



# Simulation of the Neuschwanstein castle

## Egress of a fairy castle

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Institute for  
crowd simulation

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# King Ludwig II and the Neuschwanstein Castle



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## In former times ....

- 1868 King Ludwig II. designed the castle as an idealized idea of knights castle in the Medieval.
- 1869 Corner stone was laid.
- 1884 Castle has been built.
- 172 Days King Ludwig lived in the castle.



# King Louis and the Neuschwanstein Castle

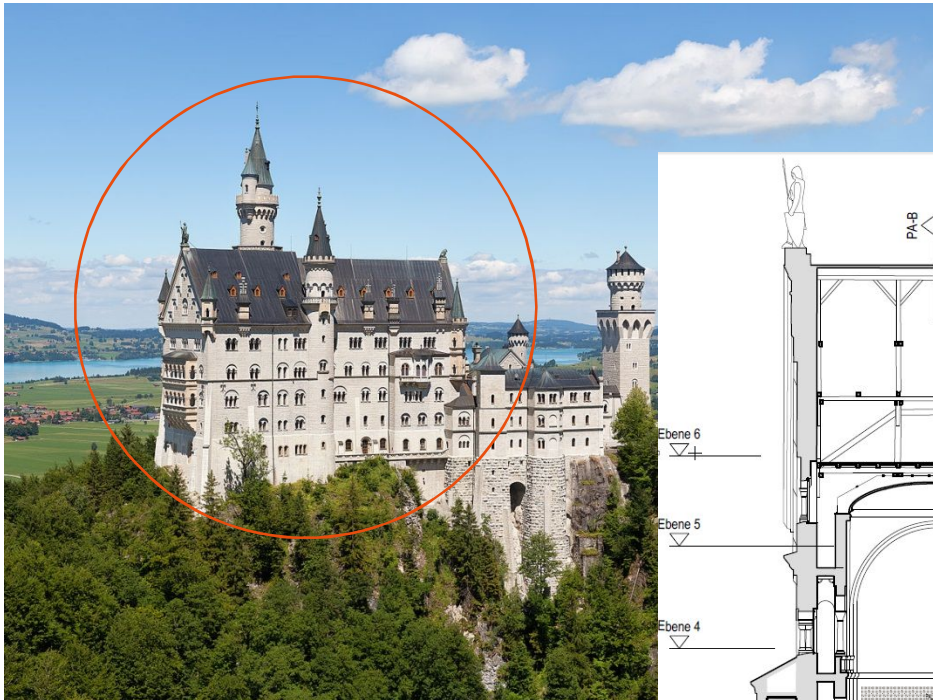


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## Today ....

2013, more than 1.52 million visited the castle.  
Up to 6,000 visitors a day, at peak times up to 10.000 visitors.

