PROJECT FINAL REPORT

"**Publishable"**

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Name, title and organisation of the scientific representative of the project's coordinator:

Dr. Christos Giachritsis, Project Manager, BMT Group Ltd

Tel: +44 (0)20 8943 5544

Fax: +44(0)20 89779304

E-mail: cgiachritsis@bmtmail.com

Project website address: http://www.getaway-project.eu/

Final publishable summary report

Efficient evacuation from transport terminals in an emergency can be constrained by the complex nature of the buildings. In such circumstances, people often attempt to evacuate via the way they entered the building, bypassing or ignoring emergency exits, due to a lack of detailed knowledge of the building layout and situational information. While terminal staff and fire and rescue personnel have their roles and responsibilities in managing the evacuation and rescue, they cannot be located everywhere throughout the station and they may not be able to reach the population quickly enough. Managing safe evacuation becomes even more challenging in situations involving a rapidly changing environment, such as may result from a fire or a terrorist lead situation, where it becomes difficult for terminal staff and the population to maintain an accurate situational awareness.

A well-established means of facilitating evacuation within the built environment is the application of emergency signage systems, which are used to convey wayfinding information to the evacuating population. However, recent research demonstrates that only 38% of people ‘see’ conventional static emergency signage in simulated emergency situations, even if the sign is located directly in front of them and their vision is unobstructed. Furthermore, emergency signs normally convey single and passive information; therefore, they are not adaptive to the situation and flexible evacuation strategies. In serious fires, the inability to locate emergency exits and inefficient evacuation management can lead to loss of life as in the Kings Cross Underground Station (1988) and Düsseldorf airport (1996) fires.

The EU FP7 GETWAY project addressed this problem for transport terminals through the development of an Intelligent Active Dynamic Signage System (IADSS), which routes terminal passengers to their optimal exit according to the distribution of occupants and the nature of the evolving incident. The idea of the IADSS is to make use of up to date situational information collected through existing sensory systems (e.g. CCTV, fire detection system, etc.) to automatically access all the possible evacuation options using faster than real-time evacuation simulation in order to identify the most appropriate evacuation option (the intelligent component of the IADSS) and then to implement the identified evacuation option using the Active Dynamic Signage System (ADSS).

The Intelligent Active Dynamic Signage System (IADSS) was developed through the GETAWAY project in three steps: First, through the introduction of lit, flashing and running signs, the traditional static emergency signage system is transformed into a Dynamic Signage System (DSS). The increased affordance offered by the DSS significantly increases the detectability of the emergency exit sign. Second, by linking the DSS to the alarm system, the DSS will only be activated when needed, thereby overcoming the ‘learnt irrelevance’ of emergency signs, thereby becoming an Active Dynamic Signage System (ADSS). Finally, the ADSS is linked to a decision support system utilising CCTV feed, Fire Detection System information and evacuation simulation to automatically and rapidly rank existing evacuation strategies as the incident develops, bringing intelligence to the selection of evacuation strategy resulting in the Intelligent Active Dynamic Signage System (IADSS). In summary, the application of the IADSS enables the terminal Incident Manager to direct the building population to follow an intended optimal evacuation procedure based on available situational information by activating the appropriate dynamic signs. Therefore, the IADSS is more efficient in guiding people in an evacuation in a safer manner, compared with the standard emergency exit signage systems. The following benefits of the IADSS have been demonstrated through actual live trials using the IADSS in a realistic application within a rail terminal:

- A significant increase in the numbers of people using the indicated exit (i.e. following the intended evacuation procedure) instead of their nearest exit (which may become unsafe or unviable due to the incident).
- A positive influence on evacuating persons in that they did not find the new signage design confusing.
- Increased confidence for evacuating persons that they were moving in the correct direction and that they had selected the correct exit.

The GETAWAY IADSS is a direct upgrade of standard emergency signage systems to improve the efficiency of signage conveying information to people in an emergency evacuation. Subject to the requirements, the upgrade can range from one-to-one replacement of the existing emergency exit signs to a substantial enhancement to the entire signage system, which integrates signage, detection and CCTV systems with added intelligent features to provide a comprehensive solution.

