

MODELING CROWD MOVEMENT IN LARGE SCALE EVENTS, THE CASE OF “STORICO CARNEVALE DI IVREA”

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Crowded events organization in urban places in Italy



The crowd events in urban places

In the past:

the events in urban places were only a **security issue** and occurred **without any safety plans**.



A concert and a market in Italy



D.M.19/8/1996:

- rules for places of public entertainment;
- urban places not included.

Today:

feeling of danger among people highlights the importance of an additional safety approach in the events organization.

June 3rd, 2017 – Turin, piazza San Carlo



During the screening of a final football match, a loud noise (the activation of a fan) generated panic and a stampede of people that thought there was a bomb.



Prescriptive point of view

July 28th, 2017: Italian Ministero dell'Interno published a directive - Circolare Gabrielli - to collect the **safety measures** to apply in case of public outdoor events, including urban places.

In Italy starting from the events of Piazza San Carlo, events in urban places must be managed in a mandatory way.

Concert in an arena



Venice Carnival in piazza San Marco



A team for an interdisciplinary approach



Communications specialist



BIM specialist



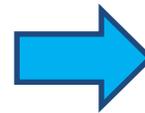
Cost analysis specialist



Numerical modelling specialist



Ex-fire brigade commander –
Safety specialist



- Carnival
- City festivals

Ivrea Carnival



In the whole center of a little town in North- West of Italy, for nine days the Carnival attracts about 35000 people.



Ivrea Carnival

- **Orange battle:** many floats cross the town carrying “on-float” fighters to the five squares where the battle takes place. In this squares “on-street” fighters wait for the float in order to start throwing oranges.

Orange battle - the float advances in a crowded square



«on-street» fighters

«on-float» fighters

Focus on a battle



Ivrea Carnival

- **The parade:** at the same time of the orange battle a parade walks along the main street and enters the five battle squares. When the parade approaches a square, battle is stopped and people make room to let the parade cross the square.

People make room to the parade



The parade



Ivrea Carnival

- **The award ceremony:** the end of Carnival is marked by the award ceremony in the main square, where it is declared which team has won the orange battle, and by the final bonfire that says goodbye to the next year.

The final bonfire



Ivrea Carnival: safety management issues and numerical analysis

SAFETY MANAGEMENT ISSUES:

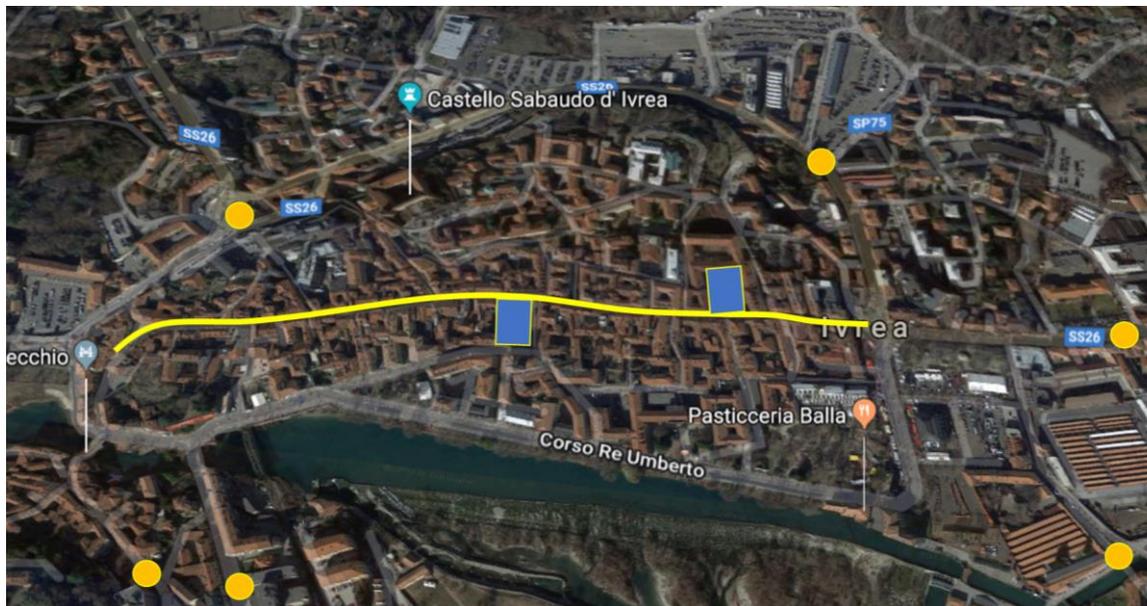
- Ordinary service;
- The passage of the parade;
- The egress after an event.

