ADVANCED SIMULATIONS FOR BUILDING DESIGN - Best Practice and Future developments

Gabriele Vigne and Jimmy Jönsson

JVVA Fire & Risk

gabriele.vigne@jvvafire.com

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Introduction

The increased use of performance-based design to develop fire safety solutions requires, for complex buildings, the use of advanced tools

- Spaces can be particularly vast
- Evacuation paths particularly complicated
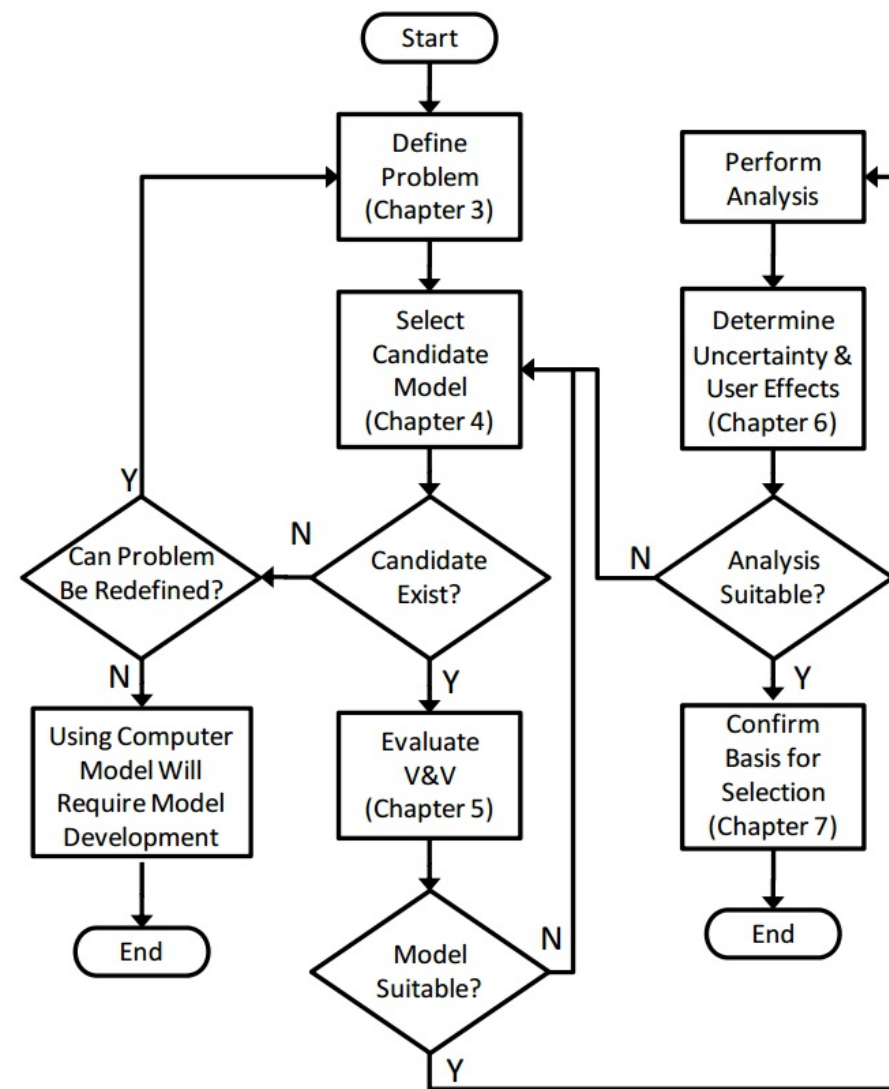- Architectural layout might impose restrictions

Perfomance Based Design Process

The role of Advanced Modelling into the PBD process
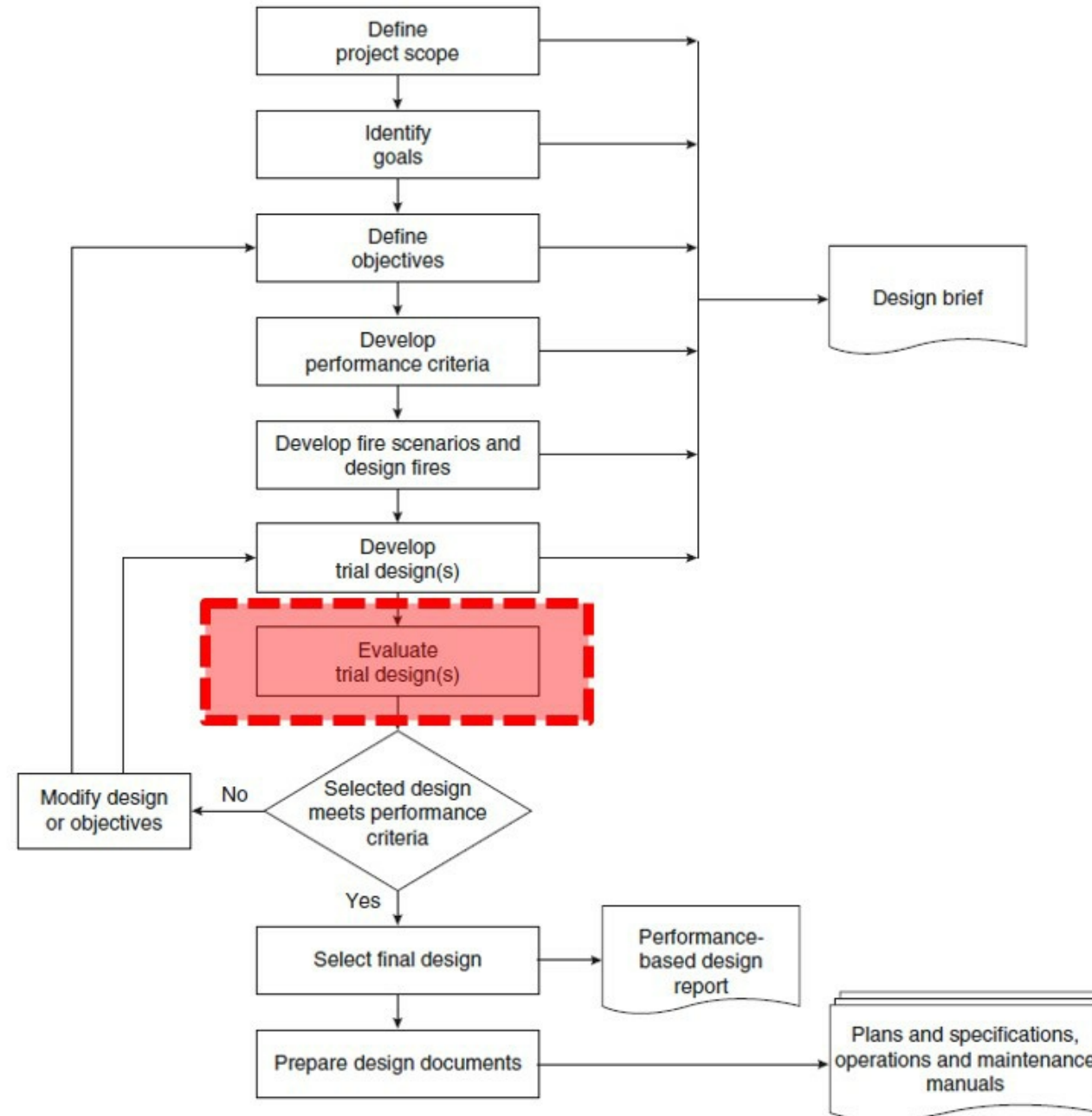
Fire Model Selection Flow Chart

Once the evaluation phase is reached in the performance base design process, it is time to get into the modelling exercise

Case studies

This section shows some example of complex projects where advanced modelling was an essential part of the design process

- Large Airport
- Interchange Station
- Hight Rise Apartment Hotel
- Logistics Centre

