FP7-313161

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

# D5.6 COPSI Final Release

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## Table of Contents

## Table of Figures

# Executive summary

WP5 has two primary goals, resulting in the 'COPSI' system. The first is to provide the user with an interactive Common Operational Picture (COP) system. The second goal is to provide the eVACUATE system the means to Simulate (SI) evacuation information for pilot scenarios where this information is not producible by other means.

This document describes the results of the eVACUATE Work Package 5 COPSI, for the period M1 to M42. It is a comprehensive list of the features developed in the D5.6 COPSI Final Release software, a description of their functioning principle and their usage.

The first chapter describes the COPSI architecture and the dataflow. The next chapter describes WP5 sub-systems extensively, respectively the Common Operational Picture and Simulation.

# 1. COPSI Architecture

## 1.1 Global Architecture

The 3D Interactive Common Operational Picture and Simulation has two main objectives.

The first objective is to **develop a novel visualisation system** to enable operational staff to have a clear, synchronized, and interactive view of the evacuation (Common Operational Picture) for indoor and outdoor situations.

The second objective is 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, the eVACUATE project 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.

The COP client software is the main software end-users will have in their hands. Each COP client software is connected to a locally deployed COP server. The COP server acts as a gateway between the clients and the eVACUATE Framework. The COP server mirrors information gathered from the eVACUATE Framework and processes it to be quickly displayed on COP clients. This way, several COPs can be connected to the same situation and share common information.

The SI software is the system simulation component. It is responsible for generating and managing a large number of entities in each of the scenarios, as well as the incidents they must react to.

## 1.2 Inputs and Outputs

This section gives an overview of all input and output connections of the COPSI sub-systems.

The COP module displays a clear view of the venues and the prevailing situation, forecasts future crowd movement, congestion and optimum routes. This goal is achieved by displaying, on top of 3D models venues, an intelligent representation of the different data produced by other eVACUATE sub-systems. The main inputs for the COP are the *WP3 Crowd information, WP4 Crowd predictions & Active Evacuation Routes, WP7 Sensors data and WP8 Alert notifications*.

The Simulation module can be seen as a sensor simulator. This module outputs information directly into the WP9 eVACUATE Framework like a genuine sensor would. This architecture enables a seamless switch between real and simulated information. The Simulation module gives the user a scenario editor tool which includes crowd simulation and incidents simulation features. This helps the user create validation or training scenarios to compensate the lack of evacuation information for pilot demonstrations.

The list hereunder describes the nature of data exchanged between WP5 and other system constituents:

- Crowd features extracted from the video streams by WP3, containing crowd density, crowd velocity, and crowd direction.
- Video streams annotated by WP3.
- Crowd simulation computed by WP4.
- Active evacuation routes computed by WP4.
- Sensors data coming from the smart spaces (WP7).
- Sensors data coming from WP5 Simulation.
- Video streams coming from the camera in the smart spaces (WP7).
- Video streams coming from WP5 Simulation.
- Alert notifications produced by WP8.

# 2. System description

## 2.1 Introduction

This chapter describes the different systems developed within WP5. It describes the different available features and how to use them.

## 2.2 Common Operational Picture

### 2.2.1 Map display

There is a clear need for end-users to be able to construct and visualise their own venue database. Creating and visualising an environment database is not a simple task, requiring data mining and optimisation knowledge, among other techniques. The COP integrates novel on-the-fly optimisation algorithms to enable a real-time visualisation of the geographic information without pre-processing. A user can add various types of information (orthophotography, elevation data, 3D models, and vector data) directly into the COP and visualise the result instantaneously.

**Figure 1: Left: Anoeta Stadium, San Sebastian, Spain. Right: Athens Airport, Greece.**

**Figure 2: STX Cruise ship**

**Figure 3: Athens Airport, Greece.**

### 2.2.2 Venue display

The user can visualise and manipulate the representation of their venue in a 3D environment. By geolocalising the 3D model, the COP enables the user to visualise the 3D model in context. The COP enables the user not only to have a clear view of the monitored building, but also to take into account the environment topology and the surrounding constrains for an evacuation process.

