Influence Of Enforced Social Distance On Jam And Exit Times

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Pathfinder

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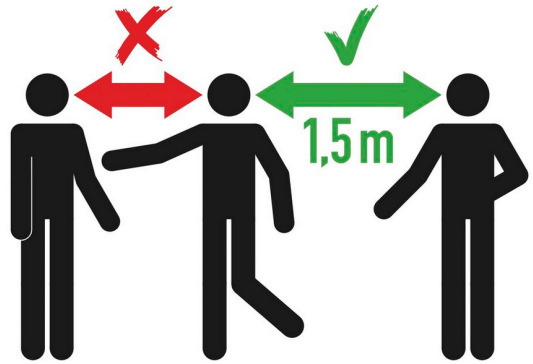
Social Distance Behaviour

Thunderhead Engineering introduced social distance behaviour to Pathfinder in August 2020 as a method to address pandemic safety in evacuation simulations.



Objective of this work was to evaluate jam and evacuation times of agents or groups:

- with forced social distances in contrast to personal distances,
- that keep different social distances from relatively small (1.0 m) to large (3.0 m).

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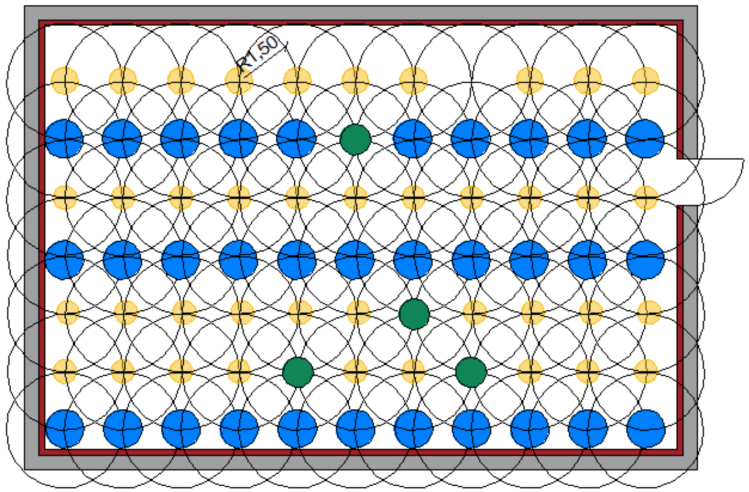
Objective of this Work

Effects of Forced Social Distances on:

- The flow,
- Exit times,
- Jam times.



Application: calculation of

- Waiting time and length of queues,
- Time to change rooms, for example in high schools, universities, cinemas.

in pandemic situations.

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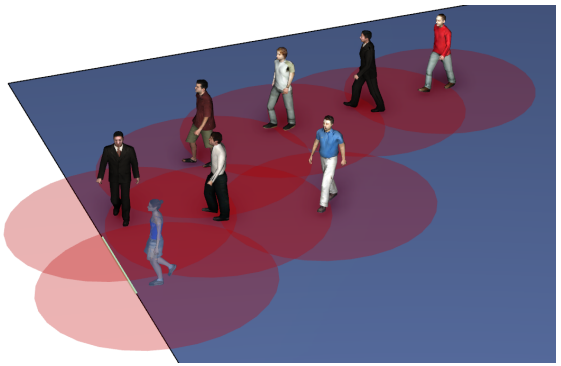
Implementation in Pathfinder

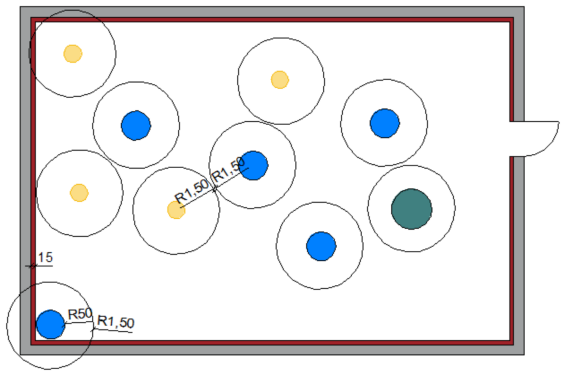
Personal distance:

