



Population Behavior, Social Networks, Transportations, Infrastructures, Industrial and Urban Simulation



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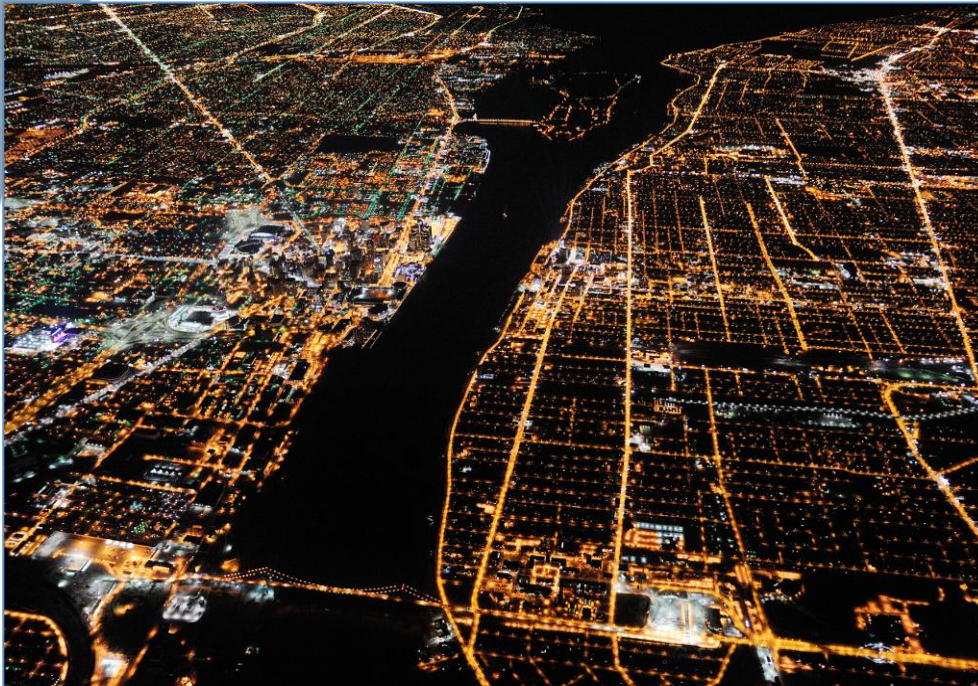
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City Management & Emergency Situations



Smart City approach allows to improve efficiency of the city management by means of data acquisition



