A holistic, scenario-independent, situation-awareness and guidance system for sustaining the Active Evacuation Route for large crowds

Contents

1. Summary

eVACUATE aims to address the needs of the safety of citizens during complex evacuation processes following normal and abnormal events (crisis). The nineteen partners of the Consortium have technical competences and access to a very diverse set of technologies. By the end of the project several systems have be developed and integrated into a common platform towards the implementation of a holistic eVACUATE Framework that is able to address the following activities:

- Establishment of an optimal evacuation strategy and path, dynamically updated as the phenomenon is evolved, by using the most efficient "incident snapshot".
- Projection of the most up-to-date Situational Awareness (SA) to the people actively involved in the evacuation process.
- Monitoring of crowd behaviour, survey of current environmental conditions (e.g., expansion of a fire), controlling of the evacuation flow and prediction of incidents that could cause problems to the overall operations.
- Transformation of the environment (crowd management in large scale areas, opening and closing doors in buildings etc.) after an early warning to evacuation mode to improve possibilities for evacuation.
- Enablement of communication between first responders, emergency operation centers and the crowd itself in order to be monitored and controlled with integrated networking platforms and ad-hoc mechanisms and assurance of resilient communication even in cases that "global networks" have failed.
- Increment of precision on disaster scale and magnitude assessments to better manage evacuation and applied strategies.

- Dynamic simulation of an evacuation faster than real-time so as to predict the occurrence of potential (future) incidents evolving as a consequence of other current events, through a game awareness framework.
- Provision of sophisticated early location sensing devices, and deployment of Wireless Sensors Networks consisting of low-power sensors nodes.
- Awareness of how an evacuation process is evolving, combining multiple types of sensors ranging from visual cameras and hyper-spectral imaging to RFID’s and pervasive technologies.
- Assurance of interoperability among engaged means/systems and especially the data transfer and communication systems.
- Supporting of a centralized Data Fusion Mediation System (DFMS) to enhance the global SA and provide together with the command and control modules, the web portal and the back-end applications, an accurate and intelligent coordination of activities during evacuation operations and decision making, emphasizing on logistics and commandment coordination throughout a network of very diverse and decentralized info providers.
- Compliance with legal and societal acceptance of crowd evacuation tools, taking into account the protection of fundamental rights of citizens such as the protection of privacy and personal data

The eVACUATE project addresses the operational challenges that involve better understanding of the complexity of large-scale disasters by identifying, prioritizing and connecting the various heterogeneous domains involved. The eVACUATE project tackles a wide series of practical operational challenges including enhanced Situational Awareness, effective and safe tactics, effective evacuation support of the crowd members, and uninterrupted info flow & decision making through different levels of commandment and logistics organization.
All these have been tested over a set of four carefully selected application scenarios of severe and diverse requirements involving: **underground operating authorities in Bilbao**, **the football stadium of Real Sociedad**, **a cruise ship of STX-FR** and the **International/Metropolitan Airport of Athens**.

2. Context and main objectives

The **dynamic capture of situational awareness** concerning crowds in specific mass gathering venues and its intelligent enablement into emergency management information systems, using smart communication devices and spaces is critical for achieving rapid, timely guidance and safe evacuation of people out of dangerous areas.

In eVACUATE, **the intelligent fusion of sensors, geospatial and contextual information**, with advanced **multi-scale crowd behaviour detection** and **recognition** will be developed. The structured fusion of sensing information with dynamic estimated uncertainties on behaviour predictions will advance eVACUATE crowd dynamic models; and **virtual reality simulations** of crowds in confined environments. A service oriented **Decision-Support System** shall be developed to dynamically distribute on-demand evacuation information to emergency management actors as the crisis unfolds.

Decision-makers at the command posts, first responders, front-line stewards and volunteers receive real-time situation aware information of updated evacuation strategies using **robust** and **resilient eVACUATE information and communication infrastructure**.

eVACUATE will yield a **holistic system**:

1. To provide a valuable tool to guarantee total **Situation-Awareness** both to the crowds involved during a crisis but also to the crews operating in situ as well as in remote locations (security crews, first responders, crisis managers)

2. To **adapt dynamically** evacuation plans to current conditions.

3. To provide a clear, easy to use (visual, multi-lingual) set of **safe evacuation instructions** for citizens/tourist/visitors, available over a multitude of alternative and complementary presentation channels under a resilient, reliable and robust way regardless of the functionality of the "global network".

4. To set-up **visible demonstrations of innovative Crowd Evacuation Support Systems** in realistic situations

5. To **support civil protection authorities** in the formation and validation of proper safety procedures for crowd management (Reconstruction of Experiences).

6. To set a cornerstone for the **standardization of equipment, processes and methodologies,** for evacuation purposes on an EU level addressing the cross-cultural issues emerging from diversity imposed by citizens.

2.1 Scientific and Technological Objectives

eVACUATE performed all needed research, development and integration work to yield a holistic system:

- **To research**, **develop** and **demonstrate** the capabilities of a framework and congruent prototype that will enhance the effectiveness of complex crowd evacuation operations that take place in any type of venue or infrastructure (including difficult cases i.e. underground structures- metros, dense crowded environments & shipping).
- To provide a valuable tool to guarantee **total SA** both to the crowds involved during a crisis but also to the crews operating in situ as well as in remote locations (security crews, first responders, crisis managers).

- **To adapt evacuation plans to the current conditions** (e.g. in case of an earthquake avoid an already saturated concentration open area outside the hotel, propose open evacuation routes).
- To dynamically survey how an evacuation process is evolved **fusing different information data** establishing an **active and dynamic evacuation framework** instead of the current passive and static one (same plans regardless of the evolution of a phenomenon and the evacuation process).
- To provide a clear, easy to use (e.g. visual, multi-lingual) set of **safe evacuation instructions** for the citizen/tourist/visitor, available over a multitude of alternative and complementary presentation channels under a resilient, reliable and robust way regardless of the functionality of the "global network".
- To set-up **visible demonstrations of innovative Crowd Evacuation Support Systems** in realistic situations.
- **To support civil protection authorities** in the formation and validation of proper **safety procedures** for crowd management (esp. tourists who are easier disoriented in a crisis) **(Reconstruction of Experiences)**.
- To set a cornerstone for the **standardization of equipment, processes and methodologies** for evacuation purposes on an EU level addressing the cross-cultural issues emerging from the diversity imposed by the citizens.

The project has a multi-fold focus linked to fully quantifiable results from a coherent set of properly scheduled research and innovation related activities. Thus, the eVACUATE project aims to:

1. ***Define a full architecture and develop underlying necessary technological backbone***, designed to provide improved data fusion, interconnection and interoperability between the different system elements and layers reducing data ambiguity to a minimum. A peer-to-peer architecture of information processing, the result of which will be accessible in a ubiquitous manner by all the actors involved, through the eVACUATE platform.
2. ***Provide a new generation Crowd Evacuation Support Platform***, comprising of a full-set of systems and services built in accordance to innovative, integrated standards and peer-to-peer architecture, supporting a vast variety of complex crowd evacuation operations. This will be achieved with:

a. **A complete system for the provision of efficient support for the application of safe and effective evacuation strategies**.

b. **A resilient and seamless communication platform** integrated to the mechanisms already in place, to allow communication with the theatre of the evacuation operations and other civil and military response units and to remotely configure communications devices in the instrumented places with eVACUATE devices by taking into account overall situation awareness (SA) information & implement an emergency plan context communication.

Towards this direction, newly adaptive communication architectures will be introduced and will be integrated to the employed platforms.

c. **Crowd modelling**: to describe specific application scenarios and develop crowd dynamics models for these scenarios, including static and dynamic assessment of crowd flow, spatial analysis and network/agent based modelling. Crowd modelling is inherently used with the simulation and crowd awareness methodologies, through the use of computer vision tools, for determine the optimum evacuation route under a real-time and active evaluation strategy; computer vision detects current crowd behaviours, and simulators predict future outcomes by exploiting information provided by the crowd modelling.

d. **Intuitive and interactive simulation & visualisation capacities:** Innovative modules will enable the monitoring of both the environment and the situation, whether they are real or simulated, as well as the creation and control of simulations that can be used to validate the overall platform during its development, to prepare evacuation plans and study "what-if" scenarios, before or during real crises. This will rely on:

i. The interactive visualisation and sharing of an easy to understand **Common Operational Picture (COP)**. This will require to progress the state of the art in the field and to adopt a full 3D approach as the COP will mainly represent dense architectural environments, most of them being indoors, enriched with sensor measurements as well as simulation results. This will also require to research new visualisation metaphors to provide relevant visual information without overloading the visual representation to preserve it legibility.

ii. The **intuitive creation of scenarios to validate the system**, to assess plans and to unfold "what-if" scenarios before or during crises. Considering the complexity of simulations inside complex structures and involving numerous participants (i.e. crowds), a new approach is required to enable non computer-experts to easily define the initial conditions of the simulations as well as their overall scenario along the time.

iii. A number of **incident simulation models** adapted to an interactive application and suitable for indoor environments. These models will enable the unfolding of potential scenarios during the development phase, to test the overall system without having access to the test-beds, or as means to evaluate what-if scenarios during real exploitation of the eVACUATE system.

iv. The **interoperation with third-party simulation models** in order to enable third-parties to integrate their own simulation model in the system. For that purpose, the platform will be as model independent as possible in order to offer the necessary level of scalability and extensibility.

e. Smart Spaces: The Smart Spaces will provide the means to support the real time in the evacuation routes, updating the exit signage according to the decisions taken, either at local (Smart Space) or global level (infrastructure level). The fusion of information produced by the sensors installed in a facility along with the information from the users' smart-phones will form a "Smart Space" of enhanced SA. On the other hand, the comprehensive and directive broadcast of the evacuation decisions is also part of the Smart Space duties. The Smart Space aims to be integrated with the various social media, to enrich the multi-channel information push and pull. The sensors comprising the smart spaces are the following:

i. **RFIDs Printed Tags on Tickets for metro/ship/stadium**, etc.: to design of a fully roll-to-roll printed low-cost passive RFID on paper or PET foil. A fully integrated passive RFID using roll-to-roll fabrication techniques has been developed and will be optimized for use in security systems. The designed roll-to-roll RFIDs allow the detection and identification of several humans or groups, counting of them and associated crowd monitoring. Since the detection range of simple, passive RFIDs is limited, humans must pass a gate for detection.

ii. **Computer Vision Driven Sensors:** hyper-spectral imaging tools will also be incorporated to improve surveillance accuracy and detection of critical crowd behaviours events. Crowd flows are monitored using sophisticated cognitive surveillance tools operating in multi-camera configurations able to learn from the monitored environment and adapt their monitoring process to the ever-changing conditions characterizing people-dense situations.. Such estimates of crowd flows/states evolution will be used by eVACUATE framework for suggesting critical-time effective plans for safe evacuation.

iii. **Standardized Integration:** The eVACUATE platform will be capable of exchanging information with other emergency management systems by using international standards, such as the one established by the Advancing Open Standards for the Information Society organization (OASIS) regarding the information exchange to advance incident preparedness and response to emergency situations. More precisely by using the Emergency Data Exchange Language / Common Alerting Protocol (EDXL / CAP) to communicate with an existing external Emergency Management System such as iSAFETY®.

iv. **Pervasive technology**: to incorporate innovative pervasive technologies in a passive or active way to aid the AER; on the one hand detection of critical information and on the other notification of the optimal current AER. Pervasive technologies include active coloured exit signage and displays able i.e. to count the people passing by.

v. **Portable Units** with reduced size and incorporating power and communication system. These units will be used for people localization.

f. **Computer vision driven Crowd Awareness:** to detect the actual/current crowd dynamics in people-dense conditions using advanced real-time cognitive monitoring (surveillance methods) and multiple clusters of sensory systems. To detect/understand/learn high level semantics of events occurring in large scale critical public areas along with their causal relationships by matching the information observations with the crowd dynamics models (Crowd Modelling) and then predict/assess the evolution of such events and how they interrelate to the overall evacuation process, and its anticipated outcome. Analysis will be performed at micro and macro-scale layer. All these are framed with automatic adaptation methodologies, able to render the system self-adaptive to environment modifications.

g. **Decision Making:** To estimate tactical plans (and consequently to design strategic plans) for effectively controlling the evolution of an emergency by exploiting the estimation tools, the information observations and the crowd dynamics models. Towards this direction, we incorporate dynamic and adaptable strategies through the exploitation of game theory, for real-time adjusting the AER so as to elaborate optimal evacuation strategy.

3. ***Integration of different innovative and existing modules*** (sensors, positioning, communications) and perform the necessary hardware and software enhancements to the aforementioned architecture, so that all involved system elements can be seamlessly integrated to the main platform.

