4TH BUILDING DIGITAL TWIN International Congress

DT for comfort condition and crowd simulation for fire safety and for emergency management

Speaker: Prof. Lavinia Chiara Tagliabue
Computer Science Department
University of Turin

ORGANIZED BY:

BDTA DigiChecks EUnet4DBP

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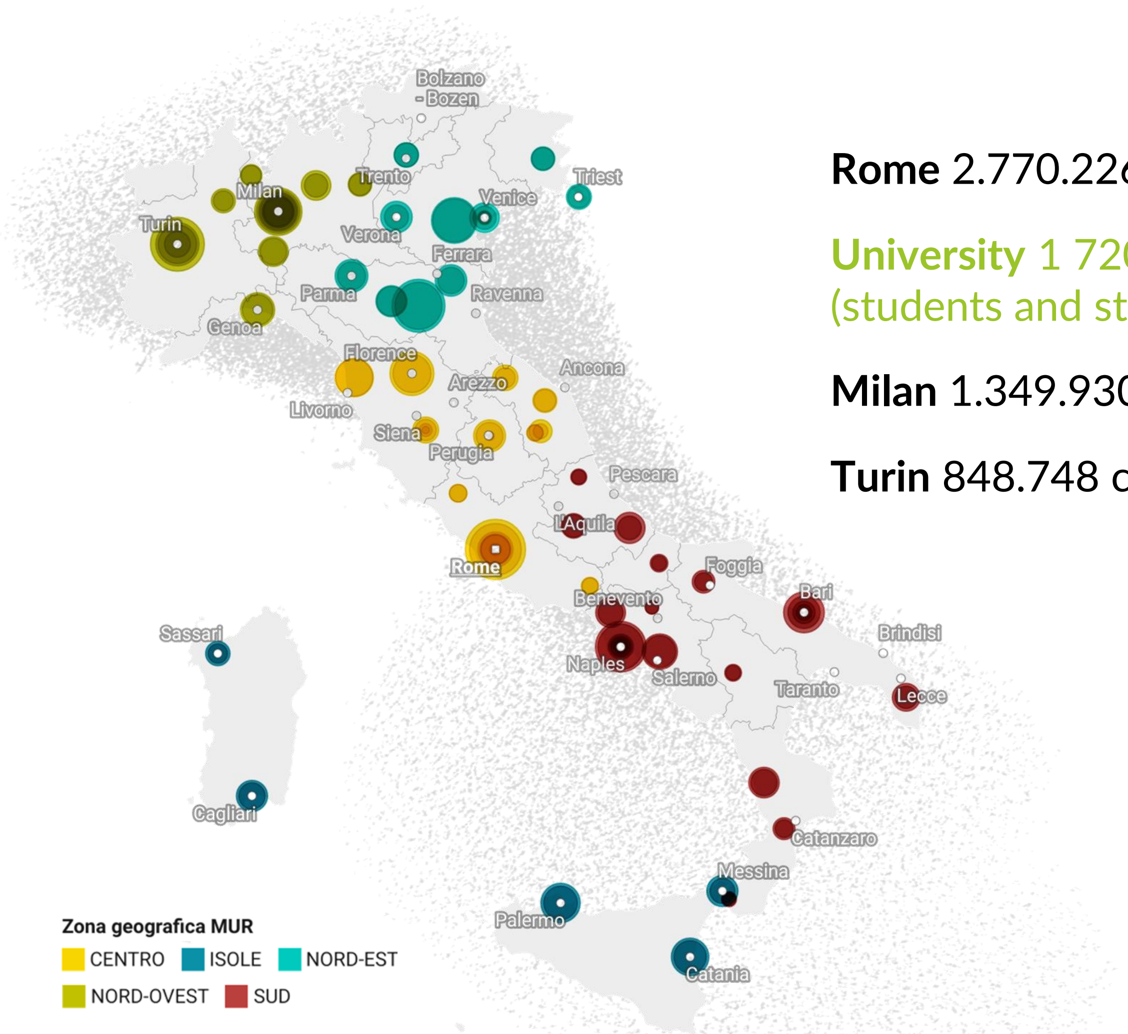
University Asset Management
The management complexity of a city

#BDTIC



Mappa: BIMGroup • Fonte: MUR - Open Data • Creato con Datawrapper

Rome 2.770.226 citizens

University 1 720 980 «citizens» (students and staff)

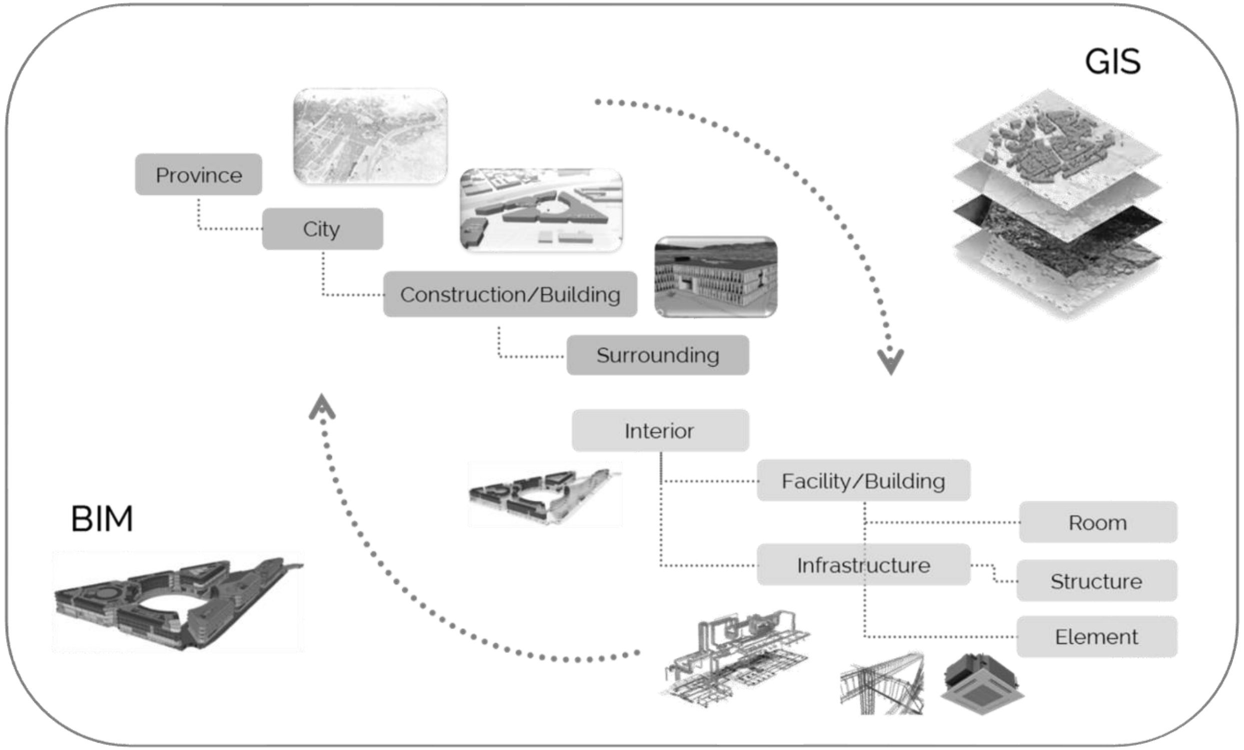
Milan 1.349.930 citizens

Turin 848.748 citizens

- Diffused and heterogeneous buildings
- Siloed and vertical management, fragmented information
- Large and varied catchment area
- Moltitude of activities, actors and disjointed processes

