



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



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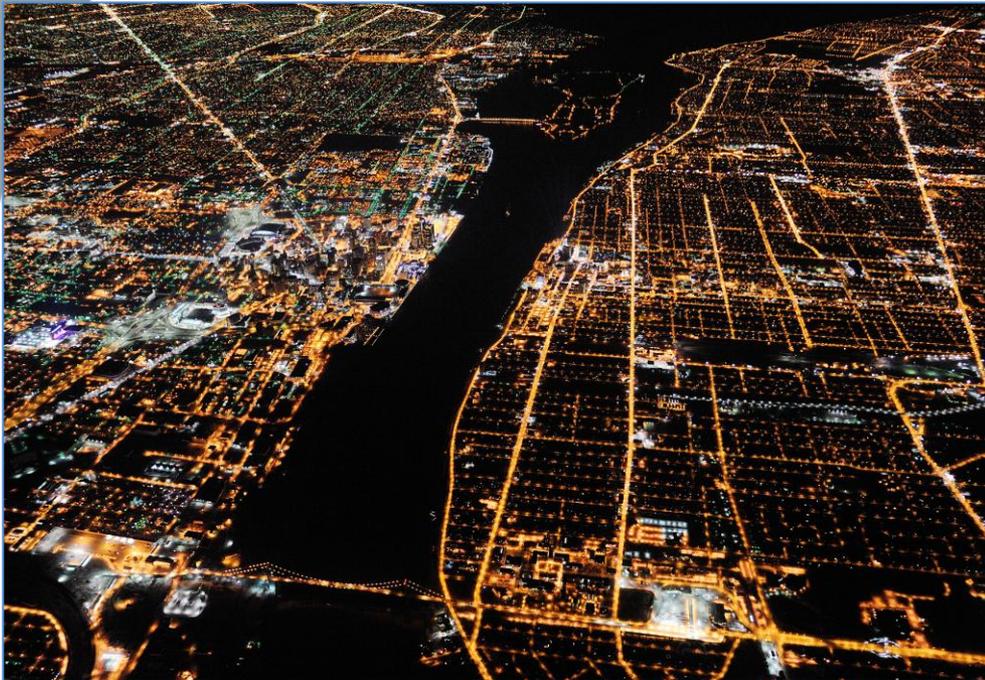
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# City Management & Emergency Situations



Shenzhen Landslide 2015



California Wildfire 2018

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

### Direct losses

- Casualties,
- Property damage

### Indirect losses

- Lost time,
- Activity interruption

## Costs of Prevention

VS

## Risks





# Simulation Solutions

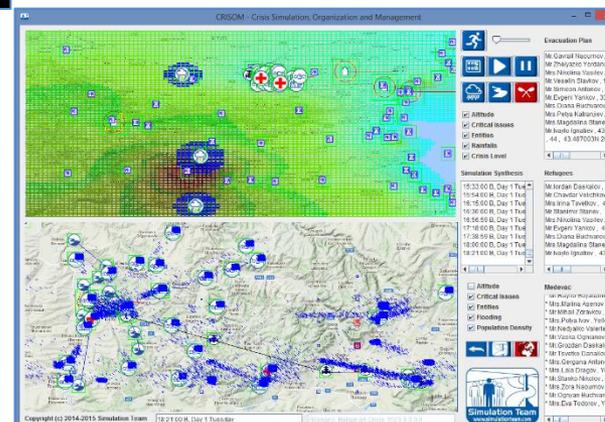
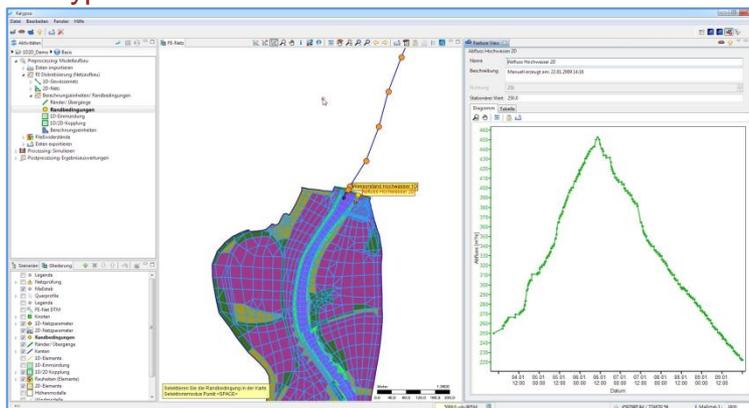