**Shenzhen
Landslide
2015**



**California
Wildfire
2018**

Direct losses

- Casualties,
- Property damage

Indirect losses

- Lost time,
- Activity interruption

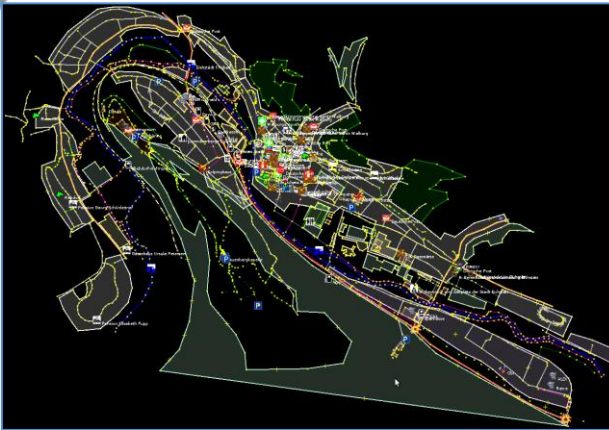
Costs of Prevention

VS

Risks

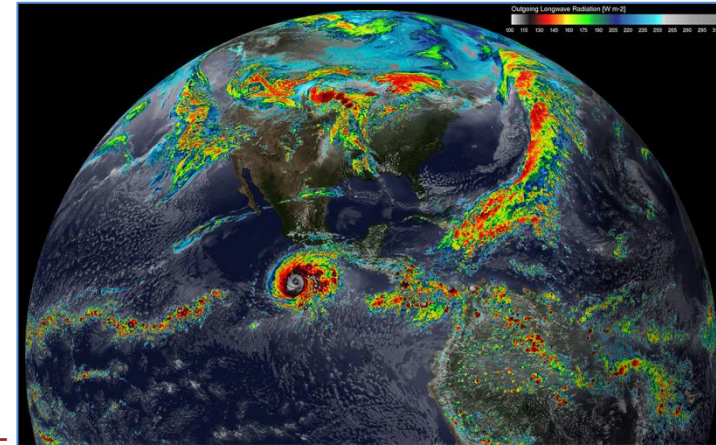


Simulation Solutions

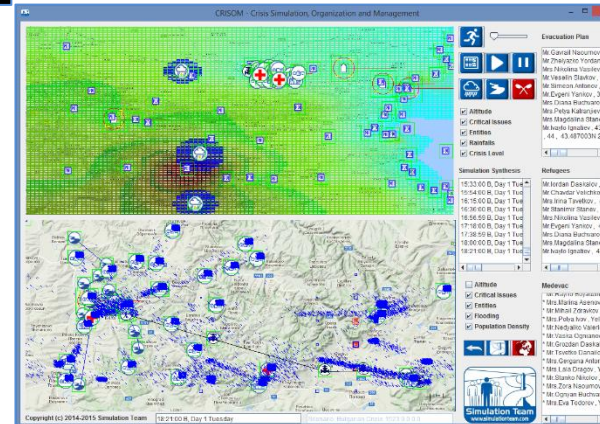
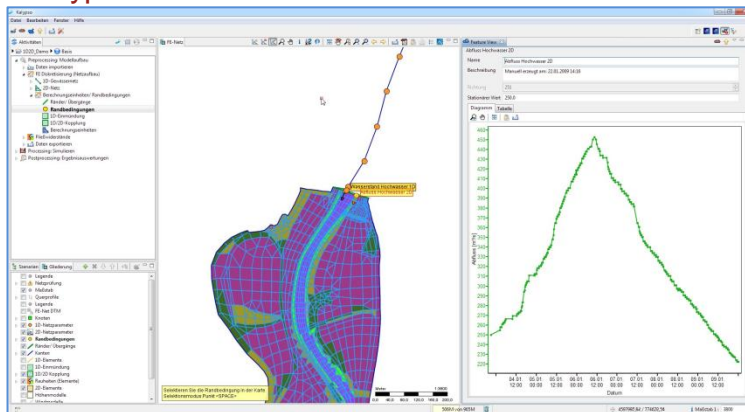


Traffic
Simulation
SUMO

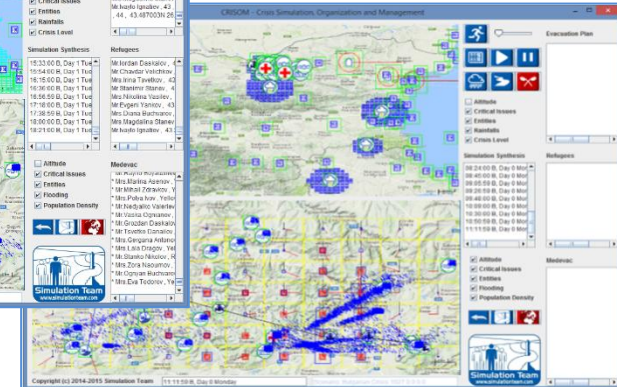
Global
Weather
Modeling
NASA GEOS-5



Flood Simulation
Kalypso



Crisis Simulation
ST CRISOM: Crisis Simulation,
Organization and Management



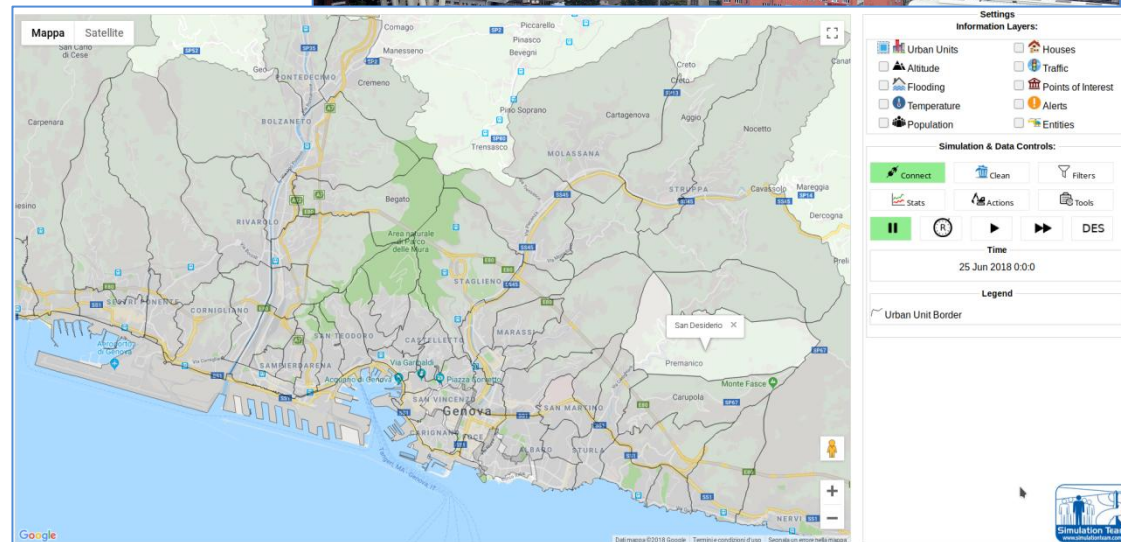


Case Study: Genoa

*Collapsed Ponte
Morandi, Genoa*

In the last decade Genoa
faced several heavy cloudbursts
which caused flooding in different
areas of the city and substantial
economical damage