Interoperability and information value

- Continuos data flow throughout the lifecycle, efficient information exchanges
- More effective workflows, structured and automatable processes
- Complete and updated data, avoid redoundancies (Shared single source of truth)
- Easier and timely decisions and interventions
- Reduced risks, time and costs planning



University Asset Management
BIM-GIS and BI tools for Smart Campuses and DTs

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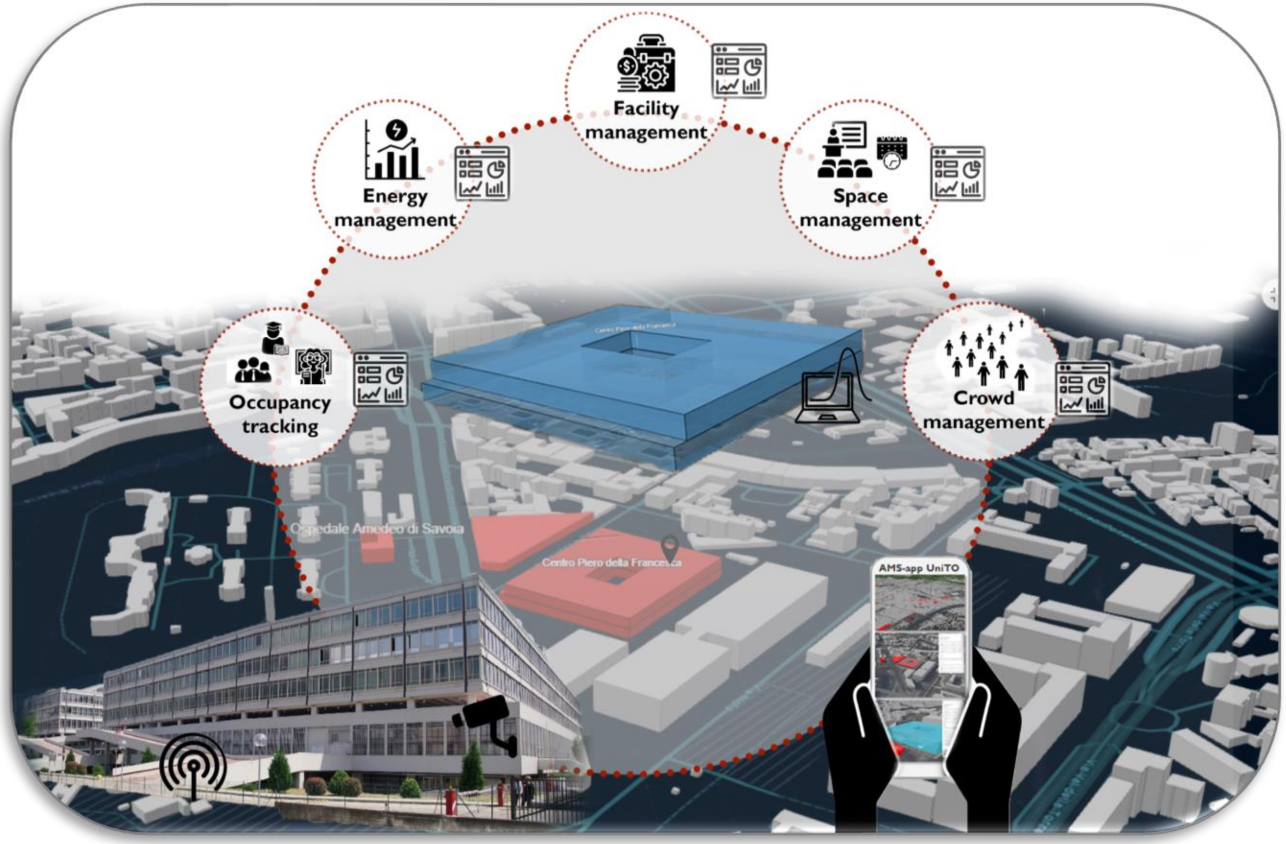

Digital Twins of strategic buildings, included in the DT of the City of Turin

- Preventive and guided maintenance
- Real-time performance adaptation
- Resources use and comfort monitoring
- Cleaning services optimization based on actual occupancy
- Real time fault detection and emergency alerts
- Mobility and routes optimization, rescue guidance

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BUILDING DIGITAL TWIN ASSOCIATION

