be estimated by a combination of the human behaviour model and the actual data of WP4. The operators will be always in control of the overall situation, both through data streams and by graphical and acoustic outputs, by the operator support module (WP6).

Use Case 3: Guidance to Travellers
According to the interfaces strategies (WP3), the WP5 DSS evacuation plan and the infrastructure (from WP4 sensors), generic guidance will be given to the public by visual and acoustic means of the WP6 collective herding guidance module. In addition, those that are equipped with open and functional mobile phones will get personalised guidance (i.e. knowing the person’s location and the nearest unblocked exit, a point to point guidance will be given), which will be adapted to the person’s profile, which is stored at his/her mobile phone (e.g. visual guidance for a deaf person, not acoustic; taking into account the existence of stairs between current position and nearest exit for a wheelchair user, thus providing him/her with an appropriate route to another exit).

Use Case 4: Guidance to Rescue Units
Rescue units will be guided by DSS decisions, according to relevant strategies of WP3 using PDAs (WP6). They will be safely guided and monitored within the
infrastructure and will be given instructions to reach highest priority users, i.e. the most endangered and/or most vulnerable citizens.

**Use Case 5: Training**
The WP7 training platform (VR-based) will be used for planned training sessions of infrastructure operations and emergency teams, both at a training centre and on site. This will optimise their performance in case of a disaster. Awareness enhancement flyers will be printed and regularly disseminated to travellers, to also improve their behaviour and prepare them to use the SAVE ME system during a disaster.

The Use Cases clusters in this section are only indicative, to better explain the intended functionality of the SAVE ME system. In each UC cluster, several UC’s will be defined (depending upon the type of disaster or infrastructure or traveller). The final Use Cases, properly detailed with their characteristics and parameters, will be defined during WP1. Among the areas that will be specified per UC are the following:

- Type of emergency (i.e. fire, earthquake, terrorist attack, flood, etc.).
- Type of transport infrastructure (i.e. train, light rail, metro, metro station, train station, tunnel, bridge, etc.).
- Key environmental factors (time of operation, such as day/night, open or closed terrain, number of levels, stairs or level access, number of available exits, etc.).
- Types and numbers of travellers.
- Types of other stakeholders involved (emergency support units, infrastructure operators, drivers of PT vehicles, etc.).
- Basic rules applied to the operation.
- Key operation characteristics (continuous, discrete, periodical, etc.).
- Time criticality (in terms of time measures), related to the time frame for effective event detection, prevention or disaster mitigation.
- Communication networks present (i.e. GSM, WiFi, etc.).
- Power autonomy and other security systems.

### 3.3 Background / foreground technologies

#### 3.3.1 Systems/models assessing human behaviour in emergencies in transportation hubs and vehicle

Crowd simulation and modelling have been an area of interest for many years. There are 3 main methods used for crowd simulation:

1. **Fluids** - it can be observed that the motion of crowds at a macroscopic level is similar to the flow of fluids. Successful attempts have been made to model pedestrians using the physical laws of fluid dynamics.
2. **Cellular automata (CA)** - discrete, dynamic, systems whose behaviour is characterised by local interactions. These systems model a lattice of cells and base the state of a cell on the states of the immediately surrounding cells.
3. **Particles/Agents** - often known as the atomic or particulate approach. Under this scheme, each pedestrian is considered as an individual entity and the interactions with the other pedestrians are individually modelled according to physical or social laws. It is probable that the majority of the work described in the literature follows this approach.

There are several models available that are based on the above three simulation approaches (Santos & Aguirre, 2005). Indicatively we may mention:

- EVACNET, EESCAPE, EGRESSPRO (flow based).
- EGRESS, Pathfinder TIMTEX (cellular automata).
- SIMULEX, EXIT89, GridFlow, ALLSAFE, (maritime, air and building).
- EXODUS, CRISP, MASC, FIRESCAP, E-SCAPE (agent based).

In SAVE ME, the fluids approach will be followed, although a hybrid algorithm with the particles/agents approach will be also considered.

3.3.2 Emergencies detection and communication systems in transport hubs and vehicles

Existing advanced emergency detection and evacuation systems for transport hubs generally comprise a series of sensors spatially distributed at each critical operational point to detect any emergency condition; additionally, a set of emergency signalling units are located adjacent to respective emergency exits, and a control panel, comprising a number of indicators, connected to emergency condition detectors, are also essential parts of these systems. Furthermore, these emergency systems are interconnected with an emergency centre, able to provide support.

Recent advances in sensor technologies make possible to install and interconnect tiny devices within existing infrastructure, such as smoke detectors or overhead lighting, for networked use in case of an emergency. These networks can provide emergency control centres with 3D building visualization, real-time monitoring of hot spots or structural failures, and tracking of victims and personnel. Central to such features is the ability to perform indoor location detection in the face of unpredictable reflections (from furniture, people or walls), occlusions (due to smoke or fire), and hanging building features (from falling walls, collapsed ceilings).

However, despite the increasing reliability and resiliency of modern telecommunications networks to physical damage, the risk associated with communications failures remains serious because of growing dependence upon these systems in emergency operations. Deploying wireless communications is typically among the first priorities in any emergency response, rescue, or relief situation.

Except for satellite communications, emergency services rely on public radio networks, like GPRS for data communications. Sometimes in disaster situations, even GSM is used for voice communication between relief workers. However, in emergency scenarios the public GSM networks may get overloaded. So, the use of publically available networks is not considered to be reliable enough for emergency situations. Moreover, GSM/GPRS is an infrastructure-based network, highly susceptible to disasters in small and medium sized areas. However, modern telecommunications infrastructure has also provided powerful and flexible tools to enable cities to cope with crises, and quickly relocate and restore displaced or disrupted social and economic activities. The Internet, mobile telephony, and satellite communications provide unprecedented communications capabilities to a wide range of institutions and communities in disaster areas.

The state-of-the-art in communication and monitoring systems in tunnels is either wire-based or built on the concept of leaky coaxial cable guided systems. However, such systems are expensive to install and maintain. There are also practical difficulties in setting up a wired network within the confines of an existing tunnel. Hence, wireless network using natural wave propagation is a more flexible and efficient solution because it is low-cost, easy to implement and scalable. There exist some research challenges before such networks can be deployed. Radio waves do
not propagate well in tunnels. Thus, there is a motivation to design an optimal wireless communication network in tunnels.

As stated above, communication is critical during an emergency and needs to be addressed thoroughly within the disaster-response plan. SAVE ME communication challenges include reaching people in different locations with different devices quickly and simultaneously; providing the right message (in terms of content, length, and format); monitoring delivery and response; and ensuring that the process is initiated and suspended at the right times. One of the ways SAVE ME will progress beyond state-of-the-art addressing these challenges will be through the use of automated-notification technology, which can rapidly distribute information to large numbers of people. In order to avoid human driven errors (such as sending incorrect messages or failing to notify the right parties) and to reduce these errors to a minimum, SAVE ME will provide extensive training exercises and conduct regular testing. To be effective, the SAVE ME crisis-communication plan will anticipate and overcome potential obstacles such as power outages and downed phone lines.

Regarding localisation of users, there are many different methods and technologies available for localising a vehicle or a person. The most common is Global Navigation Satellite System (GNSS), notably Global Positioning System (GPS), which is widely available. Such a system requires a line-of-sight to four or more satellites which is not possible in a tunnel environment and may be less than perfect in some transport hubs or vehicles, depending on the surrounding urban environment.

Thus, additional technologies are required. Some systems use inductive loops or magnetic transponders. In the past the most common methods have included radio-based spread spectrum techniques, microwave Doppler and opto-electronic devices (Fararooy et al., 1996). Frequency-hopping spread spectrum techniques (a well known technology for many military applications), is based on evenly distributed radio beacons in the tunnel transmitting a synchronous signal. This signal can be received in a vehicle and because of the different time-of-flight of the signal, a location can be estimated.

The most appropriate method to define a position within a tunnel is Dead Reckoning (DR), a localisation method which does not require continuous connectivity to satellites, anchor nodes or a network. It determines the present position by projecting past headings and speeds based from the last known position (Bowditch, 2002). DR can be used to determine a future position by anticipating future headings and speeds. Modern inbuilt car navigation systems are connected to the car's system to receive speed and heading data. This positional information can be transmitted over the tunnel communication network to the control centre. This position information helps rescuers to evacuate the tunnel as fast as possible. Also additional information (e.g. fuel level, engine temperature) can be transmitted which might allow in some cases the prediction of dangerous events. Detecting the position of the blocked vehicle, also allows the location of trapped occupants to be localised (although this is not always the case).