The full IADSS comprises of five subsystems: Active Dynamic Signage System (ADSS), Fire Detection System (FDS), CCTV Analysis Engine (CAE), Decision Engine (DE) and Evacuation Simulation Engine (ESE) (see Figure 1).

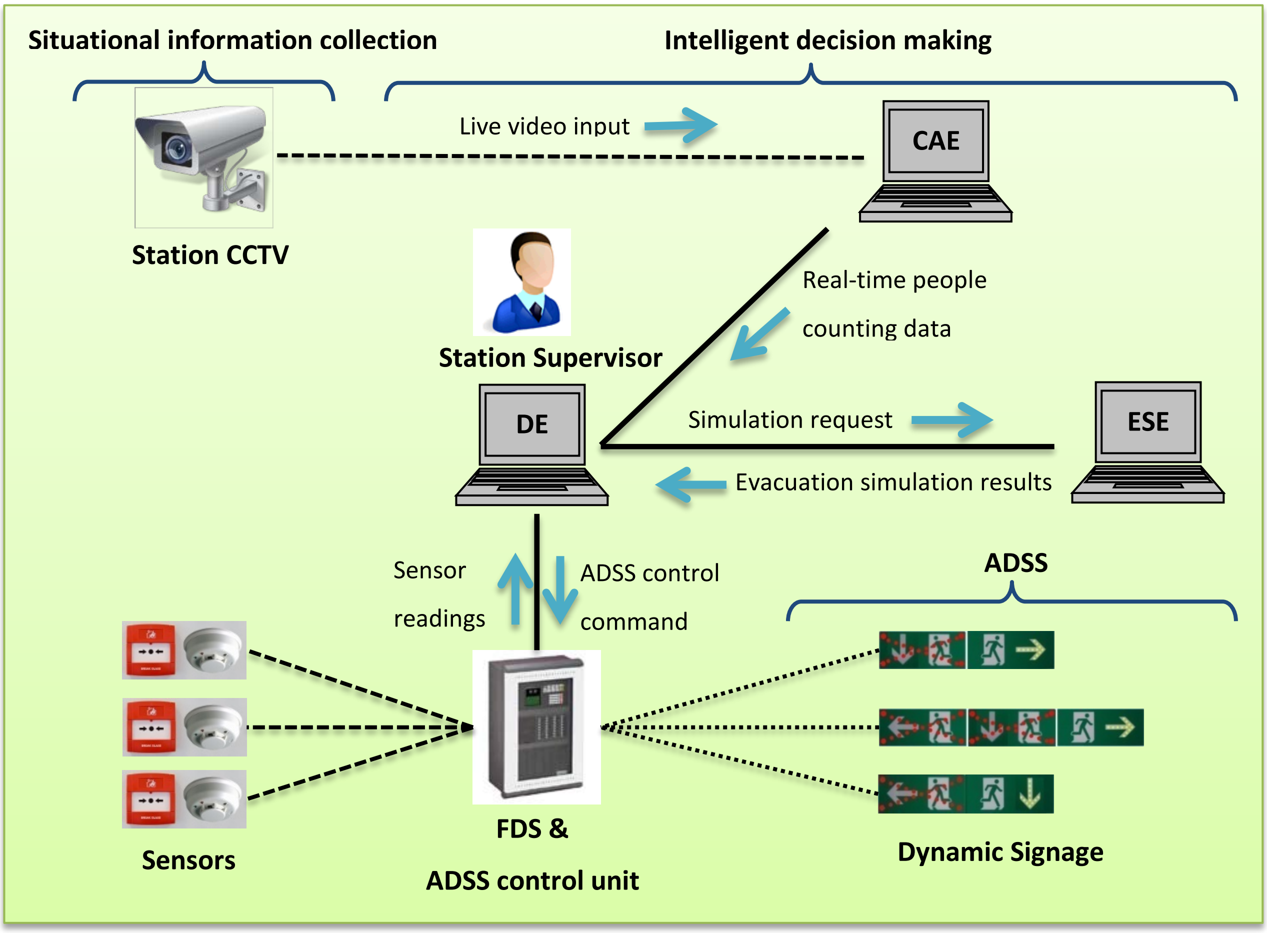

Figure 1: The IADSS (GETAWAY system).