- Desired distance one occupant will try to maintain with others in a queue or jam
- Gap distance between the occupants' shapes
- Shoulder-to-shoulder / not strictly enforced / max. 1 m



Social distance:

- Constant value or a distribution of values
- Center-to-center / enforced / $>$ 1 m
- Movement groups do not perform social distancing with other members of their group by default



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Variation

Social distance:

- Without social distance
- Constant social distance:
  1.5 m, 2.0 m, 3.0 m
- Uniform social distance:
  1.0 m to 2.0 m / 3.0 m

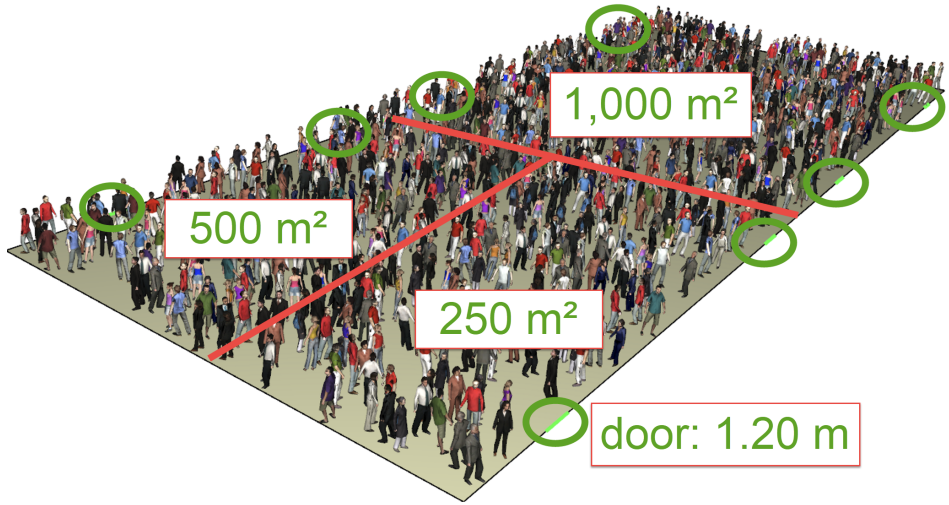

Table of variants with number of occupants [P] per room

	room 250 m²	room 500 m²	room 1000 m²
without social distance (2 pers./ m²)	500	1,000	2,000 and 442
social distance, constant: 1.5 m	104	221	459
social distance, uniform: 1.0 to 2.0 m	104	221	442 and 459
social distance, uniform: 1.0 to 3.0 m		150	126 and 300
social distance, constant: 2.0 m	60	130	260
social distance, constant: 3.0 m	28	130	126

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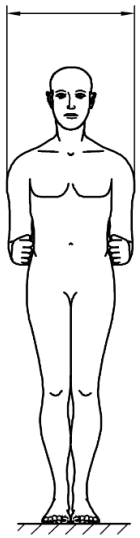
DIN 33402-2:2020-12

Tabelle 11 — Schulterbreite (bideltoid)



Altersgruppen	Schulterbreite (bideltoid) mm					
	Männer			Frauen		
	Perzentil					
Jahre	5	50	95	5	50	95
18–65	**440**	**480**	**525**	**395**	**435**	**485**
18–25	425	470	515	385	420	455
26–40	440	480	525	395	435	490
41–60	445	480	525	400	445	495
61–65	435	475	520	395	440	480

Stochastic Parameters

- Occupant speed: 0.5 to 2.0 m/s
- Shoulder width: 0.40 to 0.55 m
- Groups: 4 different with stochastic / constant parameters