Indoor position estimation is not a trivial task due to the absence of GPS signals. An additional system must be deployed in the observation area in order to be able to calculate position of objects or humans. Several technologies exist that can realize such systems and most of them are based on measuring a parameter that varies with distance from known and stationary reference points and then triangulating in order to estimate the unknown position. There are many position estimation techniques for various purposes under different scenarios. Signal strength, angle-of-arrival (AOA), time measurements (time-of-flight and time-difference-of-arrival (TDOA)) can all be
exploited for position estimation. The above techniques can be implemented in wireless communication networks offering localization capabilities without disturbing the information transfer.

A WiFi network can be used to estimate a position (Ladd et al. 2004; Bahl and Padmanabhan, 2000). Based on the position of the WiFi hotspots and a range-based or range-free localization algorithm, a user’s position can be estimated (He et al., 2003). The advantage of a WiFi network is that communication in both directions is possible. This opens the possibility to a wide range of new applications to improve the service and increase safety in tunnels or underground stations.

The communication infrastructure in modern tunnels / underground stations can also be used for localization. Most tunnels and underground stations are equipped with GSM cells (Otsason et al., 2005); based on the position of these cells and different localization algorithms a user’s location can be estimated. The accuracy depends on how tight the GSM network in the infrastructure is. It can also be improved if the clock in the GSM receiver is synchronised with the one in the base-station.

UWB (Ultra Wide Band) radios can also be used for indoor localization applications. The very short time-domain pulses of UWB systems make them ideal candidates for combined communications and positioning. The phenomenon of multipath, which is unavoidable in indoor wireless communications, is the major source of positioning errors in RF-based indoor localization techniques whilst the very short duration of UWB pulses makes them less sensitive to the multipath effect. As the transmission duration of a UWB pulse is shorter than a nanosecond in most cases, the reflected pulse (NLOS - Non-Line of Sight) has an extremely short window of opportunity to collide with the LOS (Line of Sight) pulse and cause signal degradation. There are a lot of open issues in UWB communications related to pulse shaping, channel estimation, high frequency synchronization, multiple access and interference.

A hybrid localisation system is able to combine information from the GSM network, radio beacons, WiFi hotspots, sensor networks and GPS (at the entrances) to provide position information with a high accuracy.

Other technologies for tunnel / underground stations localisation are based on infrared beacons (Want et al., 1992), RFID (Kourogi et al., 2006), Bluetooth (Aalto et al., 2004), Ultrasonic (Priyantha et al., 2000) or sensor networks (Lorincz and Welsh, 2005).

SAVE ME will use Wireless Sensor Network (WSN) technology, combined with hybrid localisation techniques, as this:
• is of low power;
• has communication capabilities;
• has (limited) computational capabilities;
• has sensing capabilities (accelerometer, microphone, cameras);
• has signalling capabilities (although limited, due to power constraints);
• offer local decision possibility, in case of communications failure;
• has localisation functions.

### 3.3.3 DSS for emergencies support in transportation hubs and vehicles

Past experience has demonstrated that two main hindrances to the movement of evacuees in a building evacuation exist: (1) inappropriate selection of escape
pathways and (2) congestion along the safest pathways (Lovas, 1998). Instructions generated for the specific circumstances leading to the need for the evacuation can lead to significant improvements in escape pathway selection. Moreover, explicit consideration of the number of people that such pathways can support in developing real-time evacuation instructions can lead to reduced congestion throughout the building.

Escape route planning optimization techniques have been proposed for use in both building and regional evacuation over the past few decades and a number of these works develop network flow-based solution techniques that consider the dynamic and, in some cases, the time-dependent network properties. All of these works assume that when two or more units of flow (i.e. the evacuees) arrive at an intermediate node, instructions can be provided that permit the flow to split among various routes.

Spatial Decision Support Systems (SDSS) are explicitly designed to provide the user with a decision-making environment that enables the analysis of geographical information to be carried out in a robust, yet flexible manner. Fundamentally, SDSS involve the coupling of GIS and analytical/decision models to produce systems especially able to cope with spatial problems (Batty and Densham, 1996). They are designed to aid in the exploration, structuring, and solution of complex spatial problems such as the evacuation process. De Silva (2000) and Densham (1991) describe a typical SDSS as having four components:
1. Analytical tools enabling data investigation;
2. Decision models enabling scenario based investigations;
3. A geographic / spatial database enabling storage and analysis of geographic information;
4. A user interface providing easy access to components 1, 2, and 3, as well as an attractive and comprehensive display of the output.

Similar to the general constituents of a SDSS (outlined in Densham, 1991), and the Configurable Evacuation Management and Planning Simulator-CEMPS (discussed in de Silva and Eglese, 2000; Castle and Longley, 2006) proposes a GIS-Based Spatial Decision Support System for emergency services for London’s Kings Cross-St. Pancras underground station (called KXSDSSSES). The KXSDSSSES will couple current pedestrian egress simulation programs with the network analysis and route optimisation of ArcLogistics™ Route to evaluate, revise, and contribute to emergency services preparedness of a major disaster within the London King’s Cross redevelopment.

The SAVE ME DSS will be based in much more advanced, inclusive and dynamic models and will involve all stakeholders (operators but also emergency support units), in a closed-loop form.

### 3.3.4 Guidelines and training schemes for emergencies in transportation hubs and vehicles

When an intervention of crisis management is needed, the possibilities to inappropriately manage or create a worse situation because of human error and inadequate team competence are particularly high. A good co-ordination of actions, an efficient communication within, between and across teams and a high level of decision making, sometimes under high levels of stress, are needed to obtain an effective emergency management by large scale and complex organizations. Therefore relevant training issues involve both technical and non-technical aspects
(i.e. social and cognitive skills). Using a point of view from psychology, such issues can be solved by an effective and efficient decision making process, an accelerated proficiency and the development of expertise in individual and team activities.

Across industries, training for emergency management consists of classroom-based training, manuals and emergency exercises. Unfortunately these kinds of methods are not always completely successful and lack in improving the non-technical knowledge.

During the last two decades, further traditional training methodologies, such as cognitive and behavioural methods and new techniques, are gaining importance to increase knowledge, skills, and/or attitudes toward specific job dimensions. Three of the recent techniques are Crew Resource Management (CRM) method, Tactical Decision Game (TDG) and assessment centre methodology.

Crew (or Cockpit) Resource Management (CRM) training tries to solve one of the most relevant causes of human error, i.e. the failures of interpersonal communication, leadership, and decision making in the cockpit (first application are in aviation domain). The primary goal of CRM is enhanced situational awareness and it recognizes that a discrepancy between what is happening and what should happen is often the first indicator that an error is occurring (O’Connor and Flin 2003). There are two benefits of CRM training: 1) an improvement in human performance and teamwork in order to minimise the risk of emergencies or accidents occurring, and 2) support to the teams to more efficiently perform once an emergency has occurred (Flin, 2001).

Another training methodology aims to develop and improve intuitive decision making and related skills in complex, hazardous, real-world environments. TDGs act as a substitute for actual experience and provide a suitable, yet low-fidelity, opportunity to enhance skill development and expertise. Normally, a TDG training session consists of one prepared scenario that is presented by a short text (of 2 or 3 paragraphs) that a facilitator reads aloud to the participants. Sometimes a “map” of the environment where the scenario is played is given to the participants. The requirement is that a plan to solve the incident is to be formulated. Participants are encouraged to illustrate their decisions about movements of personnel or materials. A great strength of TDGs is that the used scenarios allow the sampling of alternative task strategies, to compile an extensive experience bank, and to enrich experiences.

A final training methodology is the assessment centre. The purpose of this methodology is threefold: (1) consolidate the tacit knowledge, i.e. the implicit knowledge that an individual learns from experience, (2) improve situation awareness and (3) improve self-efficacy and encourage an influence behavioural change through the quality of feedback that assessment centre activities give. Assessment centres involve participation in multiple exercises and simulations, and the observation and evaluation of performance against predetermined tasks related behaviours by a team of trained assessors. A key aspect of assessment centre effectiveness is its use of simulations that provide opportunities to practise dealing with high pressure situations in a safe and supportive environment and to develop, rehearse and review technical and management skills (Paton, 2003).