4. ***Study and develop the underlying socio-economic environment by addressing:***

a. **Ethics.** In crisis situations, where the physical integrity of many people may be at risk, it is clear ethical aspects have to play a predominant role. The ethical aspects will be studied and developed in order to enable or support all project partners to perform their research activities in an ethical way. By performing research in a constant ethical way, the project intends to improve the societal acceptance of the research outcomes.

b. **Legal Issues**. Guaranteeing the legal compliancy of a crowd evacuation tool like eVACUATE is also of the utmost importance. Taking into account the legal perspective in a sufficiently timely way enables the project to avoid later costs or time-loss when further operationalizing the eVACUATE research outcomes. Legal research will be performed in a number of iterations. The most important are: i) identifying likely legal barriers or hurdles (e.g. processing of personal/location data); ii) specify requirements to be taken into account during the different phases of the eVACUATE research and development; iii) evaluate to what extent these legal requirements are met by the chosen options; iv) formulate recommendations in order to improve existing legislation.

c. **The regulation societal context:** eVACUATE will take into account the societal and procurement implications to generate an initial framework for the design & development of suitable evacuation systems/strategies in EU.

d. **Standardization.** The regulation framework, legal aspects, and the standardization issues of operational procedures (including the certification of crowd evacuation systems) as well as the societal and procurement implications so as to generate an initial framework for the design and development of suitable Crowd evacuation systems' approach in Europe.

5. ***Demonstration of the developed system and validation of its operational characteristics*** in full-scale field trials that will simulate realistic emergencies and crises. The whole system will

be tested against four diverse events in 3 countries. A strong and committed user group has already been selected, to realistically depict the diverse nature of medium and large-scale venues and infrastructures in which complex evacuation scenarios can be deployed and tested. Different scenarios which simulate real life conditions will be considered in order to highlight the added value the system.

3. Description of main S&T results / foregrounds

The methodology employed in eVACUATE project lifecycle, had the end-users in the spotlight of all envisaged systems' development and evolution. From the collection of user requirements, to the iterative development and validation of the system's technical specifications and the performance of pilot demonstrations, the user groups affected by the developments of eVACUATE – first responders, crisis managers, resource/infrastructure managers, and public agencies.

3.1 Concluded project activities

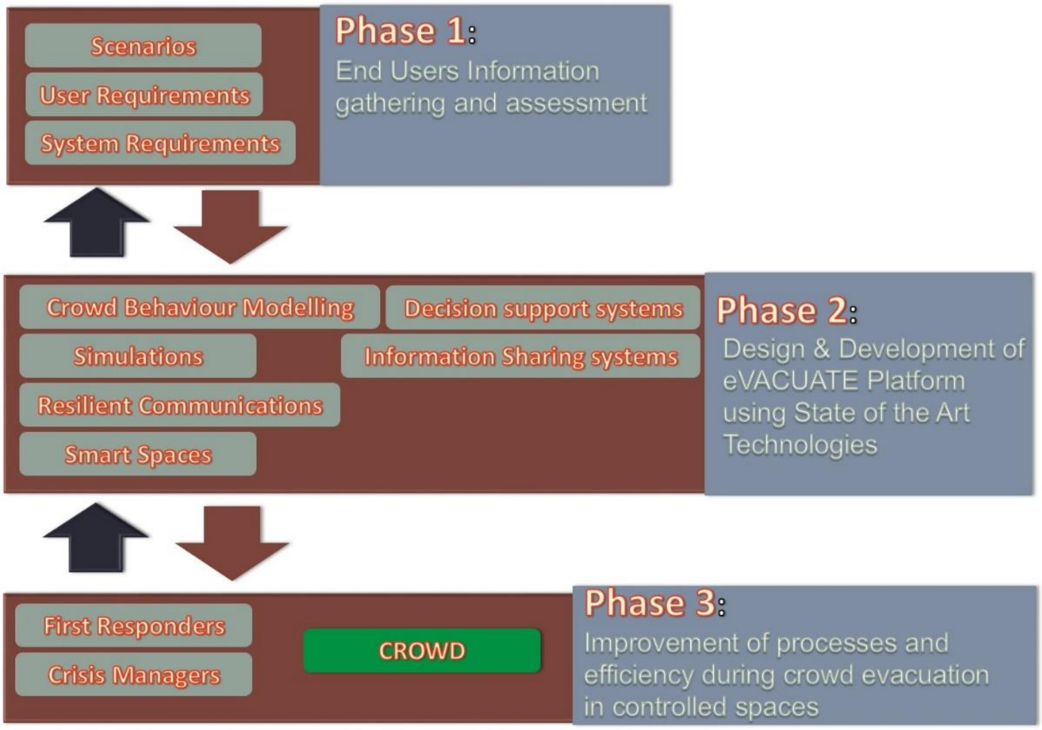


Figure 1: eVACUATE phases during project lifetime

eVACUATE has completed the final period of activity exhibiting significant results. Work started in the **first project period** with a thorough State-of-the-Art (SOTA) analysis in relevant scientific and technical domains, executed in parallel with a user requirements analysis covering operational/mission aspects. The SOTA report provided insights on decision support systems, information management systems and crisis communication systems and ends with seeral specific recommendations for the eVACUATE system (already taken into account in the design activity). User Requirements collection has been performed through real users interviews; Interviewed users came from various disciplines and operate in multiple levels of the crisis management hierarchy (First Responders, security personnel and top level Crisis Managers). Four scenarios were developed each addressing the needs of four different environments and corresponding one-by-one to the pilots foreseen to be demonstrated at the end of the project (Stadium, Airport, Cruise ship, Metro station). Also the evaluation criteria and objectives for demonstration activities of the eVACUATE system have been discussed, defined, presented and delivered. Following the requirements analysis phase, the work continued with the definition of architecture and the design of the system. This activity commenced with the high level description of the envisioned system and the definition of system's specifications. The definition of smart spaces architecture, agents and Interfaces architecture in view of being aligned with the generic architecture, as well as Communication Security and Interoperability architecture of the platform have also been finalized resulting in the in depth design and specification of the platform components. Architectural discussions have been advanced well, and with greater understanding also between WP3, WP4 and WP5 internally for the modelling and processing of crowd situations, as well as externally towards with the other architectural WPs. A definition of AER was done with existing evacuation strategies being reviewed, real-time modelling techniques researched, and optimum strategies being determined.

During the same period, the development of various eVACUATE subsystems commenced leading to the early release of at least 3 prototypes (eVACUATE platform, COP, Chipless RFID tags). Apart from the main deliveries during the first project period a preliminary set up of the legal framework with a focus on privacy and data protection as well as the ethical aspects that apply to the eVACUATE project were also defined. The aim was to outline the legal and ethical requirements that apply to the partners both during the research phase (e.g. in the course of the demos and other real tests) and to the technical solution developed in eVACUATE.

During the **second project period** the effort was mainly focused on the implementation phase. All technical partners did good progress showing a good level of advancement. Most of the mandatory features per subsystem were developed and started to be integrated into a common platform (SOFIA 2). KPIs were revised and new additional functionalities were defined based on end –users feedback collected from the 1st eVACUATE workshop. The beta and final releases of eVACUATE systems (software/hardware) have been delivered and tested while communications, CEP and the rest of the core components responsible for the data fusion and information flow were also developed. Common Operational Picture, EOC, Multi-scale crowd behavior analytics, AER simulations, Smart spaces (digital and active exit signs), Smartphone applications, Complex Event processing and decision support engine, Social media analytics, eVACUATE back-end platform and RFID tags were constituting the systems that eVACUATE was offering as main outcomes of project year 2. SOFIA2 was fully configured to operate in the security domain with all necessary modifications/improvements/vulnerability tests being successfully accomplished while a first integration with legacy systems per case study initiated. During the test period, the eVACUATE (general) project leaders and test-coordinators have been asked to do general testing tasks. They have evaluated the project goals and look whether the goals, from a holistic point of few, are met. And more general, they checked and monitored the specific test results with the overall, general project goals. With this testing session the eVACUATE project closed the first two phases, heading for the pilot exercises in which the implemented functionalities would be checked for obtaining our main goal and achieving its final requirements. In parallel with all these integration and development activities, legal activities were running with regards to the validity of the individual technological elements of eVACUATE and the overall eVACUATE solution. These activities were meant to help the partners enshrine privacy and data protection while producing a system that would be fully applicable after commercialization with existing regulations and directives from EU in the domain of security.

During the third year of the project's lifetime the project focused on the completion of the integration and validation activities, the completion of the training and standardization activities and the organization and execution of the four challenging pilots and final 2nd workshop. Four pilot demonstrators were setup and run with the eVACUATE system being fully functional at each premise. In parallel the training activities for the developed system were performed during and after every pilot demonstration. Regarding the standardization activities, the project achieved a clear identification of the context where standardization activities of eVACUATE should be concentrated and a liaison with CEN/CENELEC TC391 Technical Committee was established towards that direction.

The pilot demonstration and validation showed the full potential of eVACUATE with substantial results in the way our system reduces evacuation time (>20% in worst case) and effectively improving current evacuation processes when these are being compared with the current situations.

3.2 Final results

3.2.1 Crowd Behavior Detection and Recognition (WP3)

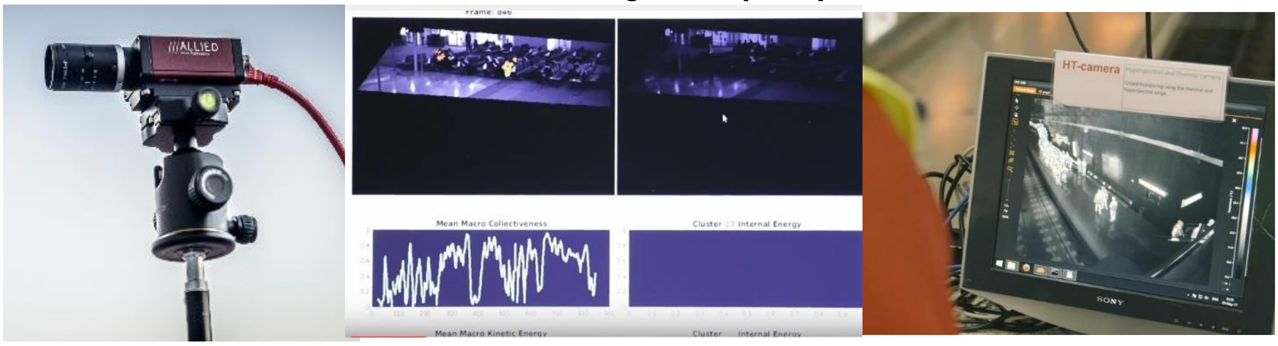


Figure 2: Crowd counting and behaviour detection and recognition systems incl. optical cameras and HT Cameras

Crowd behaviour detection and recognition in crisis situation pauses many challenges. We have met these challenges employing multi-scale crowd behaviour detection. Specifically, great progress has been made for achieving such goals in WP3 as the following:

- Detection of crowd motions characteristics at multiple scales (micro-, meso- and macro-scales) using multi-modal visual observation methods (Visible, thermal and hyper-spectral)
- The characterisation of crowds energies based on fundamental concepts of statistical thermodynamics
- Reasoning on crowd behaviour (usual or unusual) detection in context of spaces and the inherent expected eventual mass-gatherings behaviour(s)
- Deep learning among the various machine learning methods for detecting behaviour in WP3 for the final classification of behaviour and alerts to be sent as messages towards the decision-support modules for evacuation of the eVACUATE system
- Meso-scale crowd behavior simulation.

It is important to stress that in WP3, the dependency on good experimental crowd data was paramount to produce performing detection algorithms. The lesson learnt in this project and specifically in WP3 with partners was to make sure that we generate exemplar scenarios of crowd behavior using multi-modal vision observation from the early stages of the project. In WP3 we are proud to note that despite the early challenges in generating behavioural data, this was achieved and led to good research results that promoted the state of the art in detecting crowd behavior at multi-scale.

3.2.1.1 Identified innovations:

Based on you research and development work, WP3 recommends to use the invisible spectrum for crowd microscale behaviour detection. Under visible spectrum observation, occlusion is the biggest issue to overcome at such scale. With crowd scaling to high densities the challenge becomes impossible to solve using optical (visible) cameras. Thermal and hyperspectral vision observation are indeed the solution to this issue for detecting crowd behaviour at microscale.

Concerning micro-scale seeds detection using thermal and hyper-spectral vision based camera, ICCS successfully advanced their work further with regards to their targeted topics:

1. Statistical analysis of thermal imaging
2. Development and testing of different background subtraction algorithms suitable for thermal imaging.

The result derived from the statistical analysis of thermal data were used to appropriate model the background scenes in order to detect foreground objects, which, in the framework of eVACUATE project, correspond to seeds. All algorithms were tested and demonstrated during the pilots at the 4 different eVACUATE pilot venues.

In the visible spectrum IT Innovation's approach was to create meso-scale and macro-scale crowd behaviour models. New measures for crowd structure detection at higher scales (macro and meso-scales) using vision data were successfully used. These concern also 'crowd collectiveness'. The usefulness of the new collectiveness measure was evaluated in depth on a number of scenarios performed at Athens International Airport (Greece) and Anoeta Stadium, San Sebastian (Spain) pilots. Development work for capturing collectiveness in meso-scale was successfully achieved in WP3. It includes the detection and tracking of sub-groups within the crowd. Crowd energy and flows were also successfully used for modelling unusual crowd behaviour.