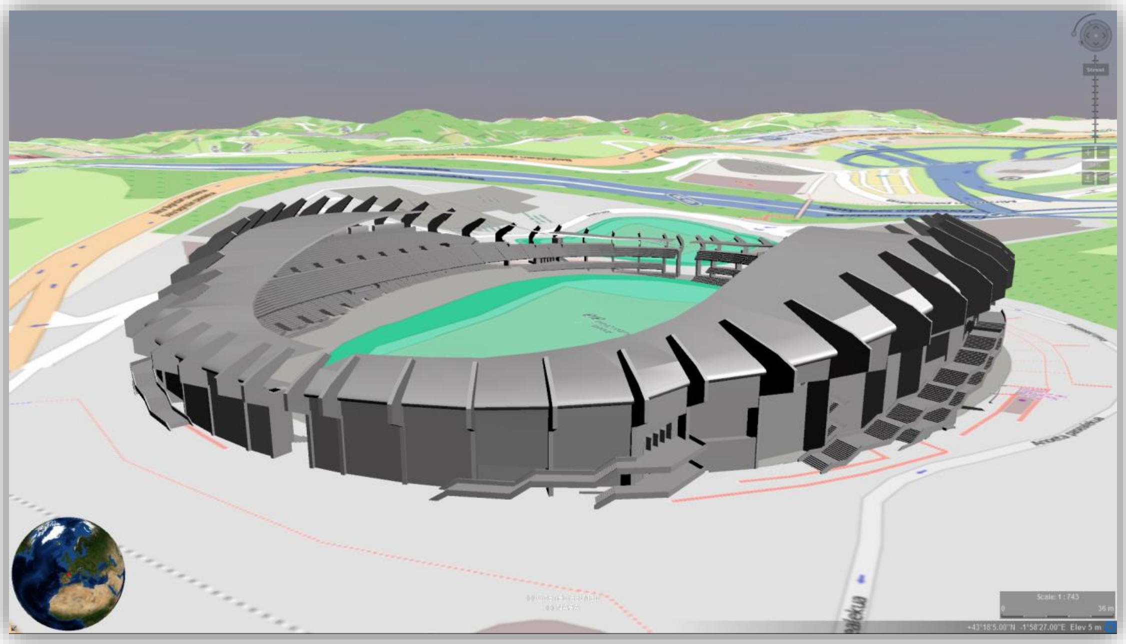

**Figure 4: Anoeta 3D model.**

### 2.2.3 Indoor navigation

To ease the venue 3D manipulation, newly developed indoor navigation metaphors enable the users to monitor their venue on each floor, and the surroundings, all at the same time. When a user focuses on a specific floor, the COP "peels" the building away by removing occluding floors. The user can continue to navigate through the building and the navigation metaphor is adapted to the currently selected floor.

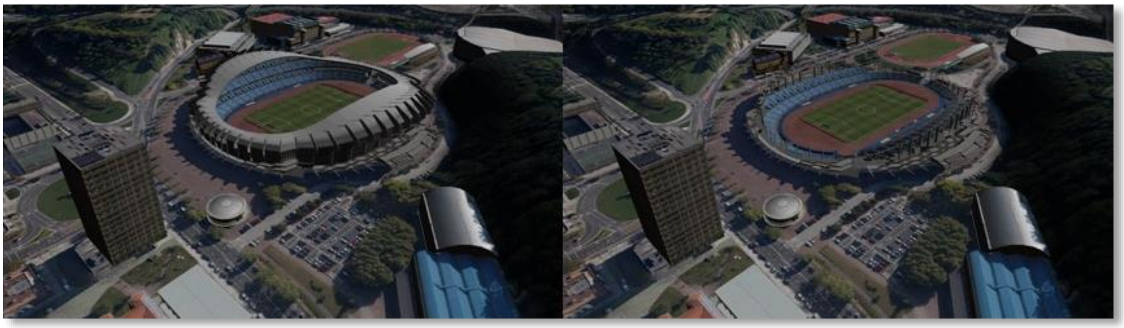

**Figure 5: Selecting a specific floor changes the display of the Anoeta stadium**

### 2.2.4 Underground visualisation

Indoor visualisation implies to be able to monitor any kind of venue. Buildings can have specific characteristics that can really change the way indoor visualisation and manipulation should be displayed and managed. For example, a stadium has no strictly defined floors, its layout shows stands and sections. This makes the partitioning of such a building a very challenging task. Another kind of specific venues are underground buildings, such as metro stations. The COP has been adapted to be able to display and navigate through underground buildings as easily as those above ground. On top of peeling out the building, the COP also peels out the earth surface to let the user see below ground level.

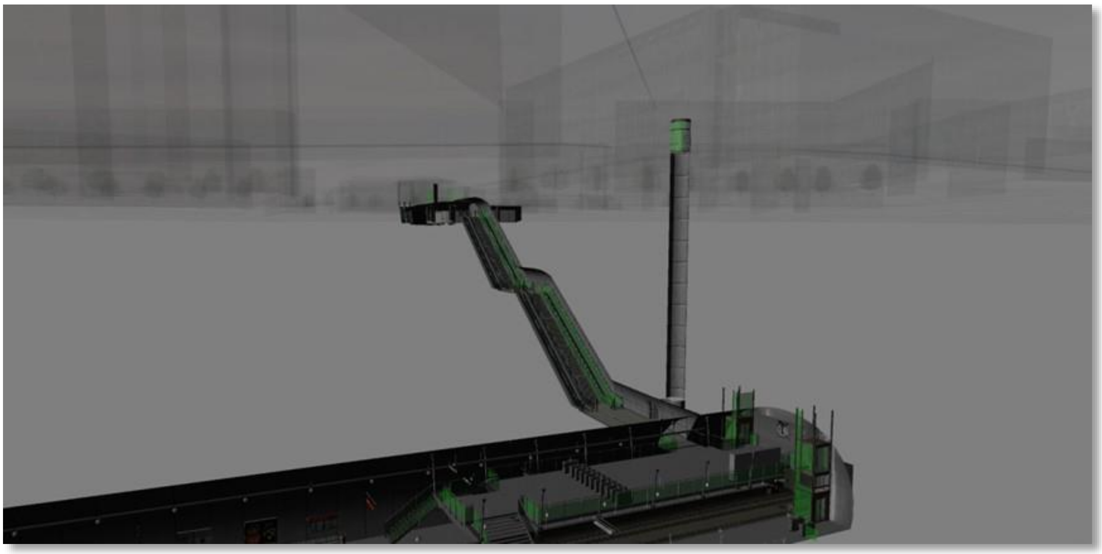

**Figure 6: Bilbao metro station of San Mamés from an underground point of view.**

As pictured in Figure 6, we can clearly see both metro station and the town buildings above. This enables the user not only to monitor the venue but its surroundings too, even in underground contexts.