Using these methodologies for training individuals and teams, SAVE ME will achieve a real improvement in the emergency management, especially regarding knowledge and skills of the infrastructure and rescue team coordinators. This will have a positive influence on the quality of the emergency interaction: better training limits the possibilities that an error occurs during a critical situation.
Finally, special training infrastructure is used by rescue teams, where the personnel undergo regular training of new methods, scenarios and tools. Such a training facility is owned by CNVVF (a SAVE ME partner) and it is located in Montelibretti, Italy. It has a road tunnel, with the possibility to instantiate realistic scenarios of fire and smoke. This facility will be used for the training measures of WP7. A couple of pictures of this facility follow below.

![CNVVF full-size tunnel training facility](image)

**Figure 2**: CNVVF full-size tunnel training facility.

### 3.3.5 Relevant national, European and international research initiatives

The CAPEVACUATION project presents an emergency evacuation system for corridor traffic control within the Washington metropolitan area, which integrates both optimization and macroscopic/microscopic simulation methods. The system features the integration of multiple functional modules. Its optimization module tries to identify the optimal control strategies during an evacuation based on a cell transmission formulation of network flows. The proposed system can facilitate system users in finding effective evacuation control strategies in a large-scale network or in real-time operations, which is especially critical when unexpected events occur during the evacuation and the implemented plan needs to be revised in a timely manner.

Several other projects have dealt with research and development in simulation, optimal routing and guidance (i.e. CROSSES and CROWD-MAGS). Similarly to the above, the Dutch government has started a research project ‘Floris’ (Flood Risk and Safety in the Netherlands) to calculate the risks of about half of the 53 dike-ring areas of The Netherlands. This project has four tracks: (1) determining the probability of flooding risks of dike-rings areas; (2) the reliability of hydraulic structures; (3) the consequences of flooding and (4) coping with uncertainties.

As part of the third track, the consequences of flooding, the Ministry of Transport, Public Works and Water Management has asked the University of Twente to develop a Decision Support System for analyzing the process of preventive evacuation of people and cattle from a dike-ring area. This Support System, named Evacuation Calculator (EC), determines the results of several kinds of traffic management in terms of evacuation progress in time and traffic load. The EC makes a distinction
between four types of traffic management scenarios: (1) reference; (2) nearest exit; (3) traffic management; (4) out-flow areas. The limited data need and efficient algorithms in the EC make it possible to model large-scale problems.

Targets in the EC development were twofold: (1) a safe estimate of the evacuation time and (2) to support the development of an evacuation planning. Optimization methods were developed to solve the problems and meet the objectives. Even though the problem that was tackled is different from the one that is to be investigated in SAVE ME, similar techniques on the development of the DSS for the optimal route planning could be applied by changing the affecting parameters, such as topology and population element characteristics.

### 3.4 Architecture, ontological framework & intelligent agents

The overall SAVE ME system architecture is shown in the following figure.

**Figure 3: SAVE ME System Architecture.**
The main components are the detection and communication system and the Decision Support System. The detection and communication system consists of a Wireless Sensor Network (WSN) grid, which is responsible for the detection of hazardous situations and the localization of travellers, as well as for the communication infrastructure that enables the realization of evacuation and mitigation strategies. Appropriate evacuation and mitigation guidelines are transmitted by the DSS.

In order to evaluate hazards and initiate action, the SAVE ME system will utilize a common ontological framework for hazards description. It is the first time that transportation disaster related hazard recognition and characteristics will be analysed towards their translation in a common ontological structure. For each hazard, the following classification fields are initially recognised:

- **Type**;
- **Cause**;
- **Severity**;
- **Environment** (train, metro, bus, transportation hub, etc.);
- **Estimated number of affected persons** (victims);
- **Area affected** (in m² or km²);
- **Mitigation** (the exact action needed and by whom).

The use of the common ontological framework will enable the automatic calculation of the imminent actions to be taken by rescue crews, speed-up the communication between different actors and eliminate any errors due to verbal communication or language barriers. The knowledge that will be encoded in the ontological framework will be the result of bibliographical surveys and interviews with experts. Moreover, the ontology will be uploaded to the project Web site, to be gradually improved with feedback from other stakeholders.

One of the major targets of SAVE ME is to provide personalized guidance and services to travellers according to their needs and preferences. Intelligent Agents are the software entities, which will act in a cooperative manner, in order to achieve this goal. These agents represent users and their preferences, thus they are able to provide safety recommendations or perform reasoning and make decisions about which are the most appropriate means of aid that facilitate users in an emergency situation, all based upon their specific profile. For each aspect of user personalisation different agents will be used. Apart from those agents which are designated to monitor user profile, other agents provide interoperability with additional sources of information and decision-making mechanisms. In the context of SAVE ME, these include the various registered Web services, the Decision Support System and the Ontological Framework. Thus, specific agents are used in order to interact with the aforementioned SAVE ME modules and exploit available information. All agents are designed in order to operate in a collaborative manner, with a common cumulative goal, which is to provide a set of multi-modal personalised services according to the user profile and real-time environment.

The architecture of the Intelligent Agent System designed in the context of SAVE ME is illustrated in the following figure.
This multi-agent architecture is composed of the following user types:

- **User Profile Agents.** These agents belong to the personal user space. Their execution environment is in direct interaction with the user, including mobile devices and wearable sensors (if any). The User Profile Agents are responsible for monitoring and handling detailed information about the user preferences. This information may include user-specific attributes, such as their potential disability or age. Moreover, the information handled by the User Profile Agents includes the type of the end-user device, as well as the attributes of user's physical environment which they conceive through suitable sensoring mechanisms. By collecting all user-related information, these agents become capable of synthesising suitable user-profile data, which they store in a local repository. In addition, these agents are responsible to act on the user personal space by announcing specific notifications according to the type of information received by other agents, in correspondence to specific information pushed by the emergency support system to the user. For this purpose these agents are coupled with an appropriate personalisation algorithm, suitable for performing information filtering of those recommendations, according to the user profile (i.e. using profile in order to provide visual or haptic feedback to deaf travellers).

- **Sensor Agents.** This class of agent includes all agents that are directly connected to and receive signals from the hardware sensors. Sensor agents are responsible for capturing the values of the hardware sensor signals in an agent-understandable format, in order to interact with the Decision Support Agents and notify them upon potential modification of the received sensor values.

- **Decision Support Agents (DSA).** These agents are responsible for interacting with the SAVE ME Decision Support System whenever a decision mechanism needs to be activated, in order to perform reasoning over an emergency situation. DSA exploit information received by all other agents of the system and also exploit the results of advanced reasoning mechanisms, which are developed in the context of the Decision Support System. These
agents integrate knowledge about all aspects of user personalisation, together with real-time data in the user environment. Thus, DSA feed the main SAVE ME decision support mechanism with all types of appropriate information, in order to enable efficient reasoning over emergency situations (as an example, a wheelchair user who is trapped in an elevated platform, cannot use the stairs and the temperature is rising; thus his/her evacuation must be prioritised).

- **Emergency Notification Agents.** These agents undertake the responsibility to notify the user in real-time about the occurrence of an emergency event. They work in close collaboration with the Decision Support Agents and the end-user devices. Whenever a specific emergency event occurs it is the responsibility of the Emergency Notification Agents to display a notification message on the user device, according to the user specific needs and attributes.

- **Service Agents.** These agents are activated whenever a specific type of information is requested by the client side, in order to fulfil the information needs of one or more use cases. The Ontological Framework of SAVE ME performs a semantic search among suitable available web services, in order to obtain content from them that best fulfils the needs of the requesting party. The results produced as outcome of the search mechanism are then fed to the Decision Support Agents, who provide a ranking of the returned services according to the specific traveller needs, in order to improve the provision of personalised services. Service agents also undertake the actual call of a requested service (e.g. a request for help), taking into account profile-specific information, in order to guarantee that the user receives the appropriate content to be rendered (e.g. guidance to the nearest unblocked exit) on the appropriate device (i.e. specific to the type of his/her mobile phone).

### 3.5 Detection system and sensors

The Detection system consists of the sensor and localisation infrastructure. A wireless sensor network (WSN) grid, including localisation (MOTES, WiFi, Zigbee or others) sensors and environmental detection (of fire, flood, temperature, gas, accelerometers, microphones, etc.) sensors, will be built. This will be responsible for:

- Identification/detection of emergency events (using specific detectors, such as thermometers, infrared sensor, chemical sensors, etc.).
- Local "limited" strategy definition and implementation.
- Signalling to person (group routing) with lights (LEDs).
- Sensing for presence of person after event.
- Counting person “on-line” for situation building.
- Support localization of evacuation people, who are equipped with enabled unit (i.e. mobile phone).
- Intelligent localisation support for rescue team, with compass function and giving local measured information.