UniTO Asset Management System: a pilot case
Integrated Databases and the AMS-app

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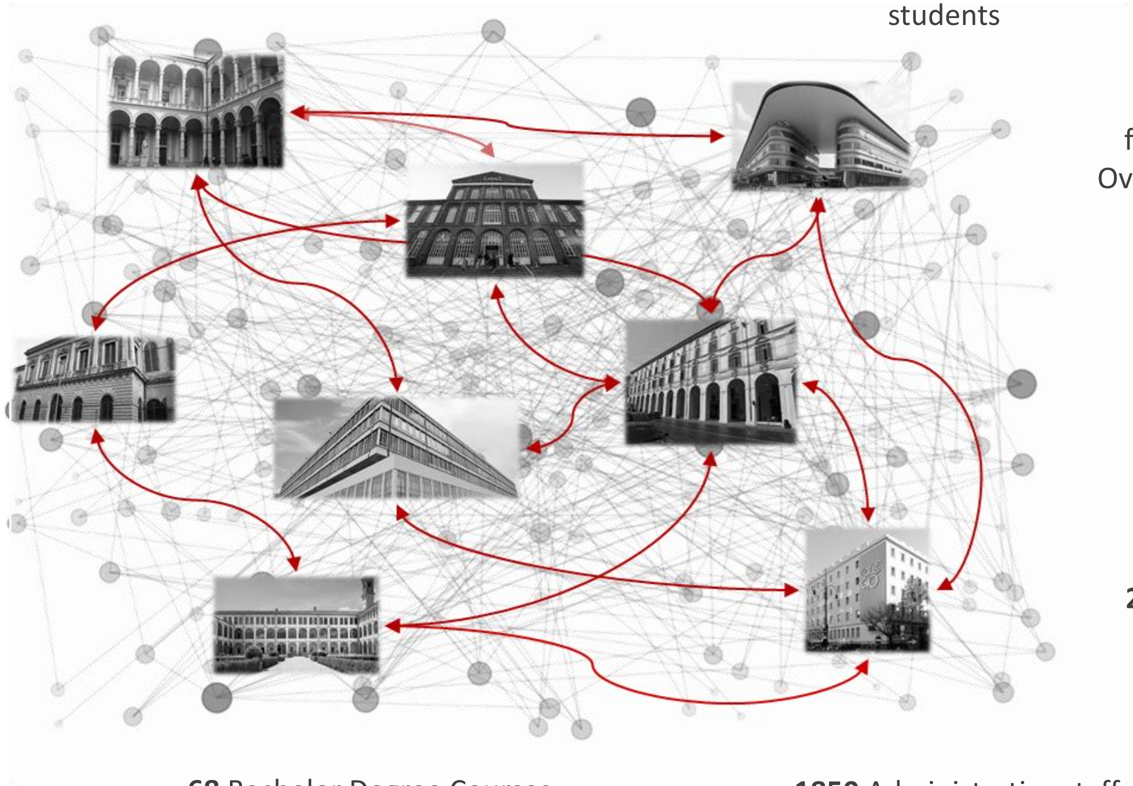
A COMPLEX MANAGEMENT

5 Provinces

120 Buildings

More than
81.700
students



Students
from **123** countries
Over than **700** Erasmus

50 Master - I Livel
36 Master - II Livel
38 PhD Courses

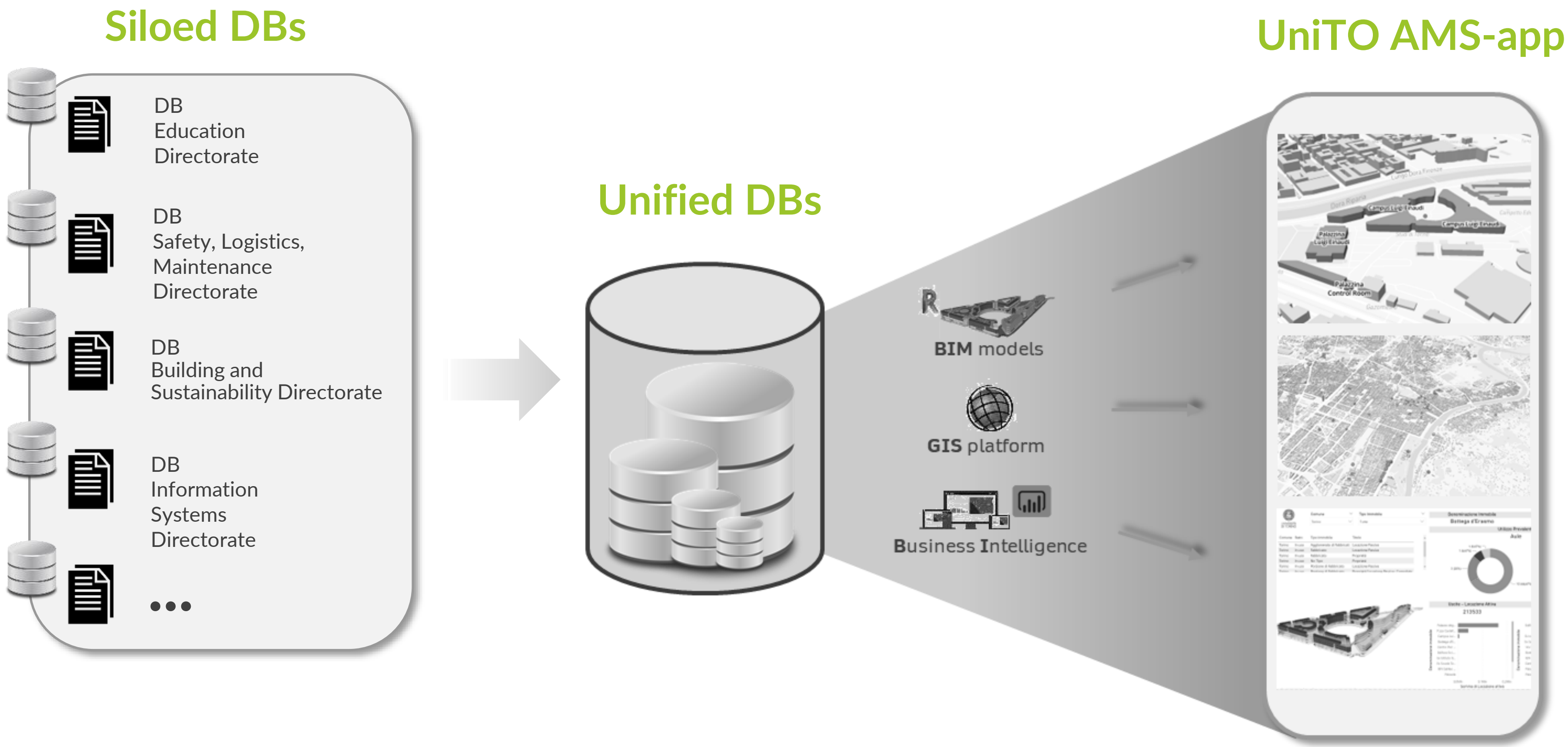
2060 Researchers
and Professors

68 Bachelor Degree Courses
82 Master Degree Courses

1850 Administrative staff

Estimated catchment area: 90’000 people ~ 59° Italian Municipality (7’904 Municipalities in Italy)