Traffic Simulation  
SUMO

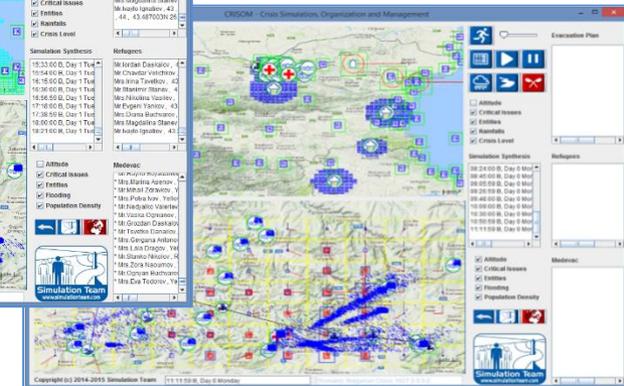


Global Weather Modeling  
NASA GEOS-5

Flood Simulation  
Kalypso



Crisis Simulation  
ST CRISOM: Crisis Simulation, Organization and Management





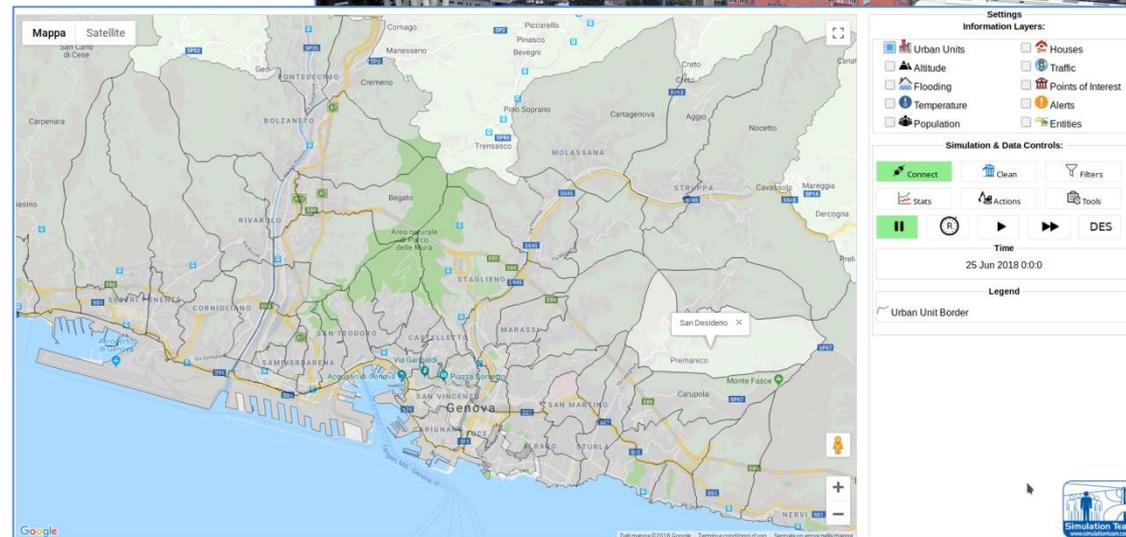
# Case Study: Genoa

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

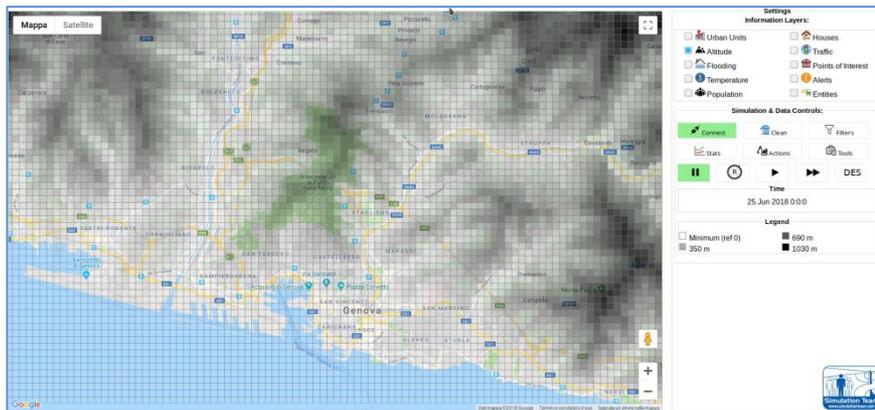
Land types: Corine Land Cover

DTM: SRTM (low detail) + Open Data