For these reasons, sensor nodes with signalling capabilities will be used, which are autonomously powered, with low energy requirements and energy saving mode, to further support public information and guidance provision to travellers. The necessary environmental situation alertness sensors (e.g. temperature, pressure, etc.), as well as sensors for storing data on the number of passengers in a vehicle or terminal space will be selected and implemented in the detection system. For this, a WSN grid will be used.
Appropriate localisation solutions vary according to the nature of the location. GNSS systems such as GPS may well suffice in above ground locations with line of sight to four satellites. However, in tunnel or underground stations locations this is not appropriate and in such situations radio-based spectrum techniques may be effective, or Dead Reckoning, which is the most common technique for localisation in a tunnel.

Mobile communications can also be used. However, the accuracy depends on how tight the GSM network in the tunnel or underground station is. GSM has the advantage that its function is not affected by fire or other damage and emergency calls can be even sent to inaccessible areas. GSM-R is a development of the system designed specifically for railway tunnels, whereby a secure platform allows each unit of a railway system to communicate with each other.

Thus, satellite, wireless and mobile technologies will be employed individually or in combination, to enable solutions to be specially tailored to certain locations.

The localization engine will be based on RSS (Received Signal Strength) and TOA-TDOA (Time of Arrival – Time Difference of Arrival) techniques that will be combined for optimum results. It will have the following submodules:

- **Data fusion and processing module**: This system will combine data from the sensors and will process them to detect alarms.
- **Communication module** (see next section).

### 3.6 Communication system

SAVE ME will develop a fault-tolerant communication architecture. The system will provide a high fault-tolerance level to enable continuous operation, which is reliable and safe in the event of any emergency scenario (from sensor detection to emergency centre). The network infrastructure will be designed following the three fundamental characteristics of fault-tolerance:

- **Replication**: Providing multiple identical instances of the same system or subsystem; Directing tasks or requests to all of them in parallel; Choosing the correct result on the basis of a quorum.
- **Redundancy**: Providing multiple identical instances of the same system and switching to one of the remaining instances in case of a failure.
- **Diversity**: Providing multiple different implementations of the same specification, and using them like replicated systems to cope with errors in a specific implementation.

*Figure 5: Three fundamental characteristic of fault-tolerance.*
The communication module will be developed as a combination of hardware and software sub-modules and systems and will be responsible for:

- The detection of the nomadic devices that exist in the monitoring area. The nomadic devices are considered as GSM devices that are registered to the GSM Base Station installed at the monitoring area. Bluetooth / Zigbee gateways will also be supported, in case of GSM network failure.
- The transmission of messages to the nomadic devices based on the output of the SAVE ME DSS. The system will be capable of formatting and sending appropriate text and multimedia encoded messages, in order to provide useful information for the evacuation procedures.
- The transmission of messages to the situated displays and the provision of voice guidance.
- The transmission of messages for the guidance of the rescue teams. Since the rescue personnel will carry dedicated wireless communication devices (PDAs, equipped with LCD screens and localization tags) the control centre will be aware of their position in real-time. According to this information combined with the DSS output, special guidance and information messages will be sending to the rescuers through dedicated wireless communication channels.

3.7 Emergency interfaces

Human interaction in emergency conditions and critical visual, chemical and noise environments shall be addressed, in order to be able to provide valuable escape instructions to the travellers in need, for a fast and safe evacuation.

Depending on the source of emergency, different scenarios will be experienced during the emergency; human interaction will also depend on the target person type, such as age, language, mental or physical impairments, that can influence the understanding of the information.

Thus, the emergency support strategies will be dependent (among others) upon the following parameters:

- Type of emergency (earthquake, terrorist attack, etc.).
- Type of the environment (tunnel, bridge, bus station, metro station, train, metro, etc.).
- Topology of the location (i.e. linear or almost linear like vessels/trains, 2D like open terminals, 3D like multilevel terminals, complex networks like tunnels at underground metro or rail terminals, etc.).
- Traveller type (i.e. young, old, wheelchair users, child, deaf, blind, tourist/foreigners with language barriers, etc.).
- Situation criticality (i.e. monitoring, drill, imminent emergency, ongoing emergency, post emergency support).
- Device type (personal or infrastructure-based).

In order to guide persons in emergency situations, different type of interaction shall be considered, such as (among others):

- On the infrastructure level:
  - VMS - variable message sign information (pre-coded).
  - VMS, programmable LED panels, which offer high visibility and flexibility at the expense of power requirements.
  - Unit and distributed visual LED elements, which can be embedded in wireless sensor nodes and can provide good power management capabilities.
Simple sound elements which can address also impaired people with Doppler effect resonator.
Sound messages.

On the personal device (mobile phone or PDA):
- Simple visual sign (direction signal).
- Complex visual sign (written text, map-based guidance).
- Simple audio (direction signals).
- Complex audio (voice-based route guidance).
- Tactual (i.e. vibrations based).

The environment shall be sensed, while giving information to persons, e.g. to avoid sound echo, or switch among signalling type during modified environment condition, adaptation to changed environment shall then be considered.

Different levels of emergency will be designed, as for example shown below:

![Figure 6: A 3-level approach for emergency handling.](image)

<table>
<thead>
<tr>
<th>Level</th>
<th>Classification</th>
<th>Activity</th>
<th>Information transmission</th>
</tr>
</thead>
</table>
| 1 GREEN | Monitoring of dangerous conditions | • Information circulation among:  
- operational headquarters,  
- peripheral stations.  
• The existence of excessive concentrations is verified, but not intrinsically critical. | • display panels |
| 2 YELLOW | Imminent emergency | • Information circulation:  
- from operational headquarters to field staff,  
- among field staff. | • display panels  
• nomadic devices  
• head-up displays |
| 3 RED | Ongoing emergency | • Information circulation:  
- among rescue teams,  
- to people located in the emergency area. | • panels  
• display panels  
• nomadic devices  
• "speaking infrastructures" |

Table 2: A draft structure for SAVE ME multi-layered emergency handling strategies.
A compromise for the timing of the delivery of appropriate information shall be considered, in order not to provide information at the wrong time that could lead to increased disaster conditions. For example, information provided too early can start the evacuation in a wrong direction and possibly cause unnecessary panic; whereas information provided too late can be either ignored or not reach the target audience in time to be effective.

The right mixture between planning for emergency evacuation and local instant decision shall be considered within A3.2.

Thus, SAVE ME will develop an integrated approach for evacuation, which considers local group guidance advice, based on local sensing and decisions, integrated with central DSS-based evacuation planning. Wireless Sensor Networks with sensing, communication, computing and interaction elements and DSS constitute the basis for fully integrated and pervasive group guidance solutions. Also, preventive information will be considered, in order to provide complete group evacuation support.

### 3.8 Simulation and modelling

For automatic path construction in the DSS, crowd simulation will be based mainly upon Smoothed Particle Hydrodynamics (SPH), in order to be able to assign to each individual with an optimal and context-aware destination path without path pre-computation. By using this method, natural crowd locomotion under a variety of conditions can be supported, such as personalised guidance, forming and separating lanes, obstacles avoidance and escape through existing exits.

Dynamic grouping structure for crowd simulation modelling in emergency situations will be supported. The dynamic grouping structure comprises a combination of the structure of the SPH and the crowd models generated in WP3, where the crowd will be treated based on individuals and groups.

The modelling activity within SAVE ME will be based upon SIMUDYNE existing models. An example of a relevant station model simulation during an emergency situation is shown below.
This is an Agent-based Modelling technique, able to simulate the actions and interactions of autonomous individuals, with a view to assessing their effects on the system as a whole. It combines elements of game theory, complex systems, emergence, computational sociology, multi agent systems, and evolutionary programming, using Monte Carlo Methods to introduce an element of randomness. The models simulate the simultaneous operations of multiple agents, in an attempt to re-create and predict the actions of complex phenomena. The process is one of emergence from the lower (micro) level of systems to a higher (macro) level. The individual agents may experience "learning" and adaptation and are presumed to be acting in what they perceive as their own interests, such as escape from danger. Within SAVE ME, the model agents will be programmed with travellers attributes (such as age, mobility restrictions, as well as psychological traits such as panic, fear, confusion, etc.) that can change over time or with circumstances in the model and can be adjusted to provide multiple realistic versions of the simulation, depicting the behaviour of SAVE ME target group in an emergency event.

Additionally, the persistent simulation will be able to be accessed remotely through a mobile handheld device (smart phone, etc.) where the user can gain insight into real-time data, as well as historic trends and predictive near future events and patterns.