NUMERICAL SIMULATIONS ANALYSIS

 **Pathfinder** Revision: 2018.1.1220 x 64

Ivrea Carnival: ordinary service

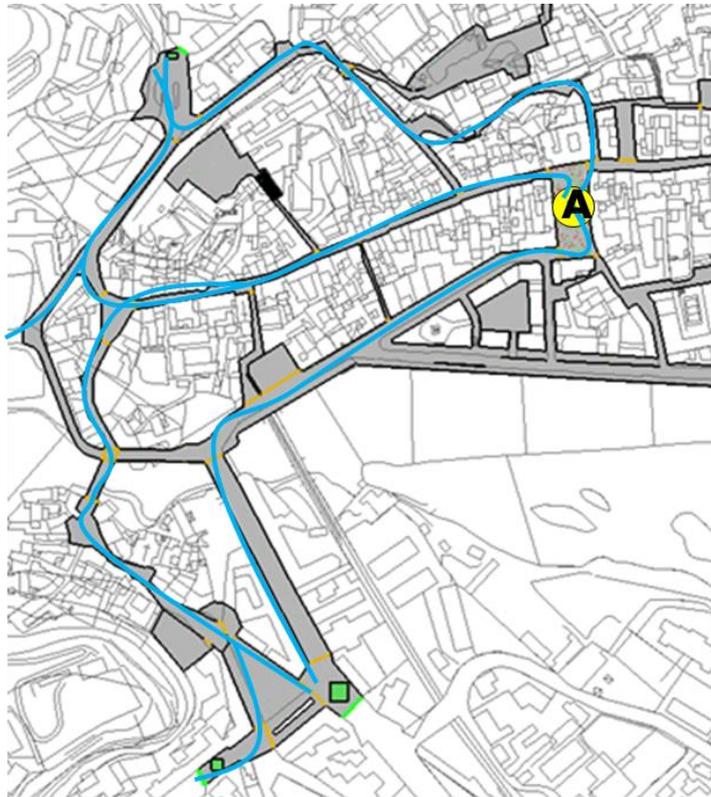
- people entering the centre of the town all day long;
- people walking around the centre to reach an event;
- people waiting for an event in a place .



Main street connects battle squares and cross the whole town center.

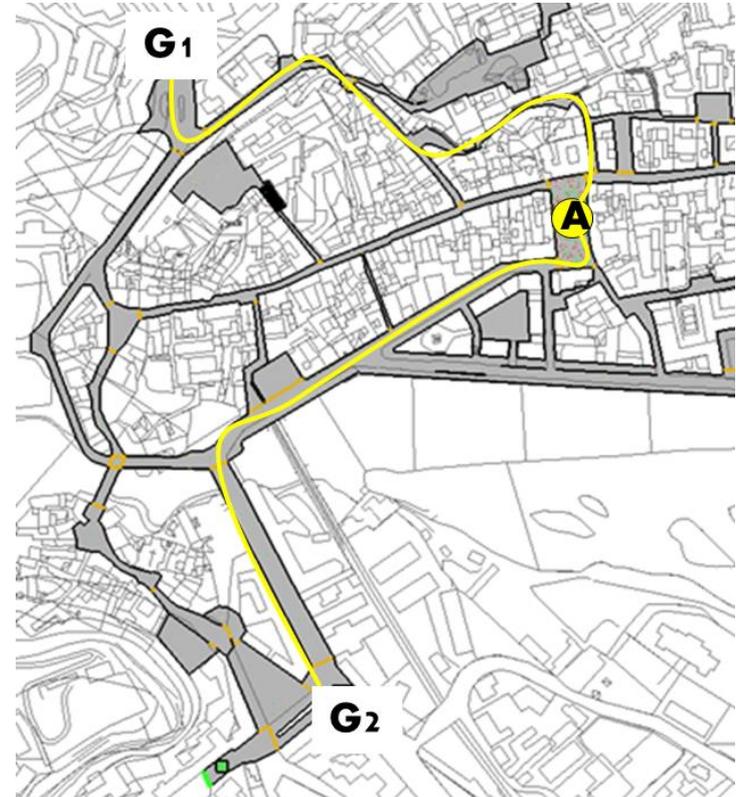
Ivrea Carnival: ordinary service – Numerical simulation verification

Free circulation



- free access from any street;
- free choice of paths.

Managed circulation



VS

- access gates;
- obligatory paths;
- maximum capacity limit.

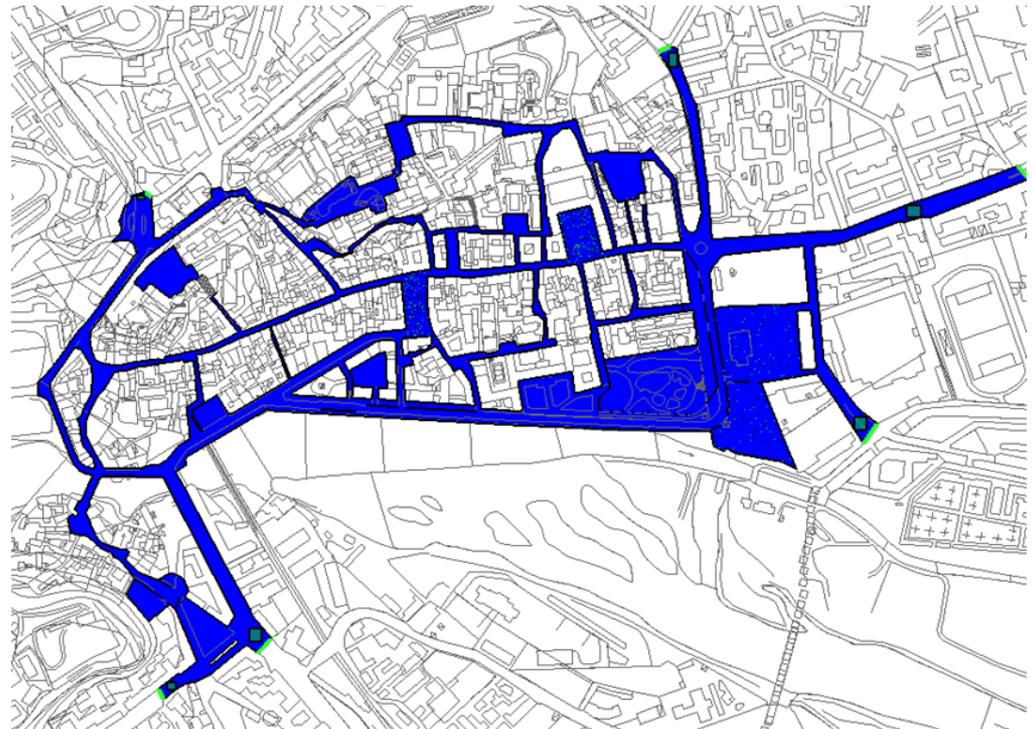
Ivrea Carnival: ordinary service – Numerical simulation verification