Flooding near the *Brignole*
Railway Station, Genoa



**PONTUS: POPulation behavior, social Networks,
Transportations and Urban Simulation**



Meteo & Terrain Modeling

Data Sources

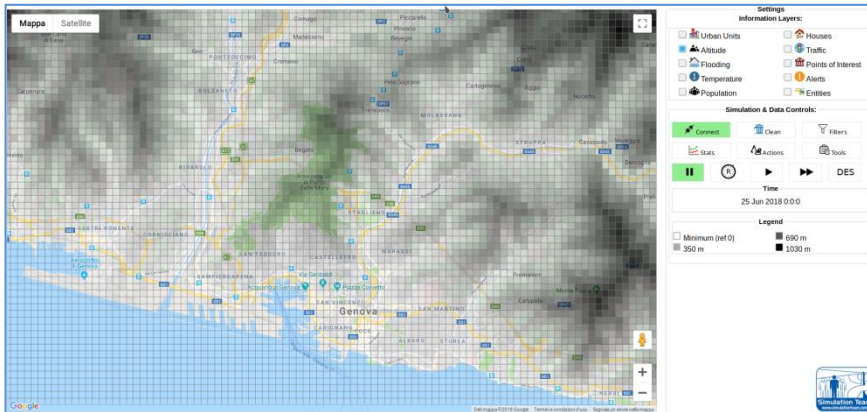
Land types: Corine Land Cover

DTM: SRTM (low detail) + Open Data

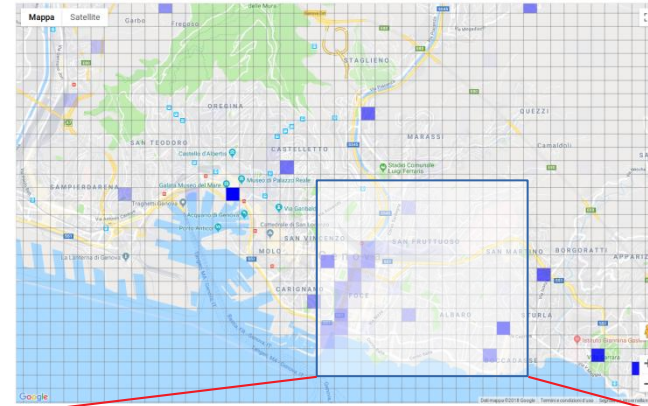
(Regione Liguria, high detail)

Weather Statistics & Forecasts:

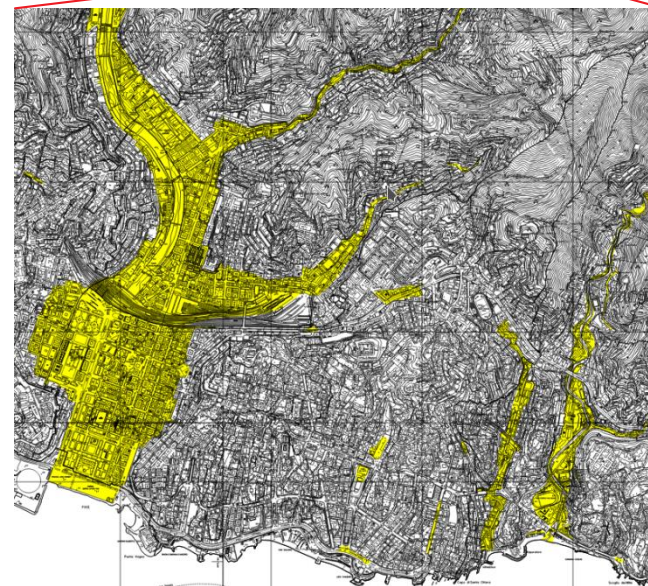
Local forecasting services



Elevation Model



PONTUS Rain Simulation



Zones with high Risk of Flooding Comune di Genova



Water Streams

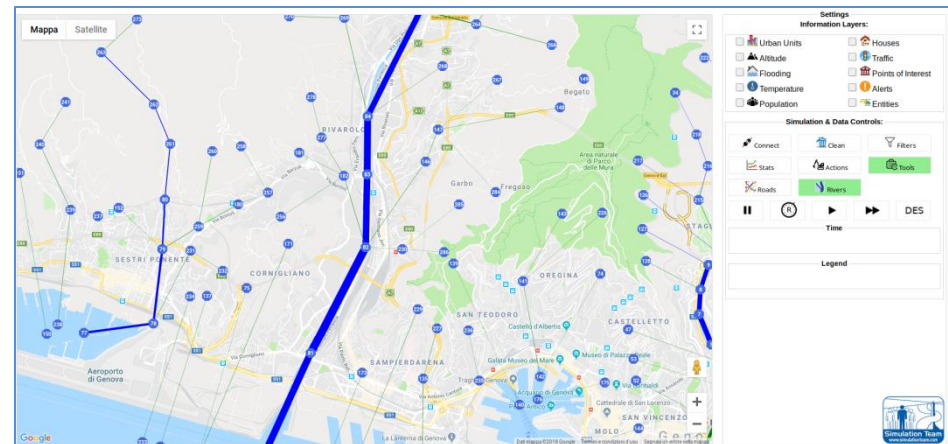
Water flows modeling considering network of rivers, channels and sewerage.