UniTO Asset Management System: a pilot case
A unified Database and an AMS-app



Digitalized and georeferenced asset

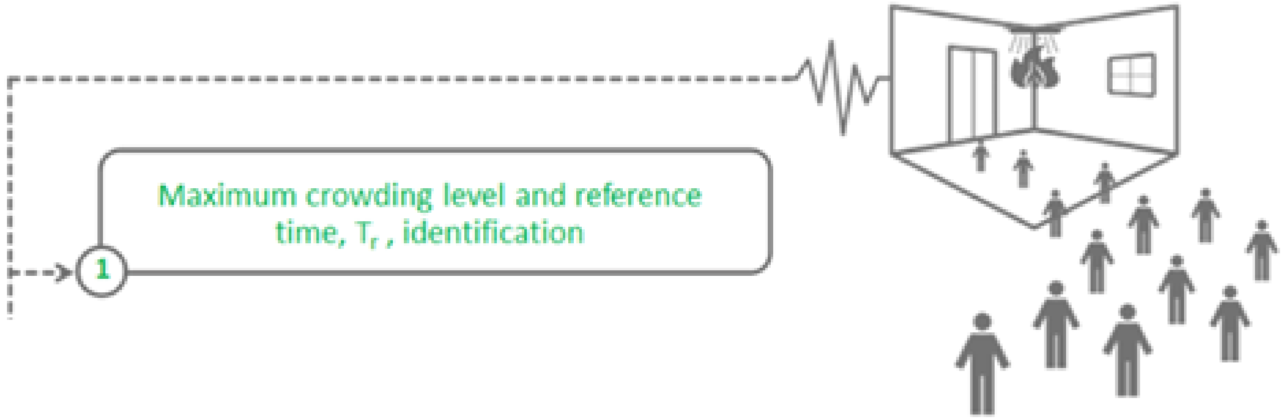
Real-time visualization in a 3D map

Spatial and functional data storage

Data queriable through Web-App

UniTO asset management: a pilot case
Crowd simulation for fire emergency management

Maximun crowd level: 5 p/smq
Reference escape time T_R
(effectiveness maximum time for the safety measures required (Italian M.D. 10/03/98)



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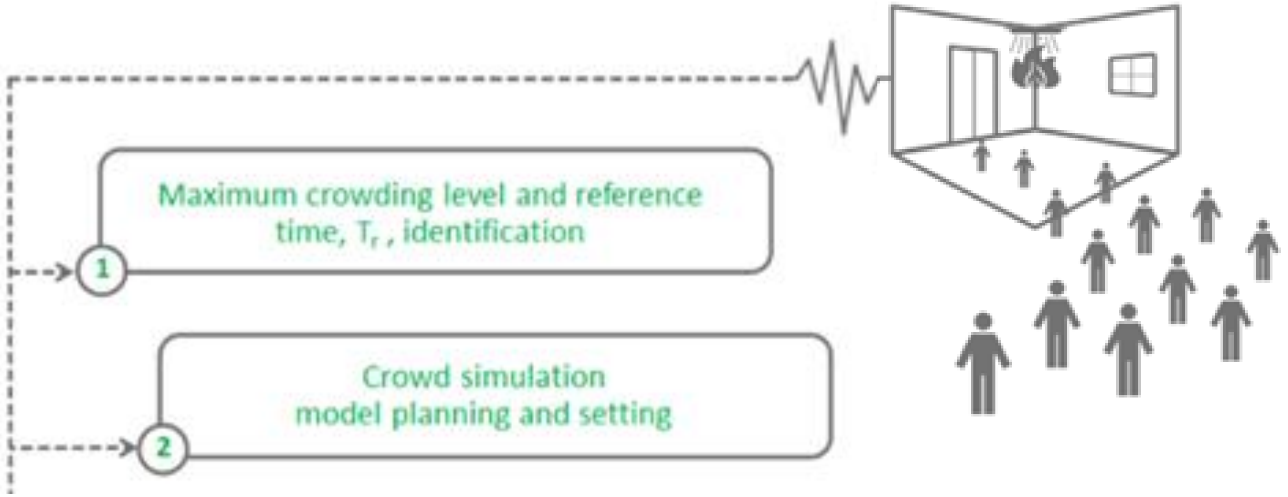
Considering the whole building or just relevant portion

Agents able to identify the best escape route according to crowd, behaviours and the least effort principle



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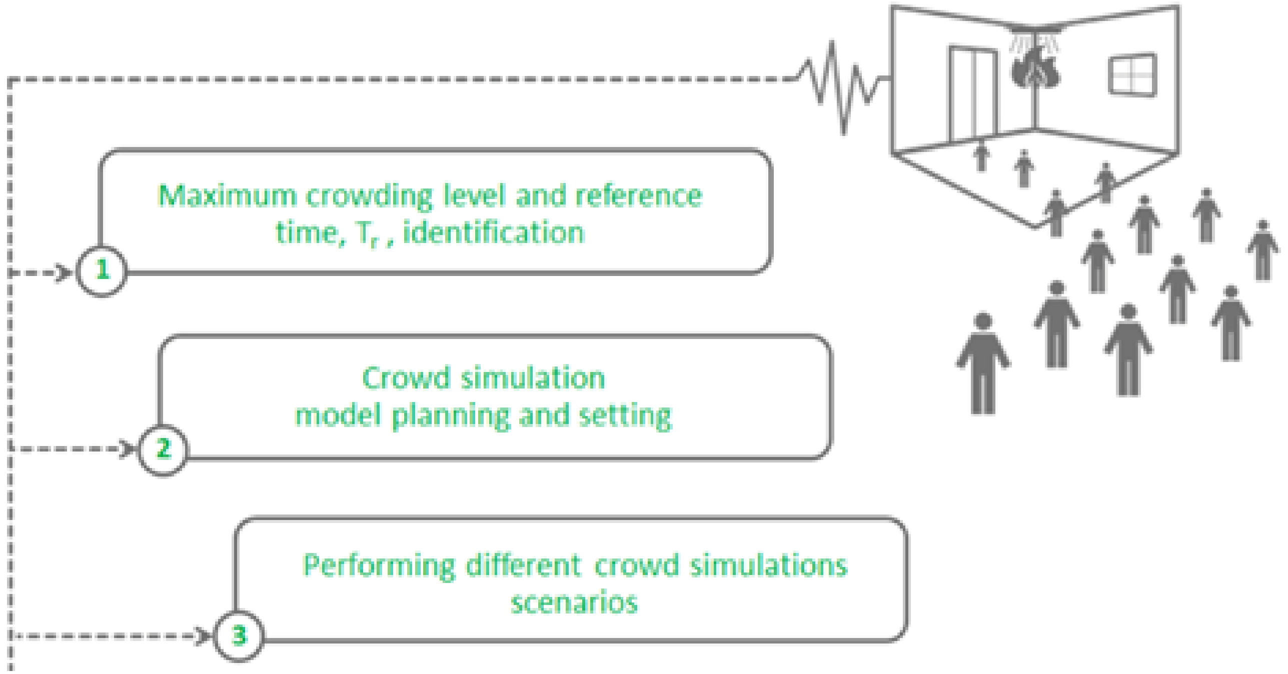
Performing crowd simulation scenarios with agents triggered to evacuate through any escape route and exits, or introducing hazardous events