POLITO and IT Innovation collaborated to understand how the behavioral and psychological features of a crowd under stress conditions induced by evacuation processes can have an influence over crowd dynamics. More in detail to enlighten how the aforementioned behaviors can induce an important modification in the behavior of individuals during evacuation with focus on the evacuation time and unsafe concentration of individuals in the same area. A practical result has been the design of a strategy toward the tuning of the model used to simulate evacuation in complex venues. The specific focus has been the identification of the initial conditions needed to start simulations, and on the assessment of model parameters related to stress during evacuations, which can increase the evacuation time and can lead to a dangerous concentration of individuals in restricted areas. This analysis is developed by taking also advantages of some sample simulations, where it is shown how stress induced by panic can generate risk situations in evacuation dynamics.

In the area of deep learning, WP3 proposes a new self-adaptive deep multi-layered neural network architecture that is able to automatically update its performance (parameters) so that the current visual environment is trusted as much as possible with a simultaneous minimum degradation of the already obtained knowledge. We prove that under the assumption of a small weight perturbation these demands can be expressed as a constraint convex optimization problem. This also results in a computational efficient adaptation algorithm. Network retraining is combined with an unsupervised learning paradigm, implemented through stacked autoencoders, in order to improve convergence, stability and performance of the object tracking and labeling process.

We performed an objective evaluation of the efficiency of our scheme both in terms of performance and computational complexity. This showed that the proposed algorithm is able to provide a good updating performance under real-time constraints, which indicates the superiority of our scheme especially for real-life demanding computer vision applications. Towards this, a new objective criterion, called adaptation power, has been introduced to measure the improvement of the classifier after the adaptation (e.g., doing work) with respect to the time needed to carry out such improvement. We show that the adaptation power, in our case, is times greater than the conventional retraining approaches. We also conclude that only few labeled samples are adequate to effectively update network performance. This is another advantage of the proposed algorithm, since finding confident labeled data is in general a difficult task.

The crowd behavior detection models and algorithms, together with a spatio-temporal context ontology developed in WP3, form a fusion framework. Various types of alerts and notifications for the detected behavior mechanisms are successfully incorporated into the SIB structure and the Sofia platform. Further, we have integrated cameras within the WP3 system in order to provide live footage for further automated processing. This is done for the analysis by the behavior detection modules at multi-scale and multi-modes in order to provide live crowd behavior detection alerts to the rest of the eVACUATE system. In our research and development work we succeeded in processing crowd behavior in real-time by using high performance computing equipment and tailoring the algorithms for real-time feeds and demonstrated this during the Anoeta Stadium and AIA pilots. In these cases we detected unusual crowd behavior in real-time and generated messages which were sent to the Sofia platform and subsequently relayed to the common operation picture as alerts. We also succeeded in the set-up of the behavior detection algorithms to operate on feeds from hand-held and CCTV cameras and used them in the STX and Metro Bilbao pilots. Real-time processing and fusion using thermal and hyperspectral cameras was also achieved and integrated with the eVACUATE system through the Sofia platform.

As a result of the WP3 participation in the experiments and the demonstrations in the 4 undertaken pilots we can conclude that the thermal and hyperspectral crowd counting and visible spectrum unusual crowd behaviour detection algorithms have used the right approach for the eVACUATE project objectives for supporting computer vision analysis on crowds. The successful application of the crowd unusual behaviour detection algorithms in various contexts and its sensitivity has given us the assurances for its further development and integration with our context ontology.

3.2.2 Advanced Strategic Spatial Evacuations (WP4)

Figure 3: displayed AER on COP per case study

WP4 focused on developing evacuation strategies and using fast predictive models to dynamically alter them in real-time depending on the situation at hand. The crowd models developed have been shown to incorporate crowd behaviour through newly developed mesoscopic modelling methods, and new methods to simulate crowd movement during evacuation through computationally efficient. highly parallel software has been achieved. A methodology was developed as to how to apply the system to different venues, alongside evacuation strategies for those venues and validation of the software has been undertaken through a formal deliverable and through the pilot demonstrations.

WP4 is at the heart of the eVACUATE goals, in generating the active evacuation route (and sustaining it) for large crowds. This output in particular is used by nearly every system within eVACUATE.

The major achievements can be summarised as follows:

- Research into venue evacuation strategies and requirements for performance of real-time simulations
- Fastest crowd simulation in the world (to the best of our knowledge)
- Behavioural crowd models using a mesoscopic scale approach from game theory
- Integration between all crowd modelling scales (micro, meso and macro)
- Computationally efficient and flexible code, exceeding all KPIs set at the project inception and developed through research alongside end users
- Validation of the forecasts of the models

As a result of WP4 participation in all 4 pilot demonstrations, the system was able to function and communicate the active evacuation routes to the volunteers involved via the other systems developed. The results recorded at each pilot demonstration highlighted that the predictions made were very close to what was seen during the demonstrations, in particular the evacuation times that were measured were extremely close to those predicted by the crowd models during the demonstrations. This is highly important for any commercial development, and was a major achievement within the work package.

3.2.2.1 Identified innovations:

WP4 has developed a state of the art innovation in crowd modelling and simulation. The computational code, fully integrated between modelling scales, and with the SOFIA platform (WP9), interacting with most evacuate system components through the SIB (WP8) and able to be displayed to the end user through the COP (WP5) is the first of its kind, and the innovations made are promising to be further developed for commercial application.

CDI, with the input of all WP4 partners developed a computationally efficient model at the micro, meso and macro scale. This innovation is thought to be the fastest crowd simulation available at this time. It is able to simulate large crowds (e.g. 50,000 people in a stadium) in seconds, where the previous state of the art simulations could take hours to do so.

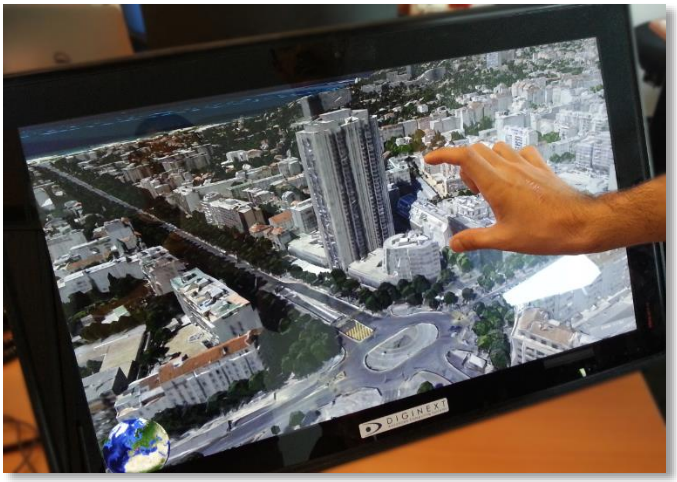
The software is capable of forecasting crowd congestion given the detected parameters in a venue, which had not been achieved before eVACUATE, and to generate an optimum active evacuation route (or in fact multiple routes if required) that is used by the system.

The WP4 partners have been able to create a behavioural crowd model, derived in pure mathematical terms by POLITO to encapsulate behavioural parameters, namely quality of environment, and crowd following/dispersion, which can be attributed to the emergency behaviours of crowds and directly linked to research undertaken in WP3. This model was transformed into a computational code by POLITO and CDI, such that results could be gained from the algorithms, and the two most appropriate venues (AIA and METB) were modelled. The integration between this and the main software component was achieved. However, given the computational complexity of such behavioural models, the results were not run in real-time, rather used to influence the behavior within the faster computationally efficient model developed.

Both crowd models, and jointly as an integrated model were validated, and applied to the pilot venues. The features within the simulation as a whole was developed to suit the venue procedures and international guidelines, and based on the end user and reviewer feedback. The innovative features can be briefly described as follows:

- Variable scales of modelling appropriate to different venue requirements
- Reaction to a blocked or reduced capacity area
- Variable crowd demographics, such as size, speed (related to age, mobility, crowd target behavior etc.)
- Input of speed vs density curves in particular locations
- Route choices based on calibrated values and known restrictions, such as stairs, elevators, escalators, objects in the passage, close proximity of physical features that affect a crowd (e.g. open edge platform)
- Optimization and real-time validation of active evacuation routes
- Split route choices from a single area
- Evacuation time prediction from any part of a venue
- Forecast congestion (crowd density) at any point in time if an evacuation were to take place, and through the evacuation
- Constant updates of simulation feedback during evacuation
- Simulation of crowd behavior
- Simulation of restricted exit occurring *during* the simulation run itself
- Simulation of staff or crew with different goals to the general venue population

3.2.3 3D Interactive Common Operational Picture & Simulation (WP5)



WP5 had two primary goals. The first objective was to develop a novel visualisation system to enable operational staff to have a clear, synchronized, and interactive view of the evacuation for indoor and outdoor situations. The second objective was to research and develop an alternative mean to enable large scale validation and training scenarios. Indeed, there are major issues in inviting a large number of human actors to evaluate an evacuation system, such as the cost of actors; the availability of such a large number; the organisation of them; and in particular, health and safety requirements. Therefore, as an alternative solution, WP5 researched and developed simulation techniques as an answer to the missing information required to enable large scale validation of the system and to provide the means to conduct meaningful training sessions.

3.2.3.1 Identified innovations:

WP5 succeeded in delivering these two systems. Derived from the user and system requirements, the COP has become an intuitive system to navigate into 3D venue mock-ups, gather data from dynamic sources and display it in an legible way in real-time. This increases the situational awareness of decision makers which now have a complete picture of the ongoing venue situation. The decision maker can display and filter data, alter the simulation initial conditions to prepare for potential issues, plot his decisions into the 3D map to create his action plan and then share it with other connected users. This enables every involved organisations to share a common ground for crisis management. The COP also enables decision makers to start the evacuation process, triggering every other eVACUATE connected components, like the AER display in the dynamic exit signs. With the help of the Simulation module, WP5 created dynamic scenarios intuitively. It provided the ability for technical partners to create simulation data to feed the system and train the algorithms / gateways during development. It also gave the possibility to create richer training sessions with more immersive data displayed into the COP.

The main challenge faced during the development of such system was to create a system that requires non-trivial computer tasks to be performed, tailored for non-computer scientist. WP5 had to aggregate and abstract all the available information provided by the system and present them to end-users in the most legible form possible. WP5 also had to adapt navigation and manipulation metaphors normally used in 3D graphics computer applications for crisis management operations. Last but not least, WP5 had to integrate all of its work in GIS environments that helps decision makers have a full picture of the whole evacuation process. The usage of GIS environments and the integration of indoor visualisation (and even more with underground visualisation of the Metro Station) into a user friendly, intuitive software went beyond every other competitor solutions currently available.

3.2.4 Resilient Communications and Adaptive Interfaces (WP6)

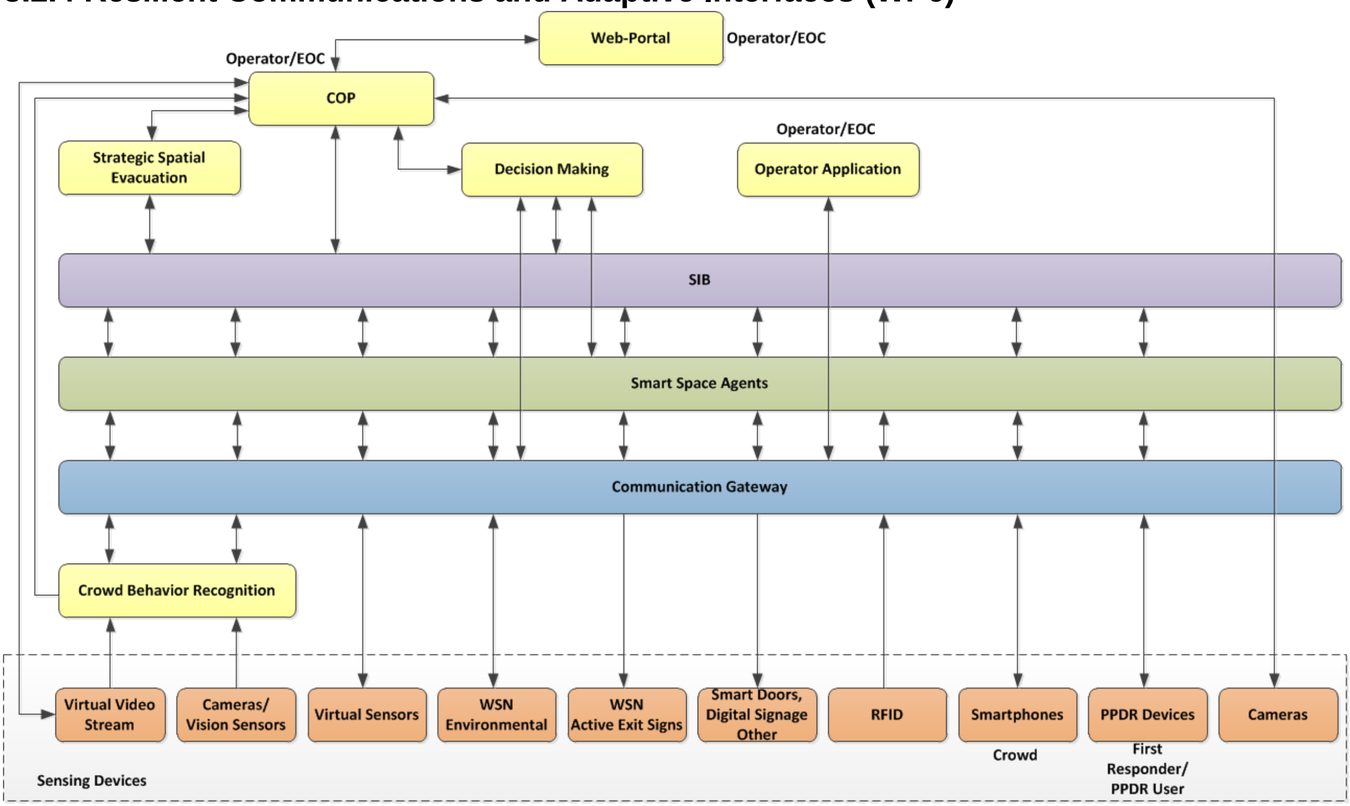


Figure 4: eVACUATE network interconnections (block diagram)