Underground Channel



River

Sewers



Streams mapping tool GUI

In Genoa one of two big rivers goes underground for about 1 km just before the sea: zone of interest

Water streams are characterized by their hydraulic radius, slope and roughness



Generated Population & Data Sources

Person Attributes:

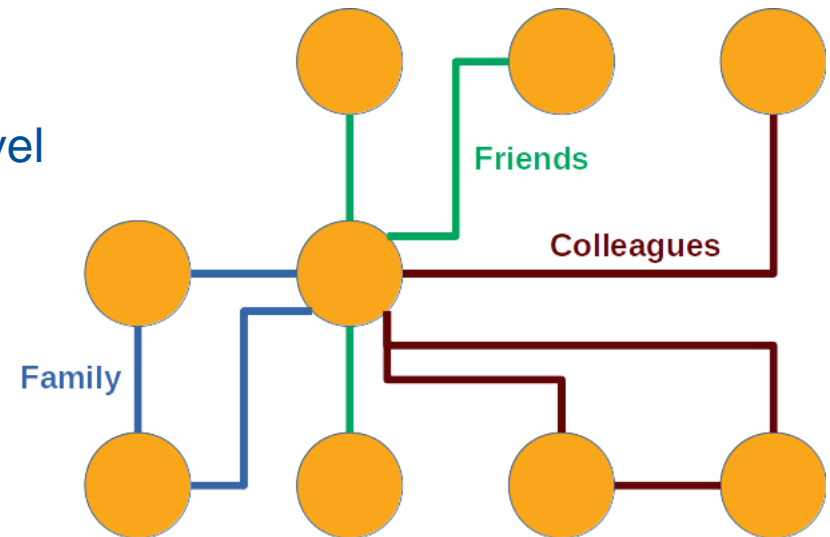
- Age
- Sex
- Nationality
- Religion
- Work type, e.g. self employment, student
- Locations of home and work
- Favorite political party
- Income and family income
- Education level
- Social network, e.g. friends, colleagues
- Preferred locations, e.g. restaurant, cinema
- Emotional status, e.g. stress, fatigue, aggressiveness, fear

World Data

- GPR per capita & Gini Index
- Fertility rate
- Religions
- Education level

City Data

- Nationality, sex and age distribution in urban units
- Income and political preferences in city zones



Persons' behavior in their free time highly depends on social network interactions

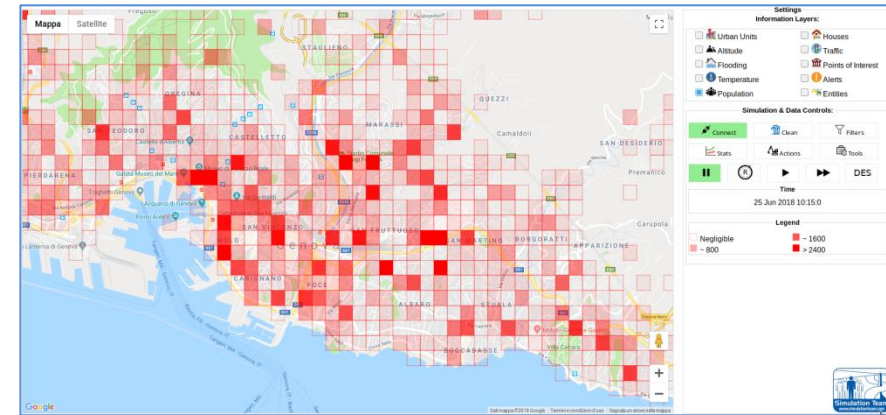
e.g. family, friends, colleagues



Population Behavior

Main Aspects

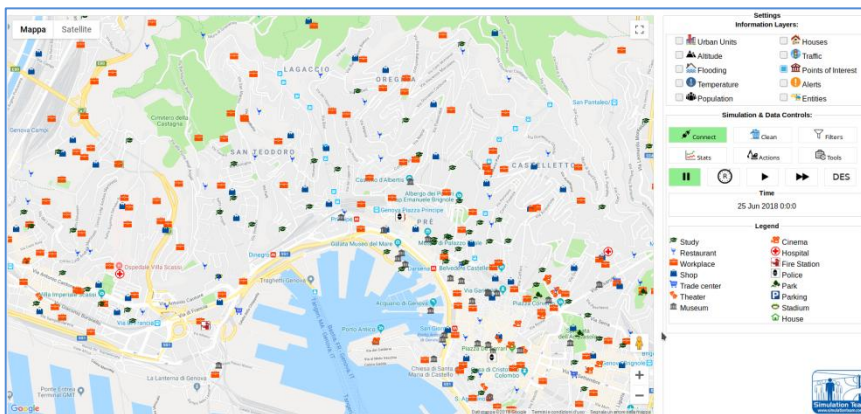
- Complete Life Cycle based on predefined patterns and individual characteristics, *e.g. worker, student*
- Habits and Opinions, *e.g. breakfast at home, like cinema*
- Social Network and Influences, *e.g. proposal of free time entertainment*
- Reaction at Environmental Conditions, *e.g. rain*