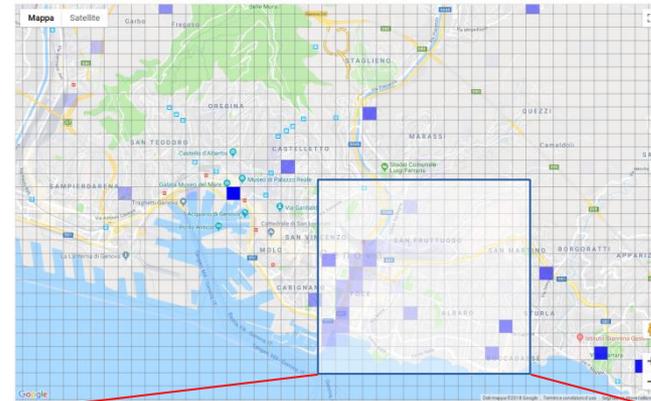
(Regione Liguria, high detail)

Weather Statistics & Forecasts:

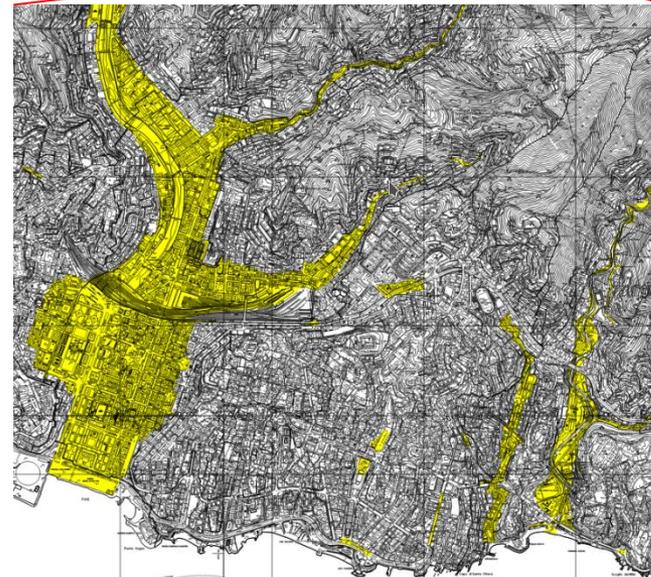
Local forecasting services



Elevation Model



PONTUS  
Rain  
Simulation



Zones with  
high Risk of  
Flooding  
*Comune di  
Genova*



# Water Streams

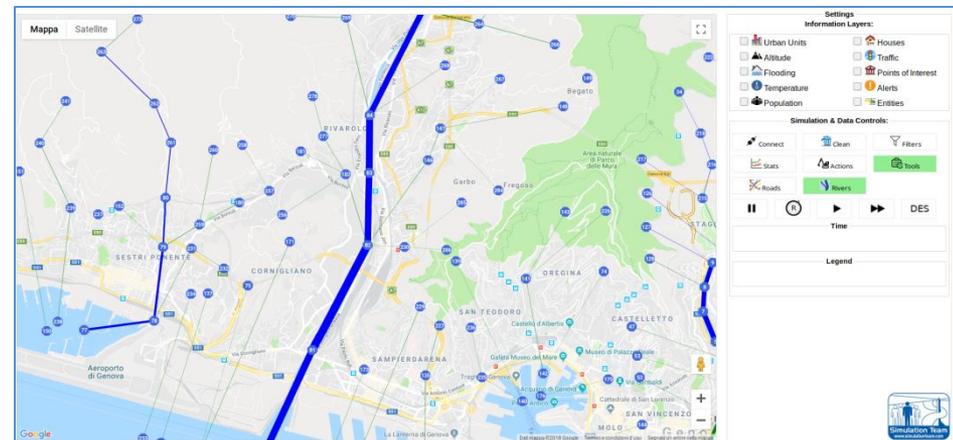
Water flows modeling considering network of rivers, channels and sewerage.