The main goal of WP6 was to develop a communication gateway which acts as a plug-and-play sensor/device abstraction layer and hides the communication details and heterogeneous hardware of the sensors/devices allowing applications or services to collect data or be able to task / configure the sensor/devices. The implemented communication gateway supports the integration of different communication protocols, sensing/actuating/end user devices and is able to be integrated with existing legacy systems. Some of the strengths of the eVACUATE Communication Gateway and Operator/PPDR gateway functionality are summarized below:

- Reduced complexity and improved productivity: supporting object-oriented distributed information modelling
- Improved performance: Due to the variety of QoS supported e.g., reliability, availability, timeliness, best effort etc.
- Fault Tolerant: Due to the broker-less and decentralized architecture with no single point of failure and fallback mechanism
- Interoperability: Works on different operating systems, support different programming languages, interoperability among various implementations
- It supports content awareness and data prioritization
- Suitable for real-time systems
- Supports different communication protocols data formats
- The communication gateway implemented is based on the international standard Data Distribution Service for Real-Time Systems (DDS) of the Object Management Group

3.2.4.1 Identified innovations:

A competitive advantage of the eVACUATE communication gateway platform is the alleviation of the overwhelming resource heterogeneity which governs the EVACUATE systems' sensors, actuator and devices. The communication gateway adapters' primary aim is, thus, exactly to drift away from proprietary protocols and data formats with respect to field devices and publish the resources in a uniform, harmonized format so that they may be integrated with minimal effort and time to any decision support system following the communication gateway data model.

The data model of the communication gateway uses of widely adopted standards in order to enable real-time communication in an interoperable and seamless way. The adaptation and harmonization of these standards have led to the definition and development of a semantic interoperability layer. The disseminated information has been semantically annotated, enabling fast deployment, extensibility and easy adaptation. The standards incorporated in the data model are:

- *Interface Description Language (IDL):* IDL is a language for specifying properties of structured data and has been used in describing software component's interfaces.
- *SWE Common Data Mode:* It defines low level data models for exchanging sensor related data between noes of the OGC Sensor Web Enablement framework.
- *SensorML:* The primary focus of SensorML is to provide a framework for defining processes and processing components associated with the measurement and post-measurement transformation of observations.
- *Observation & Measurements (O&M):* Provides general models and schema for supporting the packaging of observations, and of features involved in sampling when making observations.

3.2.5 Smart Spaces (WP7)

Figure 5: Smart spaces developed within eVACUATE. From upper left to down right: Active exit signs, Mobimesh net, smartphone applications, social media analytics, RFID Tag system, Digital exit signs

The main objective of WP7 is to provide the means to Situational Awareness and dynamic routing, integrating in a virtual environment all the relevant agents of an evacuation scenario.

This WP also addresses the design of RFID tags and development of roll to roll printing technology for detection and/or tracking of actors and elements.

It was decided to develop one agent framework, which contain all the common functionalities of all the agents, and use this agent framework as the base of the development of all the agents identified in the project, based in the following structure.

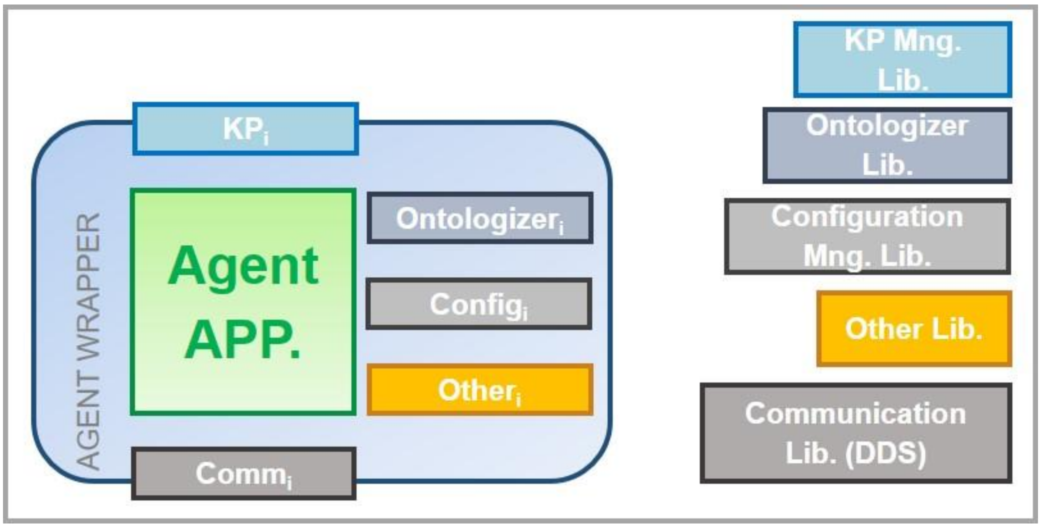


Figure 6: Agent Framework Structure

This agent framework, includes the datamodels and ontologies developed in the corresponding tasks within this WP and implements the communication interfaces with the WP6 for communicating with the physical devices, and the interface to integrate with the platform provided by WP8/WP9 the different elements which compose the Smart Space.

From those elements that compose the Smart Spaces in the different pilots, we would like to highlight those elements which are in fact novel technologies that have been developed within the scope of the project, and particularly in this WP:

- Digital Signs
- Chipless RFID printed Tags
- Computer vision (*Developed in WP4*)
- Dynamic exit signs
- Wireless Sensor Network - Temperature, Humidity and Light sensors
- Application for SmartPhones
- Information and services from Network Operator (MobiMesh)
- Information from Social Networks

While the others are legacy systems that we have integrated in the same way as the rest of technologies.

- Multimedia Devices
- TETRA Messaging
- Smoke/Fire detection
- Ticket Validating Machines
- Internal wireless DECT & Fixed phones

In this WP as well, we have developed a Rule Set Layer, able to perform automatically some simple actions based some inputs, like sensors, without the intervention of any human being. This rule set layer is quite useful for not critical actions, as critical actions should be supervised and authorised by the competent authorities.

3.2.5.1 Identified innovations:

The most relevant innovations of this WP are related with the devices that have been developed so far more and the functionalities they provide to the overall project. Of course there has been a huge work on platform integration, datamodels, ontologies definition and development and so on, but these were activities required to have everything working together in a smooth an easy way, but maybe without a high level of innovation themselves.

Therefore, the most relevant innovations have been the development of:

1. **Digital Signs**
   This module provides the capability to use any multimedia device (screens, monitors and any other existing or new device) during a crisis situation in order to give information or instructions to all the people around, this will be done in a semi-automatic way, as it has to be initiated by the authority in charge of the security in the Control Room, but once it has been initiated, automatically al multimedia systems will start providing useful information to the people.
2. **Chipless RFID printed Tags**
   One of the most innovative activities, from the research point of view, with one specific task and two partners fully dedicated to it. It has been developed chipless RFID tags, which can be printed directly and on the moment in any kind of entrance, ticket or whatever. These tickets are definitely a lot cheaper than the actual RFID tags (with electronic chip), and will be the replacement of those in the future, once the technology will be more mature. For that

goal an extensive research has been made in different type of inks, different type of substrates, different tag shapes and two different tag reader technologies.

3. **Dynamic exit signs**
   There have been developed different types of exit signs (wall, floor, door) in order to cover any deployment needs of any venue.
   These exit signs have been developed with the concept plug-play-forget® in mind, so they are very easy to deploy thanks to their wireless communication interfaces, they have batteries in case there is a power loss during an emergency, and they are automatically connected to the network, configured and so on, with almost no need of human intervention.
   Thanks to this technology, just in a few seconds is possible to modify and adapt all the Exit signs in the venue to redirect people to the safest exit at any moment, avoiding dangerous areas. According to the results of the pilots and the feedback obtained from them, lots of lifes could be saved with this dynamic reconfiguration of the evacuation routes.
4. **Application for Smart Phones**
   Nowadays, almost everybody owns at least one mobile phone, and the use of mobile applications is quite extended. In this WP it has been developed two different mobile applications, one for the First Responders, and other for the “normal” people who may be in the venue.
   First responders’ application gives valuable information to the first responders regarding what is happening in the venue at any time, they can receive specific order through the applications and also they are able to send information to the Control Room about what is really happening “in the field”. These app will be the main communication channel between the First responders and the persons in charge of the security in the venue.
   The application for “normal” people gives interesting information during a non-crisis situation, in any daily situation, but also gives them important information in a case of an crisis situation and can guide them to the safest Exit like a GPS navigation device through the building. People is able to send as well information about what is happening in the field.
   Both applications can locate each person and provide the information on where is each person in the venue in order to represent it in the COP.
   These applications can make the difference in a crisis situation in a big or “complicated” venue.
5. **Information and services from Network Operator (MobiMesh)**
   It has also been developed functionalities through a network infrastructure that can be deployed in any venue, in order to identify and localize any mobile phone which is located inside the venue, even though they have not installed the mobile application.
   Then, with this development, the system is able to know how many people is inside the venue, where are they, and it is possible even to send messages to any of these persons in case of a crisis situation.
6. **Information from Social Networks**
   It has been developed a novel tool that is able to analyse the social networks and detect predefined keywords that are being posted repeatedly from people who are near or inside the venue. Monitoring words like “fire”, “bomb”, attack or something similar when this words suddenly appear repeatedly in the social networks, while in a normal day they are not common, then an alert is raised and the security personnel would be notified in order to verify if something is really happening.

3.2.6 Decision Making and Optimal “Situation-aware” evacuation strategy (WP8)

The main objective of WP8 is to combine data from different sensors and make Data Fusion in order to establish an Optimal Situation Aware and apply Inference for Decision Making and Support to the COP Operator.

After analysis phase concluded with the deliverables D8.1 System Specification, D8.2 ICD Report and D8.3 Scenario Analysis and Reasoning Engine Development the next step was a verification of the resources available provided from framework choose for implementation. SOFIA2 platform offers a good communication infrastructure composed by a publish/subscribe Semantic Information Broker, and an optimal SDK for agent implementation with a large set of APIs (C/Java) and protocol communication (HTTP, MQTT). The store component was assigned to MongoDB, It is non-relational database but it is very fast if accessed by native operations. Also the platform was improved with the integration of a Complex Event Processing Siddhi (from WSO2 platform).

The analysis of the available resource highlight the lack of a geoserver, it is essential component for space/time correlation on the site maps. This last occurrence prompted us to develop a mediation layer that give us the same support, implementing algorithms for spatial correlation and localization on map areas. This step was essential to produce georeferenced events to be offered to the CEP for apply the rules. Normally the mediation layer is composed by the apis for communication and a first normalization of incoming data to store into a data context, anyways this lack did not limit us in capability.

3.2.6.1 Identified innovations:

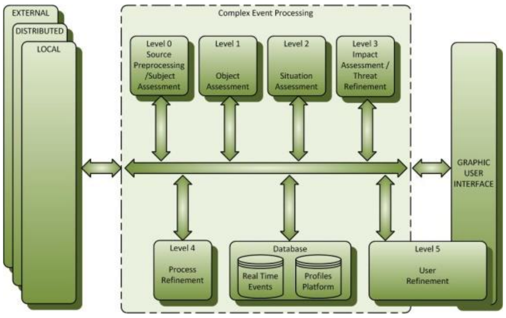


Figure 7 - JDL DFIG Model 2004

After a period of implementation WP8 SW was delivered in two steps, release 1.0 in M33 December of 2015, and release 2.0 in M36, with a complete set of rules implemented and tested on the CEP using a simulator that emulate all the components adjacent WP8.The objective was accomplished, a multi sensors/actuators signals and status was fused in order to apply inference by the rules, using JDL DFIG Model 2004 logic architecture (already applied for PROACTIVE FP7 project), and apply Dasarathy's Classification for outcome like Georeferenced Events, Alarm, Features and Decisions, this is one of the innovation for a surveillance and evacuation system.All outcomes are published in Real Time in order to be consumed by the other components of eVACUATE system.