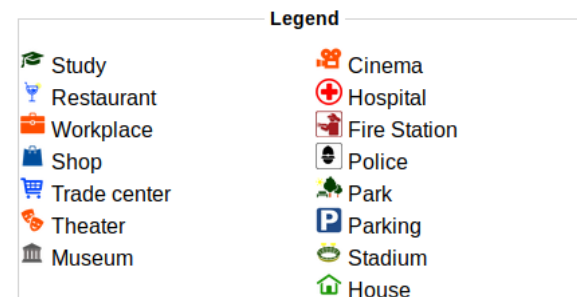
Population density

Points of Interest

Critical infrastructure, schools, various locations which attract peoples, *e.g. trade centers, shops, cinema, gardens*



Points of interest





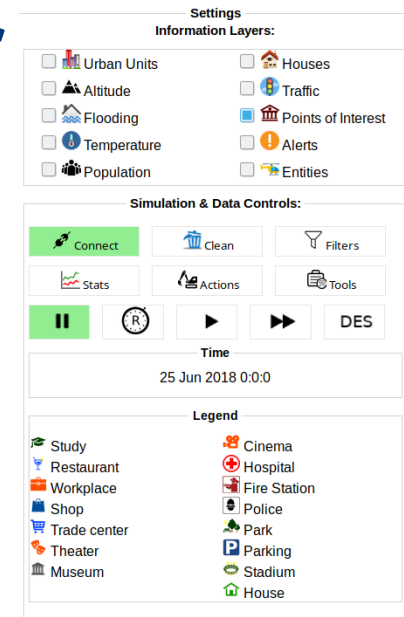
Interactions With User

The simulator is able to load predefined interventions of different types, for instance:

- Clean river bed
- Block roads
- Construct dykes

Intervention parameters

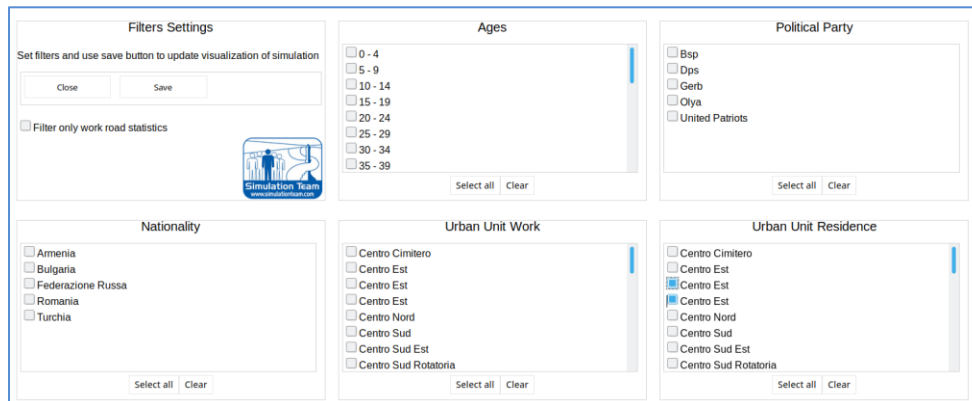
- Cost
- Required manpower
- Duration and effects of phases:
 - Planning
 - Acquisition of materials
 - Construction
 - Finalization



Main controls

During the run it is possible to filter data using following criteria:

- Age
- Sex
- Nationality
- Preferred political party
- Urban units of residence and work



Filters controls



Traffic Model

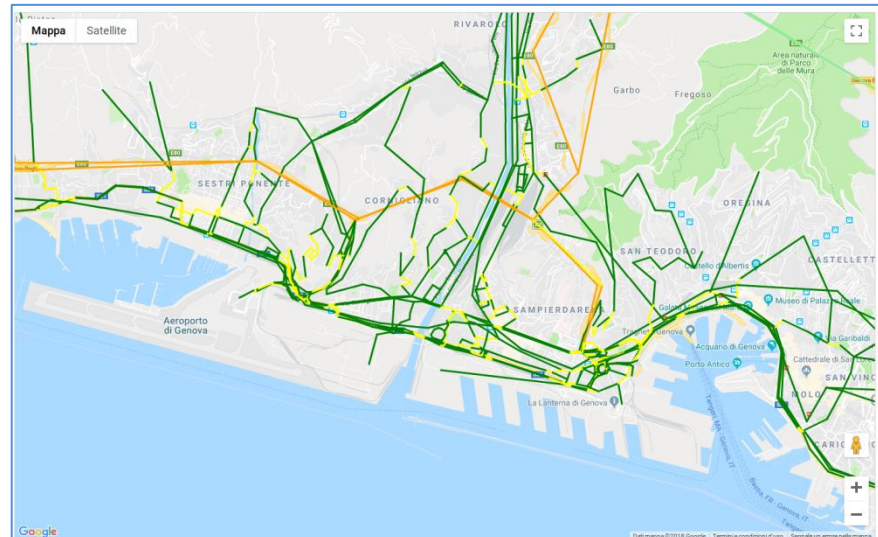
Microsimulation model operates with single vehicles and takes into account meteorological conditions