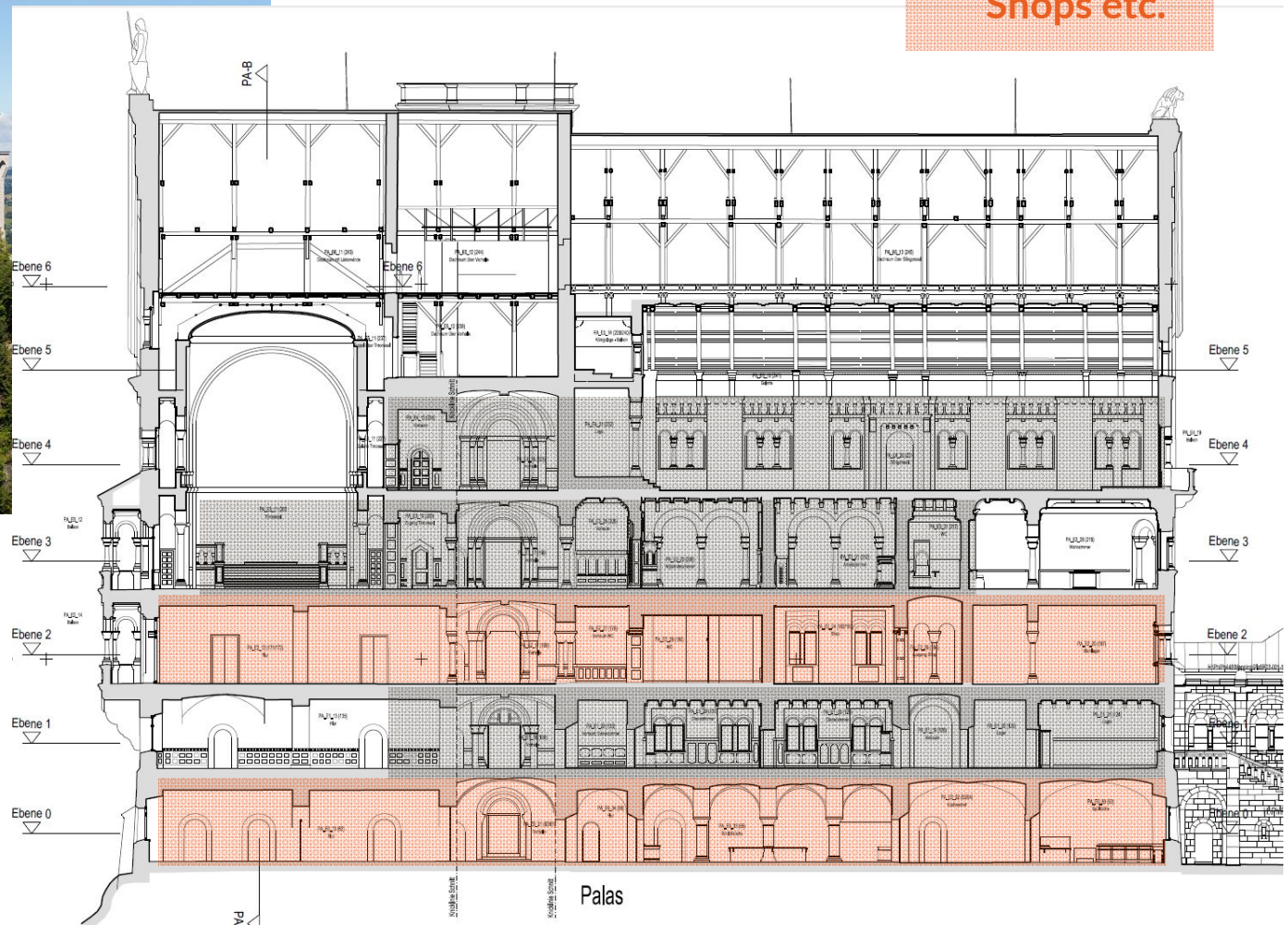
# The Neuschwanstein castle at a glance



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Guided Tours

Shops etc.





# Challenges

## Situation:

- › Every five minutes, a guided tour starts with 60 visitors.
- › Around 700 visitors are inside the castle at the same time.
- › Daily up to 10.000 visitors.
- › Eight floors which are accessible by visitors.

## Challenges to be addressed by simulation:

- › How long does it take to get all visitors out of the castle?
- › Where do bottlenecks occur?
- › Can we adjust /optimize the escape route assignment?