Case 1 - Airport

- The first example is the largest and busiest airport in Spain
- The overall objective of the project was to evaluate the current fire safety level for all existing terminals
- Both advanced evacuation analysis and Fire and Smoke modelling were performed
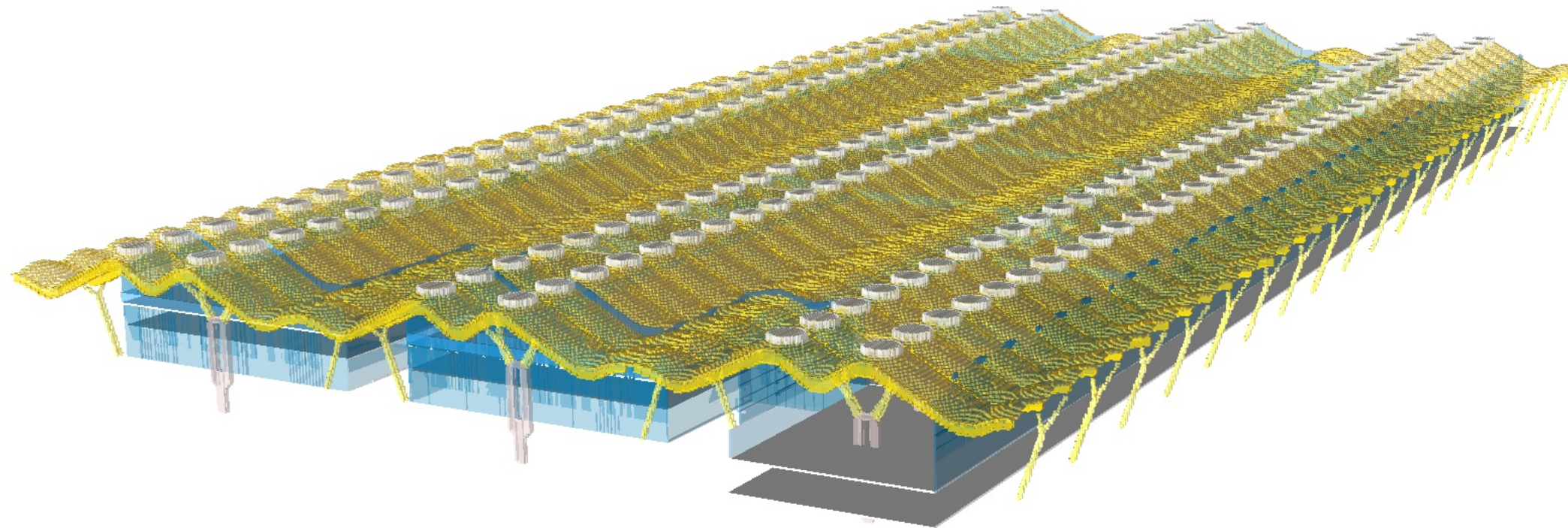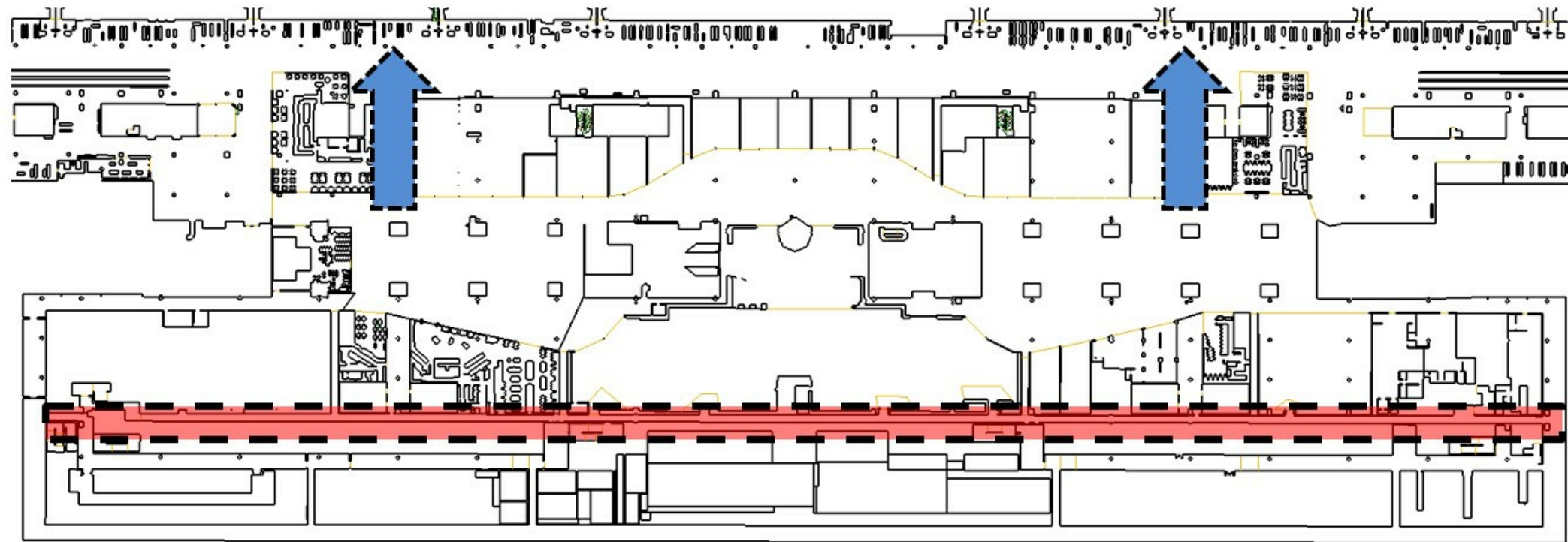
Case 1 - Evacuation - Review