### 3.9 Decision support system

The SAVE ME DSS will provide the core intelligence of the system. The SAVE ME Decision Support System will receive information from the detection system modules and the simulation module and will subsequently process this information to provide personalised and group-wise routing for people detected in the area. The DSS will work in three modes: a) provide routing for optimal evacuation on a group-wise
manner, i.e. through information displayed in the situated displays and also via utilising speech, or b) personalised routing for the individuals detected in the monitored area, taking into account the specific profile of the user and the contextual information where this exists (individuals will be targeted through their mobile phones) and c) personalised routing for the rescue teams. Care will be taken so that confusion due to conflicting information in the group-wise and personalized channels is minimized. The SAVE ME DSS will examine both pre-computed and dynamically generated, as well as personalised, path planning.

In some circumstances, individuals may ignore guidance signs due to panic or other reasons (e.g. so that they can be together with familiar persons). Societal and other relations that motivate individuals to ignore the system are impossible to be taken into account since such information is not and cannot be available to the DSS. For this reason, special focus will be given to the dynamic nature of the route planning for each individual and as a whole for the crowd. The level of congestion of the individual escape routes’ will be updated in real time to allow for alternate route planning.

Dynamic routing is also necessary in order to take into account sensor and communication infrastructure damages, and possible structural changes that may have occurred during the event, making available escape routes inaccessible. In addition, conventional escape route guidance strategies will be pursued as a backup solution for the case that the communications infrastructure has been disabled by the emergency event.

Real time, fast and reliable route planning will be achieved by optimization algorithms that take into account multiple optimization criteria such as nearest exit point, subject-related attributes (such as age, mobility and/or other impairments) and infrastructure related data that are stored in advance (such as accessibility attributes, corridor capacity, sensorial and user interface capabilities for messaging) but also real time changes of attributes such as escape route availability, structural integrity etc. The SAVE ME DSS will calculate the fastest and safest route to the closest exit for every individual and guide them to it. It will take into account the number of people in the controlled area, their exact positions, their profiles, as well as any special needs. Considering all those parameters for every single individual, it will decide on the best evacuation strategy, minimising the risk that they are exposed to, as much as practically possible. By providing personalised instructions to people with equipped devices, and general guidance to anyone else, accidents that happen at similar situations as a result of panic will be eliminated. The DSS will try to use the emergency exits and corridors as efficiently as possible, avoiding congestions at any part of them. Thus, the total evacuation time will be minimised, while every individual with an equipped device will be guided personally and reliably to the closest emergency exit.

3.10 Guidance in emergencies

According to the DSS output, a wide range of Emergency Support measures will be implemented (WP6), including interfaces for the infrastructure operators, the rescue team members, and the citizens (both personalised at their mobile phones and generic through infrastructural elements).

A data fusion and information synthesis module and its user interface will be developed at the Emergency Centre of the operator (e.g. metro, tunnel control company, etc.). This will automatically monitor and notify controllers on incidents that may occur and the affected area. It will (among others):
- Provide information on the type of incident (i.e. gas flow, fire, etc.) as well as the affected area (in m$^2$ or km$^2$), based on information received by the DSS of WP4.
- Support the operator on the next steps and imminent actions.
- Allow direct communication with the emergency crews.

Three modes of operation are currently foreseen:
- **Informative mode**: When relevant low risk level information is retrieved and identified by the system, the User Interface (UI) should be limited to a simple notification.
- **Cautionary mode**: When relevant information is retrieved which is of a cautionary level, the UI should indicate the priority and support the operator on which emergency unit to contact.
- **Alerting mode**: When relevant information is retrieved and an imminent safety critical situation is identified, the UI should clearly indicate the urgency and support the operator appropriately.

Furthermore, the routing service for the rescue team will be defined, based on WP3 interfaces and strategies and a prototype will be implemented, which will give information on the location of the detected event, as communicated by the DSS, and the whereabouts of individual trapped travellers. The rescue team guidance module is composed of the following sub-activities:
- Compass function to guide the rescue team to the disaster area.
- Localisation function for the rescue team.
- Priority guidance to individual travellers trapped in the area.
- Send Alert to Emergency Centre.

The overall information and guidance for the rescue team will be delivered at a handheld device (PDA), based upon a .NET application framework.

The trapped travellers will be informed on the emergency and be guided personally, through their mobile phones. As most people possess ‘average’ portable devices, and certainly not all have PDAs, the service must be functional in all mobile phones. Thus, the implementation will cover all MIDP 2.0-CLDC 1.1 devices (including those of later versions, based upon J2ME platforms). Full dynamic routing through the mobile phone might not be able to be supported, due to device limitations, but static maps and personalisation will be supported. The final functionality will depend upon the technical characteristics of these devices at the time of project development.

Finally, for the travellers not equipped with compatible mobile phones or not having one at all (i.e. children), cumulative guidance is to be provided (in dynamic VMS, etc.), based on the analysis of guidance needs of different users’ types. Then the prototype will be implemented in the pilot sites (tunnel and metro).

### 3.11 Training measures

The successful deployment and operation of an emergency response platform, such as that in SAVE ME, relies heavily on the correct training of its operators but also on the assessment of its operation under simulated emergency scenarios. To this end, the SAVE ME platform will incorporate a Virtual Reality Training and Guidance System that will simulate all aspects of the system’s operational features under realistic circumstances.
The Virtual Reality Training and Guidance System will simulate the operation of the infrastructure through an interactive 3D environment that will cover aspects of the system including the following:
- opening of doors, vents and other evacuation facilities;
- remote operation of emergency equipment (e.g. fire extinguishing installations, air turbines, etc.);
- handling the monitoring of individuals by remote control of surveillance equipment and the use of positioning tools through the use of intelligent mobile devices;
- guidance of emergency teams by providing a simulated communication, co-ordination and allocation of resources system;
- guidance of individuals by providing simulated route guidance on mobile devices and situated displays;
- voice guidance.

In order to provide a realistic simulation of the system overall operation and the co-ordination of efforts between control-room and on-site emergency response teams, the VR training system will incorporate simulated multi-user interaction and communication tasks, where the completion of time-critical tasks will be essential in order to successfully handle emergency scenarios.

The VR Training and Guidance system will also feature Artificial Intelligence crowd simulation techniques, in order to provide a realistic crowd behaviour feedback that will enhance its realistic appeal. Realistic crowd simulation relies on advanced behavioural models where multiple factors apply, including correct guidance by the system but also flocking patterns, psychological factors (panic, stress, disorientation, etc.), environmental parameters such as visibility, smoke, specific hazards (fire, obstacles, fumes, etc.).

The final implementation of the VR Training and Guidance system will feature a number of specific emergency scenarios, based on the indicative scenarios of use. Based on these scenarios, the locations of the emergency situations will be modelled realistically in 3D along with all the pertinent environmental parameters of these specific locations. Multiple cases of crowd parameters will be applied in these scenarios in order to provide versatility of circumstances to ensure thorough understanding of the system’s operation under adverse situations.

### 3.12 Integration and testing at pilot sites

There are two pilot sites where the SAVE ME systems will be integrated and tested:
- Gotthard road tunnel in Switzerland.
- NEXUS Metro platform & vehicle in Newcastle upon Tyne, UK.

The Gotthard road tunnel is 17 km long and is of single tube construction with traffic travels through the single tunnel in both directions. It is the third longest road tunnel worldwide and is part of the Swiss A2, one of the major European road connections through the Alps, connecting the Italian border (Chiasso) with Germany and France (Basel). The tunnel is located entirely in Switzerland, between Airolo (1’145 m above sea level) in the south and Göschenen (1’081 m above sea level) in the north. The location is illustrated in Figure 8.
The widely used expressway tunnel opened on September 5th, 1980. The traffic flows through only one tunnel, carrying traffic both ways, with each direction allocated only one lane. The tunnel's speed limit is 80 km/h but is heavily used and often home to traffic jams both at the north and south ends. Statistics show that due to the nature of the tunnel (only one tunnel at present, with bidirectional traffic flowing without a physical division), it is more dangerous than a standard tunnel (two tunnels, each having multiple lanes but going in one direction). As a result, accidents are more likely to happen.

The main safety characteristics of the Gotthard road tunnel can be summarized as follows:
- Parallel safety tunnel with 8 m$^2$ cross section
- 64 shelters every 250 m, with a floor surface of about 70 m$^2$ each

The traffic volumes in the Gotthard tunnel are much higher than for the other major alpine tunnels, shown by Figure 10. The overall traffic volume increased from 2 Million vehicles/year (project data) to 2.9 Million (1981) and to 6.5 Million (1999), with over 20% HGVs. It should be noted in this context that the total annual traffic volume through the Mont Blanc and Fréjus is of the order of 4 Million vehicles, with a higher percentage of HGVs. The average number of HGVs on working days is about 3,000-5,000 HGVs/day.
The traffic of HGV in Switzerland and thereby through the Gotthard Tunnel is allowed only from Monday to Saturday from 05:00 to 22:00.