## Sample floor plan



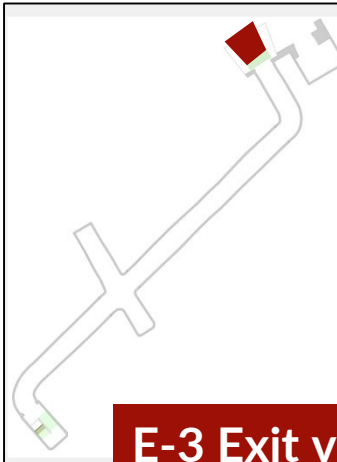
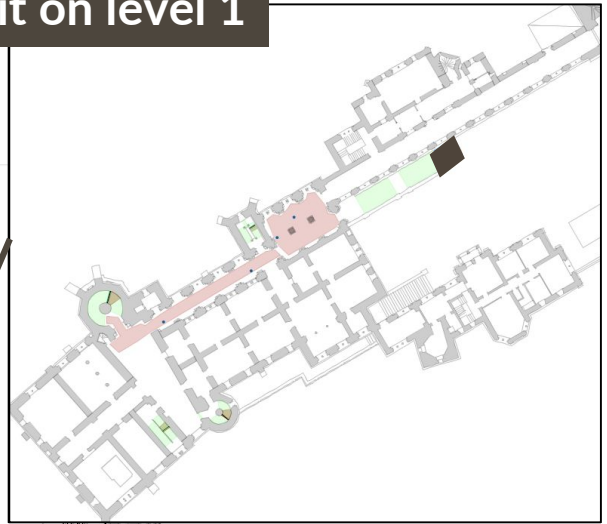
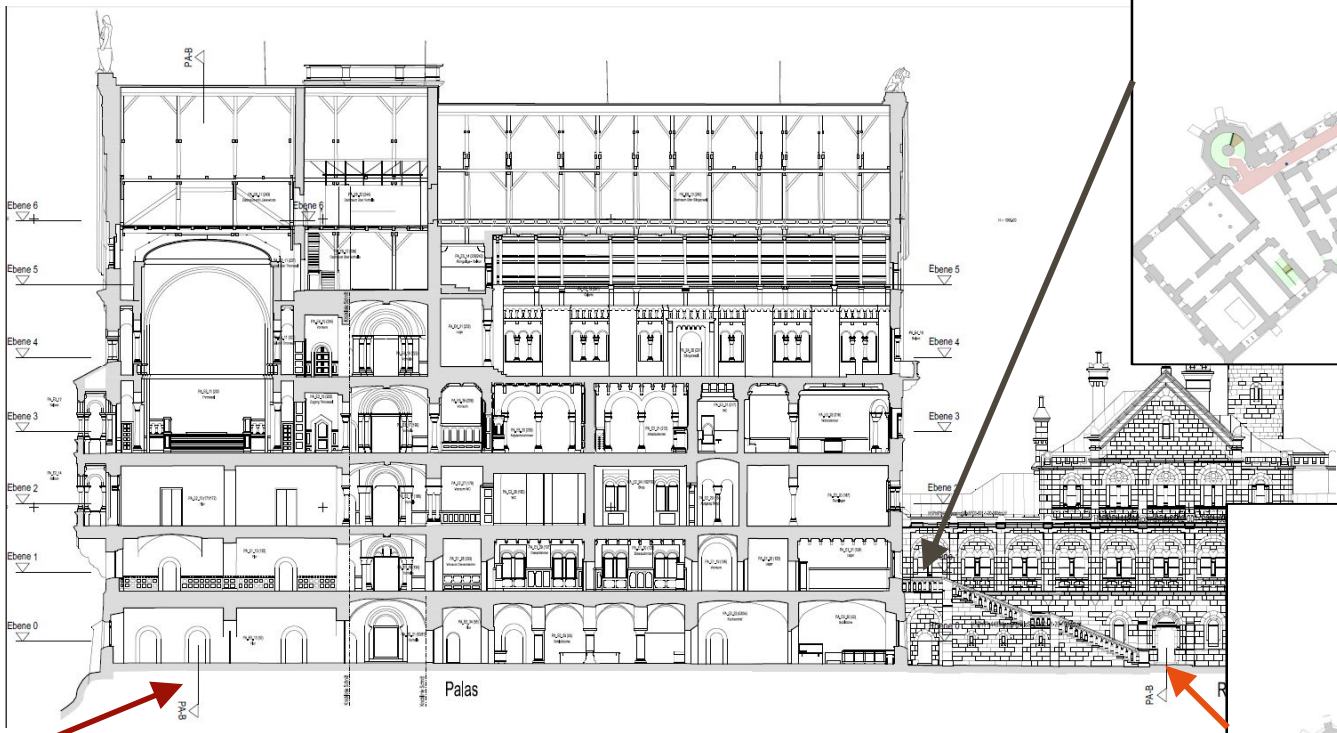
- Stair cases
- Accessible area

Escape Routes:

- › Four stair cases, two of which are spiral staircases – connect floor 4 to 0
- › One stair case connecting floor 0 to floor -3
- › Three exits on three different levels