- The first step in the analysis was to evaluate the existing configuration
- The analysis shows a few large bottleneck using the current evacuation strategy for this level
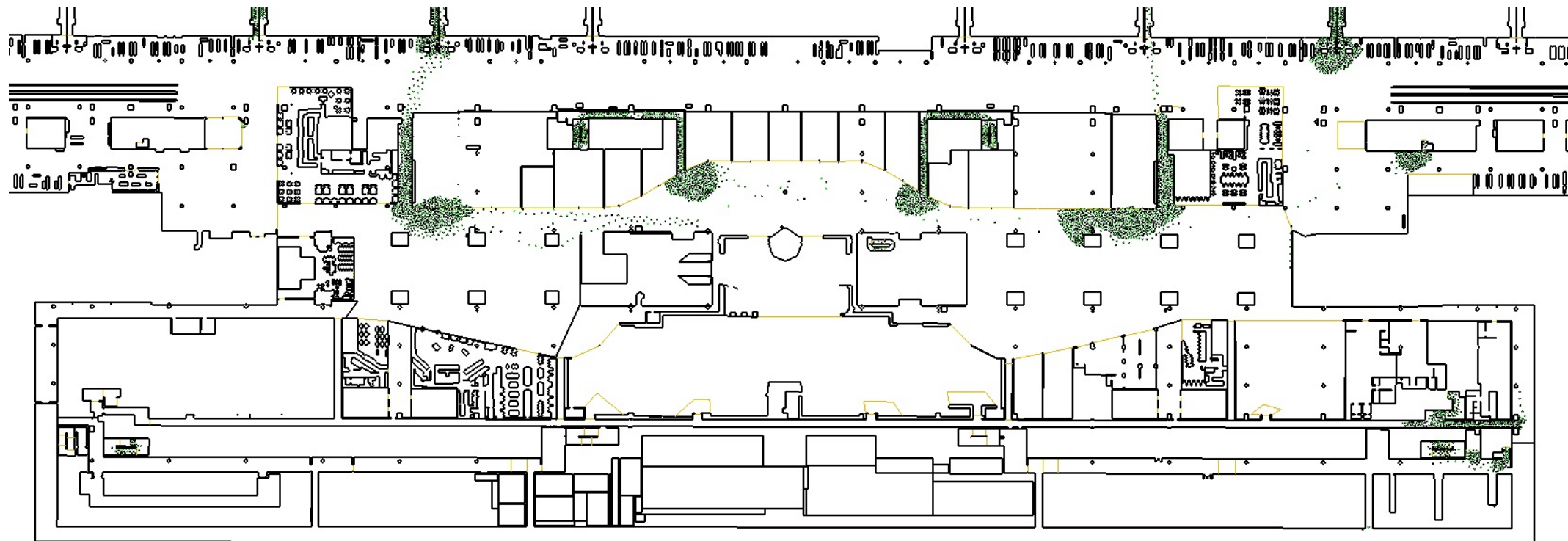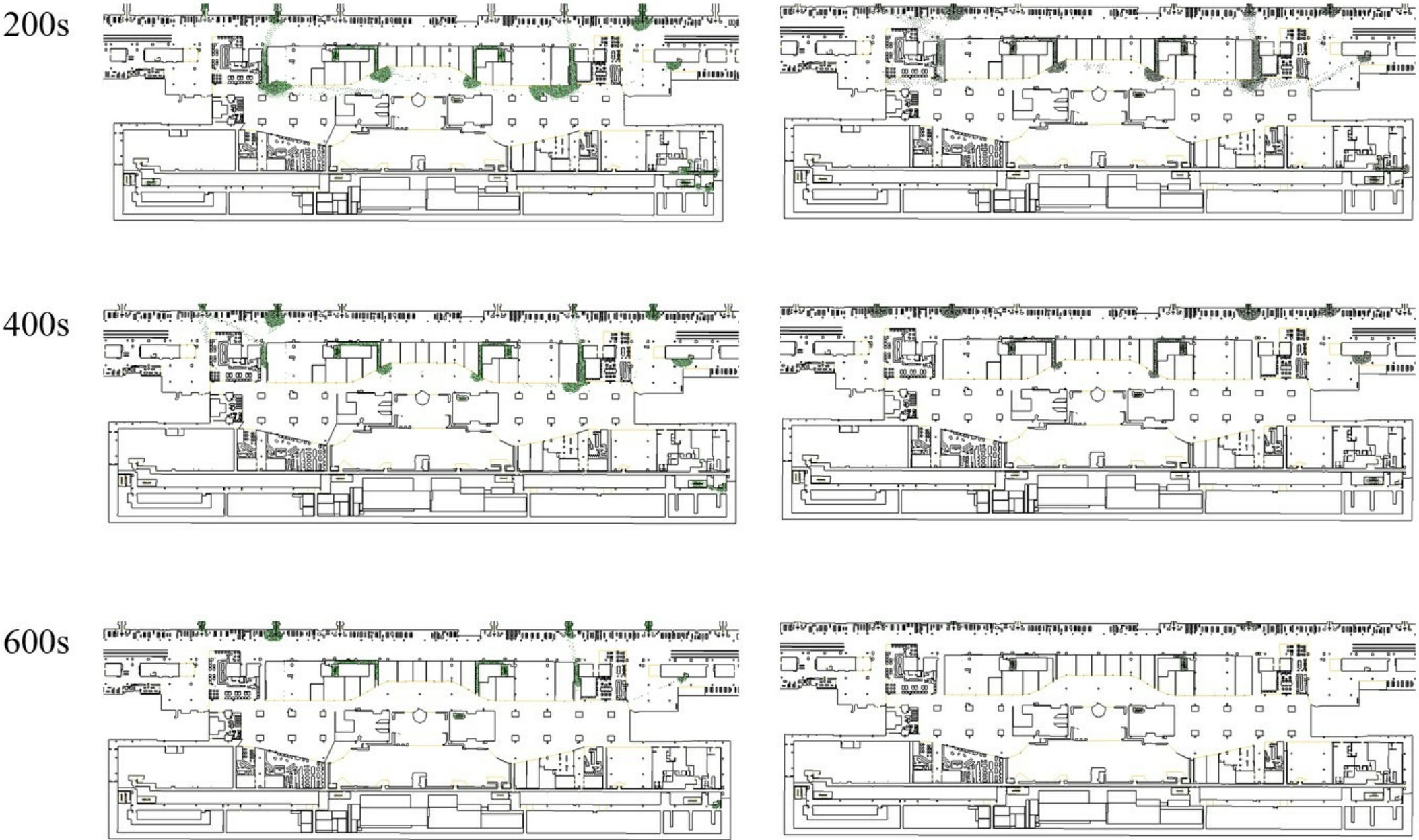
Case 1 - Evacuation - Improvement

By the increment of two corridors width together with the redirection of the part of the occupants toward the bridges instead of into a long corridors that was currently in use, the overall evacuation time was reduce by means of 30%.
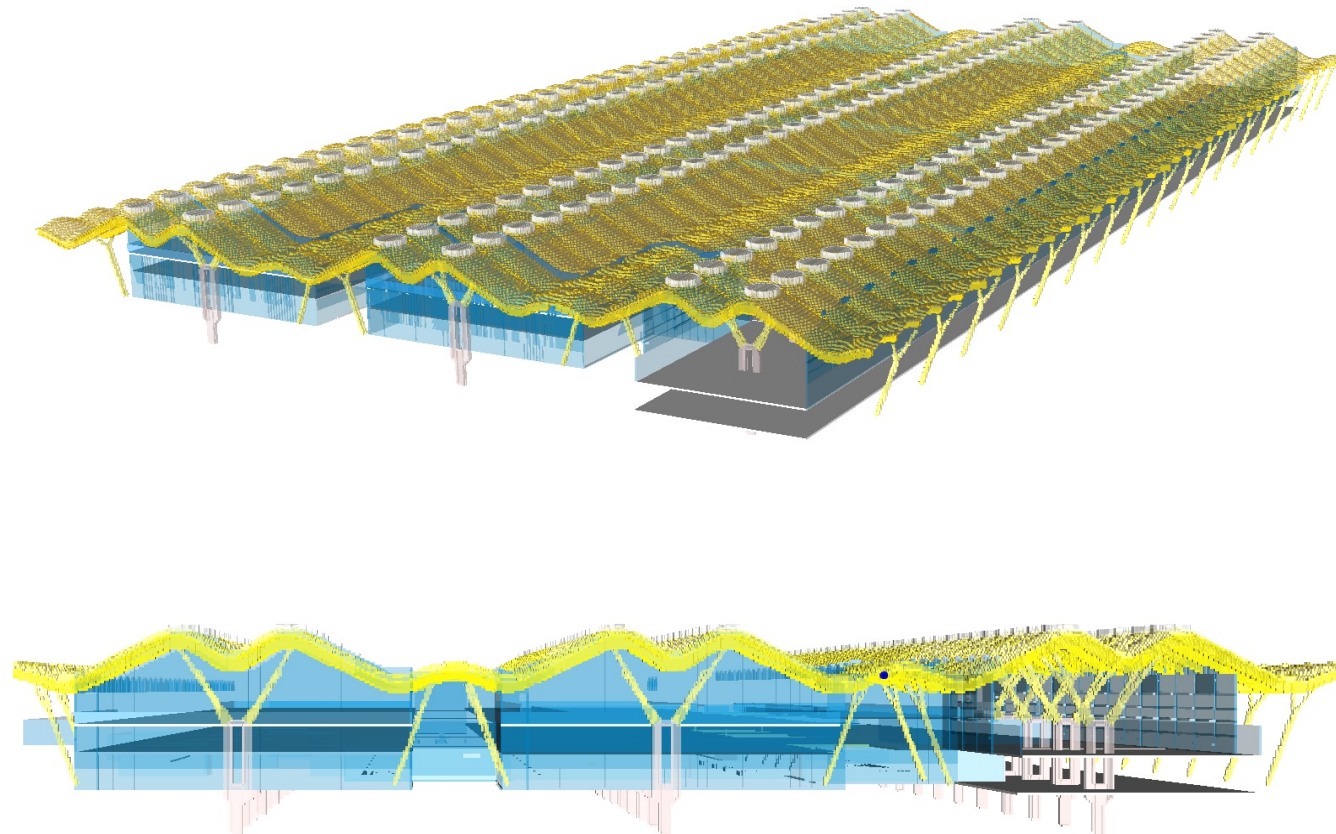
Case 1 - Evacuation - Results