Simulation takes a picture of 1-hour ordinary service

Model:

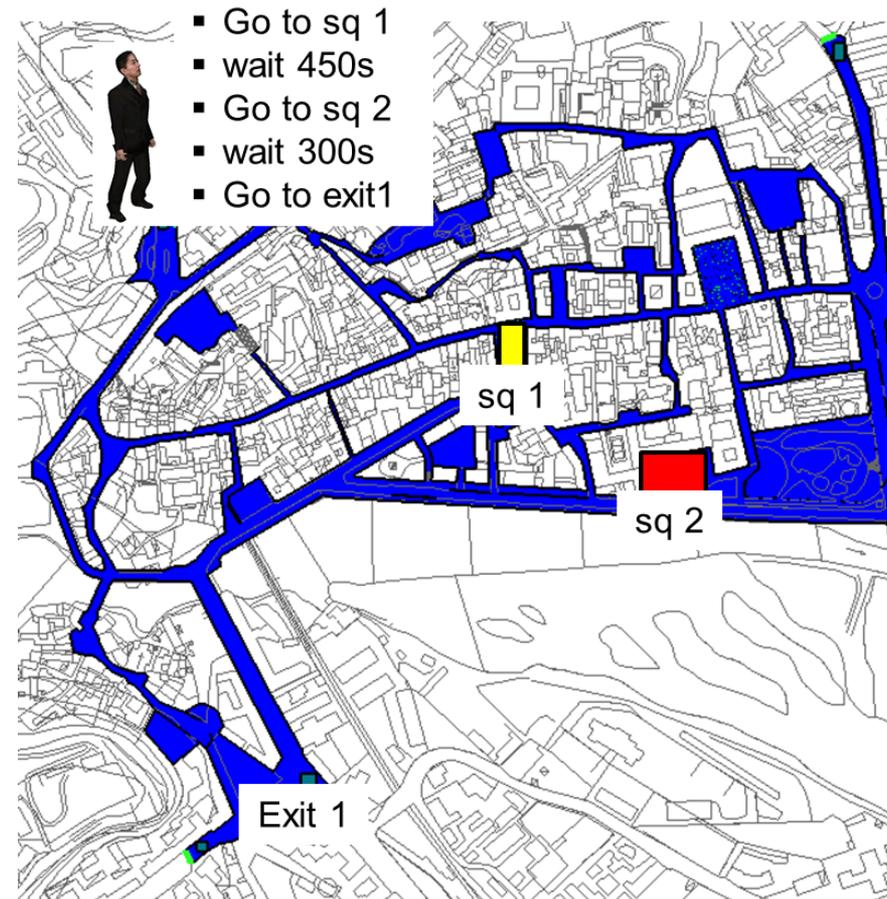
- Domain = town center;
- 120000 m² (squares + streets)
- 20000 people;
- Cases analyzed:

Case	Safety management
1	No
2	Yes



Ivrea Carnival: ordinary service – General settings

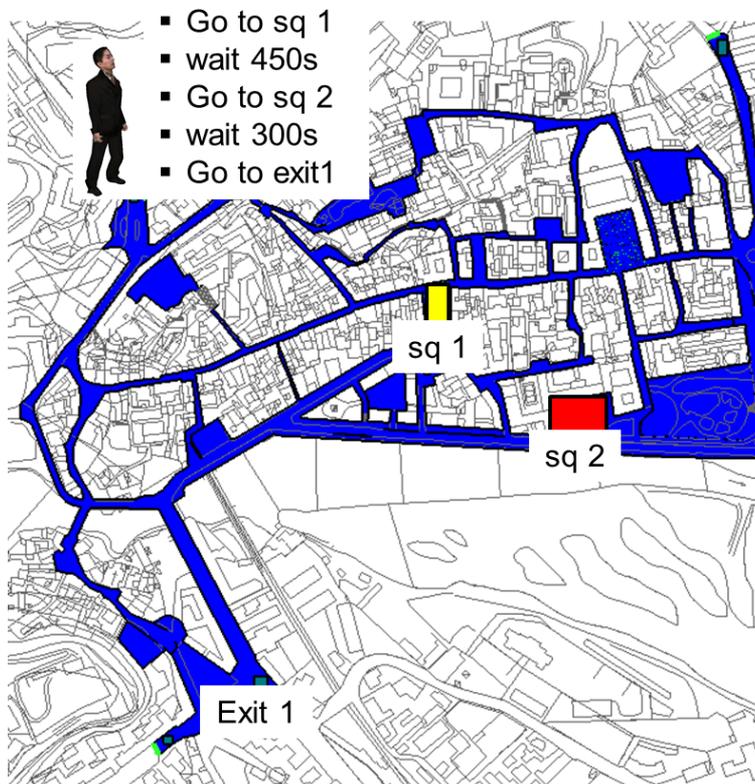
- **3 occupants profiles** with different walking speed (ISO 16738):
 - minimum = 0,4m/s (locomotion disabilities);
 - maximum = 1,2 m/s.
- Occupant sources to simulate the arrival in the town center;
- Several **behaviors** to simulate the circulation movement in the town center.