# Available exits

E1: Exit on level 1



E-3 Exit via tunnel



E0: Exit on level 0

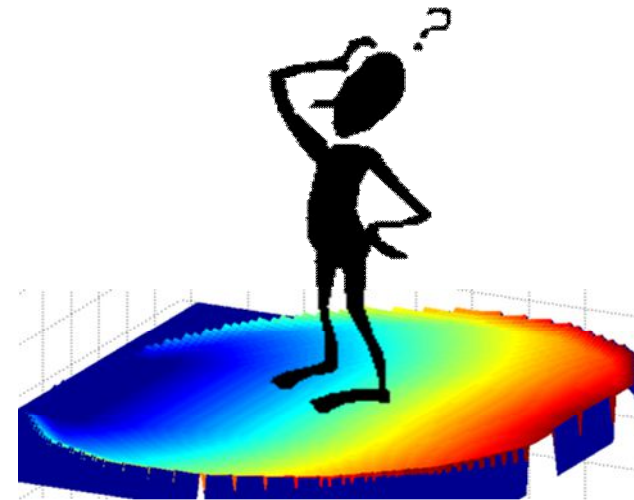
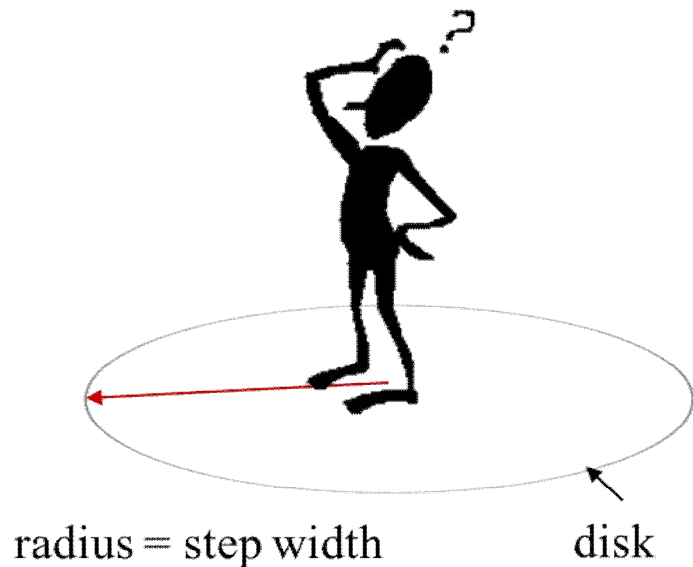


# Simulation Model



## Simulation Model

- › Simulation Tool: crowd:it
- › Locomotion Model: Optimal Steps Model used for most realistic stepping behaviour modelling [1,2] in combination with dynamic floor fields [3]
- › Tactical Model: Visibility graphs [4]



Potential field for next step

[1] Michael Seitz and Gerta Köster. Natural discretization of pedestrian movement in continuous space. *Physical Review E*, 86(4):046108 { 046116, 2012.