Results of current and proposed configuration


200s

400s

600s

Case 1 - Fire and Smoke Analysis

- The whole terminal has been modelled
- FDS v.6.2.0, 30 different meshes assigned to 30 MPI processes

Case 1 - Fire and Smoke Analysis

The overall results of the fire and smoke modelling shown that, despite the great volume of the terminal area, smoke had enough buoyancy to raise and fill the smoke reservoirs guaranteeing smoke layer stratification even with reasonably small fires with large spills (resulting in more and colder smoke).
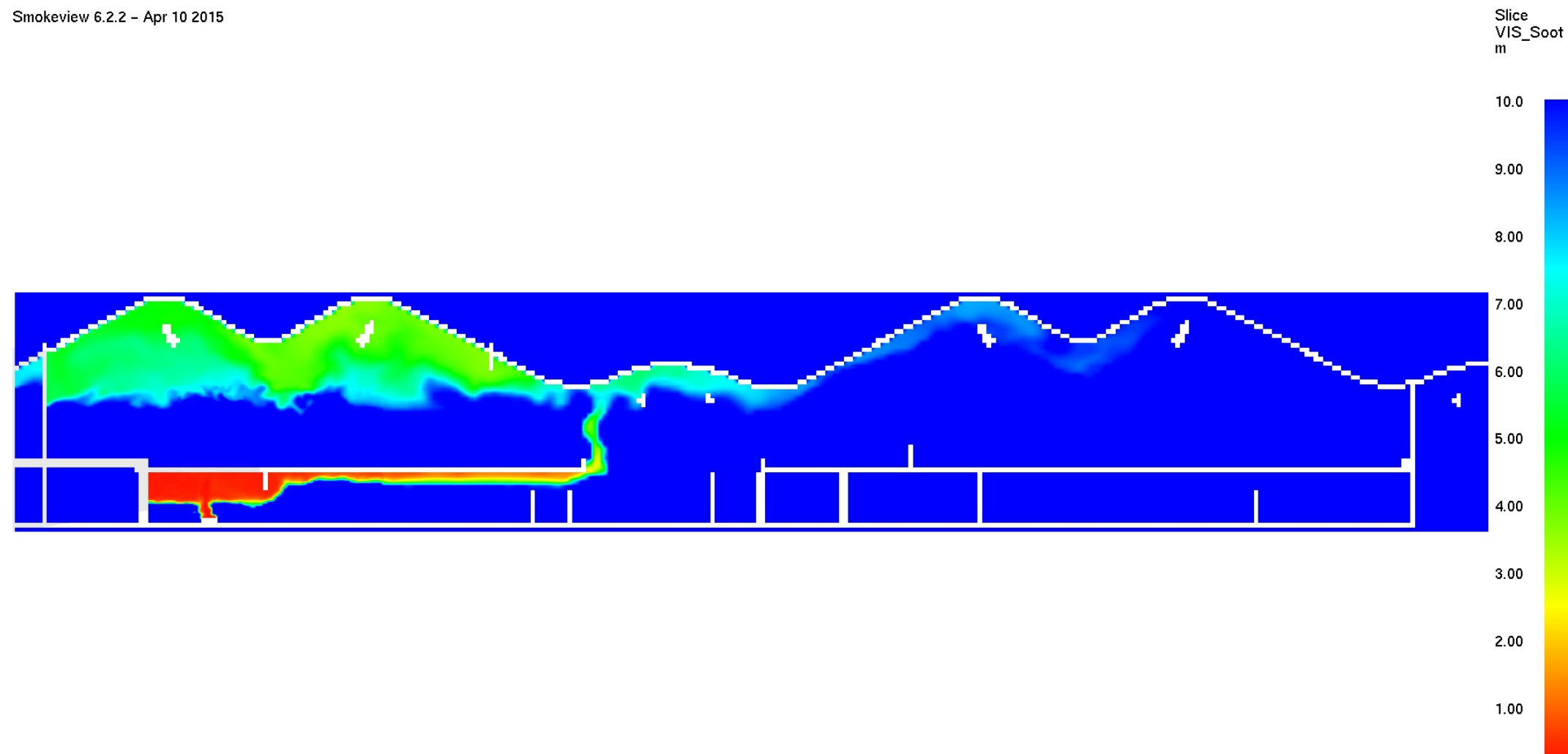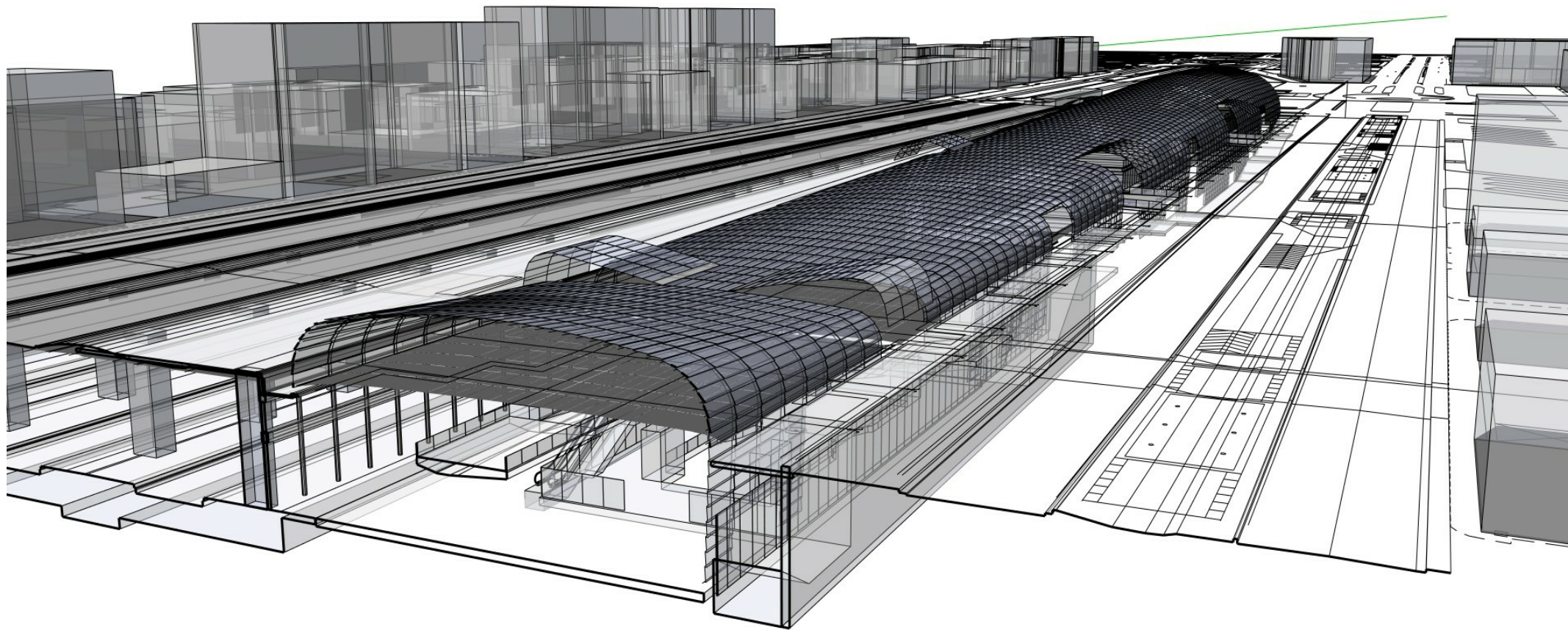
Case 2 - Interchange Station