A most important issue was to follow the end-user requirements, some apparently conflicting among themselves, like “reduce false alarm” and “early warning”. Instead of using different classes of messages to the operator, we have decided to use the standard CAP Event, using the information in order to give the right weight (AdaBoost Method) and leaving the operator to classify by the Accuracy and the Severity the incident. This is the second innovation for a surveillance and evacuation system.The last but not the least innovation for “Decision Making” was to give a decisive support to the COP operator in order to give him the ability to formulate the correct diagnosis of the incident and use

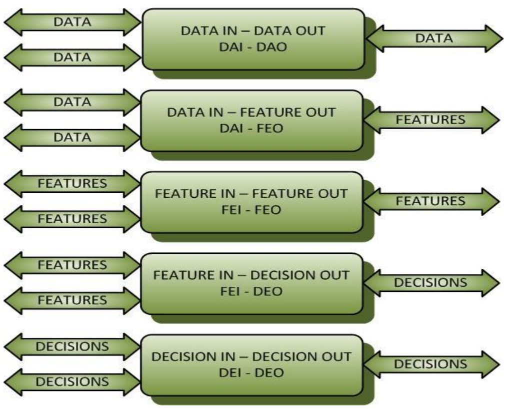


Figure 8 - Dasarathy’s Classification

properly the available resources for manage it. Inside the CAP Event, that describe the incident, we have included two fields : suggestions and predictions. The first indicate the right resources to spend for verify the real extent of the incident, such as indicate the optical camera to switch for a direct streaming, also indicate the closest list (around 20 meters) of First Responders to engage for check the area affected and verify the gravity (Using Custom Event sent by eVAMAPP). The prediction field contains the list of hazardous areas near the incident. It depends from the type of incident and from the usage destination of the area (e.g. Inflammable material depot near an area affected from Fire Alarm, or Electric Central with floodwater alarm). In conclusion, anything can limit or cause the lost of the installation resources or worsen the conditions of the incident.

Due to a particular purpose of the system like evacuation, the Decision Making component limits the Automatic Decisions to the tasking actuators (Exit Signs, Multimedia, iSafety, eVAMAPP GEOroutes, Legacy Systems), and leave the evacuation decision totally to the COP operator. Anyway, Decision Making component through the mediation layer algorithms and the Rules in the CEP can automatically tasking the actuators when the condition of the system changed (see change of evacuation routes due to an evolution of the incident).

3.2.7 SAES(Situation Awareness and Evacuation System) Framework design and system Integration (WP9)

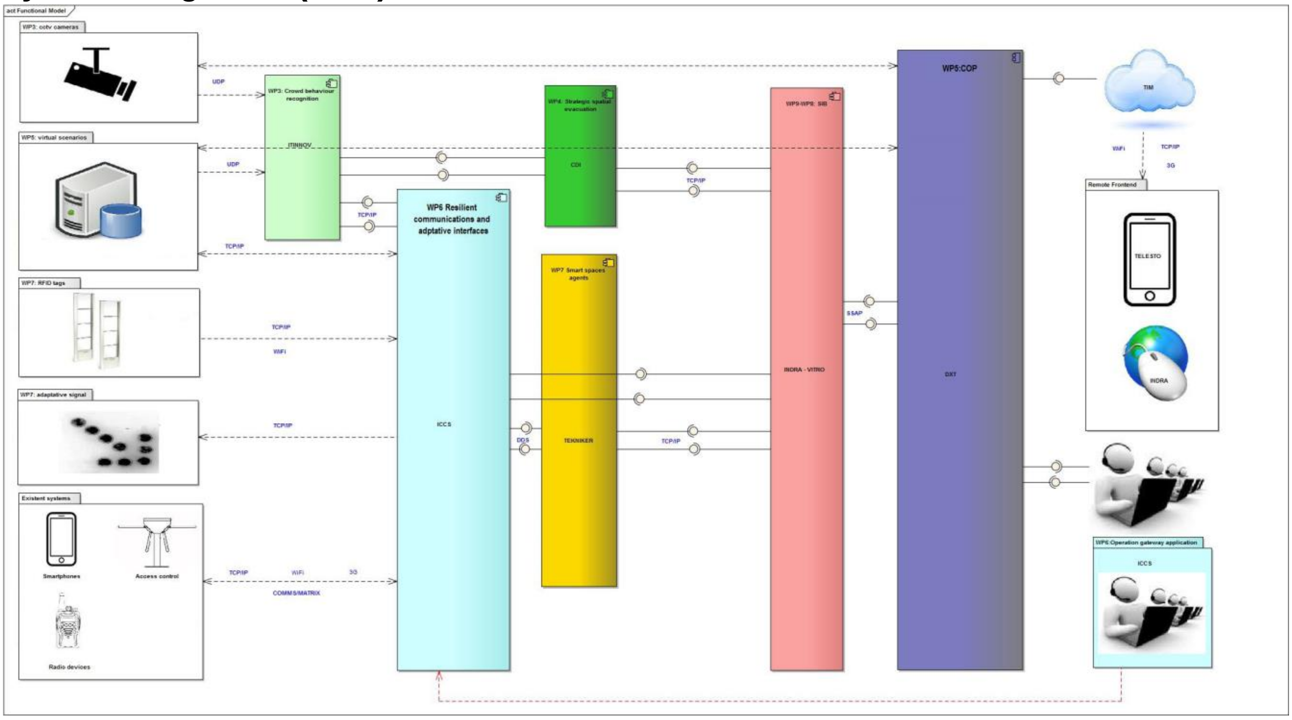


Figure 9: eVACUATE block digram

The main objective of WP9 involved reaching a highly standardized, unified eVACUATE solution, integrating all the needed components in an efficient way, hence involving many other Work Packages of the project, particularly the technical ones.

One of the first points was the design, and later development and deployment, of a framework to unify the then-future system, including aspects such as communication protocols, operating systems, interface definitions and in general the creation of an integrated eVACUATE architecture that could incorporate state-of-the-art technologies -such as behavior detection algorithms, computational semantics, Internet of Things, RFID and smartphone applications- to the domain of security and evacuation.

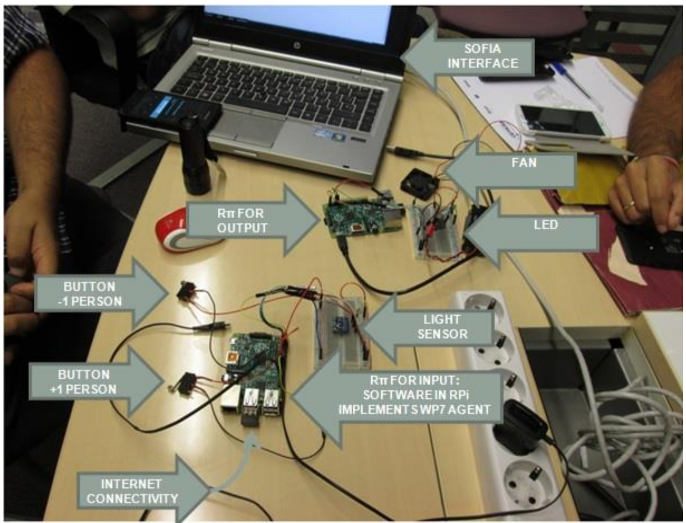


Figure 10: The first demonstrator

Once this was achieved, the following step was the connectors that would be needed to integrate devices and systems in the whole eVACUATE solution. By using ontologies to send communication and implementing a language-agnostic lightweight software known as agent in the machines, the eVACUATE contributed to relevant technological progress in the field of IoT, while also creating synergies between the technologies.

From the first moment, the eVACUATE staff knew that the involved existing technologies were to be evolved and pushed beyond their current capabilities to implement any functionality that the new solution needed. One technology that played a crucial role in this was the IoT platform SOFIA2, oriented for the interoperability of devices and systems to provide real-work information to *smart applications. SOFIA2, itself the maturation of the previous ARTEMIS R&D project, was improved in many aspects, including robustness, multi-platform compatibility, security, data persistence and incorporation of new languages and standards. Other involved technologies, including many legacy elements, were also modified in the same aspects.

The most visible result of the first year was a demonstrative prototype of the eVACUATE system that used model elements to establish, in a controlled environment, the overall use of the system in a wide scenario. That is to say, a lantern was used to force a change in the readings of a tabletop light sensor, and then the consequences of this change, including a foreseeable effect following a simple rule algorithm, were shown in a beta-version interface. The success of this test proved that the system could be extended to incorporate more complex algorithms and functionalities.

3.2.7.1 Identified innovations:

Finally, the platform was adapted and oriented, using the new breakthroughs to make it gather and process huge amounts of real-time data. The implementation in each of the four venues (Anoeta Stadium, Athens International Airport, the STX cruise ship and one Bilbao Metro station) had many specific differences that required customized approaches, which were handled in a case-by-case basis. The eVACUATE solution became a platform that can manage critical emergencies situations, and the same components can be applied to other products and services for further exploitation, in any domain.

3.2.8 Ethics, Legal and Regulatory Activities (WP11)

The main objectives of WP11 are to formulate the legal requirements applicable to eVACUATE, to clarify the impact of ethical aspects, thereby increasing societal acceptance of eVACUATE, and to contribute to the development of standardisation in the eVACUATE area.

The work spans five main tasks and six deliverables describing the process from the initial identification of high-level legal and ethical requirements to specific requirements and procedures to be followed in the validation demonstrations.

The analysis adopted an incremental approach whereby each deliverable builds on the findings of the previous deliverables and on feedback received from partners. It started from analysis of the legal and ethical aspects of crowd management, including responsibilities for emergency prevention and response and liability. It then focused on the privacy and data protection framework applicable to data processing in the context of eVACUATE. This analysis was then relied upon to focus and discuss the different elements of the eVACUATE solution, ie individual technologies, such as chipless RFID tags, eVAMAPP, social network data mining, and crowd behaviour detection through video surveillance as well as on the four demonstration validation scenarios, particularly from the perspective of proportionality as a key issue. Furthermore, partners were provided with practical guidelines on personal data processing for research purposes in the context of eVACUATE. Finally, the ethical and legal recommendations provided during the various stages of technical development of the eVACUATE technologies were formulated with the goal of making them applicable also in an operational, production environment of eVACUATE or individual components of it as well as in technological solutions that go beyond the scope of eVACUATE. The ethical and legal analysis also laid specific emphasis on the reform of data protection in the EU and covered the most important aspects of the General Data Protection Regulation that could have an impact on the eVACUATE technologies.

In addition to the legal and ethical analysis, the work in WP11 also covered various standardisation efforts. Indra has been compiling the eVACUATE components with potential to contribute to development of existing standards. It also contributed to sign an agreement between eVACUATE project and CEN CENELEC to support the standardisation activities of CEN TC 350 and other initiatives, taking into account the different approaches and local specificities which exist and provide input to European harmonisation activities. These actions were reflected in the deliverable on recommendations for standards which provides the plan for the standardization activities of the eVACUATE project. It also covers the partners' realizations and intentions in terms of participation to standardization bodies and to regulatory administrations.

3.2.8.1 Identified innovations:

eVACUATE has the potential to contribute to development of existing standards. The executed agreement between eVACUATE project and CEN CENELEC to support the standardisation activities of CEN TC 350 and other initiatives is an important step in the process, ensuring continuity of the efforts.

3.2.9 Training and logistics support

3.2.9.1 Training in situ

The training focusses on the education of decision makers and/or their supportive personnel, to be prepared for everyday (routine) situations and crises. The eVACUATE system offers an overview of the situation in buildings. Hands on training helps them to assess the full value of the system.

In the first three pilots (ASRS, AIA and STX), the training has been combined with the simulation exercise (see report in D10.3), which took part after the full-scale evacuation exercise with volunteers. In the simulation exercise in Anoeta Stadium, Athens International Airport and STX MSC Meraviglia the most important features of the eVACUATE *training mode* have been presented and discussed.

For the Metro Bilbao pilot the eVACUATE team got the possibility to give an additional training. This training has been developed and performed with security personnel (operational security managers supporting the crisis decision makers during crisis situations). These persons were asked to (co)operate the system during the evacuation exercise and to provide their feedback in the simulation exercise with the decision makers.

3.2.9.2 Training process

In the eVACUATE training we distinguish several phases in the training process:

- Familiarisation of end-users with the eVACUATE system
- Demonstration of system's operational and training capabilities
- Experience with simulated evacuation scenarios
- Hands-on training with the COP

In the eVACUATE team we have agreed on the fact that the only component/system used in the training is the Common Operation Picture (COP) while indicating that all other eVACUATE systems are also demonstrated through COP since they add information, alerts and alarm to the COP: RFID, TETRA Messages, Social Network Manager, MobiMesh, iSAFETY, eVAMAPP First Responders, eVAMAPP for passengers, camera feeds and connection with legacy systems. The relation between COP and the other eVACUATE systems have been demonstrated in the evacuation exercises and simulation exercises (see D10.3).

The complete eVACUATE team has been involved in the training preparation. During the testing session before the pilot exercise and during the end users programme, the training has been discussed and updated several times. The input from the eVACUATE partners and their technologies has been incorporated in the training programme

3.2.9.3 Training evaluation

After the training, an assessment and judgment has been done, based on interviews and a questionnaire (see results in chapter 8) on the quality of the training in order to conclude whether the project has achieved the learning objectives or not.

The evaluation process has been planned and organised as follows:

- hands off the system
- express thanks for participation
- ask for feedback on the system
- ask for feedback on the training
- ask for general feedback or remarks

The trainer, accompanied by the observer(s), focusses on receiving feedback and only ask for clarification. Discussion is being started only after several rounds of individual feedback. Persons are asked directly for their comments in case they do not participate 'spontaneously'.