### 2.2.5 User-friendly interface

One focus of the COP development is to facilitate the adoption of the system and to provide an intuitive work platform. Creating a system which requires little to no training is a challenging task. Every single feature proposed to the user must follow specific guidelines to ensure this goal.

The term NUI (Natural User Interface[1]) describes this common practice. The multi-touch technology is a great example of NUI. The growing smartphone user-base pushed this technology forward and became a standard one. By using this technology and the common associated interactions, we ensure the COP is using standard, accepted gestures. All functionalities provided by the COP have been designed to offer the most pleasant and intuitive workflow. Standard touch-screens guidelines[2][3] have been followed to design the interactions and the HMI's.

A large touch screen is the ideal platform to run the COP software. They fully exploit the potential of developments made in WP5. An example platform can be seen in the following figure.

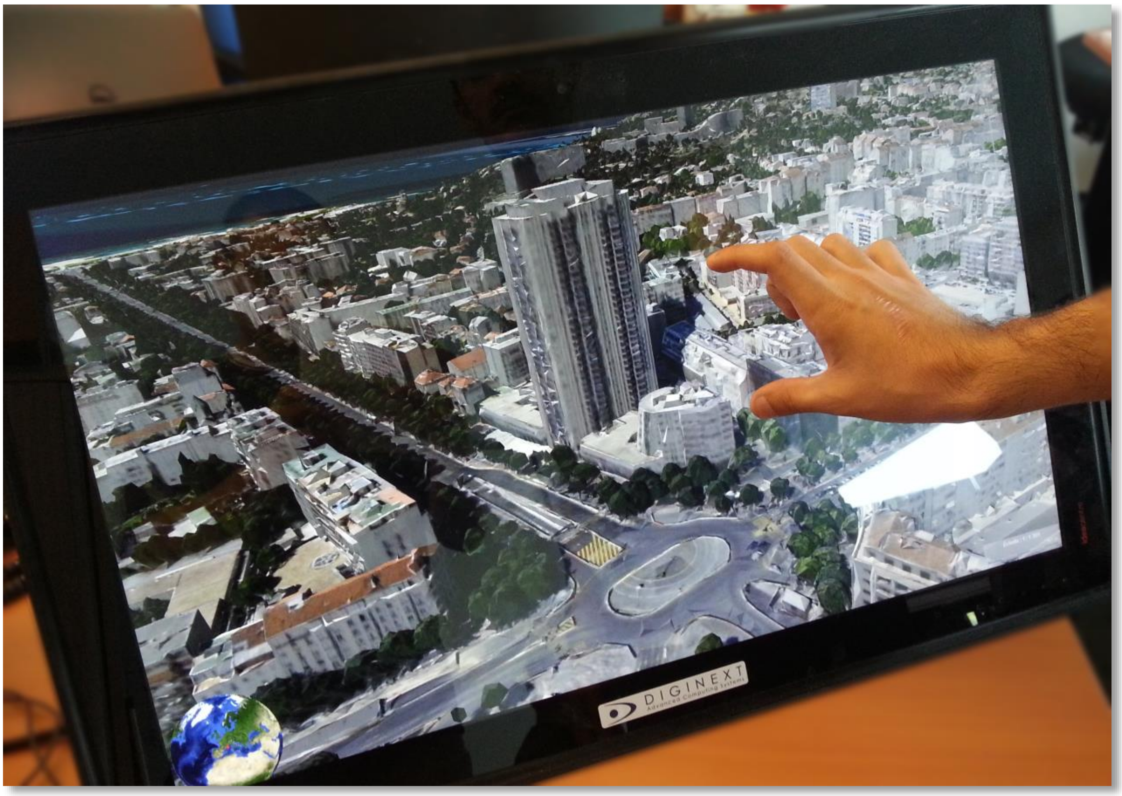


**Figure 7: 27" touch-screen computer.**

[1] http://en.wikipedia.org/wiki/Natural_user_interface
[2] http://www.microsoft.com/en-us/download/details.aspx?id=26713
[3] https://developer.android.com/design/get-started/principles.html

### 2.2.6 Sensor information

The COP provides to the user an evolving snapshot of the venue current state. By connecting to the eVACUATE Framework, the COP gathers data from the field and displays it in real-time. Localising the data in the venue provides a clear and contextualised representation of the current building situation. The COP enables the user to understand at a glance the state of the venue and identify immediately any ongoing situations. The examples of sensor display are shown in the following figures.