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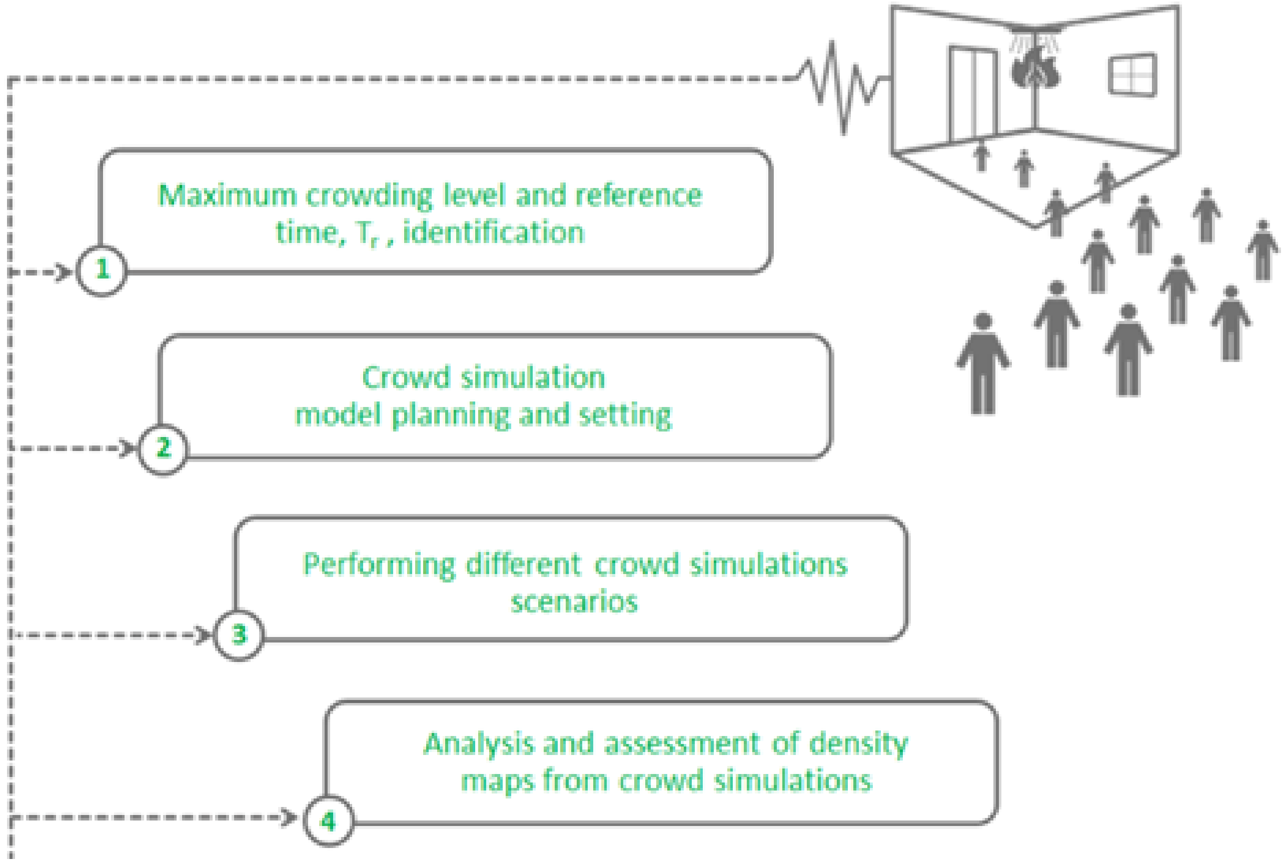
Density map analysis, it represents the maximum density of moving crowds



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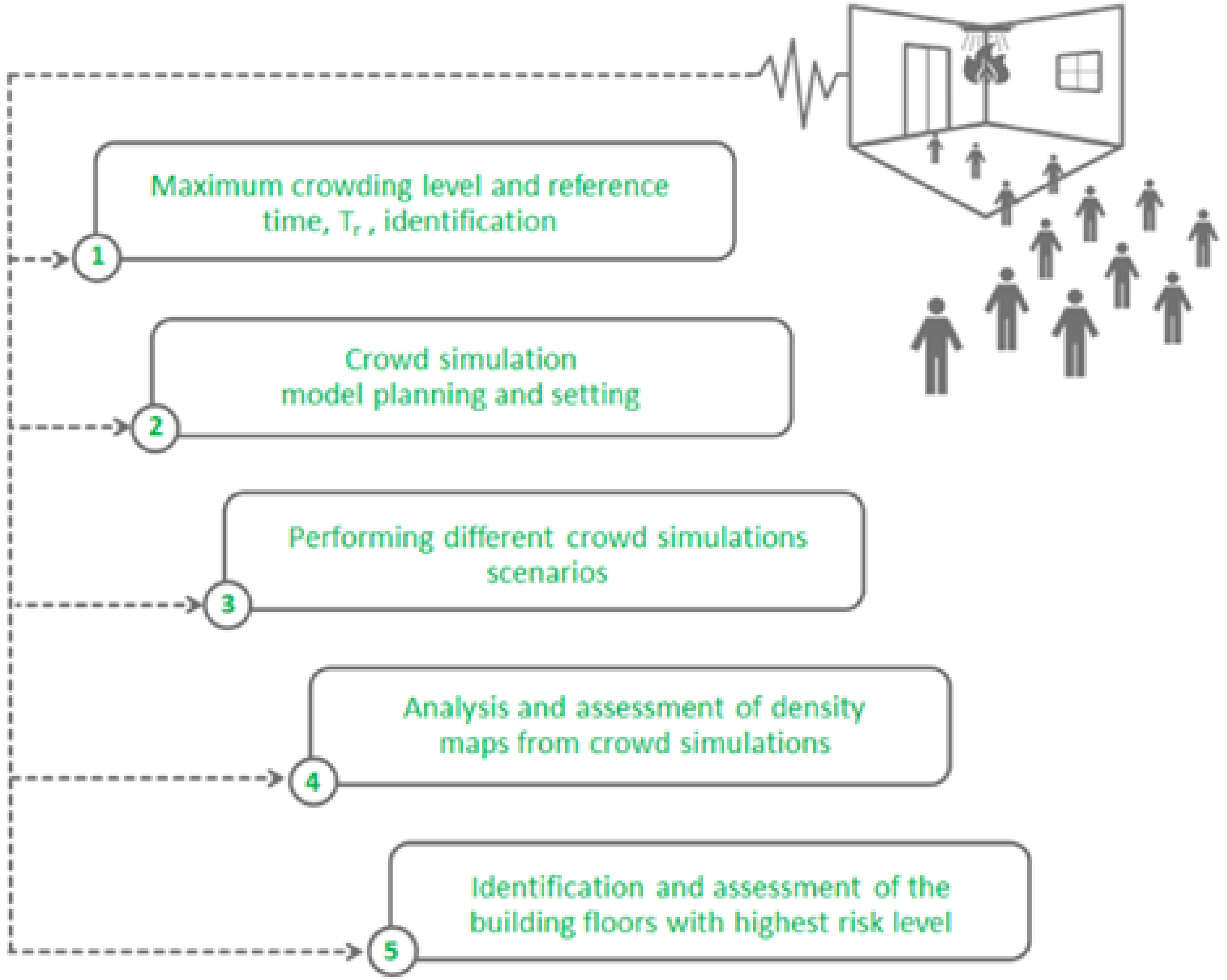
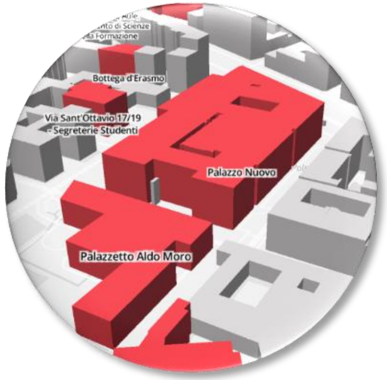