Immediately after the general feedback, the discussion starts on the main feedback or learning points. Thus we expect to gain significant and valuable evaluation results. The direct training results are presented in D10.2 report.

3.2.10 Validation of the system through demonstrations (WP10)

In the period of more than half a year (September 2016 – March 2017) the validation of the system developed in the eVACUATE project has been performed in close collaboration between the technical partners and the end users. These demonstration (field's tests) have been the result of fruitful collaboration. The pilot demonstration and validation qualitatively show the potential of the eVACUATE system in reduction of evacuation time and more effective use of routes.

The demonstrations have been set up as evacuation exercises with a group of volunteers. Each evacuation exercise was a full scale and full scope realistic exercise in which an evacuation has been activated. During the exercise crowd analysis and evacuation modelling lead to a better overview of the possibilities to avoid evacuation or to choose the best evacuation route in specific circumstances (for example in case the normal evacuation route is blocked by fire, by a dense crowd or by other incidents). The evacuation decision has been based on information in the common operation picture (COP). The exercise showed the merits of the software developments and interdisciplinary cooperation.

Anoeta Stadium Real Sociedad (ASRS)



In the Football Stadium of Real Sociedad, the crowd consists of adult people. In the stadium, a large amount of people is gathered for specific time frame in one large structure, leading to high density of people in a confined area. In the scenario differentiation is introduced between different exit gates as active evacuation routes, because one of the exits is blocked by a combination of incidents. The eVACUATE system monitors in real-time the crowd density at the exits and informs first responders and the public on the optimal evacuation routes. In addition, the monitoring of the social networks that spectators use (Twitter) assist the decision makers for assessing the actual situation before, during and after the evacuation.

The pilot demonstration comprised different loops in which different parts of the eVACUATE system were tested. Each loop started with a short instruction to the volunteers followed by an 'evacuation signal' of the football stand. The time needed for evacuation was measured and the behaviour of the evacuees was monitored by three observers: one on the football stand, one in the sector/salida and one at the COP. The eVACUATE system generated messages through the eVAMAPP and by SMS (Mobimesh) send automatically and manually (from the EOC) which were checked by the observers during the loops.

To be able to assess the possibilities of the 3D modelling is interesting from the end users point of view. They mentioned the benefits of tunnel modelling (to be able to look inside a building, by removing layers). End users discussed the possibility to integrate the 3D model with external emergency systems and/or with the outer area of the stadium (with parked cars, first responders' location, ambulance routes, 'crisis tourists', etc).

Athens International Airport (AIA)



Athens International Airport (AIA) daily works with a mixed crowd type: people of quite different age, sex and ethnological background. In the airport, large crowds are distributed at quite different regions and locations; the crowd consists of a large amount of elderly and disabled persons of low moving capabilities, speaking different languages. Throughout the building, the crowd density varies. Another notable feature of an international airport is that persons are carrying items (sometimes quite heavy). The Athens International Airport has strict evacuation procedures, which will not be affected by the eVACUATE system. The demonstration of the eVACUATE system focusses on the needs of an Active Evacuation Route due to cascade effects (different incidents at the same time or a complex combination of incidents) and on localisation of people (unusual behaviour) during the evacuation. It might be possible to demonstrate and cope with learnings from the Brussels airport attack (March 22nd, 2016).

In this second pilot some improvements in the eVACUATE system have been implemented. We have given the volunteers a better opportunity to have a look inside the system and to be aware of the impact of their movements on raising alerts and alarms in the control room. In further pilots the focus will be on the improved integrated functionality of eVACUATE systems, and emphasize its added value for end-users.

After the evacuation exercise a simulation exercise has been performed, only for end users, without volunteers. The simulation exercise is dedicated to a full demonstration of the potential of the eVACUATE system. The simulation exercise is based on an oral demonstration of the functionality of the COP and EMS. The simulation exercise is also to ask feedback from end-users on the system for further improvements.

End users emphasised the positive outcome of achieving to better evacuation times, even in a building where the times are already low and the routes to safety are relatively short. In general end users seem to be impressed with eVACUATE's functionalities and they consider it as an important system especially for airports.

MSC MERAVIGLIA Cruise ship (STX)

In the cruise ship scenario, mixed crowd types are used: elderly persons, families with kids, (groups with) disabled persons, etc. The cruise ship has got predefined assembly areas and well trained crew for evacuation procedures. The ship deals with limited exits. Depending on the type of accident, the evacuation should be quite fast. Well-trained crew inform people according to the current situation. The eVACUATE system analyses and validates a large number of evacuation scenario's in short time, in order to be able to see the differences between the current procedure (go to your cabin, get your life jacket and go to mustering station) and other procedures (go to mustering stations and receive your stored life jacket at that place). In addition, disabled people, needing help from crew during the evacuation, will be able to use the help-button on the mobile app, being developed in the eVACUATE project.

We divided the (ca. 100) volunteers into four groups and the started in each run in the same position. We did four evacuation runs and measured the time needed for the evacuation. Without blockages the evacuation times are comparable, which is to be expected since everyone knows the route from the way up and the signals are not really needed. In case of blocking the route on one side the evacuation time increases (mainly because the route is longer), but with signals the evacuation time is about 25% faster. The decrease in evacuation time is due to using the best evacuation route from the start.

An introduction of the mobile app eVAMAPP went well and we demonstrated it successfully to the volunteers interested after the last evacuation run. It was a unique opportunity to test a more complex route that includes both horizontal (as in the airport) and vertical, deck-to-deck transitions (unique to the ship scenario).

San Mames Metro Station Bilbao (METB)



Specific problems in the metro network vary from too many people struggling to enter the station to overcrowded platforms. Typical incidents in the metro stations are persons falling (on the track), an explosion in the train or station or a train accident in or close to the station. Existing systems give no information or just a few details on ticketing information, crowd flow, estimation of number of passengers and crowd distribution. The scenarios in the pilot demonstration focus on decision making to avoid panic and on communication with security personnel and public about active and safe evacuation.

The pilot demonstration took place in Sam Mamés metro station in Bilbao, one hour after midnight. The preparations for the evacuation exercise started 1.5 hours earlier, after the metro station closed up for the night.

We had approximately 90 volunteers available in the evacuation exercise, among which about 15 interested security personnel to attend the exercise at the location of COP. All explanations were held in Spanish, which was difficult to follow by the rest of the eVACUATE team. The evacuation exercise was divided into 5 loops. The last loop was a complex one including setting of smoke alarms, manual alarms and a full evacuation scenario in which one of the exits was blocked. Nevertheless the evacuation loops with the dynamic exit signs went successfully and resulted in a 20% decrease of the evacuation time. The loop was preceded with a smoke alarm (WSN sensor) generating the blocking of one exit and luggage left unattended detected on CCTV, initiating the evacuation decision.

The last pilot demonstration was the most successful and highlighted our progress and strong team work. Strong progress has been made with regard to all team efficiency.

We used the simulation exercise to explain and demonstrate the next morning what was achieved in the evacuation exercise, using video recordings. This way we could fully explain the script and the eVACUATE potential, while discussing the implications for the end-users perspective.

3.2.11 Lessons learnt from field test activities

Anoeta Stadium Real Sociedad (ASRS)

Four end users from Basque police, civil protection and Real Sociedad security dept. followed the exercise from the start. They received a guided tour in the exercise area and got explanation of the technology in place. They were very impressed by the solution we are developing. During the exercise they watched the COP (press room) and its interaction with the crowd movements in the stadium. Occurring alarms were explained by eVACUATE team members. An extra live stream camera would have been helpful to get a total picture of the exercise.

- First of all, they were very impressed by the solution we are developing.
- 3D modelling is interesting from the end users point of view. They mentioned the benefits of tunnel modelling (to be able to look inside a building, by removing layers). End users discussed the possibility to integrate the 3D model with WMS systems and/or with the outer area of the stadium (with parked cars, first responders' location, ambulance routes, 'crisis tourists', etc).
- Floor signs will not be seen by evacuating public in the corridors. A stadium might not be the most effective place to use the floor exit signs. The wall signs showed to be helpful for visitors to find the fastest way out.
- 25% improvement is a good result, although the sample is too small.
- Integration with social media alerts is innovative and an interesting feature for the club. Also the possibility to bypass the automatic functioning of the system is a good choice, from the end users point of view.
- Regarding the placement of such a decision support system in emergency centers: extra screens would be necessary + extra personnel to operate.
- End Users also focused on the importance of having the system connected with external emergency management systems (as stated by the Civil Protection respresentative in the video).
- Information sharing or even the integration with other First Responders such as Firefighters, Emergency Coordinators from 112 or Red Cross is very helpful in these situations, and they were happy that we have done this kind of integration. Local Police commented that they use different systems than the others and we should also take them into account.
- It would be very interesting to enhance the eVACUATE system outside the stadium, and integrate functions like:
  - Closing of some streets to the traffic, or to pedestrians
  - Traffic or pedestrian deviations
  - Monitor or supervise hospital saturation

Athens International Airport (AIA)

The system was demonstrated to the following stakeholders who were present:

- ✓ the EU Project Officer
- ✓ AIA as an end-user
- ✓ Police (directly involved in the operational handling of an evacuation).

- ✓ Security Company representatives employed at the Airport (who are directly involved in the operational handling of an evacuation).

Most of the feedback received was very positive due to the following reasons as highlighted by the end-users:

1. Using eVACUATE, we achieved to have better evacuation times.
2. eVACUATE provides added value in an operational crisis as it expedites the emergency response. They consider as major issue this lack of communication currently existing.
3. They claimed that eVACUATE in airports seems very helpful, providing an added value to the day-to-day operations, (especially during crisis).
4. Real time notification and communication is a valuable tool offered by Evacuate, allowing security personnel identifying the nature of a, a threat currently accomplished only through the CCTV capability
5. Automation in alerting and communication is also a valuable issue offered by eVACUATE. Very useful especially for security personnel that they are trying to identify a threat currently only through CCTV feedbacks.
6. In general the end users were impressed with eVACUATE's functionalities and they consider it as an important system especially for airports.
7. Social media functionality is also an added value especially if we consider that people are using them very frequently to communicate a new.
8. eVAMAPP was also a nice feature since it can provide some useful information to people (passengers) that have nowhere else to refer to for help during a crisis, preventing them as such from being panicked. A lot of potentials for being exploited commercially in relevant environments.

End-users main concern: The usage of RFID tags in tracking people down in a building was of concern given that several passengers print their boarding passes independently ticket but they have done the check-in electronically.

MSC MERAVIGLIA Cruise ship (STX)

The list of end-users participated in STX pilot are the following:

- Eric Lhotellier and Gerard Chaussee: STX safety and security managers
- Thierry Albert: STX Electrical and ICT department manager
- Gilles Castanie: STX ICT manager
- 2 Saint-Nazaire Firemen brigade managers (names not to be mentioned)
- 2 persons from Bureau Veritas classification society (names not to be mentioned)

With the end users an evaluation was held, resulting in a constructive discussion with the following questions being expressed from their side:

- What is the difference between eVACUATE and already existing system?
- Is eVACUATE able to connect to existing safety management system?
- Does the system require an exact count of people to generate evacuation routes? Can it work with approximated values?
- Is the project a product or still in development? Some end users seemed to be interested in a final product instead of a demonstration of specific eVACUATE functionality.

Metro Bilbao (METB)

More than 70 end users [1]participated in last pilot and during the final workshop the day after the pilot.

They were all very impressed with the eVACUATE deliveries and with eVACUATE main functionalities. An open discussion was done while some of the questions raised from their side were the following:

- Once an incident is detected is the evacuation change automatic?
- Which is the coverture of the RFID on the tickets? Nice to be not necessary to pass through the antennas. It's a very interesting technology for counting people
- Does the system detect the number of people?
- Is it possible to take advantage of the installed infrastructure?
- Is the detection of people thermic?
- How the different system does affects people in terms of radiation?

Common Feedback from all end users:

In overall they all claimed that the decision making as it is performed nowadays is significantly delayed/underperformed due to the lack of a complete picture/ enhanced situation awareness. Based on that and on what was demonstrated to the end users they all agreed that enhanced awareness and efficient response a system like **eVACUATE makes it happen**.