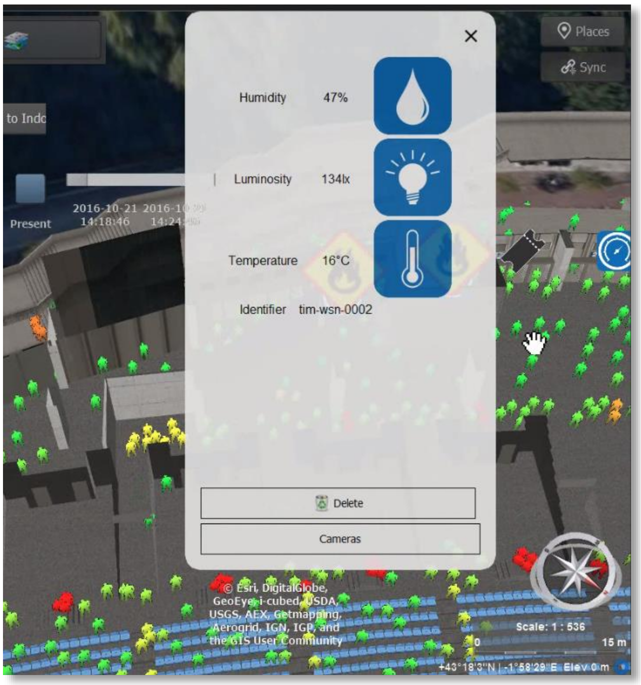


**Figure 8: Geolocalised sensor displays: Humidity, Luminosity, and Temperature**

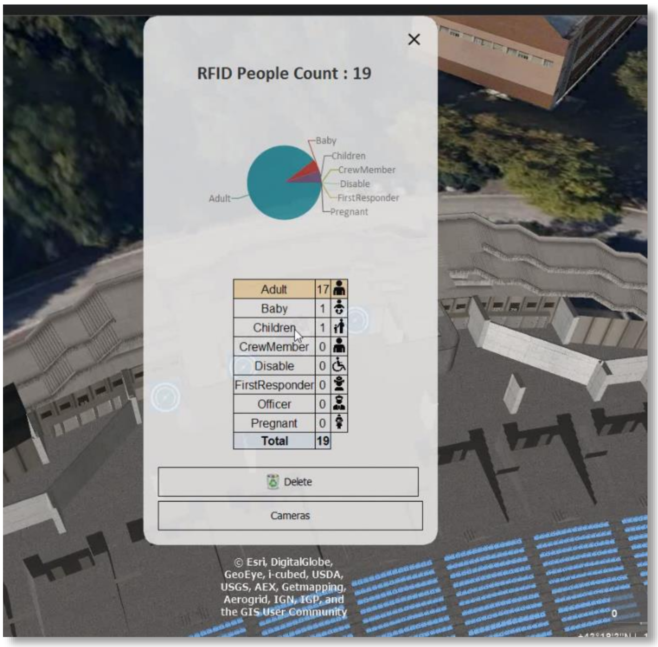


**Figure 9: People counted and categorised by eVACUATE RFID reader technology**

### 2.2.7 Video Stream

The COP is able to display real-time video streams in a dedicated window. This enables the user to have a real-time view of the venue and distinguish the small details that only cameras can capture. The COP can display any type of video streamed through standard video protocols. Moreover, the COP is able to project the streaming content directly into the 3D model venue. This helps the user to contextualise the video by displaying it directly where it points to. This removes the unnecessary mental process of mapping a video stream to its current location.