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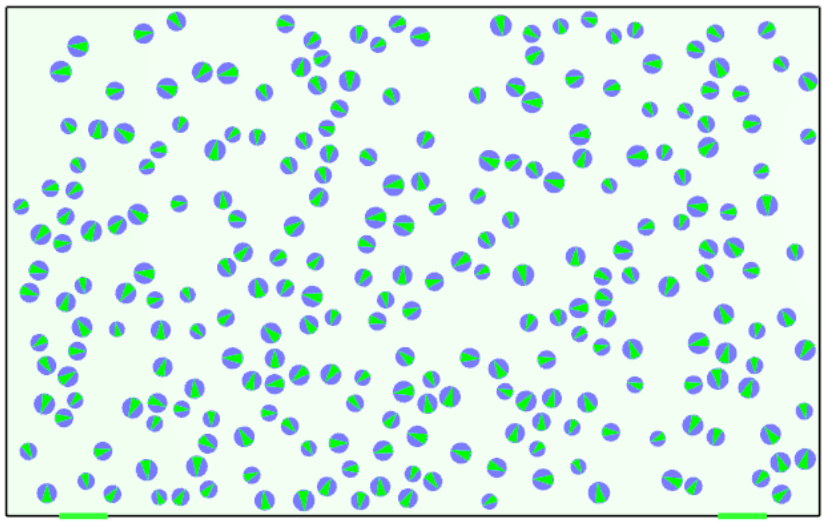
Model 250 m^2

- Room 250 m^2
- 500, 104, 60, 28 Agents
- Social distance: 0 m, 1.5 m, 2 m, 3 m, 1...2 m



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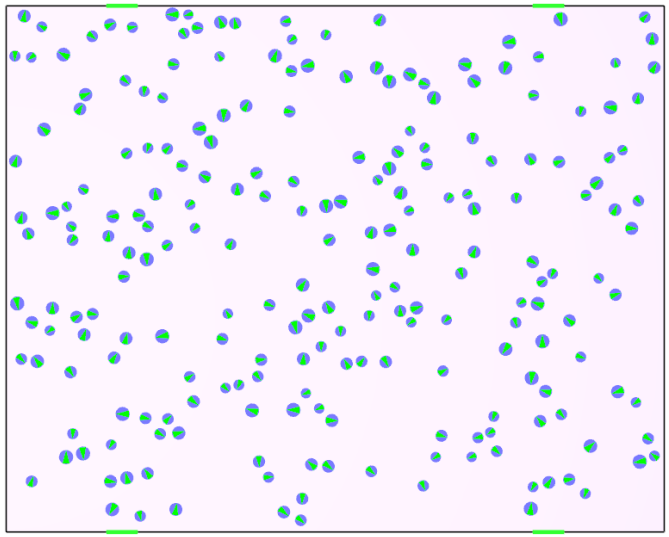
Model 500 m^2

- Room 500 m^2
- 63, 130, 150, 221, 1,000 Agents
- Social distance 0 m, 2 m, 1.5 m, 1...2 m, 1...3 m



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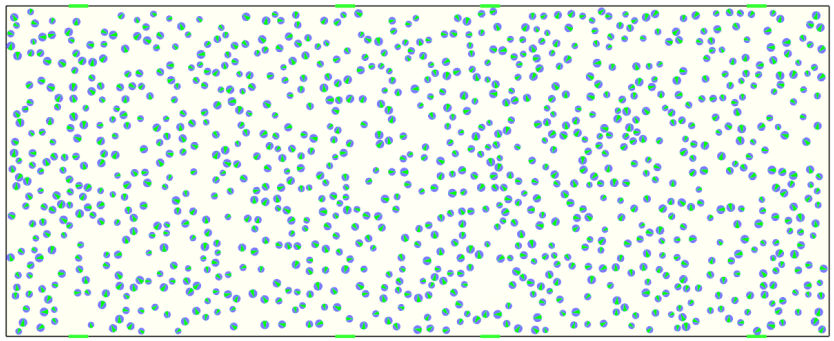
Model 1,000 m^2