**Pilot site facilities/equipment**

Among the safety systems, one should note in particular:

- Full CCTV coverage (88 cameras);
- Fire-detection system with punctual thermal sensors every about 25 m;
- Liquid-fuel collection ports and duct along the whole length;
- SOS niches with phones and fire extinguishers every 125 m;
- Connections to the hydraulic system (pipe located in the safety tunnel, connections inside and outside the shelters) every 250 m;
- Emergency lights on the lower part of the sidewall, shelter side, every 50 m;
- Traffic lights every 250 m;
- Full FM (with possibility of inserting service and emergency messages), service radio and GSM coverage.

A new distribution system for various radio signals as well as two fully redundant command centres provides support to the operations, maintenance and security organisations in their daily work. Important announcement on the current situation in the tunnel can be made from the command centres via VHF radio to the vehicles travelling in the tunnel.

**NEXUS Metro platform & vehicle**

The Metro Rapid Transit System, operated by Nexus (formerly the Tyne and Wear Passenger Transport Executive) on behalf of the Tyne and Wear Passenger Transport Authority, passes through the Metropolitan Boroughs of Gateshead, North Tyneside, South Tyneside and the Cities of Newcastle upon Tyne and Sunderland. Their responsibility covers the overseeing of the provision of all modes of public transport within Tyne and Wear, much of which is provided by private bus companies, however Nexus also own the Tyne and Wear Metro system which is the second largest LRT metro system in the UK (only the London Underground is more extensive).

All its stations are distinct stations (as opposed to on-street platforms, or stops integrated into their surroundings), consisting of full-height platforms. Stations are a mixture of former main line railway stations and purpose-built facilities. The majority of stations are on the surface, but a number in central Newcastle and Gateshead are underground (Jesmond, Haymarket, Monument, Manors, St. James, Central and Gateshead), as well as Park Lane in Sunderland. Sunderland station was rebuilt in 1965 with the station building covering the platforms, effectively placing the platforms underground.

Most stations have two platforms; the exceptions are the termini at South Hylton and South Shields (1 platform), North Shields (3 platforms, including one bay platform) and Monument (4 platforms on two separate levels). Three of the stations have interchange with National Rail services (Central, Heworth and Sunderland) - uniquely at Sunderland, Metro and National Rail services use the same platforms. All stations have ticket machines, shelters, information displays, next-train indicators and passenger information/emergency help-points. All stations are unstaffed, except for the underground stations which must be staffed by law.

The Metro system comprises over 60 stations, of which 8 are underground, and it is these that will provide the case studies for the SAVE ME project. A number of
stations are now almost 25 years old and are undergoing significant upgrade, including the Haymarket station, which is a deep underground station, close to Newcastle University. The features of each station on the metro system are provided below:

**Haymarket Station**
Public access to the Haymarket Station is by escalator, stairs and lift. The station itself is manned (all underground stations in the UK must be manned, a legal requirement following the fatal Kings Cross Fire in 1987).

CCTV is extensively deployed throughout all stations for security monitoring and safety. Smoke and chemical detectors are deployed throughout the underground facilities.

![Figure 11: Southbound platform at the Haymarket Station.](image)

**Metro Major Incident Plan**
A Contingency Plan has been compiled by Nexus, in co-operation and consultation with Northumbria Police, Tyne and Wear Fire and Rescue Service, North East Ambulance Service, the Health and Safety Executive, Tyne and Wear Emergency Planning Unit, and Network Rail – (who operate along adjacent tracks at some locations, are fully responsible for rail infrastructure on the route to Sunderland terminal of the Metro).

The Plan has been written in response to the requirements laid on the Passenger Transport Authority by the provisions of the Fennell Report, although there is of course no suggestion implicit in this of any increased risk of an accident on the Metro system. The Plan is however an additional level of preparation should such an event occur.

The aim of the Metro Plan is to enable speedy mobilisation of any resources required to deal with an incident, to provide communications and command at the incident, and co-ordinate the activities of the Emergency Services deployed.
Upgraded Emergency and Evacuation Communications for the Metro Extension to Sunderland

Railtrack, now Network Rail is the company, which owns and operates Britain's railway infrastructure - the tracks, signals, tunnels, bridges, viaducts, level crossings and stations.

Sunderland Direct was the project to extend the existing Tyne and Wear Metro Service to Sunderland and beyond. The project was a Public Private Partnership between Railtrack and Nexus - the Tyne and Wear Passenger Transport Executive - and cost in the region of £98 million. Central Government and European Regional funding was granted. Construction began in Spring 2000 and the project was completed less than two years later.

The 18.5 km Sunderland Metro provided a fast, frequent and convenient link between Sunderland and Newcastle city centres. The link also encourages integrated public transport services by providing direct journey opportunities by Metro to the region's main air and rail services and to the rest of the Tyne and Wear area.

Team Telecom was employed to deliver a "Retail Telecoms" system providing 600Mbit/s data transmission between the Metro control centre and the new 12 stations, 2 of which are sub-surface via an optic fibre ring laid by the track side. Also provided to the scheme by Team Telecom were CCTV, Passenger Information Systems and Help Points on all stations, new Ticket Machines, Data and telephony to travel centres, Evacuation Public Address Systems and Positive Train Identification.

Signalling and Communications
Magnetic track circuits operate fixed-colour light signalling, generally three-aspect in tunnels and two-aspect on surface lines. A train identification and control system carries information from on-board transponders to track-level equipment, which operates the points and station information systems. T&W Metro uses a train-stop system based on the Indusi signalling system used by German and Austrian railways.

"In January 2007, future plans for the system were put forward in the £600m 'Re-Invigoration of Metro' programme by the transport authority."

Metro Control Centre at South Gosforth has two-way radio contact maintained with the trains, which are driver-only operated. In September 2007 a new central system control desk for all signalling and communications was installed to replace the original equipment.

Stations have passenger alarm points and are monitored by closed circuit TV. Nexus offers a comprehensive range of tickets covering the area, incorporating the services of other public transport operators that are designed to stimulate demand among various market segments that include commuters, young people, shoppers and leisure use.

The Metro has become the first underground rail system in the UK to offer complete mobile phone coverage. All of the network operators are currently working on a new antenna system that will provide continuous coverage through the central underground part of the Newcastle Metro including all tunnels, platforms and concourses.
Underground coverage overlaps with existing coverage to nearby shopping centres, allowing customers to move freely without losing a call. The Metro is a busy regional public transport system that supports 40 million passenger journeys every year.

3.13 Business elements
A market analysis will be performed, to explore the market potential for SAVE ME products. The necessary Market data will be gathered through literature survey, web site search as well as interviews with relevant parties (operators, professional emergency personnel, etc.) in at least 4 countries. In parallel, the business scenarios will be drawn for ensuring the promotion and financial viability of SAVE ME in the market. To this end, requirements and limitations of the marketing system and the key actors will be identified.

12 main potential products have been preliminarily identified, but these will certainly need to be updated as the project work evolves. All these products, including information of the sharing percentages (where applicable), will be among the contents of the Exploitation Agreement that will be formulated among SAVE ME Partners.

3.14 Guidelines for secure vehicles and stations
Guidelines will be devised that will prevent an emergency becoming a disaster and minimise the injury and damage to people. The procedures will include the establishment of communication protocols for the quick deployment of the mechanism for disaster relief and management. These protocols will address roles and responsibilities, definitions, standard operating procedures and monitoring of possible interventions, additional containment measures and communications strategies.

Relevant guidelines and specifications will be disseminated and promoted, among others, by the project partner CNVVF (Italian Firefighters Association) to all its Member Organisations, as well as to relevant European Organisations; by the Coordinator UNEW to ONE NORTHEAST (Local Government) and TfL (Transport for London, the London PT authority); by the partner Gotthard tunnel to the European Association of tunnels and by CERTH to the ERA-NET working groups on tracking and training.
4. Expected achievements

SAVE ME will develop solutions for the quick evacuation of passengers from trains/metros and other PT infrastructure, congested tunnels and PT terminals, with due attention to psychological aspects that may occur in panic situations, merging optimised prediction models with real time data as well as taking into account the feedback given to travellers during evacuation and foreseeing their responses. SAVE ME will provide vital solutions at a critical time, for example, security issues surrounding the 2012 Olympic Games which are to be held in London, UK, a country that was severely hit by terrorism a few years ago, Terrorism is unfortunately a real threat to several European countries at the present time.