- The second example is the largest interchange station in Turin, Italy
- The objective of the study was to evaluate the fire safety level for the station, and this to be performed for the whole building
- This was done by using the well-established ASET vs RSET methodology
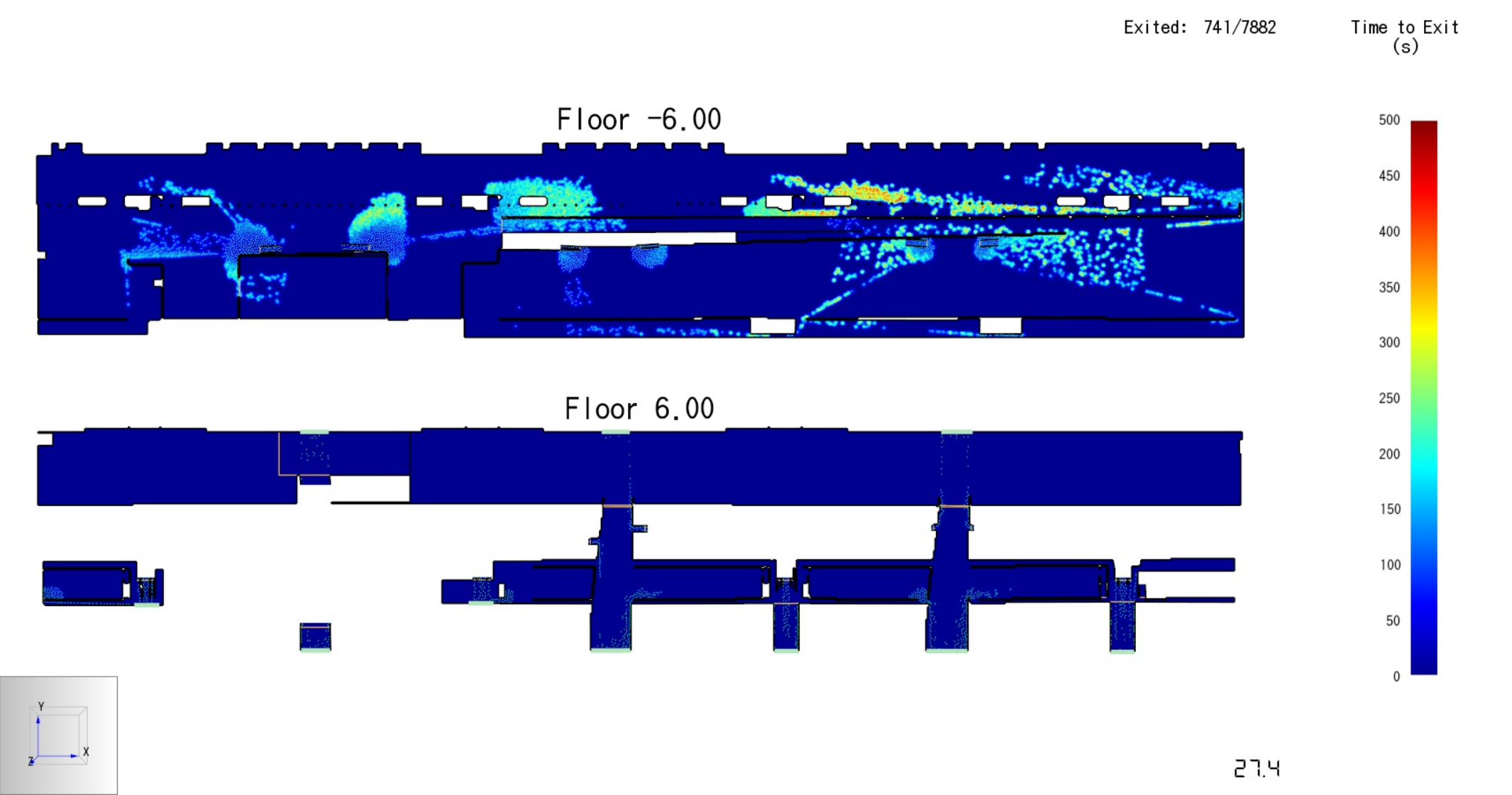
Case 2 - Overview