Analysis of the building floors with high-risk levels of moving crowds to identify the escape time, T_N (time until the last agent reaches the safe place or the floor exit) **compared to** the reference time T_{Rc}

UniTO asset management: a pilot case
Crowd simulation for fire emergency management

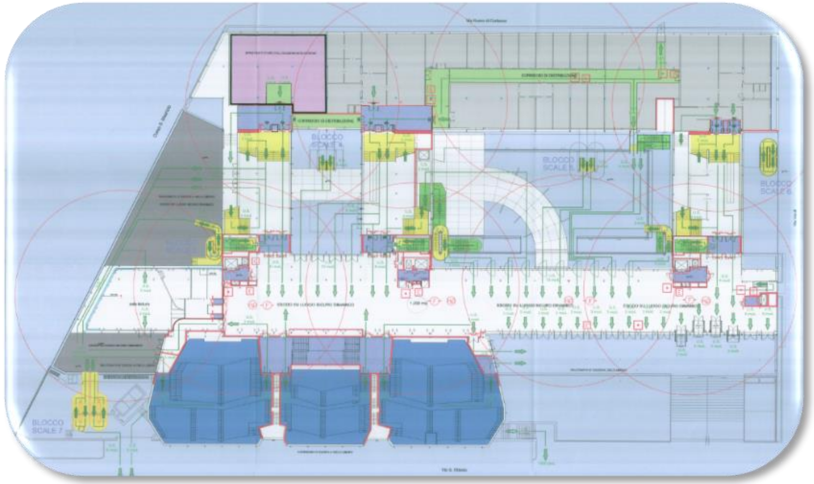
Demonstrator: a complex building



Palazzo Nuovo

- 5 departments, 33 degree courses
- ~ 7’000 sqm, complex geometry
- Numerous and various types of activities
- **~ 23000 students plus administrators, professor and researchers**

Standard floor plan



7 floors above ground
3 basement floors
3 huge classrooms separate from the main body
Net area of almost **7’000 sqm**
~ 8’000 seats

Building compliant with the prescriptive standards for fire and emergency safety measures

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Crowd simulation for fire emergency management

Definition of Palazzo Nuovo simulation model

- **6 floors above ground**, **1'765 users**
- **6 escape routes** represented by the stairs
- **Risk: 5 people/sqm**
- **Variables definition**
  Field of view angle, avoidance range and avoidance preference

  User speed as a triangular function of high value (1.75 m/s), medium value (1.35 m/s) and low value (0.8 m/s)
- **2 safe places at ground floor**
- **Ground floor excluded** as most of the spaces exits lead directly to safe places

- **Demonstrate prescriptive approaches limitations**
- **Identify the data-set to identify buildings fire risk level** through the **AMS-app and manage crowd simulations towards a real-time emergency management with DTs**

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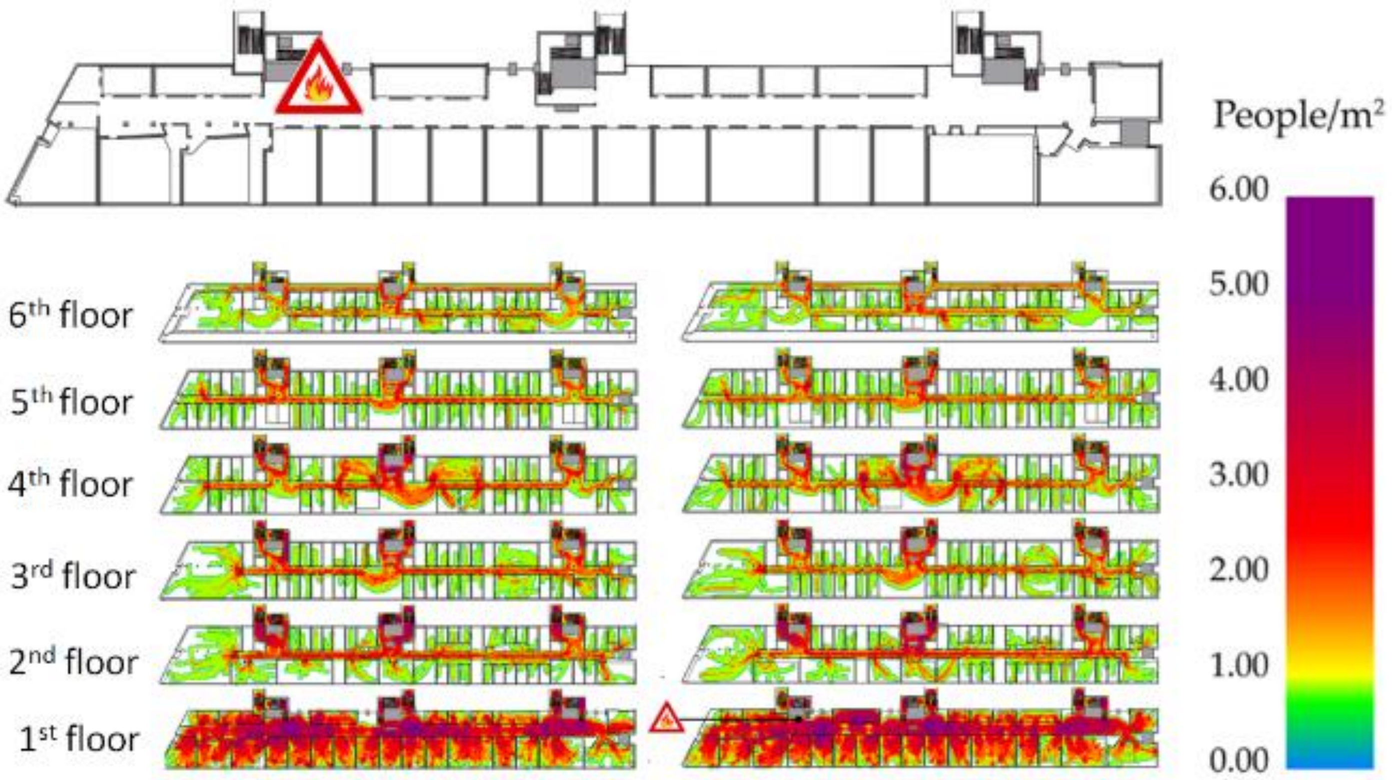
Crowd simulation for fire emergency management

Analysis of the density maps in two scenarios

- **1st scenario**
  considering the **entire building section**

- **2nd scenario**
  a hypothised hazardous event on the first floor, with the greatest number of users.