The output of SAVE ME includes technologies (algorithms, models, DSS) and an intelligent system (integrating intelligent sensors, infrastructure communications, interfaces to nomadic devices and VMS/VDS, using intelligent agent technologies) to protect all travellers from physical disasters and terrorist attack-related risks; with emphasis on ensuring the security of the most vulnerable users (such as the elderly, children, and the disabled). Risk analysis, mitigation methodologies, algorithms, tools and systems will be developed for emergencies related to PT vehicles (i.e. metro, light rail, bus), stations and other critical infrastructures (i.e. tunnels and bridges). Also, measures at policy and legislative levels will be proposed, including decision support and validation tools.

As analysed in the above sections, innovative and substantial achievements are planned to be delivered through the project’s lifetime. The main deliverables are listed below:

- **Deliverable 3.2**: Disaster mitigation strategy and novel interfaces for it
- **Deliverable 3.3**: Service personalisation platform
- **Deliverable 4.1**: Environmental detection sensors module
- **Deliverable 4.2**: Localisation sensors module
- **Deliverable 4.3**: Telecommunication module
- **Deliverable 5.1**: Enhanced simulation model
- **Deliverable 5.2**: Decision Support System
- **Deliverable 6.1**: Operator support module
- **Deliverable 6.2**: Rescuers guidance module
- **Deliverable 6.3**: Individual guidance module
- **Deliverable 6.4**: Collective guidance module
- **Deliverable 7.1**: Training tools, scenarios and curricula
5. Expected impacts

5.1 Scientific impact and innovation

Recent events have raised concern among public transit agencies regarding the potential for disaster events in confined spaces such as tunnels or subways. In essence, the problem is that subway systems are unprepared for the detection of physical disaster incidents, terrorist attacks as well as the quick and optimal mass evacuation of those in trouble and distress.

The preparation of subway systems to deal with terrorist chemical or biological agent attacks is an important and difficult problem. Early warning, rapid response, and engineered mitigation methods can potentially save many lives in such an incident.

Uncontrolled crowds and poor management of crowds have been known to lead to emergency and panic situations. Deaths and injuries have often resulted from such situations and so tools and models are required to study behaviour in emergency and panic situations. A well-prepared system can significantly reduce the impacts of an attack and may discourage such attacks from taking place.

The proposed project develops very important innovations in the area of surface transport systems which are expected to potentially bring a great impact in the transportation of the general public. The objective is the development of solutions for quick evacuation systems of passengers from large vessels, trains, congested tunnels and terminals, with attention to psychological aspects in panic situations. New technologies and innovative solutions addressed the improvement of safety and security in transport operations and the protection of vulnerable users such as elderly, disabled, illiterate, and children. The research on completely novel approaches in order to provide advanced protection systems, intelligent vehicles, vessels and infrastructures is expected to increase the level of protection of the transport system’s users, with focus on the protection of vulnerable users.

The proposed project introduces an advanced system for detection and protection. Its innovation emphasizes on the human factors involved as it gives attention to impulsive reactions to physical events.

SAVE ME aspires to develop solutions for the best use of detection technologies in subway systems. Detection, warning and response, the three dimensions of SAVE ME could be the keywords for every novel technological or research innovation as they are critical for saving the lives of the general public.

SAVE ME is expected to have major strategic impact in the area of evacuation systems considering the innovations below:

- The standardisation and automation of communications and key actor interfaces, through the use of SAVE ME ontological framework, which will minimise errors and response time.
- The rapid and accurate response in case of disaster, facilitated by SAVE ME detection and communication infrastructure, will minimise casualties.
- The better preparedness of rescue teams coordination, through the SAVE ME DSS with its much improved dynamic simulation model, will optimise disaster mitigation and operator control of the situation.
- The provision of individualised information to each traveller regarding the best escape route for him/her (on mobile phones or PDAs) and point by point guidance and intuitive guidance of SAVE ME (by standardised icons, earcons
and haptic elements), will avoid panic reactions and help people to remain calm and thus escape the danger.

- The proposed training, guidelines and policies will lead to improvements of the security level of PT hubs, vehicles and critical infrastructure.

5.2 Market penetration and economical impact

Safety in Subways and tunnels
As highlighted by the 1995 sarin nerve gas attack on the Tokyo subway system, underground transit is especially vulnerable to chemical weapon attacks. The trains and stations offer confined spaces filled with potential victims, therefore in the event of such an attack, rapid response is crucial.

Another recent example, the largest and deadliest terrorist attack on London in its history (7 July, 2005, also called the 7/7 bombings) confirms the necessity of advanced monitoring systems and technologies related to rescue and crisis management.

The recent catastrophes in the Mont Blanc tunnel, the Tauern tunnel, and Gotthard tunnel have demonstrated the urgent need for improving the prevention and mitigation of tunnel accidents, including adequate detection systems in combination with being prepared operation staff and emergency services.

![Figure 12: Gotthard Tunnel fire in October 2001 (SINTEF).](image)

Communication in tunnels is especially important and challenging. Studies have shown that the first 10 to 15 minutes are crucial for self-rescue and to minimize the damage (Khoury, 2003).

SAVE ME systems provide critical detection as well as critical response, based on the detection and communication system. Through its Decision Support System (DSS), SAVE ME increases the level of safety and security of the whole transport system and its components as it provides:

- operators'/drivers'/rescue teams' training,
- construction guidelines for vehicles and stations,
- more accurate and efficient response by emergency operators,
- guidance of emergency teams,
- guidance of individuals (through mobile devices),
The SAVE ME DSS enhances the positive interactions between operators/infrastructure, in order to decrease the level of human error and increase the safety performance of the infrastructure.

Major public benefits are expected as the proposed solution will primarily attract travellers to transit and will offer them efficient solutions for a calm and effective management in critical events.

**Economical impact**

Economic damages from natural disasters are enormous, as can be seen from the following figure:

![Figure 13: Annual reported economic damages from natural disasters, for 1975-2006 (EM-DAT).](image)

In transport, economic damages are typically of several million € per disaster (from 1.2 million € for the 1997 fire in the Gotthard Tunnel, to 155 million € in the Mont Blanc Tunnel incident in 1999). After each catastrophe to a transportation infrastructure, hub or vehicle, recovery and reconstruction measures take place that have an equally high cost. For example, after the Tauern tunnel fire in Austria (1999), the measures taken costs were (Haack A., FIT project):
- Reconstruction measures: approx. 5.8 million €.
- Improvement measures: approx. 2.2 million €.
- Maintenance measures brought forward: approx. 0.7 million €.
- To these costs must also be added the loss in income from tolls, which is estimated at approx. 19 million €.
- It was possible to reopen the tunnel to traffic approximately 3 months after the fire occurred.

To that, we should add the very big cost of human life lost (in fact priceless, but conservatively being estimated to 1-2 Million € per person by various European countries).

Obviously, it is much better to act proactively. To invest in a low cost technology, such as those proposed in SAVE ME, in order to protect infrastructures worth several millions of € and moreover save hundreds of human lives within them, can only be an economically justified investment.

In addition, economic benefit is expected to be further created by:
- Increased travellers’ attraction: Innovative solutions that could deal with issues of high importance such as **human integrity and safety** will primarily be
acceptable and obviously expected to attract developers’ and travellers’ interest.
- Creation of jobs and wealth through the proposed new services and products for disaster mitigation are expected to invite for new investments in several transportation infrastructures on advanced technologies and systems, thus creating gains for the European Industry and especially SMEs-installers, operators and maintainers of these infrastructures.

- **Social benefits from the optimum crisis management**

It is difficult to estimate future responses to physical catastrophes or terrorist attacks on the transport networks, which can cause huge loss of human life. Problematic psychological behaviour basically boils down to either an exaggerated response or denial. A blanket refusal to take public transport could be what experts call ‘maladaptive behaviour’. On the other hand, in a situation where a specific warning is issued about a threat in a defined location but someone went there anyway, his/her behaviour would be equally maladaptive. There are parameters of normal behaviour, within which people weigh up the information available to them and calculate the immediacy of the threat to their personal safety.

Ultimately, the important thing is to remain in control of a situation, because terrorism hinges on its ability to destroy people’s trust in the predictability of their environment. While terrorism first and foremost claims lives, its effect is also based on a manipulation of people’s fears. They don’t know when or where the next attack will come, and they don’t know how to protect themselves against it: they are rendered powerless in a situation which they cannot control. This is hard to accept, because people are used to being in control of their lives and what terrorism does is demonstrate to people that they actually have no control over what happens - their lives are in someone else’s hands.