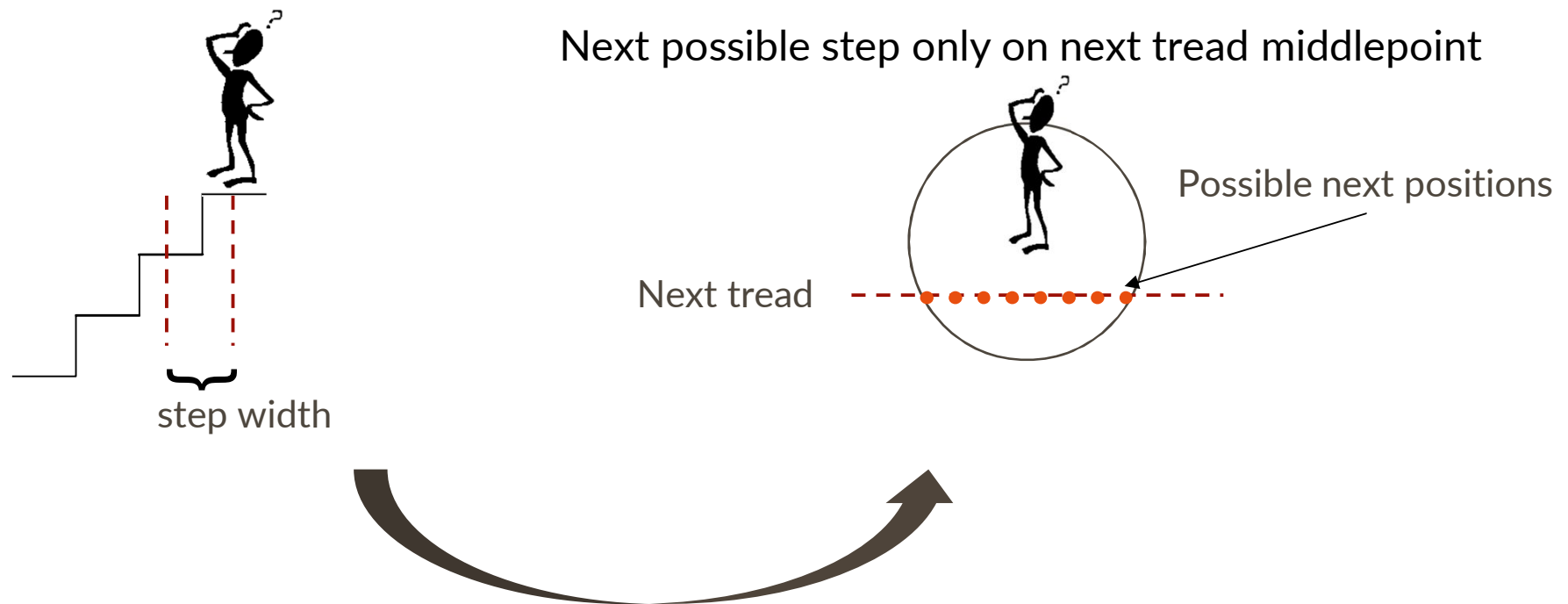
[2] Isabella von Sivers and Gerta Köster. Realistic stride length adaptation in the optimal steps model. In *Proc. of the TGF 2013*, Jülich, Germany, 2013.

[3] Kneidl, Angelika; Hartmann, Dirk; Borrmann, André (2013): A hybrid multi-scale approach for simulation of pedestrian dynamics. In: *Transportation Research Part C*, in press.

[4] Kneidl, A., Hartmann, D., Borrmann, A.. Generation and use of sparse navigation graphs for microscopic pedestrian simulation models. *Advanced Engineering Informatics*, 26:669{680, 2012.

## Simulation model on stairs

- › Modelling of stairs based on the Optimal Stair Model [2]:



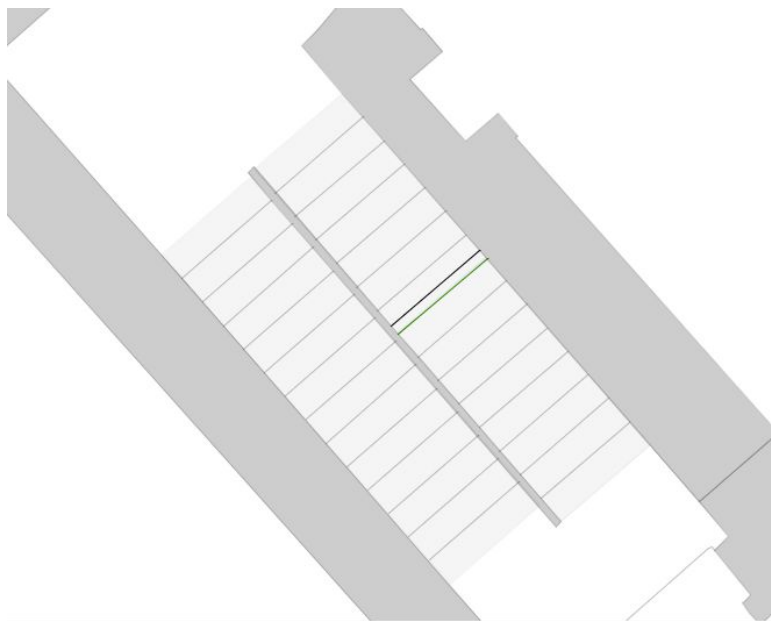
- ✓ Step width of pedestrian is predefined by tread width
- ✓ Pedestrian is implicitly slowed down by its reduced step length

[2] Gerta Köster, Daniel Lehmborg, and Felix Dietrich. Is slowing down enough to model movement on stairs? In Proc. of the TGF 2015, Delft, Netherlands, 2015.