4. Potential impact and main dissemination events

4.1 eVACUATE mission and vision

"I saw people running and screaming towards one direction and then many were turning around to run back the other way"
Witness statement reported in the **mirror.co.uk** for Manchester bombing in May 2017

"There was panic as fans stampeded to an exit which was padlocked. Two or three burly men put their weight against it and smashed the gate open. Otherwise, I would not have been able to get out."
Witness statement reported in **BBC News** for Bradford Stadium Fire May 1985

eVACUATE Need: An evacuation in response to a risk or threat is the movement of people away from a designated area that is under threat to a safer area. The need for evacuation can arise from naturally occurring events, human induced events (both intentional and unintentional) and events caused by technological failures. Evacuating a large and complex facility such as a football stadium, a shopping mall, a cruise ship, an airport or even a metro station is a safety-critical and strictly time-bound task, which typically involves a number of people moving within a part or the whole of the facility assisted by a number of security personnel, and a complex decision making process based on the situational information available.

eVACUATE mission/vision. In most cases, evacuation plans insufficiently address the actual challenges of an evacuation, which include the human behavior during stressful situations, their diminishing fidelity over time as the facility evolves to adapt to new usages (a stadium may be used for concerts and this may have not be foreseen), their lack of resilience (in current evacuation plans there is only one pre-defined alternative route for each position within a stadium, while there are not alternative routes if both primary and secondary routes are blocked and may not respond to extended structural failures. **The current evacuation plans are static, failing to effectively manage evacuation situations that evolve and change over time**. Thus, real-time, dynamic management of the evacuation phenomenon is of paramount importance and paper-based evacuation plans are

[1] Names and occupation of attendees upon request

of low value in actual conditions. In reality, managing an emergency evacuation is a challenging task that requires knowledge of the situation as it unfolds. The dynamic capture of situational awareness concerning crowds in specific mass gathering venues and its intelligent enablement into emergency management information systems, is critical for achieving rapid response, timely guidance and safe evacuation of people. The algorithms in use today by evacuation modelling software, only calculate the movement time, based on the maximum “flow” of the crowd, which is however, only part of the evacuation time. All-important in every evacuation scenario is the total “required safe egress time” to complete an evacuation (RSET) that is the sum of the various time intervals required to: 1st detect a threatening event, 2nd assess, decide and notify safety personnel for the evacuation, and 3rd the time until the evacuation is complete [2,3]. This can be summarized as:

$$t_e = t_d + t_a + t_m \quad \text{(Eq.1)}$$

where t_e = time to evacuate and is the sum of t_d = time from ignition of the threat to its detection from the system, t_a = time from detection to notification and t_m = movement time.

Current safety procedures are thus plagued by paper-based, outdated evacuation plans, insufficiently trained personnel and lack of sufficient situation awareness. There is an apparent need for a solution that will support decision-making, increasing the potential for an effective response, and strengthening preparedness of the facility owners/operators. In real time, during an emergency the system needs to provide an accurate representation of the situation as it unfolds and maintain location-specific, dynamic evacuation route, regardless of the circumstances. This means that in the above equation Eq. 1, to decrease the evacuation time (te), (1) the detection time (td) needs to be minimized (hence the need for a multitude of sensors), (2) the time until the crowd starts evacuating shall be improved (need for improved situation awareness by safety coordinators, to ensure timely decision making, efficient communication mechanisms for mobilizing safety personnel and training of the stewards to implement the evacuation), while (3) the movement time (tm) need to be minimized (by optimizing the evacuation routes in real-time, also adapted to the evolving evacuation circumstances). Moreover, the need for a system that will support the complete lifecycle of planning, training/simulation, and assessment is vital.

eVACUATE is a Security Management Platform for enhanced situation awareness and real-time adaptive evacuation strategies for any large crowded facilities.

eVACUATE aims to address the needs of the safety of large facility visitors during complex evacuation processes, following normal and abnormal events (crises) and creates an easily deployable system that will be able to timely identify threats, designate and sustain an Active Evacuation Route, increase situation awareness and improve response times under any circumstances. Moreover it will support the complete lifecycle of evacuation planning, simulating complex scenarios, training of safety personnel and assessment of the performed actions.

4.2 eVACUATE anticipated impact

4.2.1 Increased situation awareness

First responders require effective physical tools, as well as intangible information tools, to evaluate and manage risk and, at the same time, increase their overall capacity for effective response. eVACUATE suggests and requires the adoption of information technologies that both increase capacity and leverage existing informational resources toward prevention and preparedness.

[2] Sfpe Handbook of Fire Protection Engineering 3rd Edition (Section 3 Chapter 14 of the SFPE Handbook 3rd ed.)
[3] Fire Protection and Evacuation Procedures of Stadia Venues in New Zealand, By Kristin Hoskin

a. To the evacuees. eVACUATE provides up-to-date real-time and actionable information and guidelines to the people while they move through the Active Evacuation Route through smartphone applications (eVAMAPP App.).

b. To the first responders in support of the evacuation operations. First responder crews are aware of what to expect during an intervention and are continuously informed on the evolution of the operation through Tetra messaging and smart phone applications (FR, missing person App.).

c. To the crisis managers at the Emergency Operations Centre and/or the venue managers. Ability to provide the COP (Common Operational Picture) to the decision makers in real-time, assisting them in the decision making process through the eVACUATE expert system.

4.2.2 Improved Command and Control Decision Making

The drawback with existing systems lies with the coordinated command and control operations that should coordinate the actions of the separate services and turn them into an effective, multi-faceted crisis response mechanism. Thus, police forces, fire brigades, and medical emergency teams that currently use outmoded mechanisms to interface with each other will be turned, using eVACUATE, into one coherent force, eliminating the duplicate application of force, sharing intelligence and information as it becomes available. eVACUATE's contribution, however, is not limited to this - its decision support features that help decision makers at command and control centers not only exert more centralized control over their forces, but to use this control in better ways in order to make better more educated decisions. Better decisions, in this context, can be characterized as decisions that are based less on assumptions that need to be made in the absence of concrete information, and more on information deduced through advanced data analysis

4.2.3 Better Coordination of Emergency Services in Real Time

The system promotes the sharing of information—force locations, reconnaissance results, risk assessments, etc. –during times of crisis. eVACUATE disperses the most up-to-date information it has immediately, and so gives more actionable information to decision makers to make a situation assessment. Thus, it helps them determine the best ways to neutralize the crisis. In turn, this will help save lives, cost and time when solving a crisis situation.

4.2.4 Effective public alert system

eVACUATE allows the rapid dissemination of the alert messages to emergency authorities and to citizens. At times of security event or crisis, this may prove to be a critical benefit. When considering the spectrum of possible events versus the "herd mentality" that may develop during these events, it becomes clear that the effective and concise transmission of alert messages to the population in the crowded evacuation area is critical. eVACUATE allows the controlled evacuation that can make the difference between a controlled crisis and a mass tragedy. Another example includes the dissemination of instructions to people on how to cope with the event.

4.2.5 Improved emergency force preparedness

eVACUATE creates new possibilities for preparing towards crisis events during normal times. eVACUATE achieves this by defining rules and serving technologies for emergency or crisis response and recovery as well as providing historic data after the crisis for assessment and possible redefinition of crisis plans. eVACUATE is not focusing solely on the reaction during the crisis or emergency event – on the contrary, it also cover the whole life cycle of the event. This increases emergency services preparedness, by defining rules for crisis management and a simulation tool for various scenarios generation and running.

4.2.6 Socio-economical benefits of the project

Natural or human-made disasters in large crowd hosting infrastructures invariably result in potential loss of life and material, the (partial) destruction of infrastructure, and the waste of thousands of person-hours for disaster recovery. Societies cannot afford to ignore the possibilities of disasters, and must do their utmost to limit their economic impact**. eVACUATE is doing much to reduce the high costs of disasters, since an effective crisis response leads to substantial monetary savings**. Evacuation situations are characterized by incomplete information based on which commanders need to make life and death decisions. By helping decision makers and the actual operatives take decisions based on better and more complete data, is effectively guiding people away from dangerous situations. eVACUATE helps limit the consequences of crises, ultimately saving human lives. **Thus the major societal impact is the increase of perception of security among citizens, especially in times where the threat of a terrorist attack in large crowded areas is considered as imminent, and the minimization of potential loss of lives or injuries during an evacuation due to timely and more efficient decisions taken with the help of eVACUATE.**

4.2.3 Contribution to Standards

eVACUATE Project is to support the standardisation activities of “CEN/TC 391 - Societal and Citizen Security” by taking into account the different approaches and local specificities which exist and provide input to European harmonisation activities.

The main objective of CEN/TC 391 is to elaborate a family of European standards, standard-like documents (e.g. procedures, guidelines, best practices, minimal codes of practice and similar recommendations) in the Societal and Citizen Security sector including aspects of prevention, response, mitigation, continuity and recovery before, during and after a destabilising or disruptive event. Verification and training will also be considered. **As a result of this contribution, some of the eVACUATE approaches related to emergency and evacuation will be included hopefully in the document “prEN ISO 22315 (WI=00391015) Societal security - Mass evacuation - Guidelines for planning (ISO 22315:2014),** document in status of “Under Enquiry” (its forecasted voting for approval date is February 2018)

4.3 Main features of the eVACUATE solution

Because of the complexity of the overall eVACUATE system we cannot describe all features in detail but we want to highlight the following ones that we consider the most important:

4.3.1 End-to-End platform for all involved actors in a crisis event

On the highest level, eVACUATE provides a suite of software elements that connects all involved actors in a crisis event. This leads to higher transparency that in turn means increased situational awareness, improved command and control decision-making as well as better coordination of emergency services in real time. At the same time, the system is also expected to save lives by supervising main actors (evacuees, FRs) position preventing them of running in to dangerous situations.

4.3.2 Interoperability with legacy systems

eVACUATE was from the beginning all about interoperability, which is crucial in building complex security systems. We provide interoperability on different levels. At the component level we apply apart from the most common technological standards (e.g. OGC Sensor ML, WSO2 CEP, MODBUS, Java Messaging Services, etc.) also custom interfaces to ensure interconnectivity of our system with other legacy sensors or actuators installed in any facility while on a systemic level, eVACUATE platform is capable of exchanging information with other emergency management systems by using international standards, such as the one established by the Advancing Open Standards for the Information Society organization (OASIS) regarding the information exchange to advance incident preparedness and response to emergency situations. More precisely by using the Emergency Data Exchange Language / Common Alerting Protocol (EDXL / CAP) to communicate with an existing external Emergency Management System such as iSAFETY®.

4.3.3 Collection of field data and data fusion in real time

The volume of data exchanged during a crisis event in which hundreds of people are involved can be huge. The data fusion techniques must therefore consider as a key point, the storage and management of data. The management of the data is based on Data Base Management Systems (DBMS), which use relational data models and query languages to provide data access. The role of the Data Fusion function in eVACUATE is to mediate between all the information collection elements at the front-end (mainly at the COP and EOC) and the rest of the applications at the back-office in order to implement a central point where all the gathered data are collected from the front-end, combined, analysed and fed into the applications developed for the back-office. This task will also include extraction of inferred information as a result of combining heterogeneous data from various sources (sensors, external systems, end-users).

4.3.4 2D/3D User interfaces

Ease-of-use is of highest importance, especially when operating such a complex system during a crisis event. eVACUATE will offer end-users various ways to interact with the system. eVACUATE's COP focussed on the presentation and visualisation of the available information in efficient and intuitive ways, so as to enhance the perception that back-office users have about the situation in the field. This perception is created from information coming from smart spaces, first responders or external sources (e.g. legacy systems). On the other hand, apart from presenting information, the UI enables the operators to perform several actions in order to control or react to events and incidents. eVACUATE users distinguish between three different levels of data representation depending on the level of information needed at each one. These are the *operational*, the *tactical* and the *strategic* levels. All these levels are accommodated by the UI design as well. eVACUATE developed both 2D and mainly 3D (using special equipment) user interfaces that provide basically precise multi-layered information on the way the AER is structured and the appropriate indoor guidance of FRs inside the crisis area.

4.3.5 Resilient communication and Interoperability network

eVACUATE has been designed in such a way that it does not depend on an existing telecommunication infrastructure, which may not provide that necessary bandwidth or might even not be available at all after a catastrophic event, such as a fire case or an earthquake where an evacuation is needed. In the project a communication gateway has been developed using (a) Crisis WiFi Network Implementation (MobiMesh) and (b) Seamless failover and failback implementation of communication gateway servers) technologies, towards the achievement of a seamless and resilient communication network. By providing at least 2 alternative communication channels in case of failure or overloading and supporting several technologies (Wi-Fi, Ethernet, 3G/4G, Bluetooth beaconing, etc.) the eVACUATE platform is exhibiting crisis support capabilities and connectivity between FRs and COP/EOC operator at any time and in any circumstances.

4.3.6 Non-discriminatory

All of the above-mentioned features support the fact that eVACUATE developed a non-discriminatory system. It not only frees civil protection organizations from costly vendor lock-ins, it also opens up the market for other players providing new equipment, applications and services. In fact it would allow growing its own ecosystem that everybody can benefit from. With eVACUATE civil protection organizations can choose their equipment based on their own requirements, such as pricing, performance, bandwidth, etc.

4.3.7 Mobile based communication and dispatch mechanism for personalized evacuation routing and guidelines to citizens and security personnel.

A Mobile Application platform developed as a component of the eVACUATE project is an application for the safety of spectators as well as for the dispatch of safety personnel. In case of an emergency, the application notifies the individual about the situation; the messaging mechanism is push notifications, thus the user is notified about the emergency, even if he is not currently using the application. Then the application supports the evacuation process by determining the actual position an evacuee (using state-of-the-art hybrid indoor and outdoor navigation to achieve accuracy of better than 5m) and indicating the directions for the nearest safe exit. It also helps identify visitors who do not seem to progress with the evacuation who may thus require assistance (this is also registered at the Security Operations Center to be managed by the safety command chain). It is proved that the safety manager gain increased awareness about the progress of the evacuation process, thanks to the connection of the mobile app with the COP. It is also proved that even in the case that not all the spectators have downloaded or activated the mobile application, the trends obtained on statistical indices (%) based on the situation and whereabouts of hundreds of users in an area will produce significant value for the situational awareness of the safety authorities. Citizens who wish to report an incident that could represent potential threat also use the application. The reported incident shows up on the COP screen as an icon, which the COP operator can select to get more details as in the following screenshot.