Road statistics

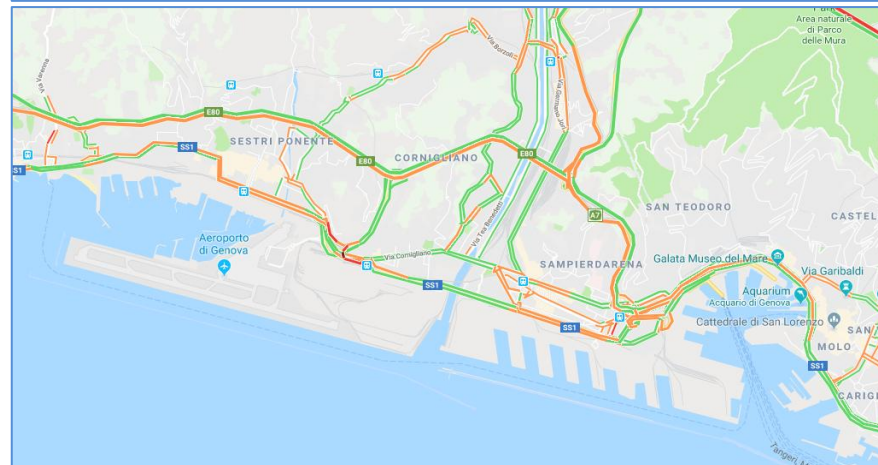
- Time
- Duration
- Estimated Cost



Transportation Statistics



PONTUS



Google
Maps
Traffic
Data



Results & Observed Effects

Reconstruction
of underground
stream channel
Genoa, Italy



In case if heavy rain occurs during construction phase of dikes or river bed cleaning, the probability of flooding increases due to partially blocked stream

For selected points of interest it is possible to generate hourly reports with number and age composition of present people

Comparison of different scenarios

- Without rain
- With heavy rain
- With heavy rain after intervention in the river's bed



People presence in POI in zone with high risk of flooding

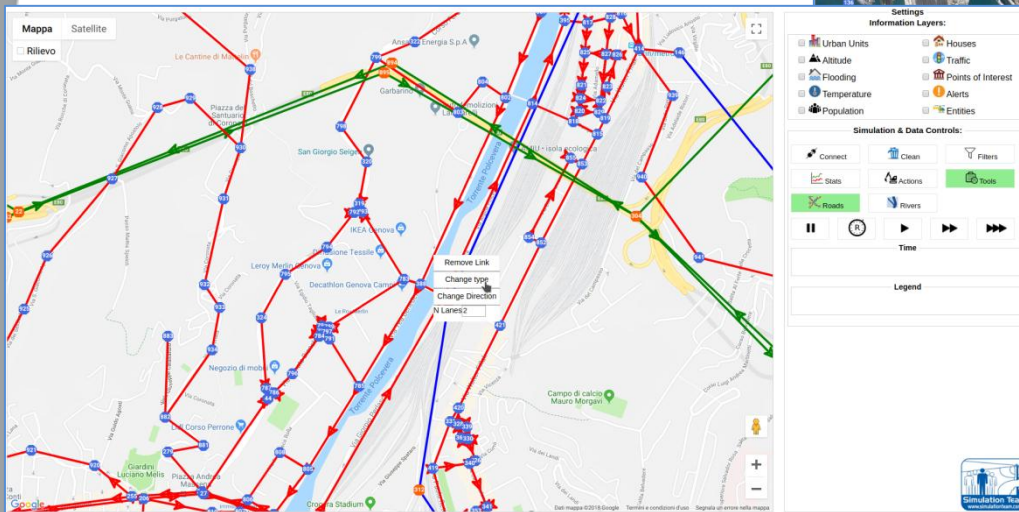
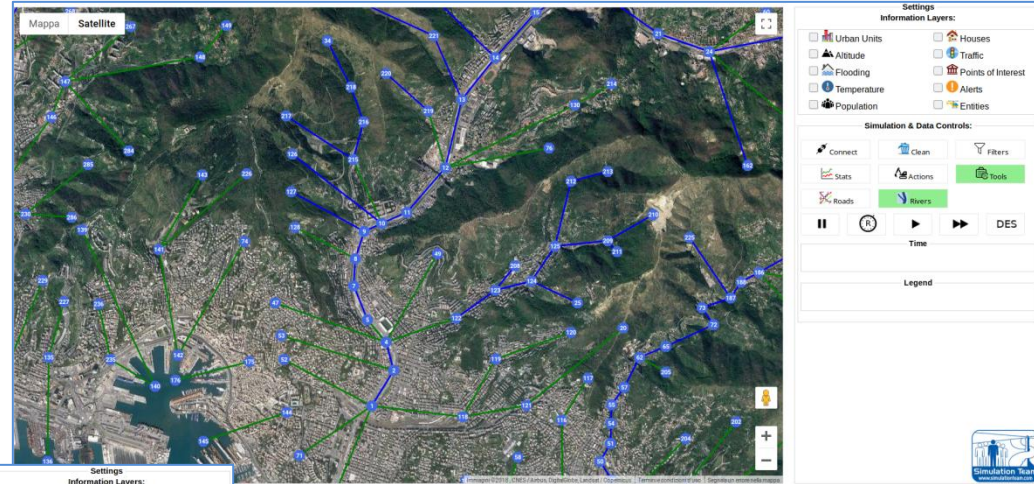
20 locations, 1 week, 1 rainy day

	Normal	Rain	Rain after intervention
Persons flow total	14071	13719	13766
N persons blocked due to rain	0	102	10



Auxiliary Tools

Additional tools integrated in the main GUI allow to easily map transportation network and water streams.