## 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:

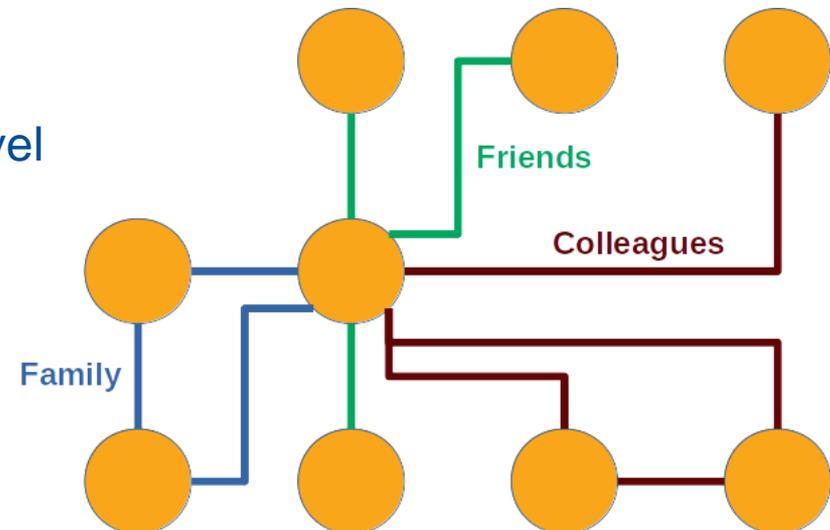
- Age
- Sex
- Nationality
- Religion
- Work type, e.g. self employment, student
- Locations of home and work
- Favorite political party
- Income and family income
- Education level
- Social network, e.g. friends, colleagues
- Preferred locations, e.g. restaurant, cinema
- Emotional status, e.g. stress,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

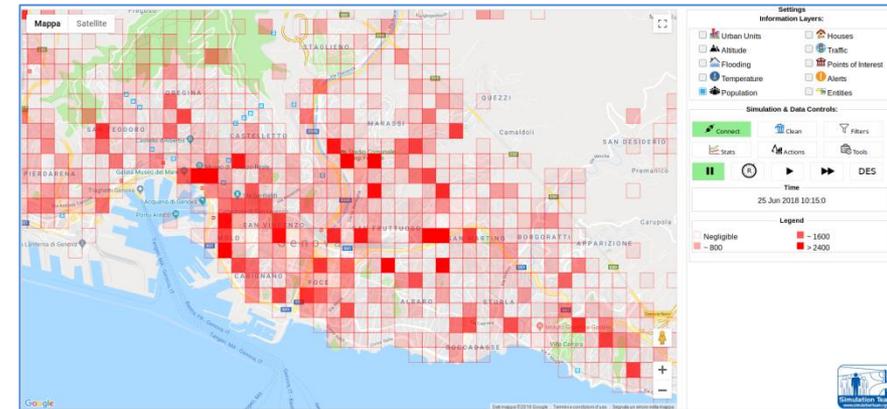
*e.g. family, friends, colleagues*



# Population Behavior

## Main Aspects

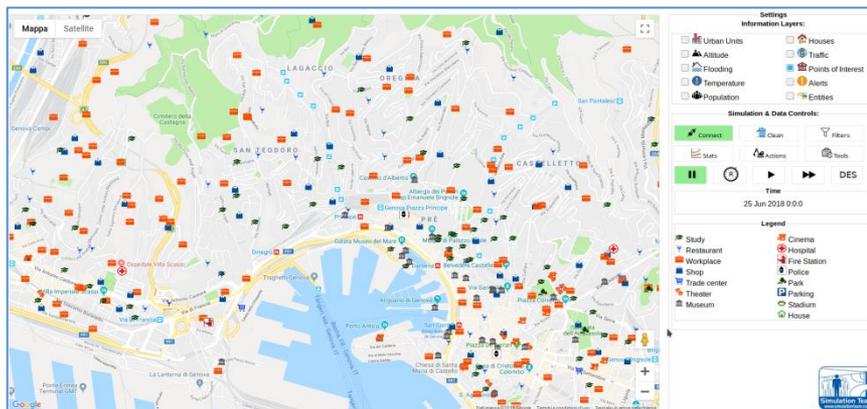
- Complete Life Cycle based on predefined patterns and individual characteristics, *e.g. worker, student*
- Habits and Opinions, *e.g. breakfast at home, like cinema*
- Social Network and Influences, *e.g. proposal of free time entertainment*
- Reaction at Environmental Conditions, *e.g. rain*



Population density

## Points of Interest

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



Points of interest

Legend			
	Study		Cinema
	Restaurant		Hospital
	Workplace		Fire Station
	Shop		Police
	Trade center		Park
	Theater		Parking
	Museum		Stadium
			House