Ivrea Carnival: ordinary service – General settings

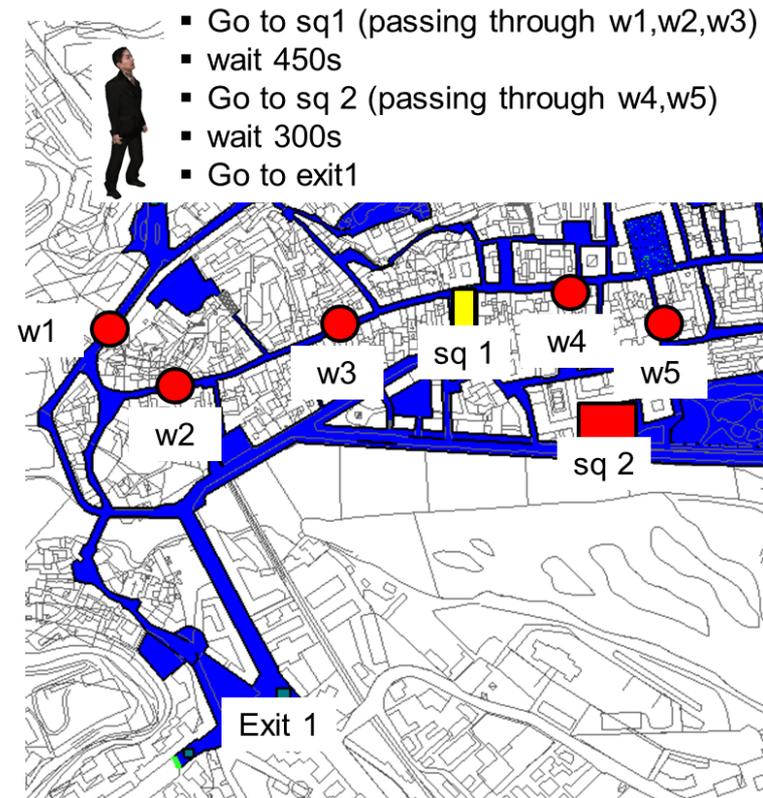
Case 1 - Free circulation:

- no waypoints;
- occupants sources along the town center's boundary.



Case 2 – Managed circulation

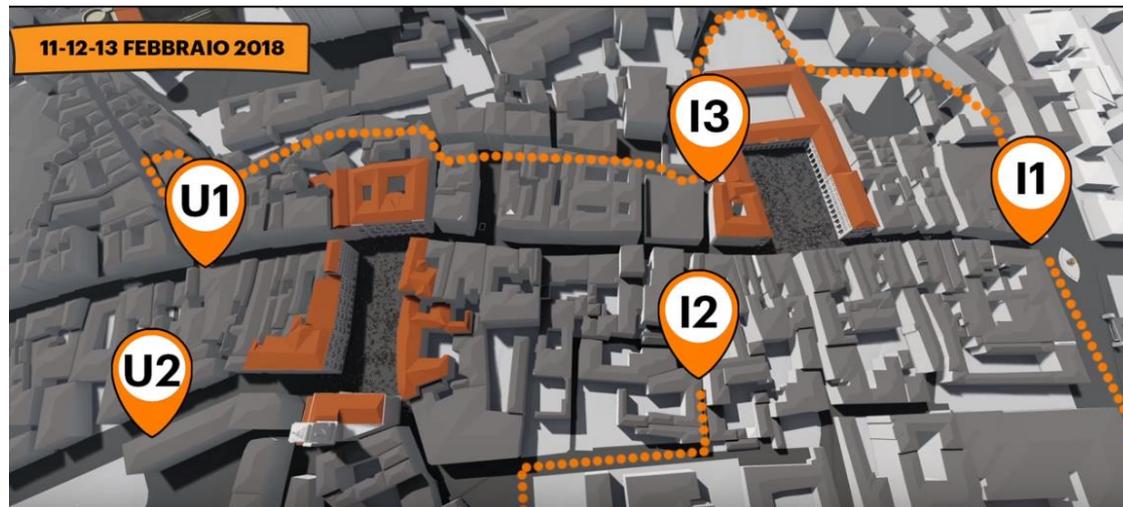
- intermediate waypoints;
- 6 occupants sources because of 6 access gates.



Ordinary service: results for safety management

A crowd management permits:

- ❖ to limit the number of people in the town center, especially in the main street and in two battle squares;
- ❖ not to have critical density values in the whole town center.



Indication of the access (Ix) and the exit (Uy) from the main street between two battle squares

Ivrea Carnival: the parade

- Crowded square with the orange battle;
- People hold each other to let the parade pass.

Management crowd directive:

- Limiting the density of the battle squares.