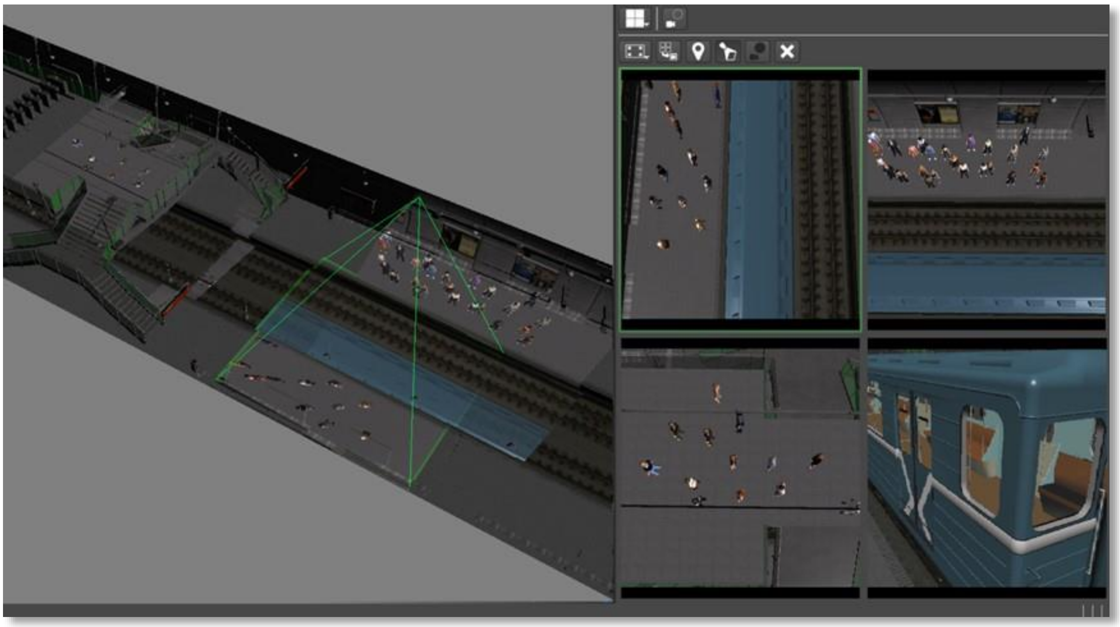

**Figure 10: Camera stream projected into the COPSI Visualisation Module.**

### 2.2.8 Crowd densities

The COP is able to give the user an overview of the crowd present within the monitored venue. By translating raw data gathered from the eVACUATE Framework to contextualised, readable data, the COP enables any user to immediately visualise dense areas and possible congestions. The crowd density is represented by silhouettes in the COP.

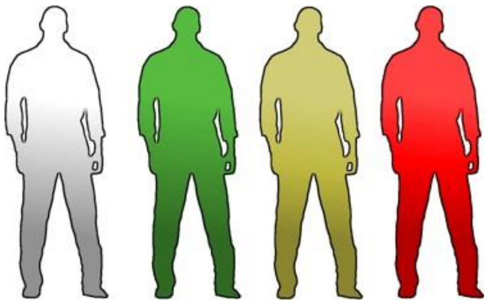

**Figure 11 - Silhouette used to display crowd statistics.**

The denser the silhouettes, the denser the actual crowd. To reinforce the visual impact of this information, the COP also colour codes the silhouettes, from green to red representing low to high people density. The parameters for such display can be adapted for different venues so that each colour may represent different densities relevant to different types of crowded situations.


**Figure 12: Correlation between video input and crowd display in the COP (Only middle stands are counted in real-time, the rest of the stadium is simulated)**

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### 2.2.9 Crowd prediction

By displaying to the user the predicted crowd congestion in the COP, the user can foresee what will likely happen given the actual situation. Decision makers will be able to evaluate the

best course of action during an evacuation, the time to evacuate and which areas are likely to require closer monitoring as the evacuation progresses.

The user can navigate in time and directly see the unfolding of an evacuation process from the current time to the end of the evacuation.

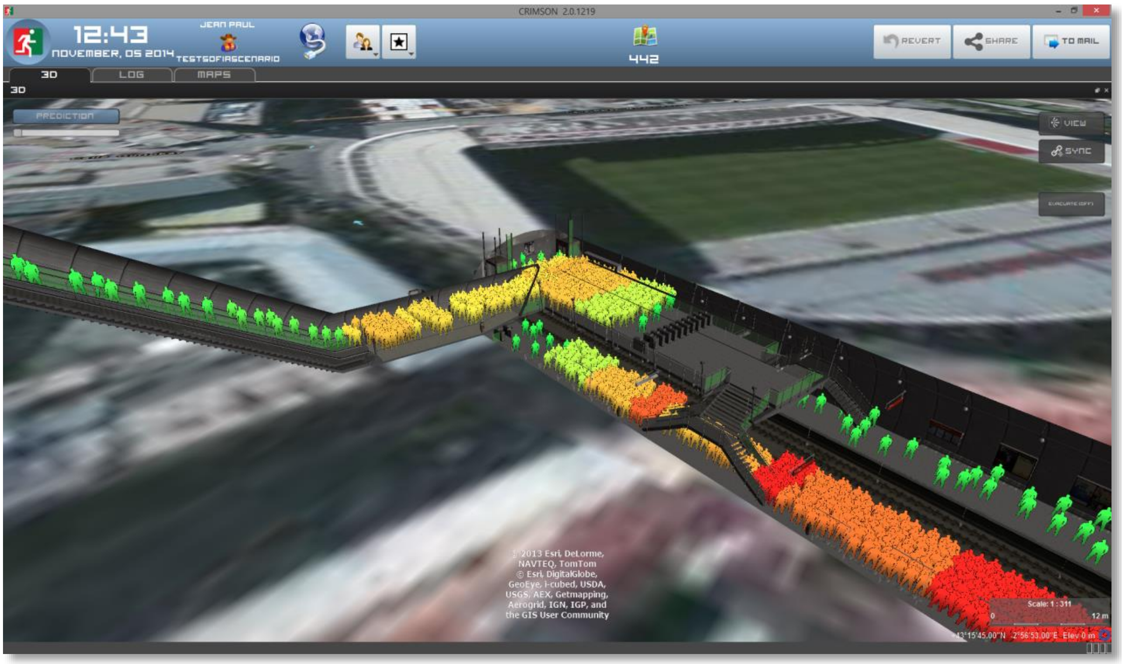


**Figure 13: Crowd prediction in Metro Bilbao.**

### 2.2.10 Active Evacuation Routes

To guide the user through the evacuation process, the COP displays the Active Evacuation Routes generated by WP4 crowd simulation algorithms. Active evacuation routes represented as directed arrows are presented to the user. The active evacuation routes indicate the shortest path to leave the building, from any given location in the venue. The AER representation uses traffic light colours to codify the evacuation time. A green colour represents the fastest route to evacuate, red the longest.