Streams Mapping Tool:

- Depth, Width
- Roughness
- Stream Type

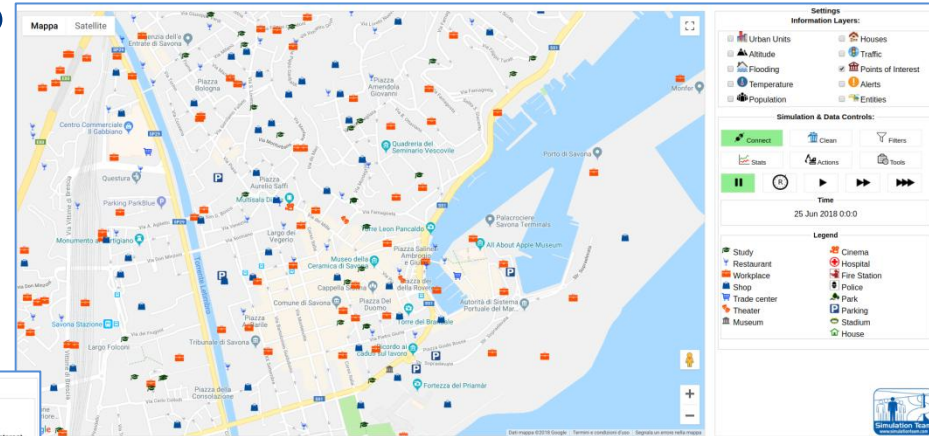
Transportation Network Mapping Tool:

- Road Type
- Number of Lanes
- Direction (if available)

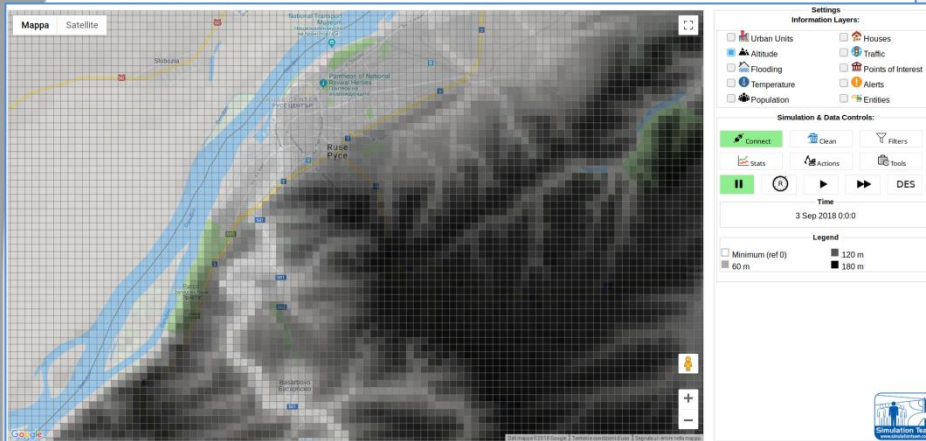


Adaptations

PONTUS architecture and auxiliary tools allow to adapt the simulator to various cities in short time span

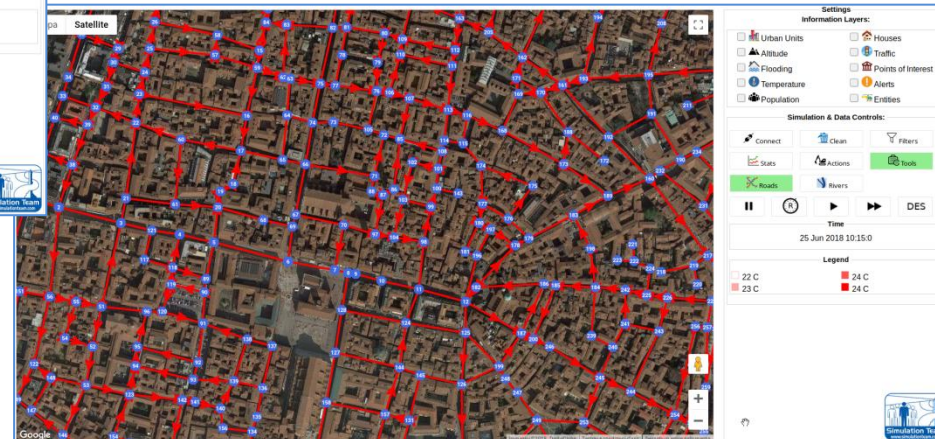


**Points Of Interest:
Savona City Center, Italy**



**Terrain: Ruse,
Bulgaria**

**Transportation
Network Graph:
Mapping Bologna
City Center, Italy**





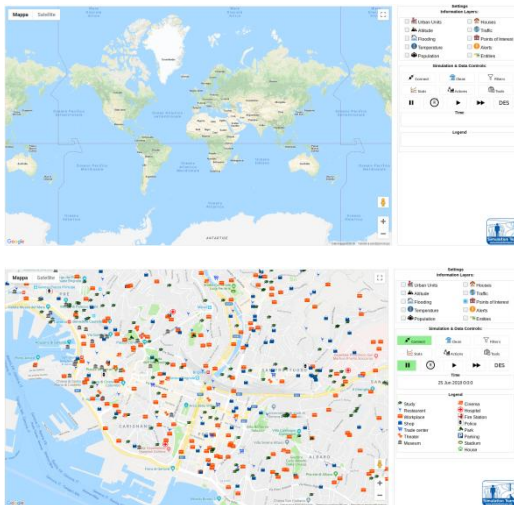
System Architecture

PONTUS allows to clients to simulate in parallel various scenarios with different conditions and even distinct cities