Density maps of crowd simulation of the first scenario

Density maps of crowd simulation of the second scenario

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Crowd simulation for fire emergency management

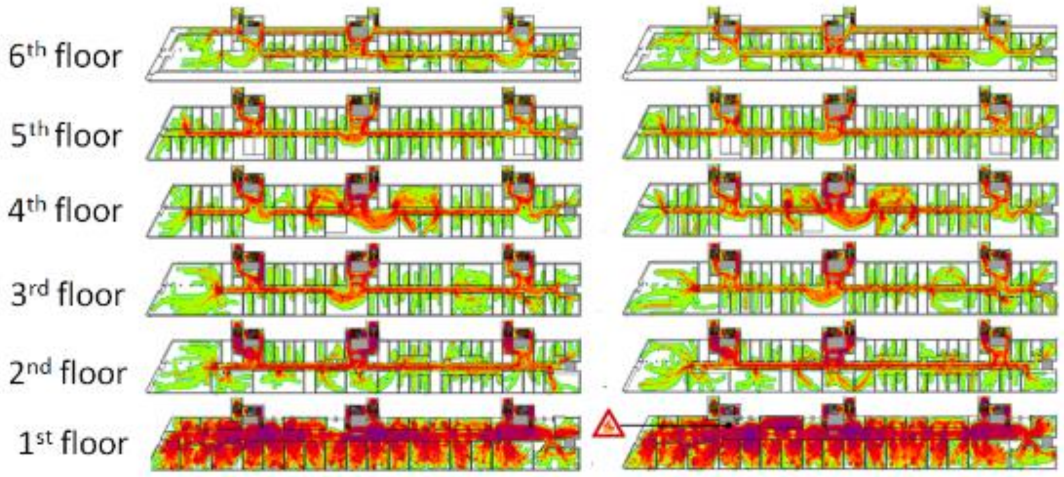
Comparison of the results in the two scenarios

- In the **2nd scenario**, **non-safe places** area with density values over 5 p/smq is **14,23%, greater than** in the **1st scenario**

- **Analysis of each floor with detected density values over 5 p/sqm** in the two scenarios

- **Tn is defined for each floor** as the **time at which the first agent of the floor is triggered by the emergency alarm**, **ending when the last agent of the floor has reached the fire exit** which leads to a safe place or to the protected or external stairs.

T_1 = 12 min 52 s > T_R (1 min); 12.86 time greater than T_R
T_2 = 15 min 48 s > T_R (1 min); 15.80 times greater than T_R



The comparison shows T2>T1 with T2 22.79% greater than T1

- **Strong negative impact that a hazardous event** can have both on the evacuation and on the occurrence of dangerous phenomena.

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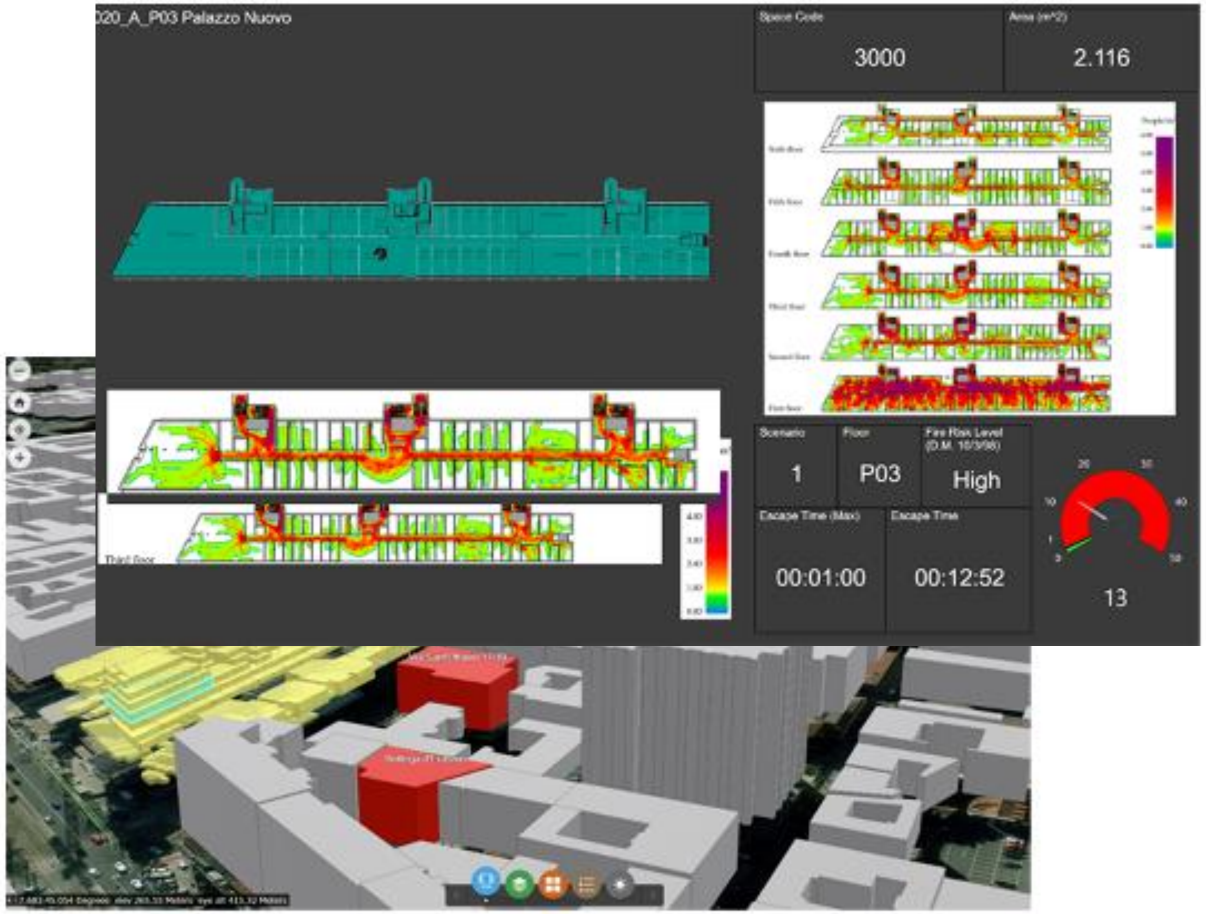
Crowd simulation for fire emergency management