- Room 1,000 m^2
- 300, 244, 1,000 and 2,000 Agents
- Social distance: 0 m, 1...2 m, 1...3 m



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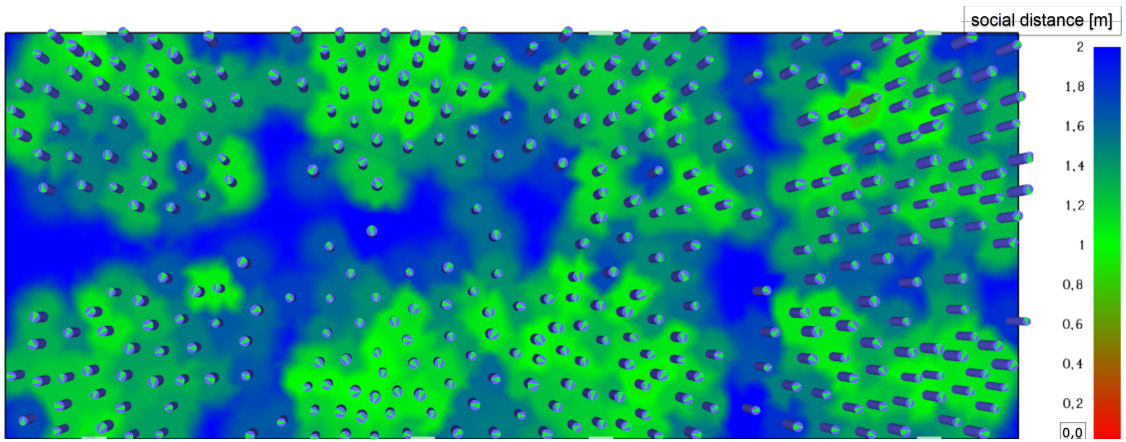
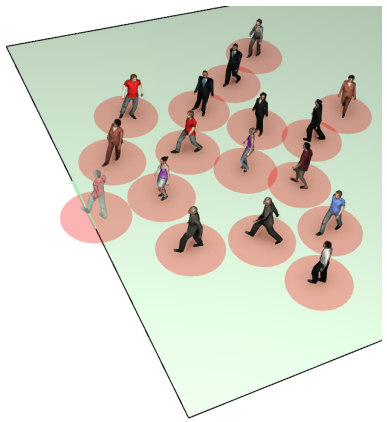
Results in Pathfinder

Generating occupants contours / heat maps:

- **Social distance:** Spacing disks full / half size - overlap of disks
- **Social linkage:** Number of agents within radius R of an occupant
- **Social usage:** Number of all agents within radius R for any spot on the floor, without regard to occupant movement groups
- **Analysis of approach:** Over what period of time are how many occupants closer than a given distance