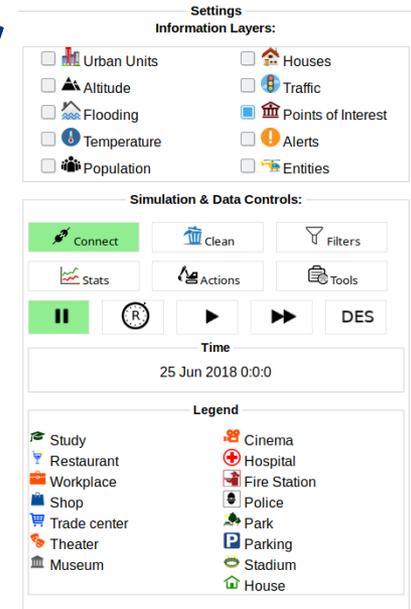
# Interactions With User

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

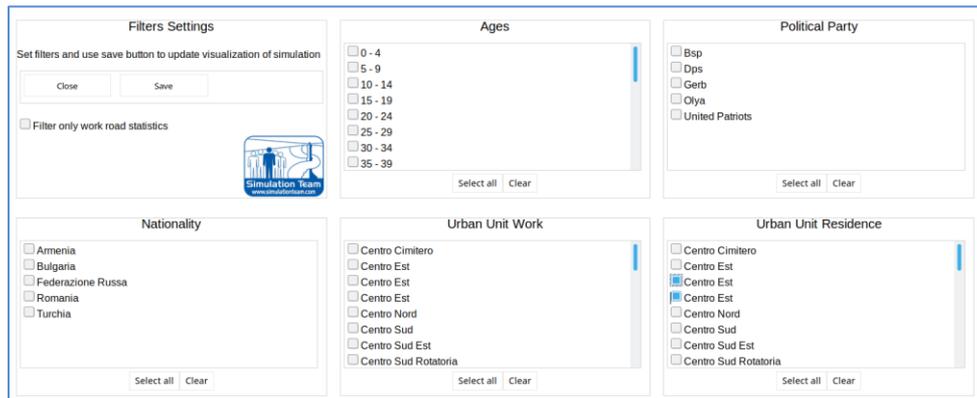
- Clean river bed
- Block roads
- Construct dykes

## Intervention parameters

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



Main controls



Filters 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



# Traffic Model

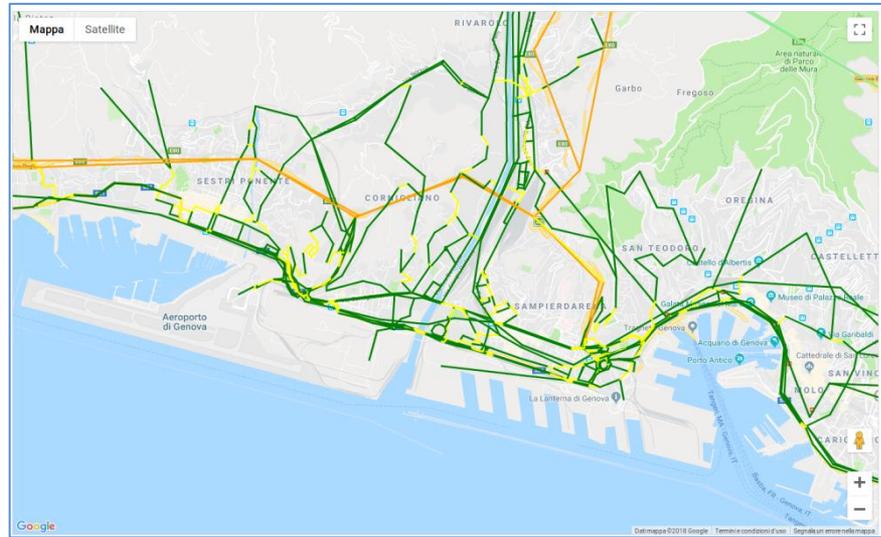
Microsimulation model operates with single vehicles and takes into account meteorological conditions