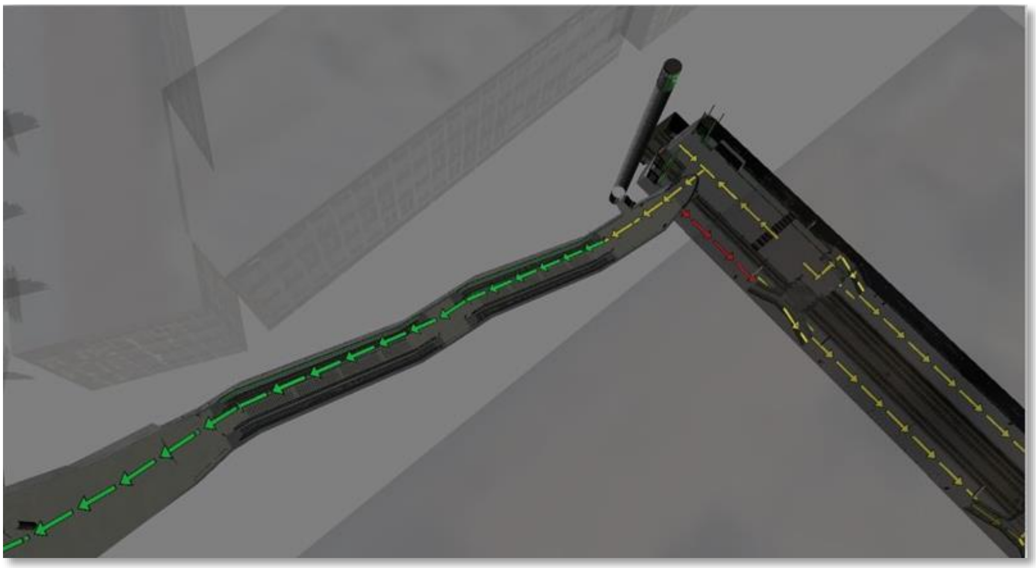

**Figure 14 - Active Evacuation Route**

The COP also displays the time to evacuate from each point of the building. It helps the decision maker to focus on the critical areas of the evacuation process.

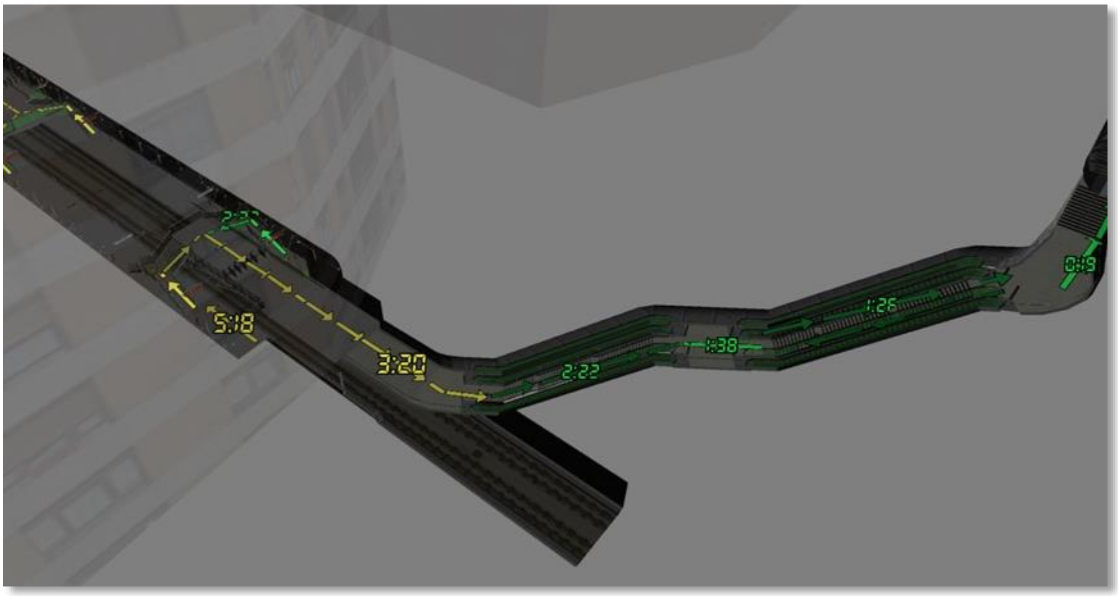

**Figure 15 - Time to evacuate at any location**

AER computation integrates the possibility of 'blocking' or 'obstructing' an area in the building and to adapt its output accordingly. The user can decide to partially or totally block part of the

building. This action triggers a re-computation of the AER, taking into account user defined blockages. In this way, the user can translate real problems into actual obstacles for a precise AER computation. The user can also experiment with alternative AER by blocking an area where people should not go and may find more appropriate routes to evacuate.