Case 2 - Evacuation - Tools

Pathfinder was used to determine the overall evacuation time of the station both due to legislative requirements and to evaluate those areas where the smoke was rapidly descending and affecting the evacuation routes.
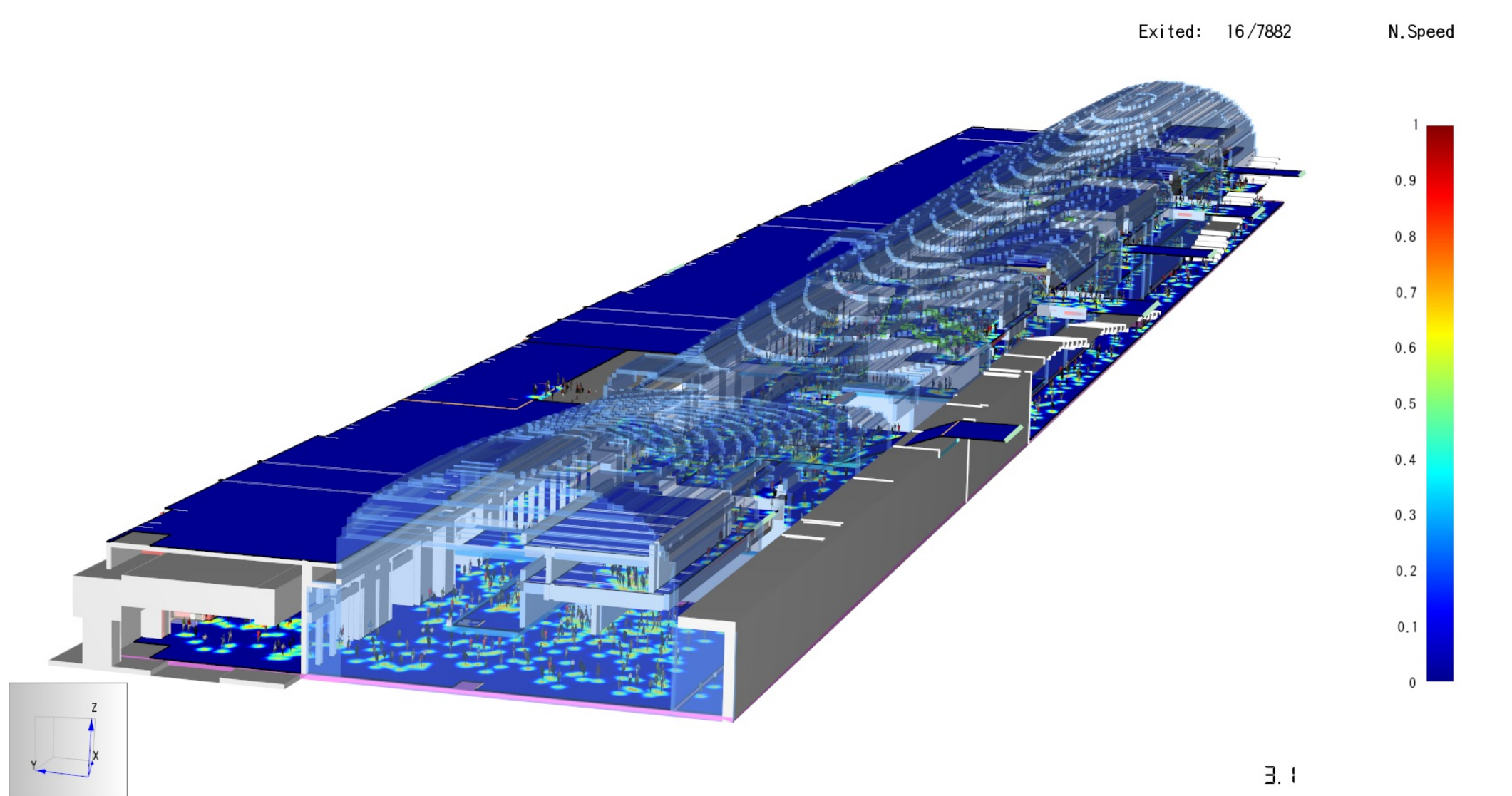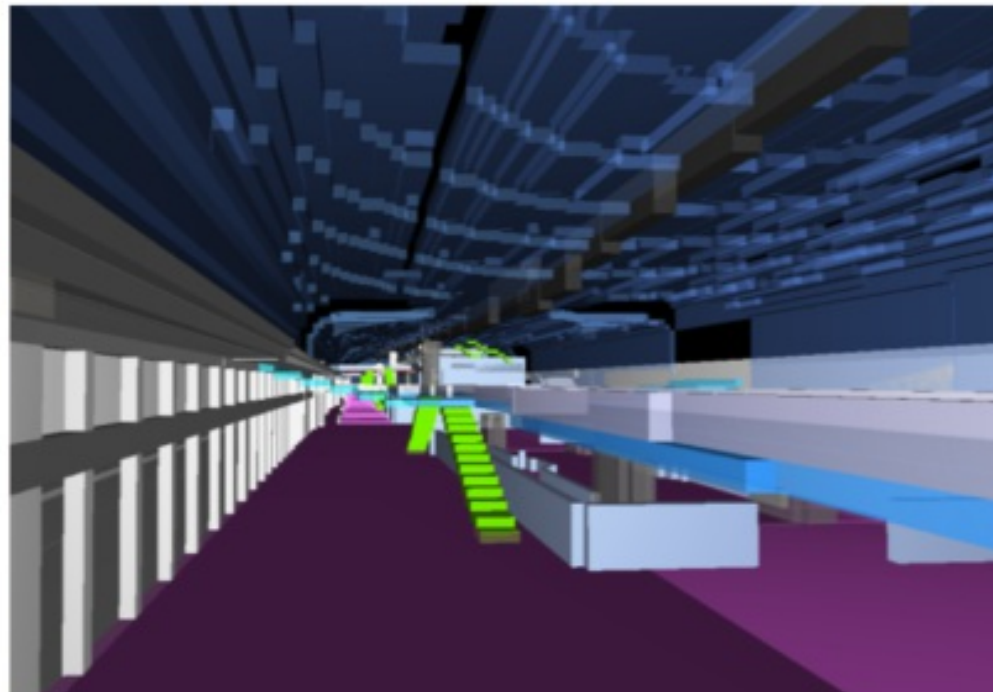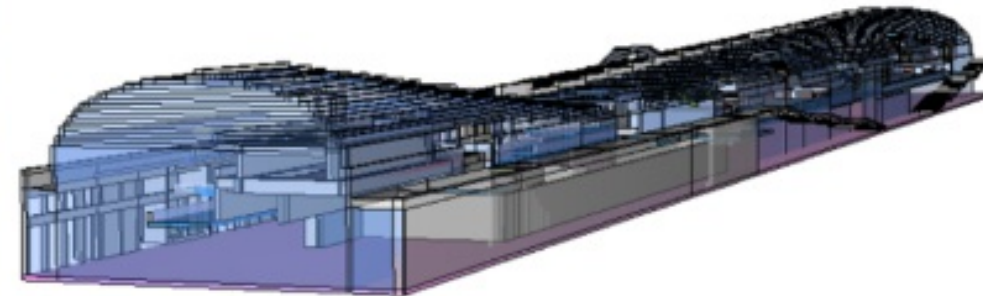
Case 2 - Evacuation Analysis

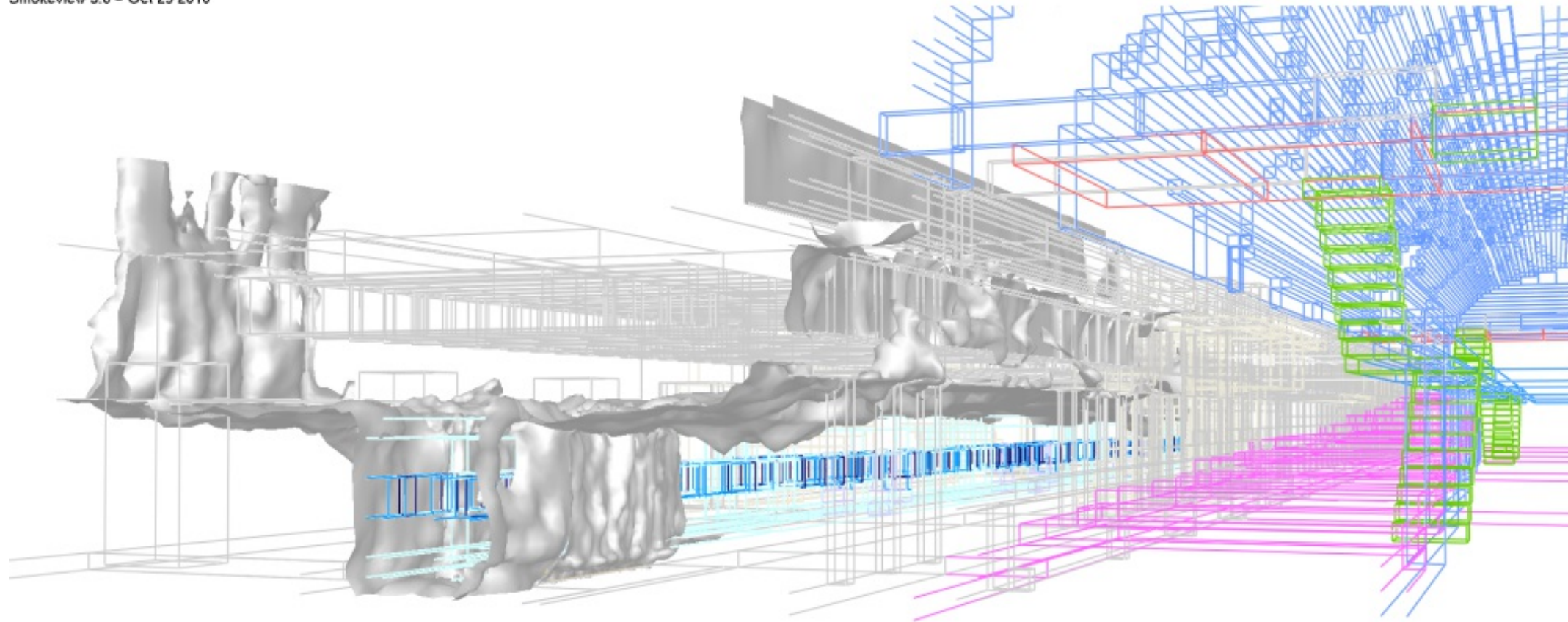# Case 2 - Fire and Smoke Analysis

The CFD model was processed with FDS v.6.0.0, the domain was split into 15 different meshes assigned to 15 MPI processes, with a resolution varying from 0.15 m in the fire region up to 0.30 m in the regions far from the fire.