## Road statistics

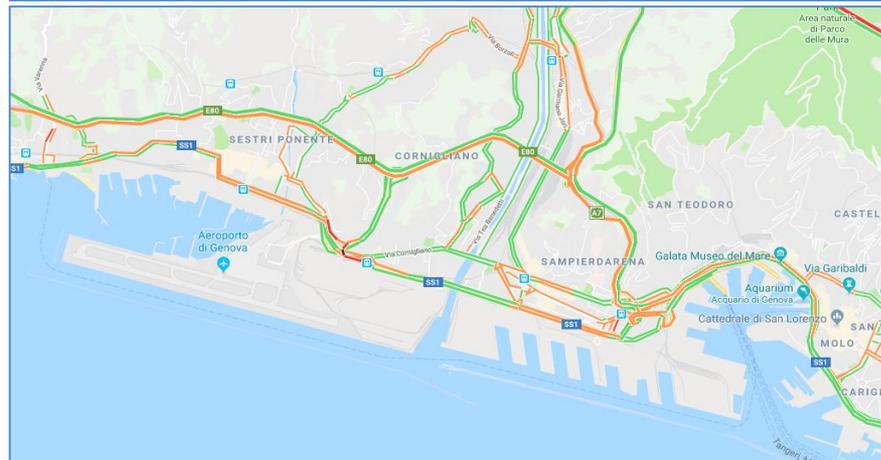
- Time
- Duration
- Estimated Cost



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

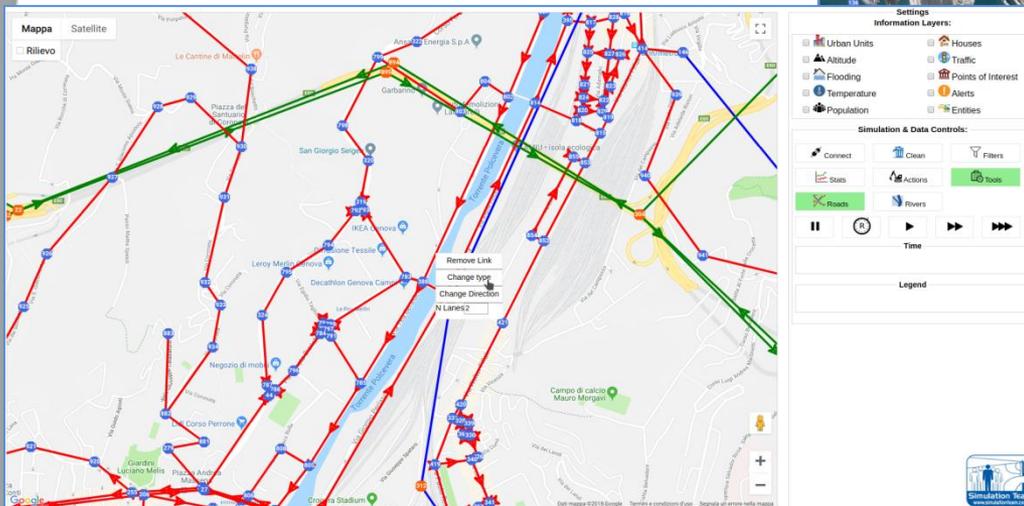
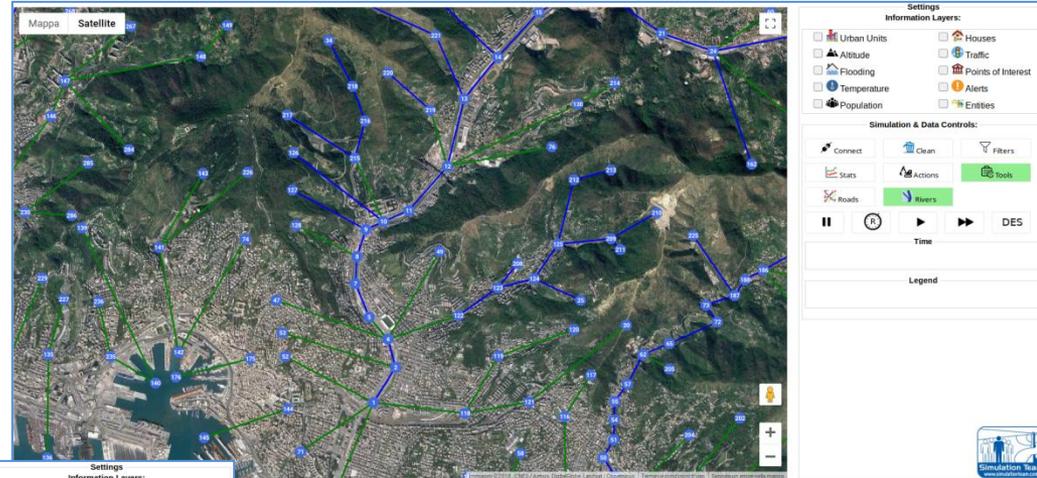
20 locations, 1 week, 1 rainy day