## Modelling of the stairs

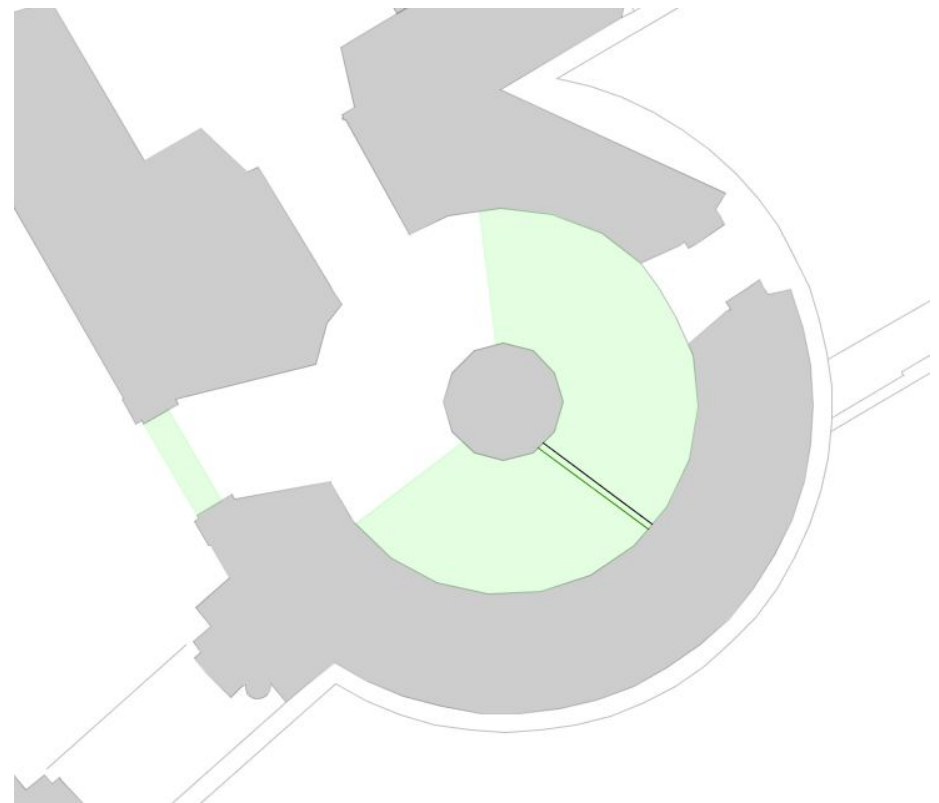
Straight stair cases:

- › Optimal stair model



Spiral stair cases

- › Scaled velocity areas





# Simulation Setup

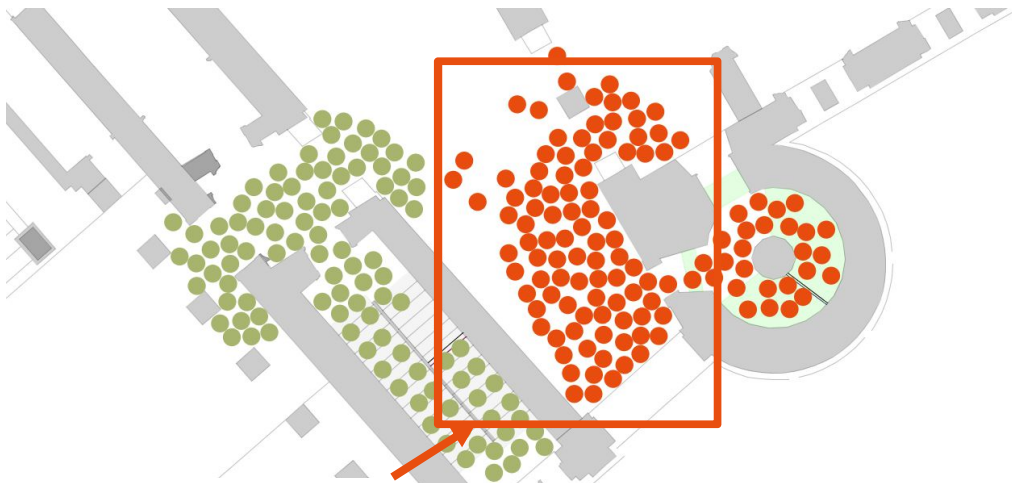
## Requirements:

- › Escape routes towards moving direction.
- › Stair cases should be utilized equally.

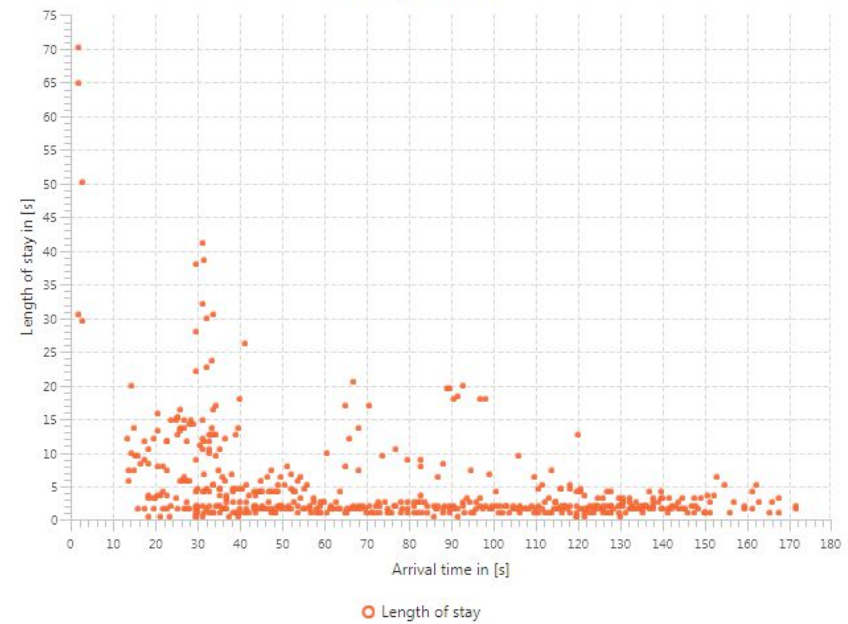
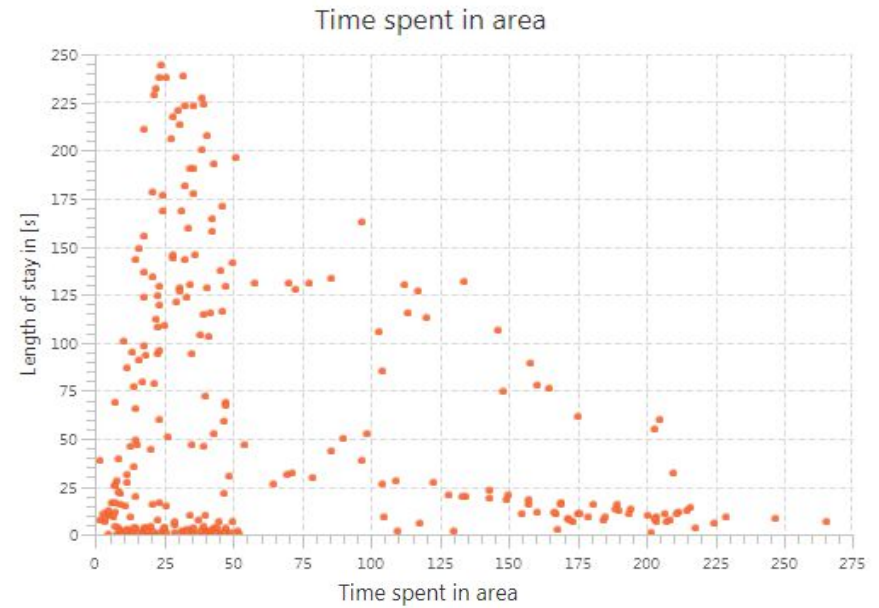
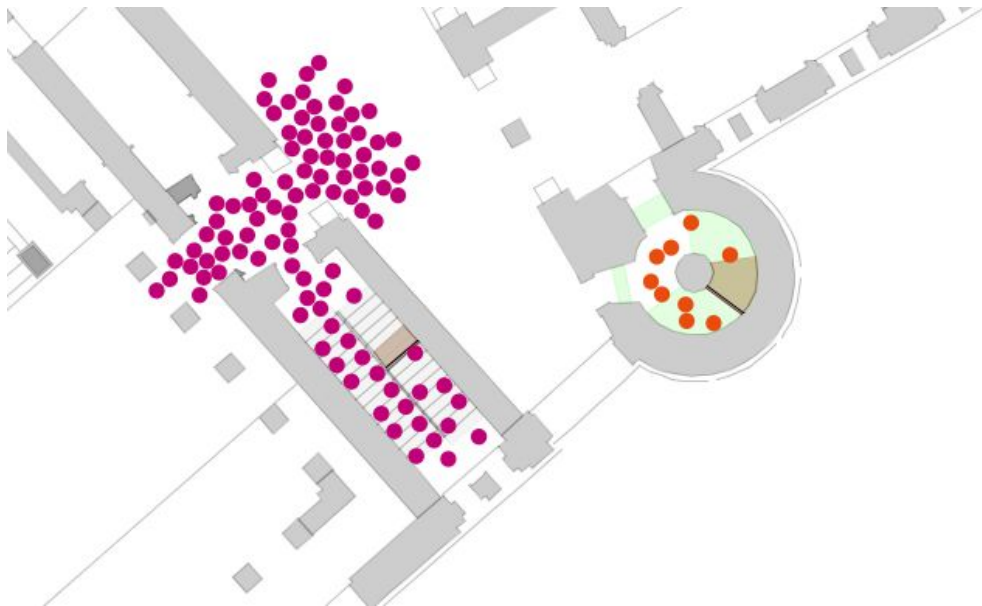
## Population:

- › 750 agents.
- › Distribution of agents on each level upon consultation with building authorities.
- › Different pre-movement times depending on the level (guided tours vs. free flow areas).

# Screenshot of first and second iteration

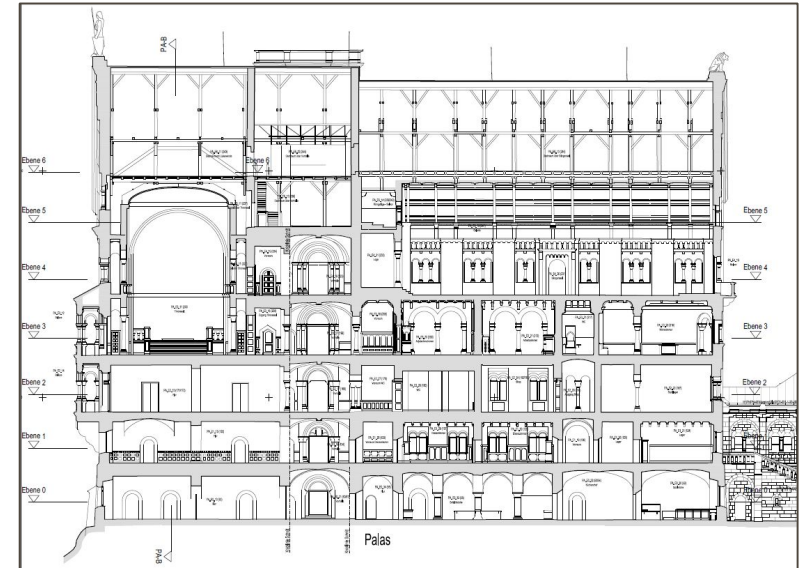


Measurement area



## Results and Summary

- › Resolving of spatial-temporal relationships.
- › Improvement of evacuation times.
- › Less congestions due to better distribution to different stair cases.
- › Groups can be evacuated in moving direction.







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I'm looking forward to your questions or comments!