Active Dynamic Signage System (ADSS)

The dynamic signage design is proposed to enhance the signage affordance while maintaining the maximum compliance with existing signage regulations and practice (e.g. Directive 92/58/EEC, EN ISO 7010). This design increases the detectability of the signs through the introduction of lit, flashing and running signage component (see Figure 2) to the existing standard signage design. The conventional static signage system is then turned into a dynamic signage system (DSS), whereas the size of the sign and the format of the signage information remain unchanged. Moreover, the dynamic nature of the sign (i.e. the flashing cycle) is only activated during an emergency situation when the alarm is tripped, thereby overcoming the ‘learnt irrelevance’ of emergency signs.

Figure 2: An example of the dynamic exit sign based on the standard exit sign design showing the flashing arrow in four successive phases.

The new dynamic signage design was tested through a series of experimental trials as part of the GETAWAY project to quantify the effectiveness of the design and compare that achieved by the conventional signage. The results of the laboratory based trials show that 77% of people ‘see’ the dynamic sign and 100% of them go on to follow the sign. This is a significant improvement compared with the conventional signage which is only ‘seen’ by 38% of the testing population under almost identical experimental settings and conditions. In addition, the results show the dynamic signage reduces the time people spend on choosing the direction of evacuation at places where doubt exists about the choice of escape route or exit. The increase in detection rate and the reduction in decision time mean the dynamic signage had a more significant impact on participant exit selection than the conventional static signage.

Furthermore, it is considered important to convey to the population that a normally viable exit route is no longer considered safe, for instance, if information from Fire Detection System suggests so. Thus, exit directions which are considered potentially hazardous are effectively shut down by negating emergency exit signs pointing in those directions. As with the flashing light concept, it is desirable to develop a negated sign which could replace existing signage on a like for like basis, is easily interpreted by the population, is relatively inexpensive to install and which would fail safe should it fail to operate. Several new negated design concepts to indicate that an exit route highlighted by an emergency sign is no longer viable were tested via international survey to gauge understanding of the new signage concept. The results demonstrate that a simple red cross passing through the entire sign (see Figure 3) is correctly interpreted by over 90% of the sample as indicating that the exit route is no longer considered viable and so should not be used. Thus in addition to highlighting the desirable emergency exit route, dynamic signs may also be able to highlight which routes should not be taken.

Figure 3: Negated signage design in operation depicting a single operation cycle.

Both dynamic signage design concepts were tested through full-scale evacuation trials that demonstrate, quantify and evaluate the performance of the IADSS as a whole in a realistic application within a rail terminal. The results show that the ADSS concepts succeeded in directing 66% of the test population to the desired target exit, while only 34% of the population made use of their nearest exit, compared with 100% in the baseline trial using conventional passive signs.

Fire Detection System (FDS)

The Fire Detection System (FDS) has two functions within the IADSS. First, the FDS manages sensor readings and sends the data to the core component of the IADSS, where the information is used to form situational awareness concerning the environment. The IADSS can assess and suggest evacuation strategies that best avoid areas considered potentially hazardous. Second, considering the capability of the FDS in connecting and controlling devices across the building, it can be adapted to receive instructions from the core component of the IADSS to configure the signs and active them accordingly (turn flashing signs on or off and switch between the green arrow and red-cross symbols).

CCTV Analysis Engine (CAE)

The CCTV Analysis Engine (CAE) connects to an existing CCTV and use the live video input to identify the location and number of occupants in the building. This information is then sent to core component of the IADSS, where the information is used to form situational awareness concerning the occupancy status. Based on the distribution of the occupants, the IADSS can assess and suggest evacuation strategies that direct people to use routes that are less hazardous and more efficient.

Decision Engine (DE) and Evacuation Simulation Engine (ESE)

The Decision Engine (DE) and Evacuation Simulation Engine (ESE) are the core components of the IADSS which are responsible for identifying the optimal evacuation strategy (see Figure 4). Within the IADSS, the ESE runs faster than real time evacuation simulations for pre-defined evacuation strategies, taking into account the situational information collected by the FDS and CAE. The DE utilises the simulation results to identify the optimal evacuation strategy, which is considered to be not only more efficient, but also safer than the others.