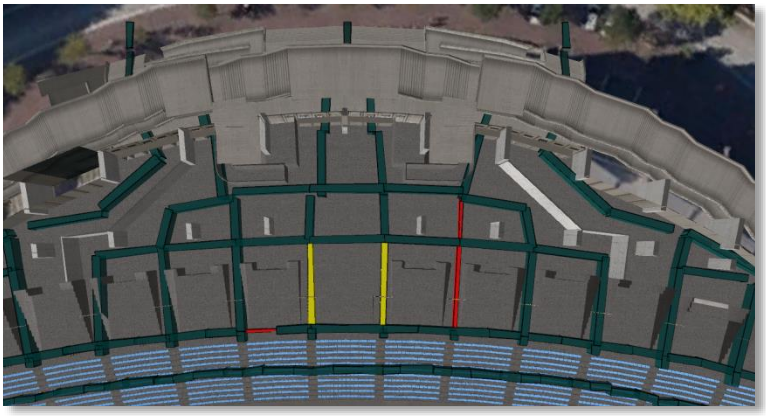

**Figure 16: A user can add blockages to the Active Evacuation Routes**

Modified active evacuation routes are also transmitted to the eVACUATE mobile application. In this way, venue customers are alerted in real-time of the safest route decided by the security decision maker.

### 2.2.11 Alert notifications

On top of high level information such as crowd predictions or active evacuation routes, the COP receives alert notifications from the eVACUATE Framework. These notification alerts are generated by the system depending on several criteria. Alerts can be generated by the eVACUATE system directly by monitoring a sensor value (e.g. high temperature), by meeting several conditions together (e.g. low visibility and low humidity means probably a smoke), or by receiving alerts from higher level computations (e.g. unusual behaviour detection). Alerts can also be triggered by social media analysis (e.g. occurrences of a set of keyword exceeding a specific threshold). The first responders can also send alert notifications directly with the first responder mobile application.

All these alert notifications are categorised and gathered by the COP. The COP then displays them using a compiled list and directly in the 3D model. Every alert notification is labelled with an icon, description, source, suggestion, severity and accuracy.

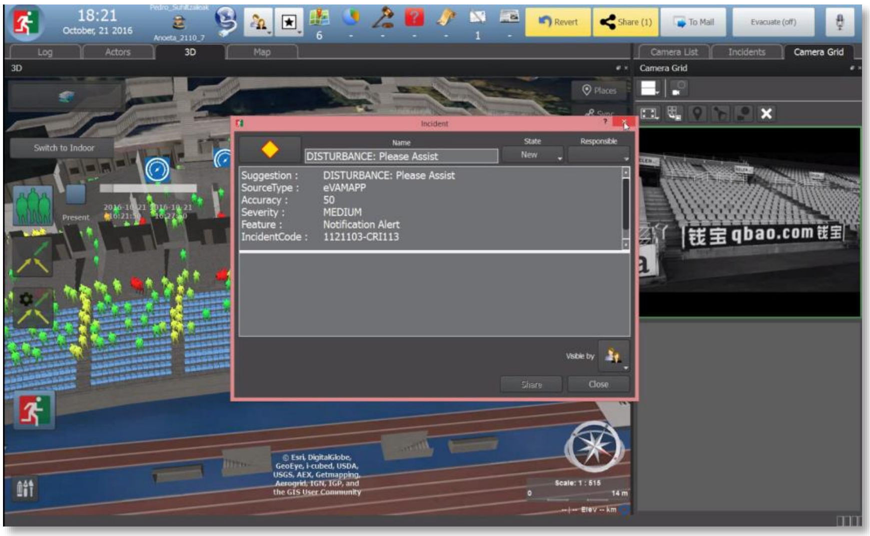


**Figure 17: Alert notification**

Every alert notification can be assessed, dispatched to every COP user and terminated if the immediate danger has been eliminated.

### 2.2.12 Annotation

The user is able to intuitively annotate a 3D scene containing a building, and choose between several representations. Annotations can come in different forms, such as text, icons, lines, polygons, complex shapes and 3D models. The creation of these annotations has been designed to be easily performed by non-expert computer user. A preconfigured annotations library is available in the annotation toolbar. This library is easily expanded with the user's own symbology. All of these annotations can be shared between different COP users or groups of users. The annotations can be filtered by groups of users to avoid cluttering in the COP display. Annotations can also be filtered by type when a user wants to focus on a specific task or issue.