	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

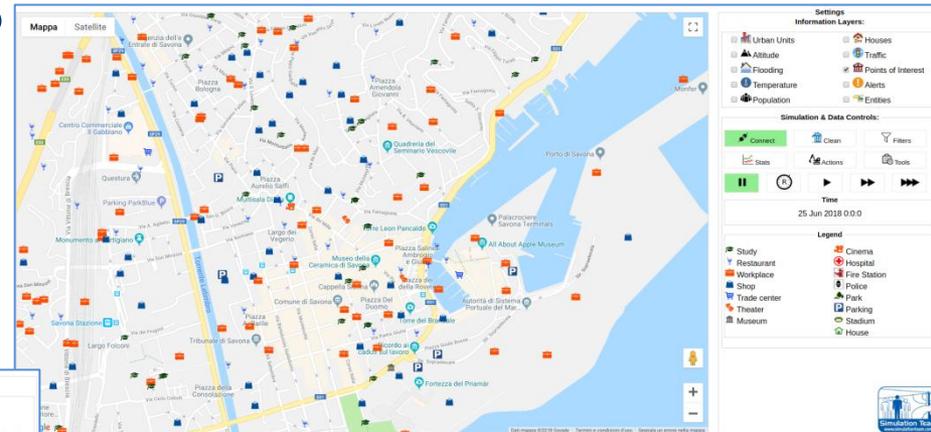
## Transportation Network Mapping Tool:

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

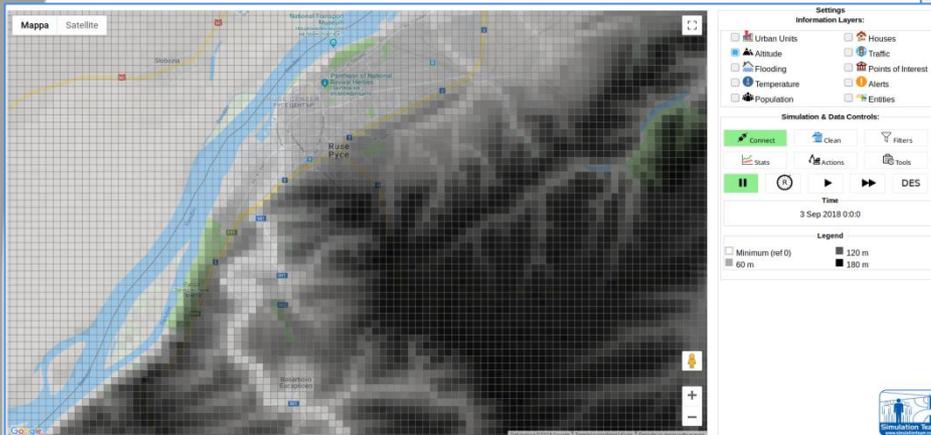


# Adaptations

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

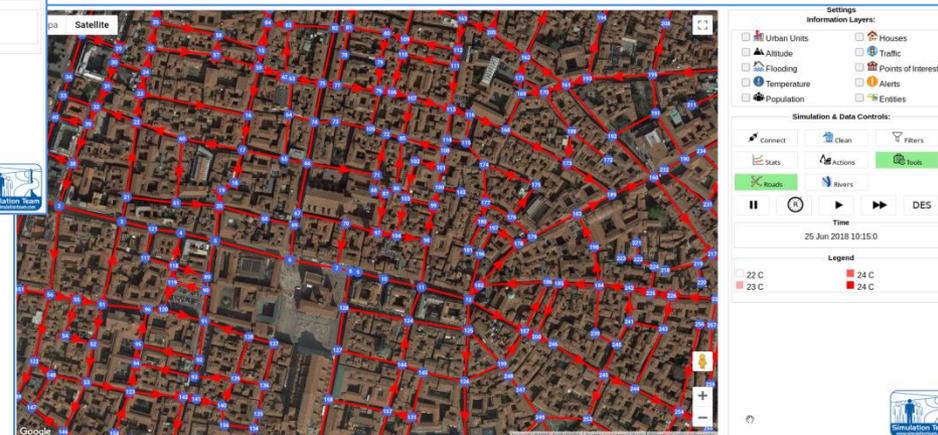


**Points Of Interest:  
Savona City Center, Italy**



**Terrain: Ruse,  
Bulgaria**

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





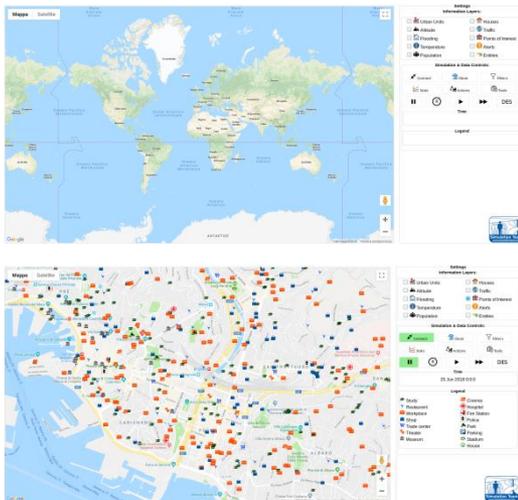
# System Architecture

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

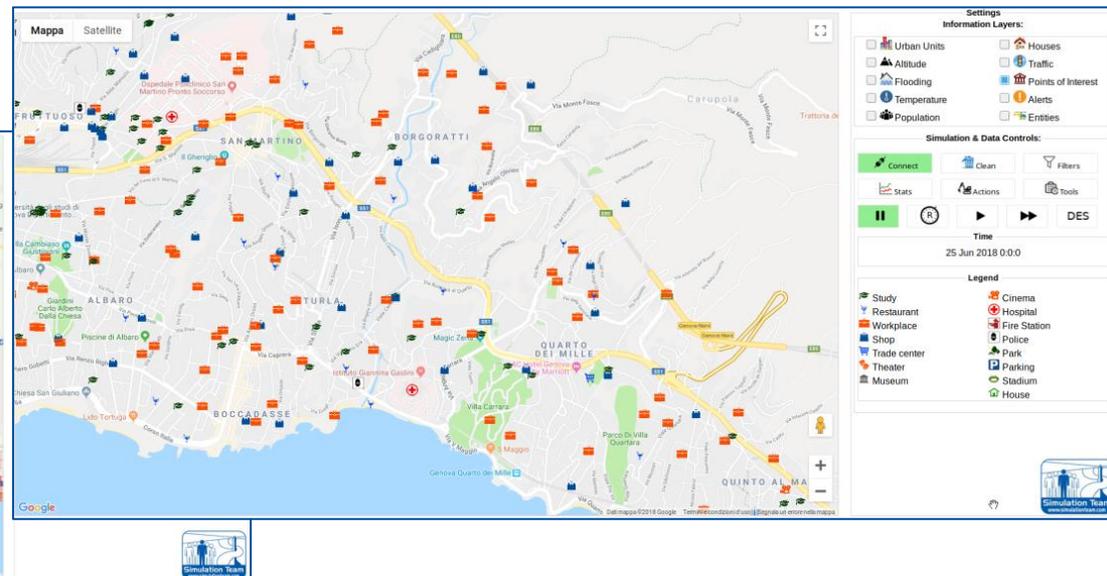
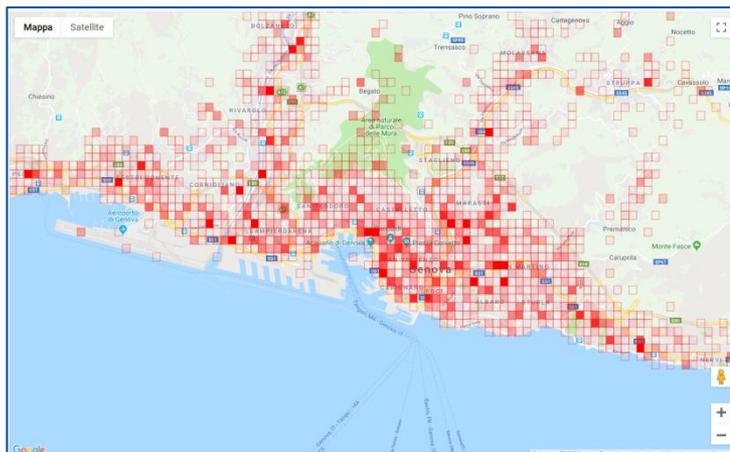


PONTUS client-server architecture allows to provide Modeling & Simulation as a Service



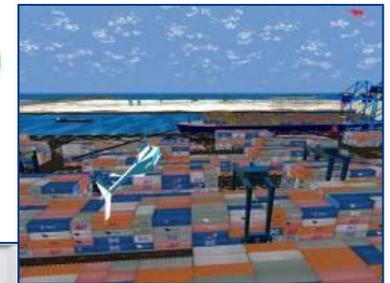
# Conclusions

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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