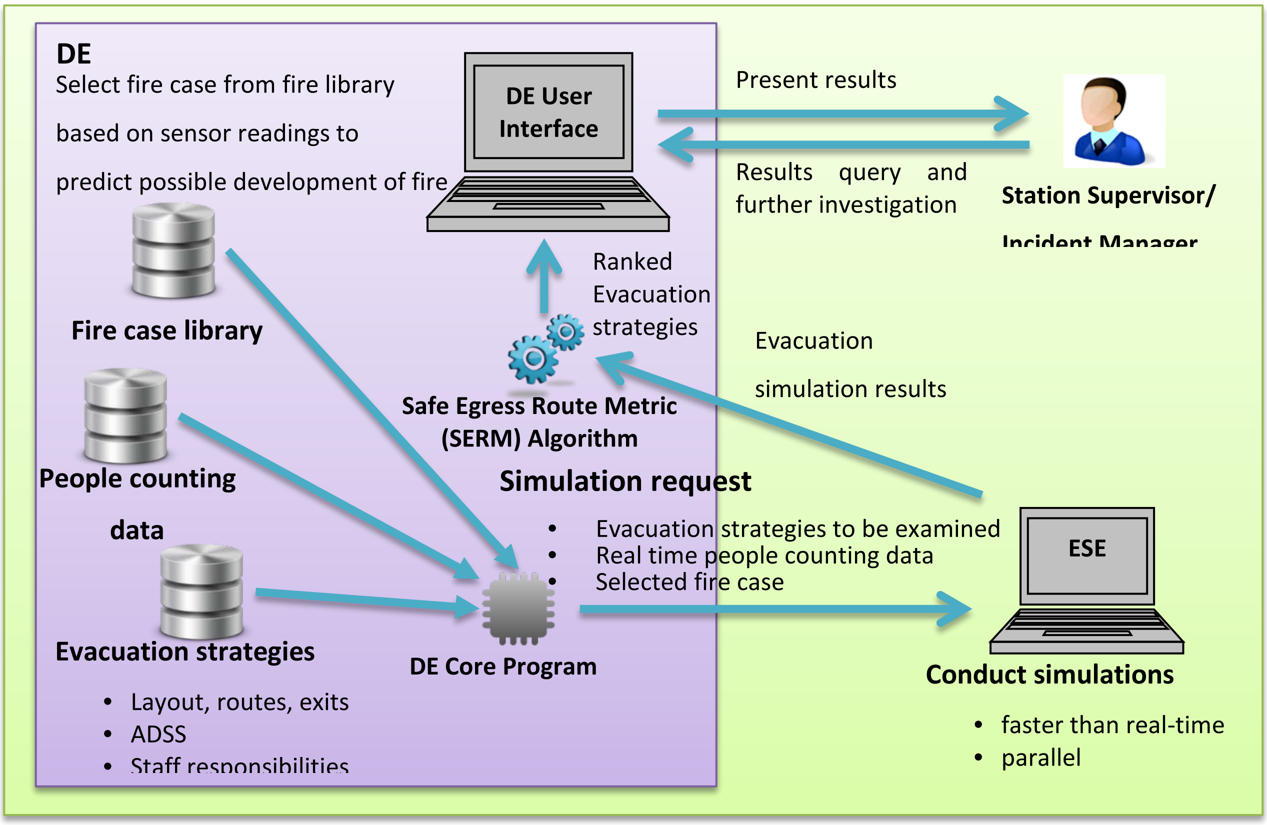

Figure 4: Intelligent decision making within the IADSS.

The level of IADSS application

The application of the IADSS is scalable and therefore, subject to the upgrade requirement and the features of existing peripheral systems, the upgrade of an existing signage system to IADSS can have several levels. The upgrade requirement concerns the size of the building and the complexity of wayfinding within the building. Small buildings or buildings with simple routes may require a modest IADSS configuration, while bigger buildings and buildings with complex routes may require a comprehensive IADSS configuration. Furthermore, the IADSS will make use existing peripheral systems such as FDS and CCTV. The features of these peripheral systems will influence the extent of the IADSS configuration.