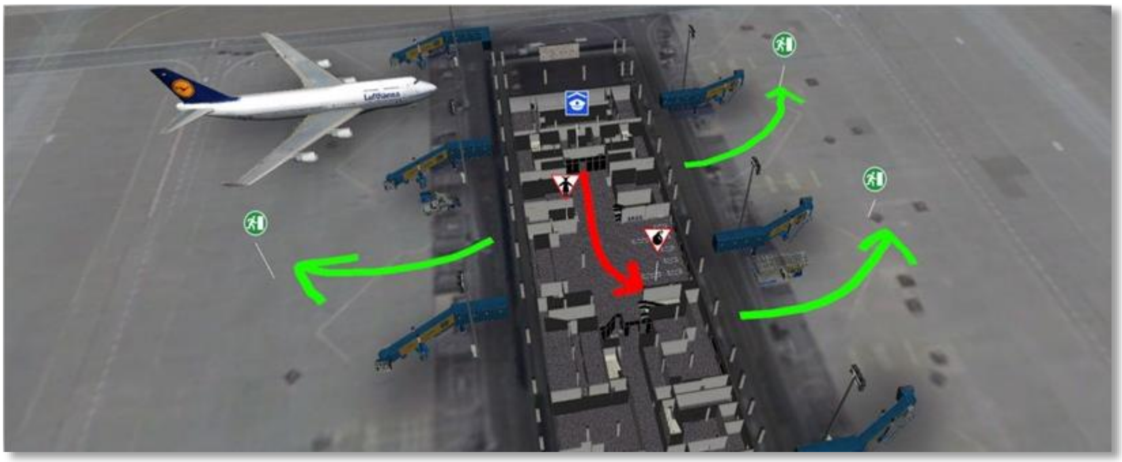

**Figure 18 - Annotations in the Athens Airport (icons, arrows)**

## 2.3 Simulation

This section describes the WP5 Simulation software tool that allows the crowd and incidents creation in a scenario.

### 2.3.1 Venue display

To enable the user to create an in-situ 3D real-time dynamic scenario, the Simulation Module allows the user to import and display the 3D representation of the venue. The technology used is the same as the COP, adapted for dynamic scenario definition means.


**Figure 19: San Mamés Metro Station (Bilbao).**

### 2.3.2 Scenario definition

The Simulation Module gives the user the ability to define the unfolding of a scenario within the venue intuitively and dynamically. The user can create a scenario, configures the initial conditions, and run the simulation. They can then control the execution of the scenario simulation by modifying the conditions in real-time. With Natural User Interface principles at the core of the software design, the user is able to "paint" people and incidents within the 3D scene directly a finger tip.


**Figure 20 - Simulation module user interface**

**Figure 21 - Characters brush on San Mamés model**

**Figure 22 - Creation of smoke, characters, and fire before launching the simulation**

The user can change the camera point of view among carefully chosen within the scenario. These camera views cover identified hotspots for crowd congestion.

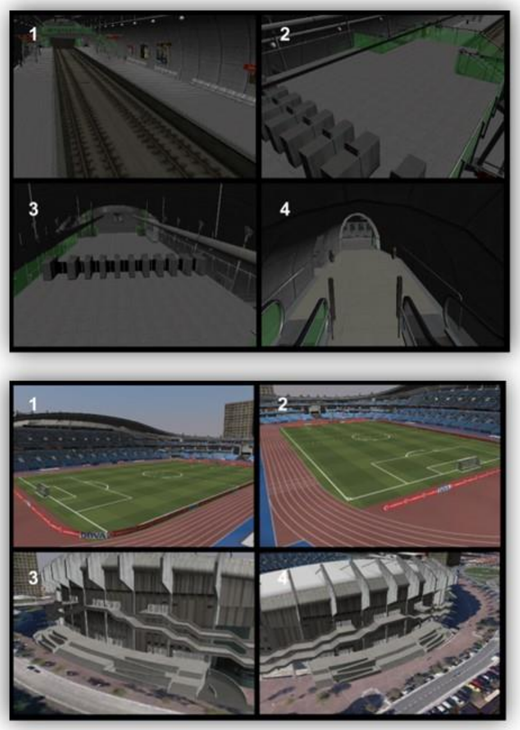

**Figure 23 - CCTV simulation**

The Simulation Tool can create live video streams from the predefined viewpoints, simulating real CCTVs. These video streams can then be watched in the COP or sent to video analysis to extract the crowd properties.

**Figure 24 - Scenario simulation of San Mamés metro station, Bilbao**

# 3. Conclusion

The COPSI system development has successfully followed the established roadmap and obtained results of high quality. The COPSI has been used and demonstrated in several occasions, from online and onsite system validation platforms, real-time evacuation monitoring in the first pilot, communication showcase for dissemination, etc. The results of the first pilot showed a high level of maturity and all of the major features were successfully demonstrated and reviewed.

The development achieved on the COP enables the user to have a clear view of the venue and its actual state showing sensor data coming from WP3 crowd information, WP4 crowd predictions & active evacuation routes, WP7 sensors data and WP8 alert notifications.

The obtained results in the simulation module give the user the ability to define crowd scenarios and produce training or validation material for the system. It is possible to generate a simulated video streaming directly to the system or simulate crowd counting sensors.

**Figure 25: By unifying all data in a contextualised environment, the COP is an ideal tool to facilitate information sharing.**

## Annex A – List of Acronyms

| Acronym | Meaning |
|---|---|
| **COPSI** | Common Operational Picture and Simulation |
| **COP** | Common Operational Picture |
| **SI** | Simulation |
| **WP** | Work Package |
| **GIS** | Geographic Information System |
| **CCTV** | Closed-Circuit Television |
| **AER** | Active Evacuation Route |
| **2D/3D** | Two/Three dimensions |
| **XML** | Extensible Markup Language |
| **WGS84** | World Geodetic System, revision 84 |
| **NUI** | Natural User Interface |
| **RTSP** | Real time streaming protocol |