Case 2 - Fire and Smoke analysis

Effectiveness of the smoke ventilation shaft between station and platforms

Case 3 - High Rise Apartment Hotel


- The third example is a heritage protected multiuse building in the centre of Madrid, Spain
- Part of the building was to be transformed into an apartment hotel, the refurbishment was heavily limited due to the heritage status of the building

Case 3 - Evacuation Analysis

The final solution was based on the concept of introducing a protected corridor connecting the two stairs
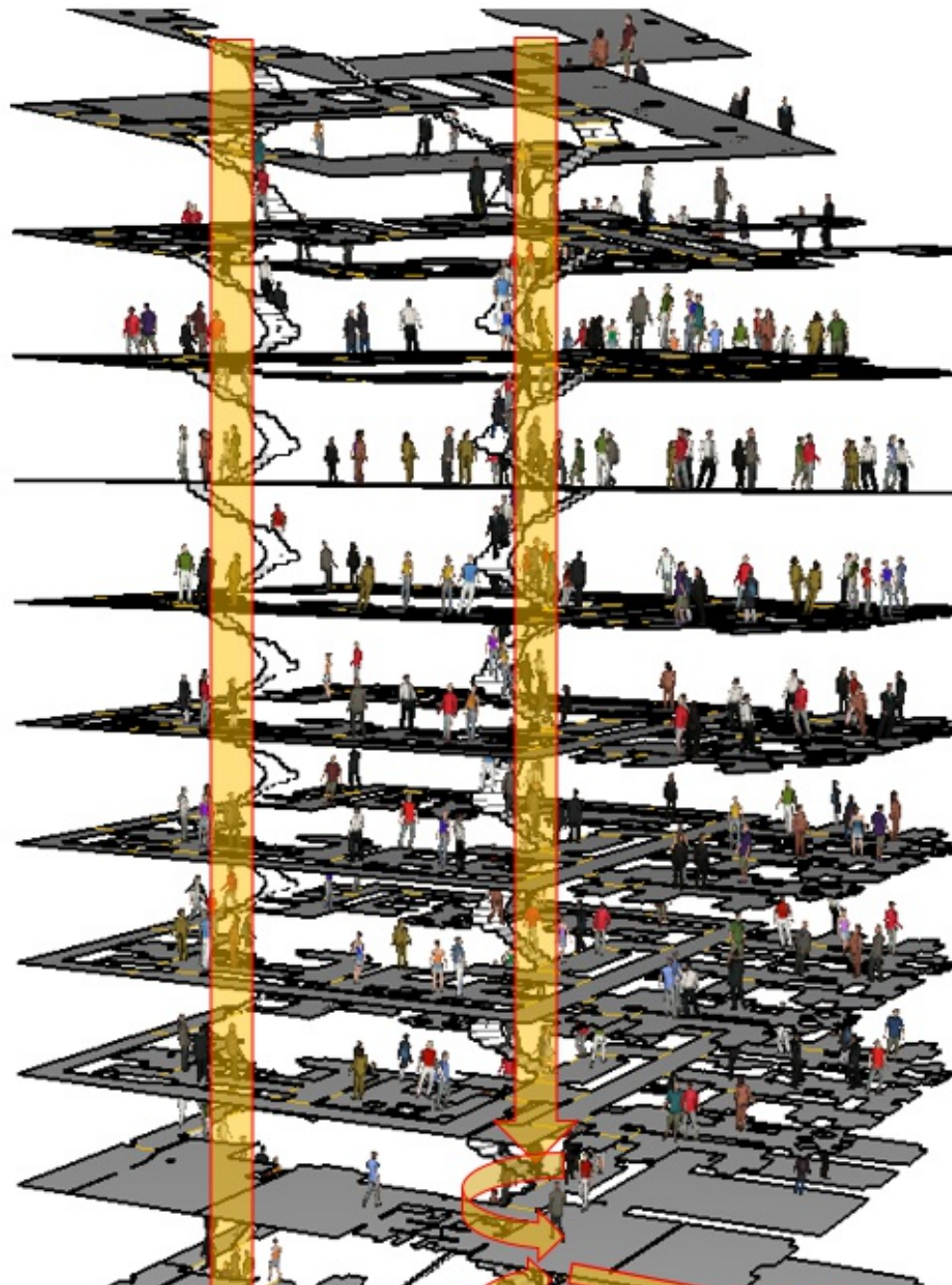
Case 3 - Evacuation Analysis
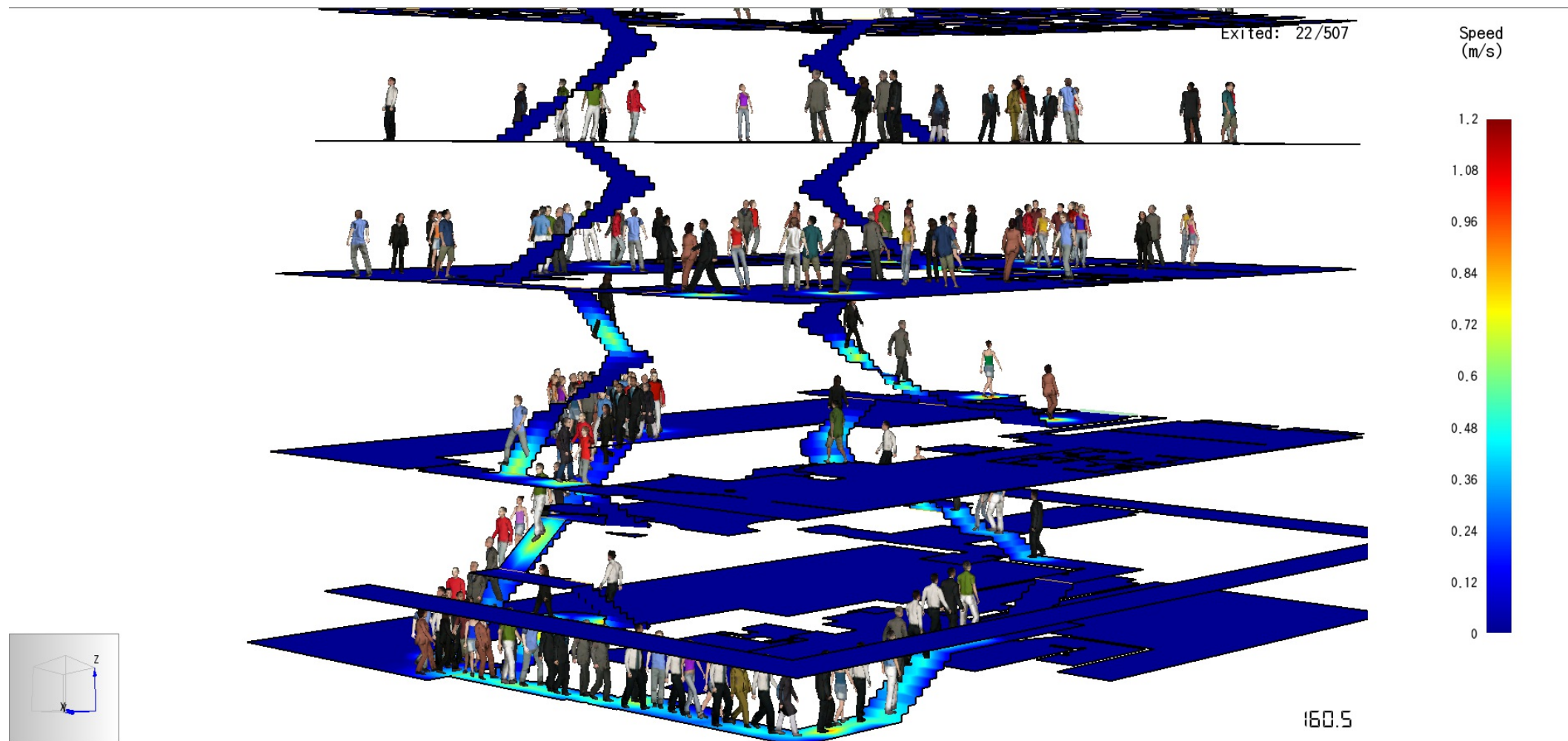
Case 4 - Logistics Centre

- The last example is a large logistics centre
- The objective of the study was to develop an alternative floor slab design, compared to the code requirement, so that the operation of the centre was not compromised