Ivrea Carnival: the parade – Numerical simulation verification

Output to safety management:

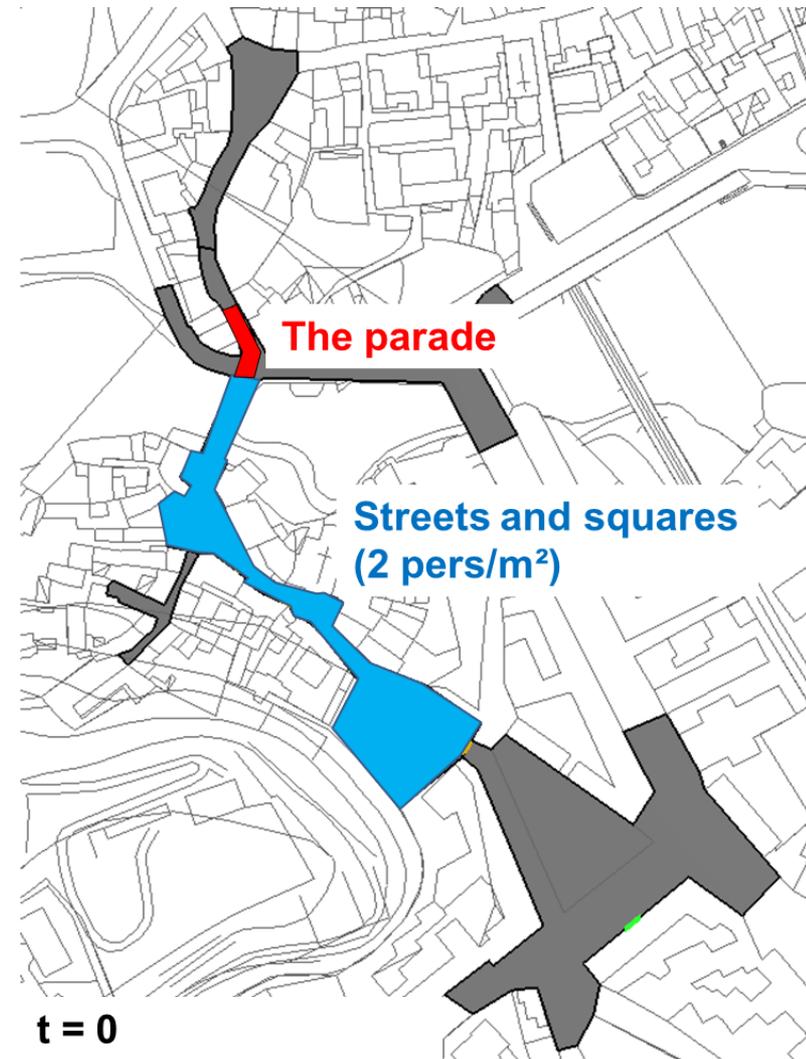
- the maximum density values in the crowded squares and streets during the passage of the parade.

Model:

- Domain: 14000 m²
- Density in the square before the passage of the parade = 2 pers/m²



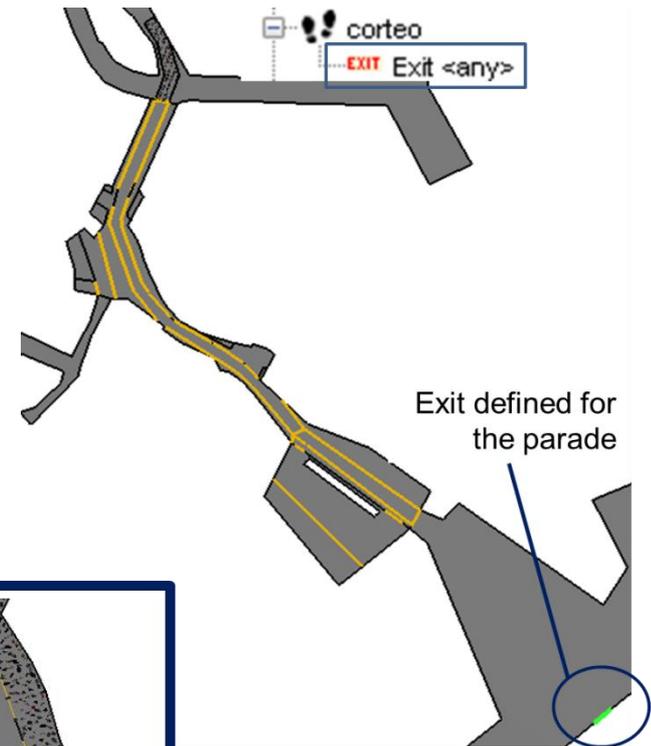
Path of the parade



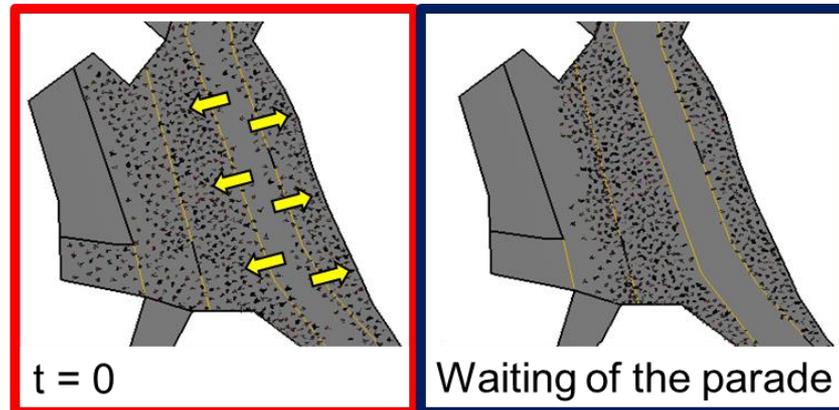
Ivrea Carnival: the parade – Settings

- Maximum speed = 1 m/s (uneven terrain);
- **2 occupants profiles** with different walking speed:
 - parade = 1 m/s;
 - people in the streets = Unif (0.75 - 1) m/s
- **2 behaviors:**
 - parade = «go to Exit» function;
 - people in the streets = «Go to Room» than «wait» functions.