4.4 Main dissemination events

4.4.1 Organization of workshops

Two workshops were organized by eVACUATE consortium, dedicated to the stakeholders and industrials. The aim was apart from sharing the innovative outcomes of the project, also to increase the awareness of the Stakeholders community in the eVACUATE project results. Useful feedback from the end-users and stakeholders both in the beginning of the project (design phase) as well as during the end of the project (delivery phase) was received. The two workshops performed within eVACUATE project were:

Athens End-Users workshop 2014: An one day Workshop at 14th of November in Athens (Athens International Airport Premises) was scheduled, to promote the main ideas of the project and its current technological findings while informing/sharing with potential end-users, ideas upon ways to enhance security measurements especially when dealing with an evacuation process during a crisis event. The target group of this workshop was mainly focused on personnel specialized in security management issues and end-users from diverse areas both in a National as well as European level consisting of Airports, Cruise ships, Metros, Stadiums, Museums, Civil Protection Authorities, Shopping Centers, etc.

Bilbao End-Users workshop 2017: This workshop was organized by Metro Bilbao, in which the eVACUATE system was demonstrated and eVACUATE functionalities were described and explained to all participants. The target group of this workshop was mainly focused on personnel specialized in security management issues and end-users from public and private agencies with key role in crisis incidents when these happen.

eVACUATE participated as well in several other workshops like:

- *Models and Mathematical Tools for Complex Systems Workshop* (Turin, October 2013)
- *Biomat 2014*: bi-annual meeting with the main purpose of bringing together high level international researchers involved in the study of Complex Systems. Due to the high level of scientists invited as main lecturers, the congress is recognized as a fundamental meeting to capture the state of the art about these topics, both for senior and young researchers involved in the study of complex systems (among them, problems related to the study of crowd

dynamics) and in particular for people involved in these research from the point of view of applied mathematicians.

- *Simai 2014:* a bi-annual meeting that at national level brings together researchers involved in applied and industrial mathematics.
- *"Smart Spaces as enabler for the Internet of Everything*" Future Internet Assembly Workshop, Athens March 2014, aimed to provide a forum for Greek SMEs and research organizations to present their achievements and planned initiatives on innovative software and services that enable application innovation in the context of the Future Internet.
- *ISCRAM Workshop* on "Ethical, Legal, and Social Narratives for IT Design for Disaster Response." Kristiansand, Norway, 24.05.2015

4.4.2 Participation to exhibitions, congresses and other workshops

- ✓ **European Data Forum 2014**: **European Data Forum** 2014 on 19th - 20th of March 2014 which took place in Athens. EXUS participated as a platinum sponsor on this event and within this context, **the eVACUATE project was presented**. (www.2014.data-forum.eu)
- ✓ **Cebit Exhibition**, and specifically in the "Future Match" brokerage event (16-19th of March 2015): https://www.b2match.eu/futurematch2015/pages/how-it-works
- ✓ Participation to the **ISCRAM 2015 Workshop** on "Ethical, Legal, and Social Narratives for IT Design for Disaster Response**.**" in Norway, 24 May 2015.
- ✓ Participation in **InnovAthens** (http://www.innovathens.gr), the Hub of Innovation and Entrepreneurship of Technopolis Athens that was held in October 30th 2014, by presenting the eVACUATE project and how Internet of Things technology, already applied in Smart cities, can be also exploited in next generation systems for security purposes.
- ✓ Presentation of our innovation activities in the **Smart City Wold Congress** celebrated in Nov 2015, including evacuate. The relevance of the project was shown in Indra's venue with special emphasis on municipalities' mayors.
- ✓ Presentation in the **IoT Congress** celebrated in Barcelona October 2015, our Smart Cities Innovation offering, including eVacuate. We also have leaflets of the project in our stand to inform about the project.
- ✓ Participation in **European Satellite Navigation Competition 2014**, in Athens November 25, 2014 and again on May 1 2015, presenting the eVACUATE (and specifically the Mobile App for the Safe evacuation of passengers.
- ✓ Participation at the **TACTIC workshop 2 for Case Study 1: Terrorism in Europe,** that took place in November 3, 2015 in London
- ✓ Participation in **IDEX 2015** and **2017** that took place in Abu Dhabi.
- ✓ Participation in **GLOBAL SECURITY ASIA 2015** that took place in Singapure in March 3rd, 2015
- ✓ Participation in **MILIPOL 2015** that took place in Paris in November 17-20, 2015
- ✓ Participation in **ACI Europe AVSEC Committee**, held in Prague, October 2013
- ✓ Participation in **Posidonia 2016 – International Shipping Exhibition** (6-10 June 2016, Athens – Greece) (www.posidonia-events.com) exhibiting eVAMAPP application and Missing Person Application
- ✓ Participation in **Seatrade Europe Cruise & River Cruise Convention** (6-8 September 2017, Hamburg - Germany) (http://seatrade-europe.com)
- ✓ Participation in **Researcher's night** in October 2015 inAthens, Greece, that takes place every year in more than 30 countries and over 280 cities in which eVACUATE was demonstrated, disseminating eVACUATE projects results to the research community.

Details on eVACUATE website: http://www.evacuate.eu/news-events/other-events/past-events/researchers-night-in-athens-october-2015/

- ✓ Participation in **ASIA PACIFIC CHINA POLICE** in Beijing, 20/05/2016-23/05/2016: Vitrociset presented the eVACUATE project and solution for emergency management in critical infrastructure evacuation.
- ✓ Participation of eVACUATE project in **21st Security Commission** meeting in Zurich, Switzerland in April 2016
- ✓ Participation of eVACUATE project in **World ATM Congress 2017**,March 7-9, Madrid, Spain
- ✓ Participation of eVACUATE project in **Aeromart Toulouse**, November 29 – December 1, 2016, Toulouse, France

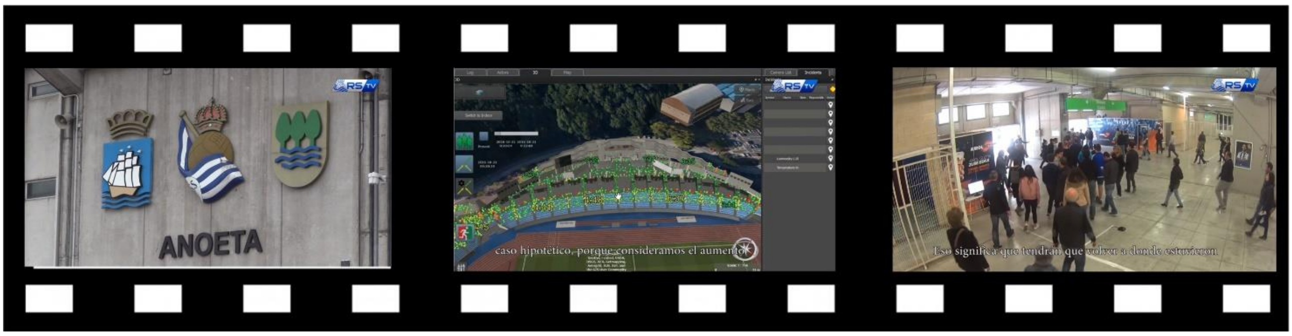
4.4.3 Videos and Photos

During the project duration, 1 video was designed by some partners to promote the eVACUATE concept while 4 more videos were designed by end-users, in order to explain the functioning of certain parts of the system, or to present results of the field tests. All videos are uploaded on eVACUATE website under the link and also available in Youtube:

http://www.evacuate.eu/publications/media-center/videos/

The following videos (available online) showing the eVACUATE consortium/platform in action during the field tests:

OPERATION 1: eVACUATE in **ANOETA STADIUM**, San Sebastien, Spain



OPERATION 2: eVACUATE in **ATHENS INTERNATIONAL AIRPORT**, Athens, Greece

OPERATION 3: eVACUATE in **MSC MERAVIGLIA CRUISE SHIP**, Saint Nazaire, France

OPERATION 4: eVACUATE in **SAN MAMES METRO STATION**, Bilbao, Spain

Several photos can be also found from each pilot activity in website under the link below:

http://www.evacuate.eu/publications/media-center/photographs/

4.4.4 Newspapers, press releases and interviews

- ✓ An interview performed within the frames of the **European Union's Research and Innovation Magazine** www.horizon-magazine.eu in which the eVACUATE Coordinator (Dr. Petrantonakis Dimitris) was questioned about security aspects in general as well as for the main deliveries implemented within the project and how they will impact to the real world within the next decades. More details in the article 'High-tech grass helping shape Euro 2016' which features your work on the eVACUATE project.
- ✓ Crowd Dynamics' eVACUATE work disseminated in **Stadia magazine September 2015**, page 42. http://viewer.zmags.com/
- ✓ eVACUATE Project has been published on the **Vitrociset Project Book** distributed to ALL our stakeholders and Partners. http://www.vitrociset.it/brochure/Project%20Book%202012_it/files/basic-html/index.html
- ✓ **Several press releases** have been also performed in corporative portals announcing project's objectives and concept while all can be found in the link below: http://www.evacuate.eu/publications/dissemination-material/other/
- ✓ Ik4- Tekniker gave an **Interview into Radio Euskadi** (part of the public radio and TV group "EITB) about eVACUATE Project (audio file) (link)
- ✓ **Virtual Lectures** carried out by INDRA presenting the Project to the Company audience in the "Virtual Aula" (Virtual Lectures).
- ✓ **INDRA** published in "**EL Mundo",** Spanish biggest Newspaper, an article about eVACUATE: **"Evacuar anoeta un 23% mas rapido on el internet de todo"** http://www.evacuate.eu/publications/dissemination-material/articles/el-mundo-newspaper/

4.4.5 Brochures, posters, flyers and Newsletters

In order to introduce eVACUATE to various stakeholders, an envelope formated flyer was created during the first year, presenting the project overview, objectives, and foreseen platform, as well as the consortium members. Apart from that several other material was created for dissemination, explaining and promoting eVACUATE in a more visual manner, such as leaflets and Project inclusion in EU catalogue 2013 (see figure below). 3 Newsletters have been created and also distributed to the stakeholders community of eVACUATE to keep the synced with project's innovations and deliveries. Each partner is able to print this material and use it to visually present eVACUATE during conferences, fairs or various events. This material was also used during field tests to explain our project to end-users, external people and volunteers joining the exercises.

4.4.6 Presentations and scientific publications

During the project life, consortium members presented their work and the whole platform to various conferences, meetings, workshops while several publications in national and international journals were written by eVACUATE consortium. During the first project period, **12** presentations were done in international and national events. **14**[4] presentations were made in during the second project period. During the third project period **25** presentations of eVACUATE project in journals and conferences and **3** lectures about *Kinetic Theory & Modeling of Behavioral Social Crowds* from one of our partners in different Universities .In order to share our results with the scientific community all uploaded on website. The total number of publications consists of scientific articles conferences and book chapters. Further details about eVACUATE publications in the links:

http://www.evacuate.eu/publications/scientific-publications/

4.4.7 Dissemination package

In order to disseminate eVACUATE results to workshop attendees and to the invited observers, specific materials were designed for them:

- **Plastic envelopes**: it allows giving all information about eVACUATE easily.
- **Notebooks**, **accessories, and pens**: small accessories as presents to invited personnel.
- **eVACUATE information**: in a folder specifically designed for eVACUATE containing the project flyer, EXODUS dissemination material and project information.

[4] Exhibitions, press releases and other events have been excluded from the number of presentation counted per project year

5. Consortium and Contact Point

The eVACUATE consortium consists of the following industrial, academic and research partners:

EXODUS S.A. (EXO) www.exodussa.com	KU-Leuven (KUL) www.law.kulueven.be
University of Southampton IT Innovation Centre (ITINNOV) www.it-innovation.soton.ac.uk	DIGINEXT (DXT) www.diginext.fr
Institute of Communications and Computer Systems (ICCS) www.i-sense.iccs.ntua.gr	Politechnico Di Torino- Dipartimento di Mathematico (POLITO) www.polito.it
HKV (HKV) www.hkv.nl	STX France S.A (STX-FR) www.stxeurope.com
Telesto Technologies (TEL) www.telesto.gr	Technische Universität Dresden (TUD) www.ccn.et.tu-dresden.de
TEKNIKER-Ik4 (TEK) www.tekniker.es	Technische Universität Chemnitz (TUC) www.tu-chemnitz.de
Athens International Airport (AIA) www.aia.gr	Real Sociedad De Futbol S.A.D (ASRS) www.realsociedad.com
Vitrociset (VITRO) www.vitrociset.it	Metro Bilbao S.A (METB) www.metrobilbao.net
Crowd Dynamics International (CDI) www.crowddynamics.com	Telecom Italia (TIM) www.telecomitalia.it
INDRA (INDRA) www.indracompany.com	

For more information on the project, please contact Dr. Dimitris Petrantonakis (dpetr@exodussa.com), or visit the project's web site www.evacuate.eu