In general, there are three levels of IADSS configuration.

Level 1: The first level is the simplest upgrade which involves a one-to-one replacement of the emergency exit signs with the dynamic exit signs. The dynamic signs will have the flashing green arrow activated when triggered during an emergency evacuation. The increased affordance offered by the dynamic signs will increase the detectability of these signs in an emergency, hence reinforcing the compliance with the direction indicated by the signs. This level of IADSS configuration is suitable for small buildings with simple routes, where the enhancement of the compliance with a single evacuation strategy is required. It can also be used in large complex buildings that do not possess a comprehensive CCTV coverage and a continuously staffed security control centre.

Level 2: The second level is the medium upgrade. This level of upgrade involves upgrading to an IADSS without the intelligent decision-making components (i.e. the CAE, DE and ESE) that support the selection of evacuation strategies. The IADSS will include dynamic exit signs that can be activated with either flashing green arrow or flashing red cross. For this installation to be most effective, it is essential for the building to have extensive CCTV coverage and a FDS as well as a continuously staffed control centre. These peripheral systems provide situational information to help the Incident Manager decide what evacuation strategy to implement. Then the signage system can be configured and activated accordingly. This level of IADSS configuration is suitable for complex buildings with multiple manageable evacuation strategies that could be subjected to different types of threats.

Level 3: The third level is the most comprehensive upgrade which involves upgrading to a full IADSS as illustrated in Figure 1. The IADSS will include FDC to detect the early sign of an incident and CCTV and CAE to monitor the occupancy status of the building. The information will be used by the intelligent decision-making components, i.e. the DE and ESE, to rank pre-defined evacuation strategies in order to support the Incident Manager in making a decision on the selection of evacuation strategy. Finally, the signage system can be configured and activated according to the selected evacuation strategy. This level of IADSS configuration is suitable for complex buildings with multiple manageable evacuation strategies that could be subjected to different types of threats and which require support in deciding the optimal evacuation strategy.

The GETAWAY IADSS can be applied as a direct upgrade of existing emergency signage systems to improve the efficiency of signage conveying information to people in an emergency evacuation. The IADSS will be most applicable in complex environments that may offer occupants a choice of many exit routes and where it is possible that one or more exit routes would be unusable in certain emergency situations. For example, the following building profiles will benefit from the IADSS:

- Large service providers such as major railway and underground stations, airport terminals,
- Large multi-storey office buildings, large hotels, hospitals,
- And other large public buildings such as stadia, music venues, museums, libraries, shopping malls, university buildings, etc.

Beneficiaries

Name	Contact	Email
BMT GROUP LIMITED	Dr. Christos Giachritsis	cgiachritsis@bmtmail.com
UNIVERSITY OF GREENWICH	Prof Edwin Galea	E.R.Galea@greenwich.ac.uk
EVACLITE LIMITED	Brian Stevens	bstevens@evaclite.com
Ferrocarrils de la Generalitat de Catalunya	Albert Tortajada i Flores	atortajada@fgc.cat
HOCHIKI EUROPE (U.K.) Ltd	Paul Adams	padams@hochikieurope.com
VISION SEMANTICS LIMITED	Robert Koger	rpkoger@visionsemantics.com
LONDON UNDERGROUND LIMITED	Paul Ebbutt	Paul.Ebbutt@tubelines.com
KINGFELL BULGARIA EOOD	Paul Bryant	paul.bryant@kingfell.com
BMT TECHMAR NV	Jenny Rainbird	jrainbird@bmtmail.com

Website

URL: http://www.getaway-project.eu/

Contact: Dr Christos Giachritsis

Senior Research Scientist (Project Manager)

BMT Group Ltd

Goodrich House

1 Waldegrave Road

Teddington

TW11 8LZ

United Kingdom

Tel: +44 (0) 7795364419

Fax: +44 (0)20 8977 9304

Email: cgiachritsis@bmtmail.com