Identification of needed information and development of analytic dashboards



Queried BIM model in the AMS-app

- **Set of data for fire emergency management and crowd simulation** (Building fire risk level, T_R, T_n, density values, walking speed, FoV angle, avoidance range, expected occupants, and avoidance preference)
- **Key both for** dynamic simulations aimed at **mapping the current asset fire-risk** level through the AMS-app and **defining "fire emergency DTs"**
- **Actual occupation as the first, crucial data,** should be provided in real-time **through IoT networks**

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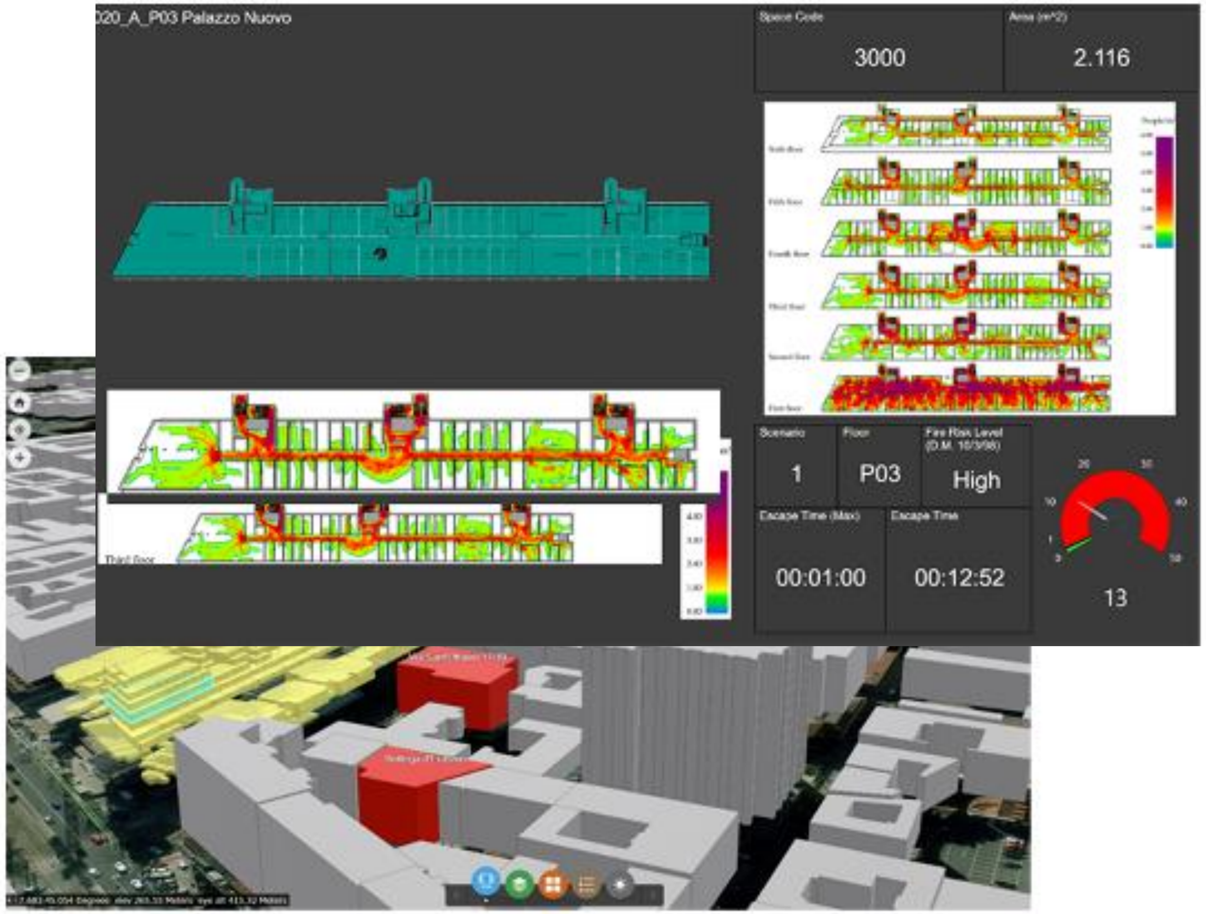
Future developments



Queried BIM model in the AMS-app

- **Replicating the crowd simulation** throughout the whole UniTO asset
  → "fire risk map" in the AMS-app
- Investigating **AI and VR to enable** cognitive features for **«Fire emergency DTs»**
- **Active wayfinding to drive users'** evacuation through audio-based systems or lighting signals **according to IoT data and actual occupancy**
- **Users guided through the safes and shortest evacuation routes** with paths loaded in the AMS-app
- **Rescuers alerted and guided** to life in danger or fire breakout point
- **Timely and effective interventions and decisions**

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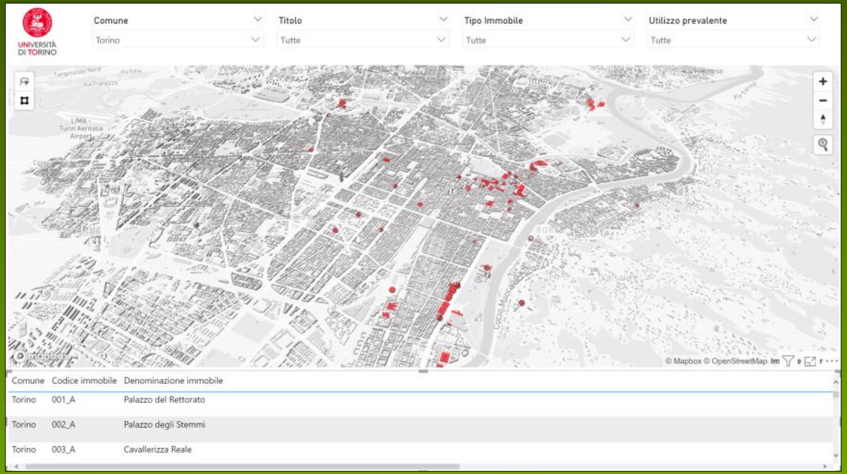
Thanks for the attention

laviniachiara.tagliabue@unito.it
bimgroup@unito.it



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