Simulation Modes

- Normal client-server, **multithread**
- HLA integrated, **single thread**
- Headless report generation, **single thread**

Web-based GUI



WebSocket
connection



Server

Scenario
Simulation

World
Generation

City
Data

World
Data

The simulator has various time management possibilities:



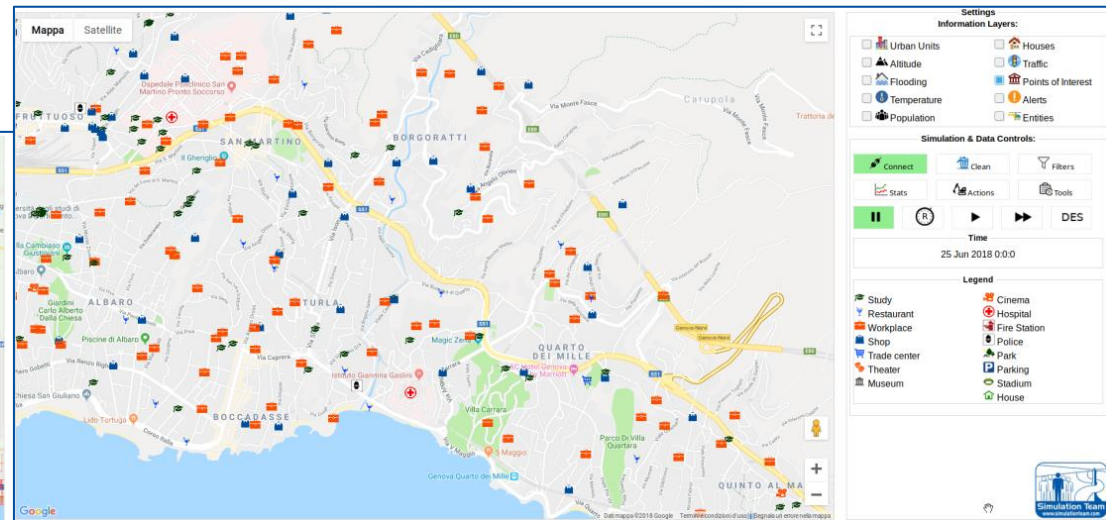
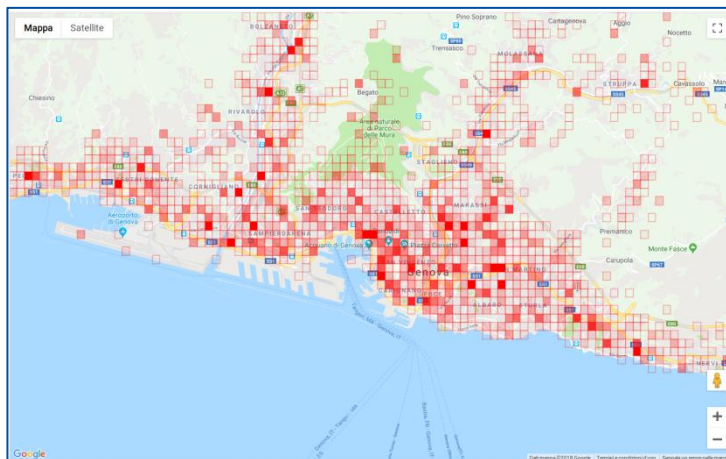
- Real time
- Scaled Fast Time
- Discrete Events

PONTUS client-server architecture allows to provide Modeling & Simulation as a Service



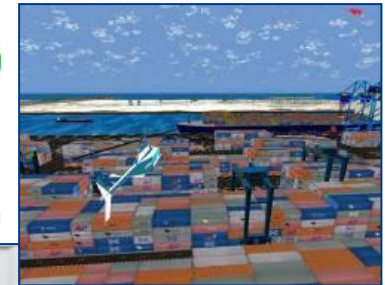
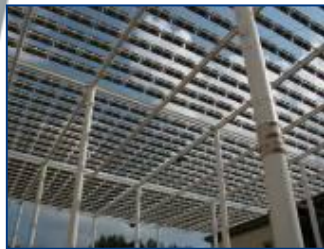
Conclusions

The simulator considers the City as System of Systems (SoS), taking into account of weather conditions, transportation network, human behavior and social interactions. This elements allow to predict results and consequence of alternative solution to be adopted by the Decision Maker in numerous environmental conditions and to estimate costs and risks. PONTUS Simulation could be easily extended to other cities, while its modular structure allows its Extension with other Models





References



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