Logistics Centre

- The national fire safety industrial code, specifically requirements regarding smoke movement, requires that intermediate floors have an opening area of at least 50% of the floor slab in the circulation areas, this is to permit smoke movement upwards
- The operation of the centre, the use of trolleys, needed a significantly less percentage of the floor to be open (steel mesh) due to operations procedures

Comparative analysis (prescriptive vs proposed)
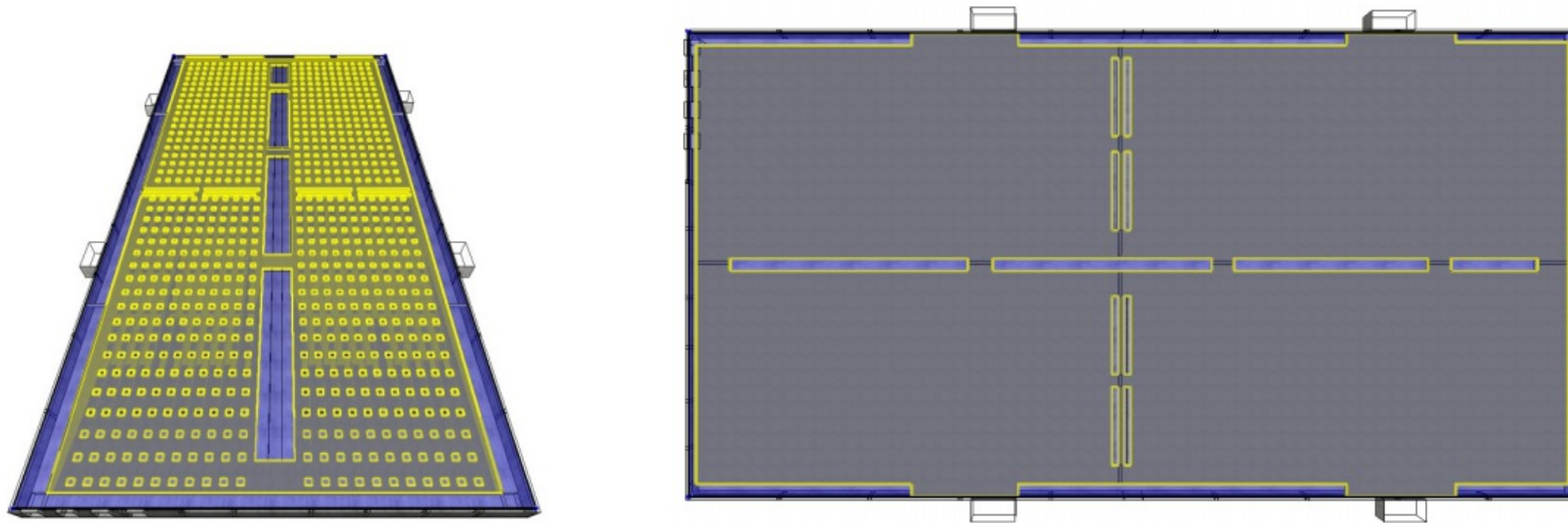
Results (prescriptive vs proposed)
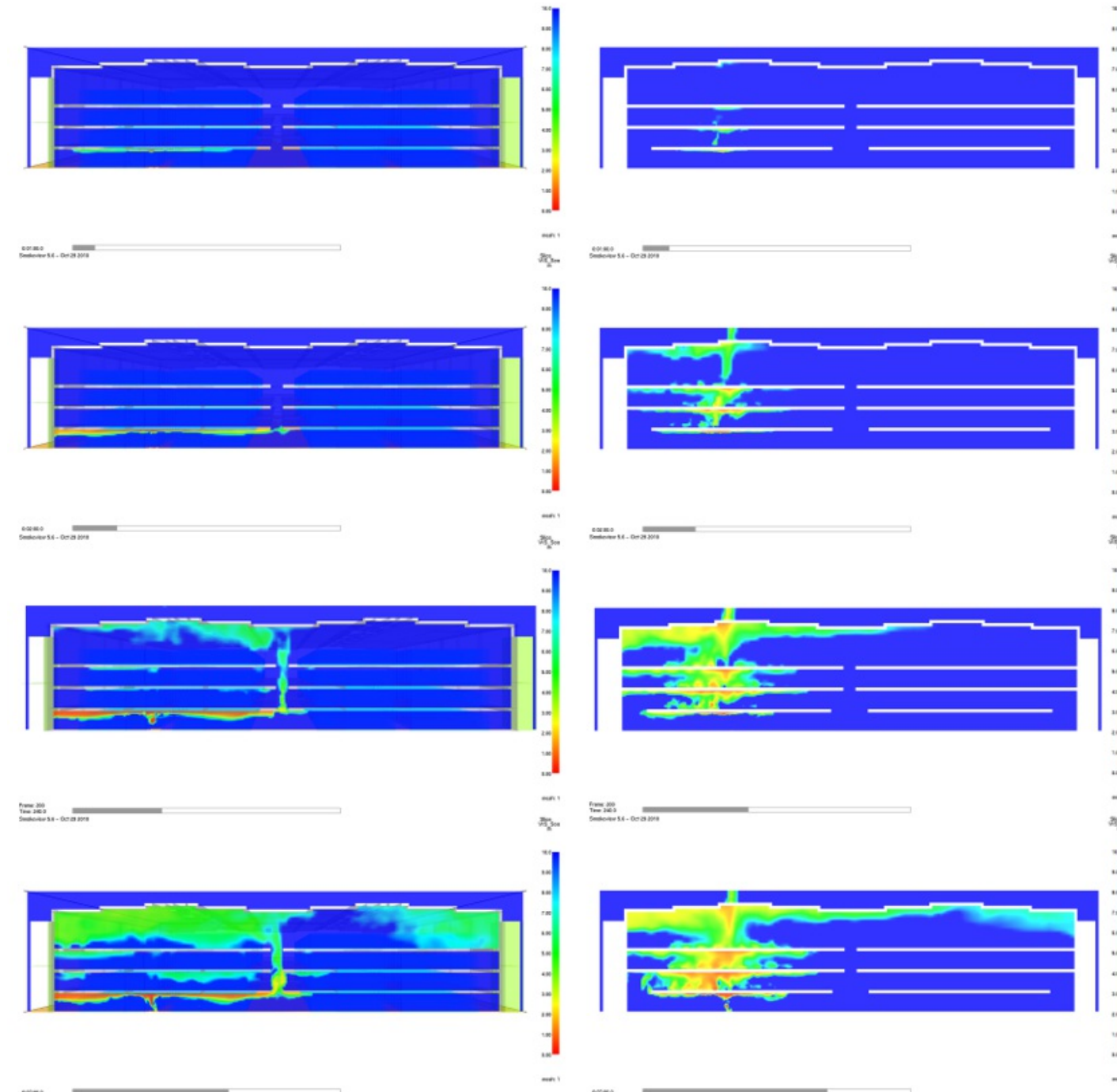
Conclusions

- The role of modelling in PBD projects is clearly gaining more and more importance
- Both models used and shown in this paper, Pathfinder and FDS, has substantially evolved during the years

All that being said, engineers must be aware that buildings might have been designed with the first versions of FDS and when Pathfinder was not as developed as it is now or probably not even born.

Are those buildings unsafe?

Conclusions

- Such buildings are (or at least should be) as safe as modern buildings built nowadays and this is because of the engineering judgement undertaken in the analysis
- Without the Engineering Judgement, the results obtained by advanced models might be totally useless; and this is not because of the models themselves but because of the inaccurate approach to them.

Driving a car

- It requires the driver to skillfully deal with the steering wheel, use the brake, the clutch the gear and the accelerator
- And what about cars circulating in the opposite direction, curves, slopes, velocity limits, signs to be read in real time, rear mirrors to be used simultaneously when looking at the road in front of you?
- Knowing how to deal with the controls is not enough to survive in a busy street

Please drive safe