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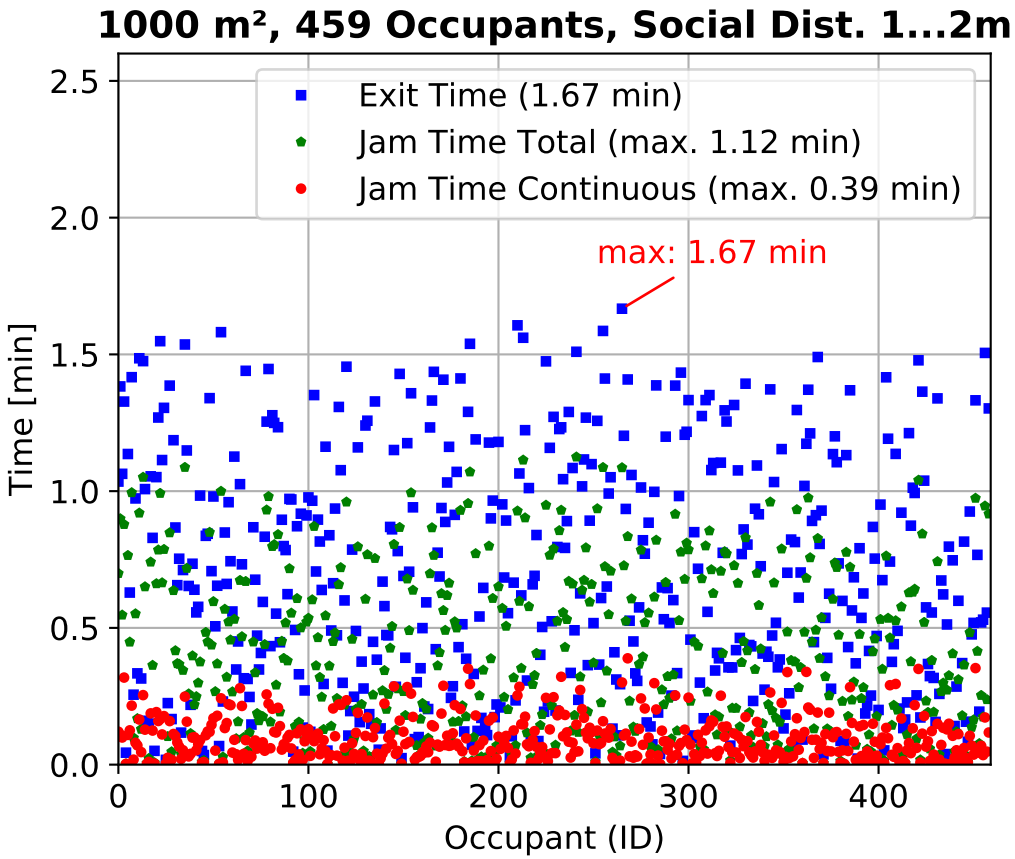
Example for Results Evaluation



Distribution of exit times and jam times

- 1 Sample
- Room 1,000 m^2
- 300 Agents
- Social distance: 1...3 m

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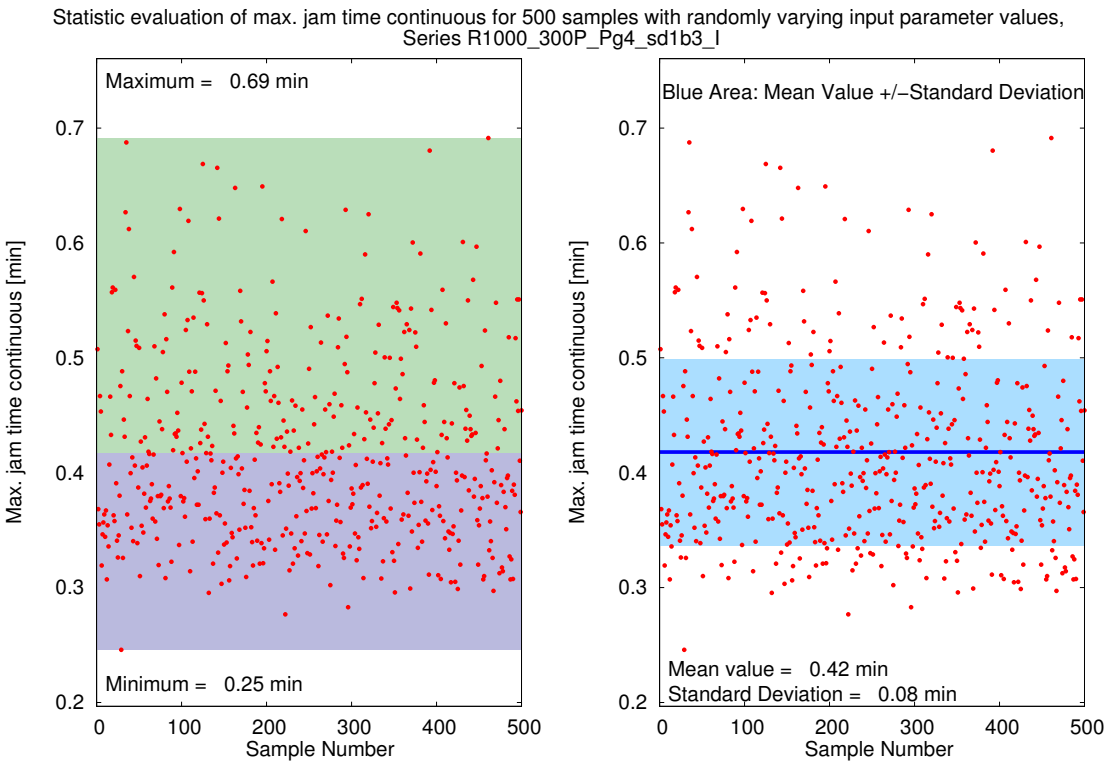
Monte Carlo Simulation