However, public transportation is critical to a nation’s transportation system and is essential to the socio-economic quality of citizens’ lives. Therefore systems and technologies have to increase the level of protection of users when within the transport system’s giving special attention to the most vulnerable ones.

SAVE ME proposed solutions, based on the physiological aspect in emergencies or disaster events, directly addresses the core of the problem: instinctive human reactions in panic situations.

Another important issue is that a percentage of users have various mobility difficulties and can be expected to behave in an extremely anguished situation in the event of a disaster.

**Stakeholders benefits**

SAVE ME encompasses significant benefits for all key actors involved, as well as society as a whole. More precisely, it:
- Offers personalised escape routes as guidance patterns to the **travellers**.
- Provides the optimum context-aware management in critical events to the **operators**, in order to help them to avoid panic emotions/ reactions of the crowd.
- Offers adapted support to **vulnerable travellers** (i.e. elderly, disabled, and children), to satisfy the implications of reduced mobility, agility, reflexes or risk awareness and significantly supports their evacuation.
- Offers **emergency planning units** appropriate knowledge and training on the exact users’ behaviour under various emergency situations (including those of
vulnerable travellers), thus helping them to plan in advance their evacuation and guarantee that relevant resources are in the correct place at the required time, and that the local infrastructure is adequately adapted.

- Enhances the efficiency and safety of *emergency response units* by effective PDA-based guidance to the trapped travellers, according to the environmental conditions and their need for support.
- Provides the necessary tools (i.e. guidelines, standards) and policies recommendations to *governmental bodies*, to secure vehicles, stations, and transportation infrastructure at a very favourable cost ratio.

### 5.3 European dimension

As transportation in Europe is increasingly becoming a seamless and cross-border activity, and as natural catastrophes and terrorism also know no geopolitical borders, the issue of disaster mitigation in transport is a truly pan-European one, calling for standardized and harmonized Europe-wide solutions. SAVE ME is a Europewide project, with partners and pilot sites located across Europe, in order to gather the necessary expertise to provide European solutions to the problem, taking also into account the specific areas of interest (e.g. earthquakes are more often in South Europe), the fact that terrorist attacks are more prone to happen in specific, targeted areas and infrastructures in place, thus targeting a modular and cost efficient-system.

Furthermore, SAVE ME presents an effort on a pan-European level, to “catch-up” and support European industry and SME’s, with novel technologies and transport systems with competitive advantage to:

- Increase the level of safety and security of the whole transport system and its components so as to offer advanced solutions for the crisis management in disaster events.
- Penetrate the European markets whilst applying innovative integrated solutions for quick and optimal mass evacuation.
6. Conclusion

The innovate aspects of SAVE ME address the critical issues of disaster mitigation and mass evacuation in tunnels, transportation vehicles and platforms. The project aspires to offer advanced emergency planning before the incident occurs, as well as advanced emergency management and mass evacuation after the disaster event occurs. The specific needs of the most vulnerable users, such as elderly, disabled and children, are planned to be integrated into the SAVE ME system from its initial design phase, leading to personalized guidance and effective evacuation.

There is no doubt that the aims of SAVE ME and the intermediate objectives are very challenging, thus a tight work programme is scheduled, with clear outcomes, deadlines and milestones. The project success is also ensured by the multidisciplinary Consortium, the Quality Assurance procedures in place and the strong management scheme.
7. References


Annex A: SAVE ME contractors

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Annex B: Two pages project presentation

1 Introduction and aim
Natural disasters (earthquake, floods, etc.), are becoming all the more frequent, and these disasters have obvious impacts to transport operations and means. Fires with the most serious consequences (involving injuries, fatalities or extensive infrastructure damage) have primarily been the result of tunnel accidents. Over 200 people have died in Europe as result of tunnel fires in the last decade, 16 fire accidents occurring in road tunnels in Europe from 1986 until 2006. Unfortunately, fires within public transportation infrastructure occur quite often and a great menace of our time is terrorism. Transportation infrastructure, hubs and stations are all targets of terrorist attacks.

The needs of all travellers, as well as the specific needs of the most vulnerable users, i.e. elderly, disabled and children, need to be integrated into any disaster mitigation system from its initial design phase. Furthermore, their specific behaviour, speed of movement and mobility limitations must be included in any human behaviour model. Rescuers need precise information on the situation, seamless communication between them and the operations centre and proper guidance to help them reach the trapped travellers.

SAVE ME aims to develop a system that detects disaster events in public transport terminals / vehicles and critical infrastructures (i.e. tunnels and bridges) and supports quick and optimal mass evacuation guidance, to save the lives of the general public and the rescuers, giving particular emphasis to the most vulnerable travellers.

The application areas of SAVE ME are the metro terminal, platform and vehicle and the tunnel (both highway and urban tunnels).

2 The workpackages in short
SAVE ME work is distributed among 10 Workpackages (WPs) and is shortly described below:

The project work starts (WP1) with a detailed analysis of the different transport groups, the key transformations environments (PT hubs, PT vehicles, tunnels, etc.) and the most important disaster events (both for natural and man-made disasters). Stakeholder needs (including operators, emergency units and travellers) will be analysed by interviews and literature surveys, emphasising the particular needs of vulnerable travellers (including the elderly, disabled and children). Also, a thorough benchmarking exercise will be performed on relevant technologies, algorithms and policies. As a result of the above, the project Use Cases (UCs) will be developed.

In WP2 a holistic and standards abiding System Architecture will be issued, to satisfy the above UCs, leading to sensor and system specifications. Also, an innovative and open ontological framework will be developed for hazard recognition, classification and mitigation in transportation related disasters. This will be publicly available on the Web, to be gradually updated and ultimately constitute a basis for Pan-European standardisation of procedures in the area.
Development starts with new algorithms, interfaces and intelligent agents (WP3), which will give to SAVE ME its “intelligence”. The influence of stress, panic and other emotions on human behaviour will be researched (in relation to all SAVE ME traveller groups, disaster types and taking into account the system feedback); novel and adaptive interfaces will be built for traveller guidance & intelligent agent-based info personalisation algorithms will be developed.

In parallel, the disaster detection and analysis system will be built (WP4), in the form of a Wireless Sensor Network (WSN) grid, which supports detection of the disaster, localisation of travellers in the disaster area and follow-up of their movements, collection of key environmental data (e.g. on temperature, air quality, smoke, etc.), communication to the operator’s centre of all measured data and provide an interface to any existing databases (e.g. of the PT regarding the number of passengers on-board). This system will provide the real time data required by the SAVE ME system, to adapt its models and emergency support policies. The necessary telecommunication infrastructure to deliver information/warning/guidance under the adverse emergency circumstances will be built here.

Based upon the above “intelligent” concepts of WP3, the real time data collected by WP4 sensorial system, the WP2 System Architecture and the WP1 UC’s, the SAVE ME Decision Support System will be developed (WP5). It is based on existing simulation and modelling tools (modified, to include vulnerable travellers data and adapted to the particular UC’s), which will be enhanced to a dynamic and closed-loop system, recalculating the situation constantly, by fusing real time data to the model as well as the estimated impact of emergency support measures (i.e. trapped travellers guidance and info) to it. The DSS constitutes “the heart” of SAVE ME.

According to DSS output, a wide range of Emergency Support measures is implemented (WP6), including interfaces for the infrastructure operators, the rescue team members, the citizens (both personalised guidance at their mobile phones and generic guidance through infrastructural information elements). In addition, acute disaster mitigation measures, “soft” measures, related to proper training of operators, rescue teams and travellers are also developed (WP7). Training is related both to generic response to transport related disasters and to the optimal use of SAVE ME.

All the above modules, systems, and measures (including training) are to be thoroughly tested (WP8) in 2 sites, at a metro platform, vehicle and station of Nexus in Newcastle (UK) and the very long tunnel of Gotthard (Switzerland), assessing their reliability, usability, user acceptance, economic and safety/security impacts.

In WP9, the project results are widely disseminated through a concise dissemination strategy; CEA and CBA analysis, exploitation and business plans will be prepared; guidelines and specifications for secure vehicles and stations will be issued and interfaces are built to standardisation bodies; all aiming at maximising the Market viability and penetration of the final project results. In the same WP, the project ethical issues policy will be defined. All WPs are coordinated in terms of administrative, technical and financial Management by WP10, which also includes a detailed quality assurance scheme.