Parade behavior



People behavior



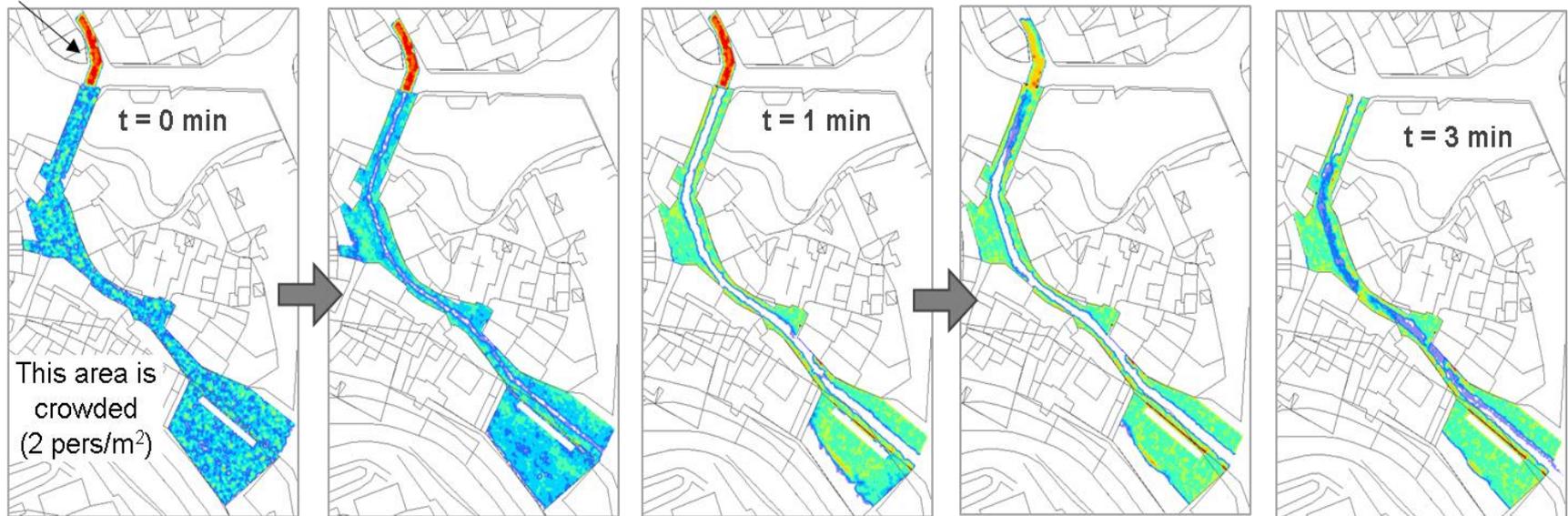
The parade: results for safety management

- ❖ There are no critical density values
- ❖ Maximum density in the streets and squares ≤ 3 pers/m²

Parade is stopped and waits to cross the bridge

Crowd parts to make room for the parade

Parade cross the area



Ivrea Carnival: egress after an event

- Crowd streaming out after an event
- Square with particular geometry: arcades along the whole square

Square of the simulation



Ivrea Carnival: the egress – Numerical simulation verification

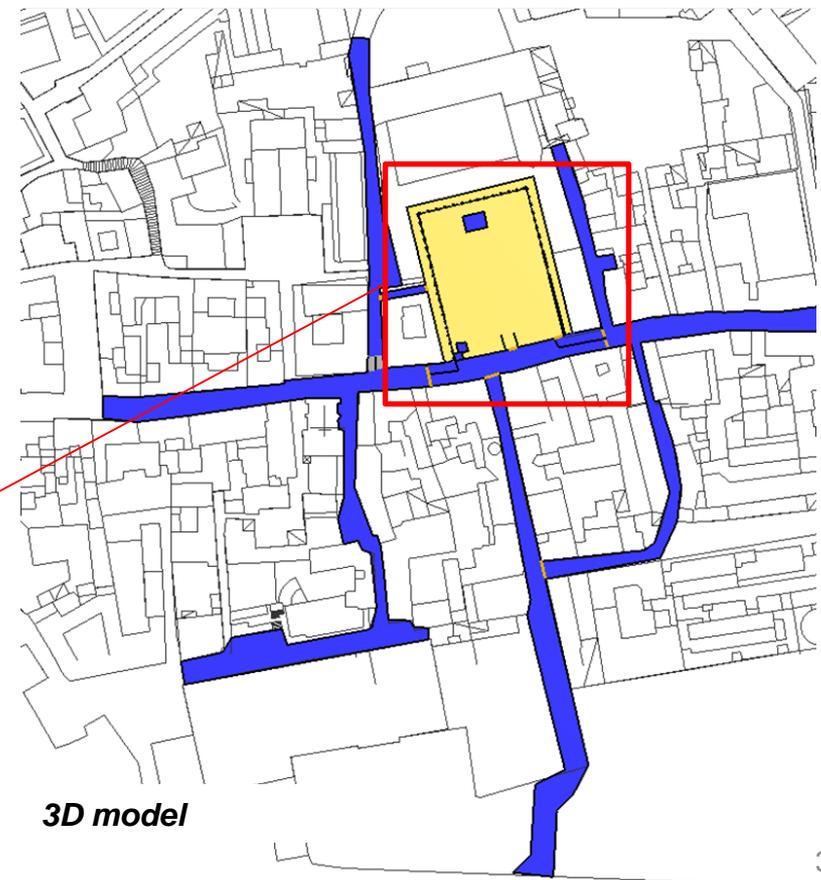
Output to safety management

- maximum density values that occur during the egress of the people from the square.

Model:

- Domain: 9300 m²
- People are distributed on the square and under the arcades;
- Initial density = 2 pers/m²;
- Egress on two sides of the square

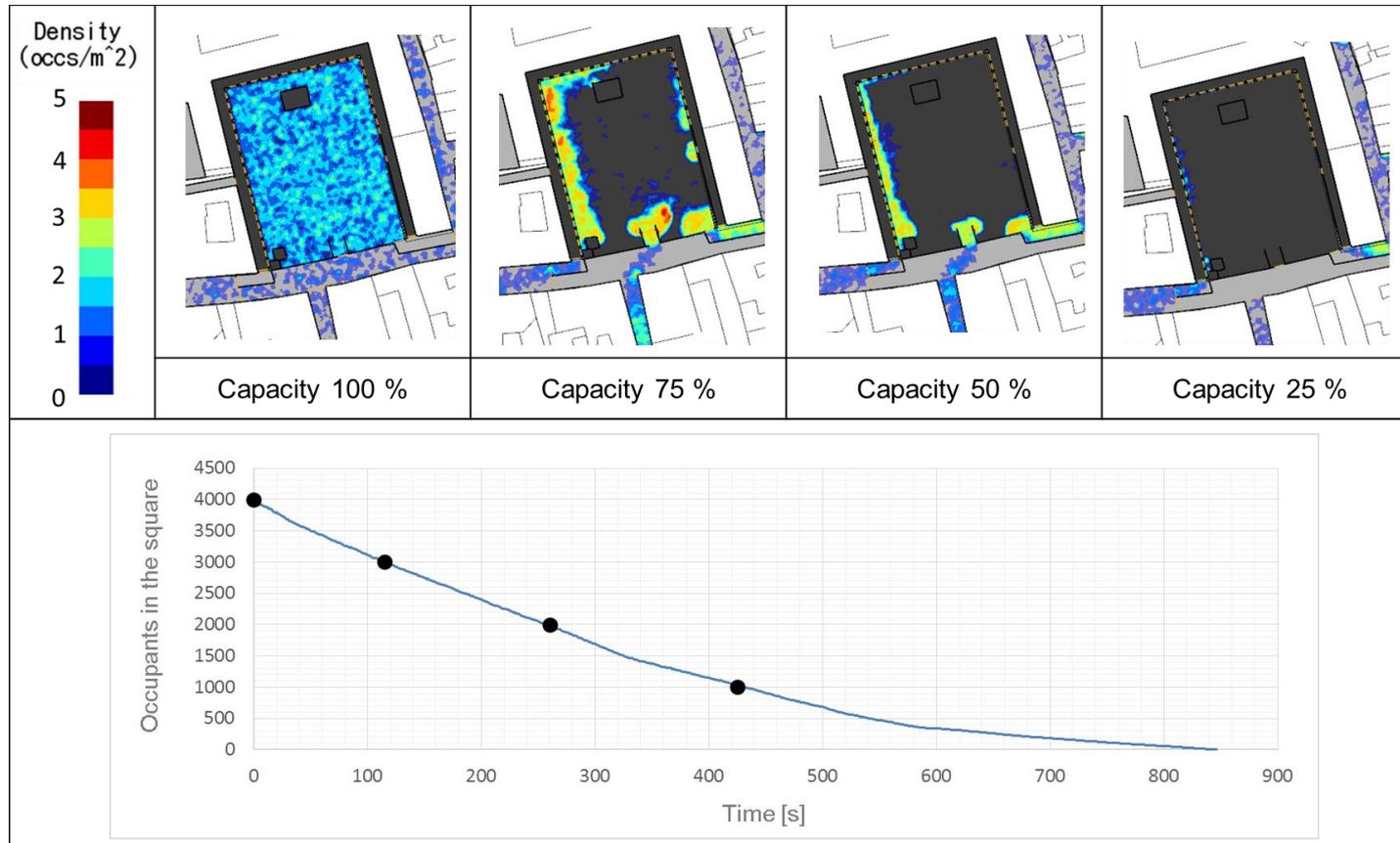
*Means of egress
from the square*



3D model

The egress: results for safety management

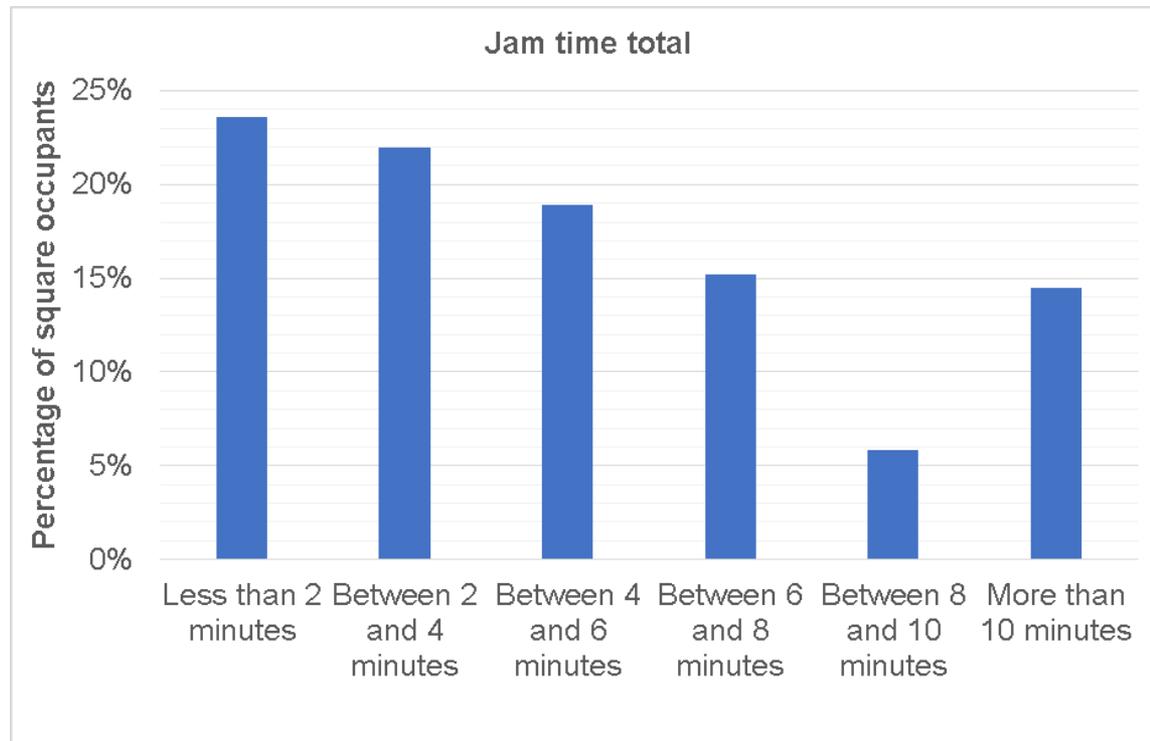
- ❖ No critical density values;
- ❖ Egress time compliant with the requirement of the safety management (<25 min).



Egress time:
time when the last occupant leaves the square.

The egress: results for safety management

- ❖ Queuing time is less than 2 minutes

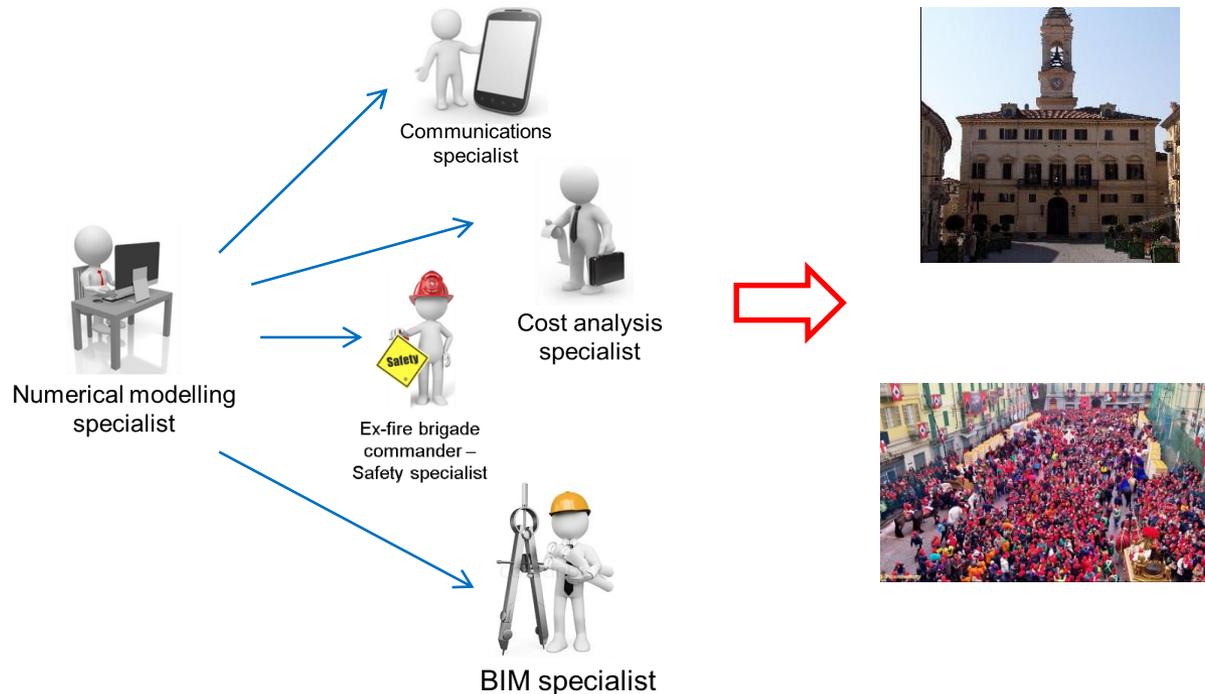


Jam time total: total amount of time the occupant spent moving at less than a fixed velocity

Conclusions

- ❖ The numerical simulations increased the knowledge of the event before it happened:
 - ❖ of each specialist of the team that organized the event;
 - ❖ of the municipality;
 - ❖ of the participant.

- ❖ Validation of the model event after the event occurred



- ❖ Safety plan;
- ❖ Training stewards.
- ❖ APP for mobile phone;
- ❖ Website.

Thank you for your attention