Distribution of max. jam time continuous

- 500 Samples with statistically distributed parameter values
- Room 1,000 m^2
- 300 Agents
- Social distance: 1...3 m

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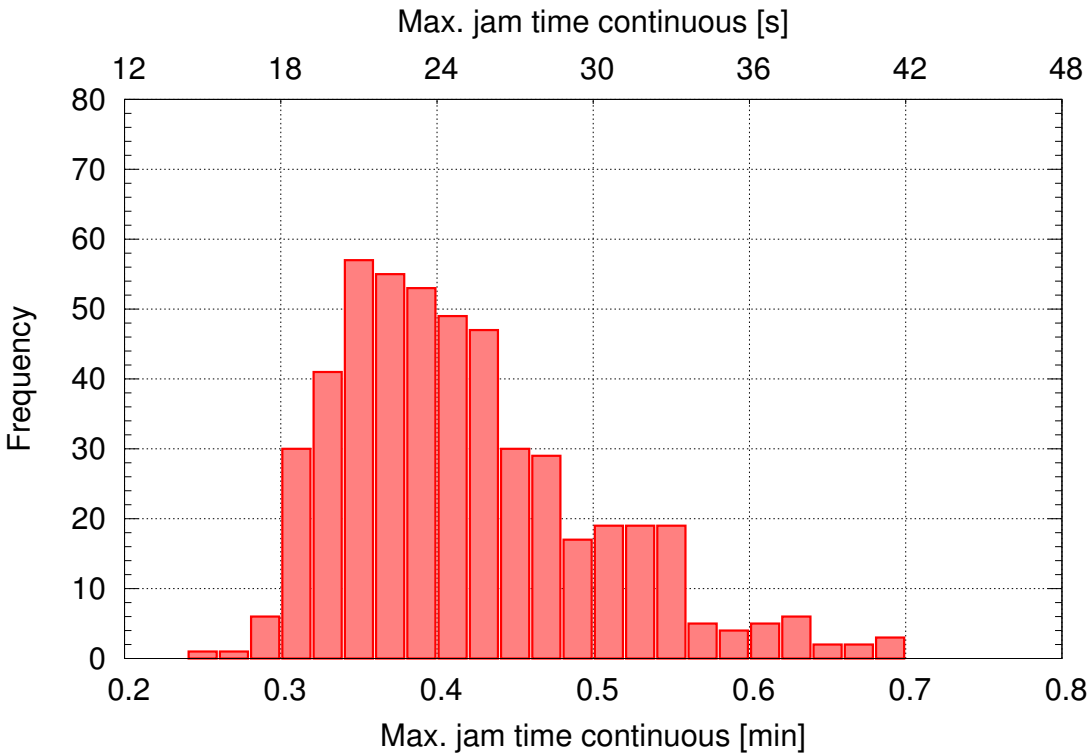
Monte Carlo Simulation



Histogram of max. jam time continuous

- 500 samples with statistically distributed parameter values
- Room 1,000 m^2
- 300 agents
- Social distance: 1...3 m

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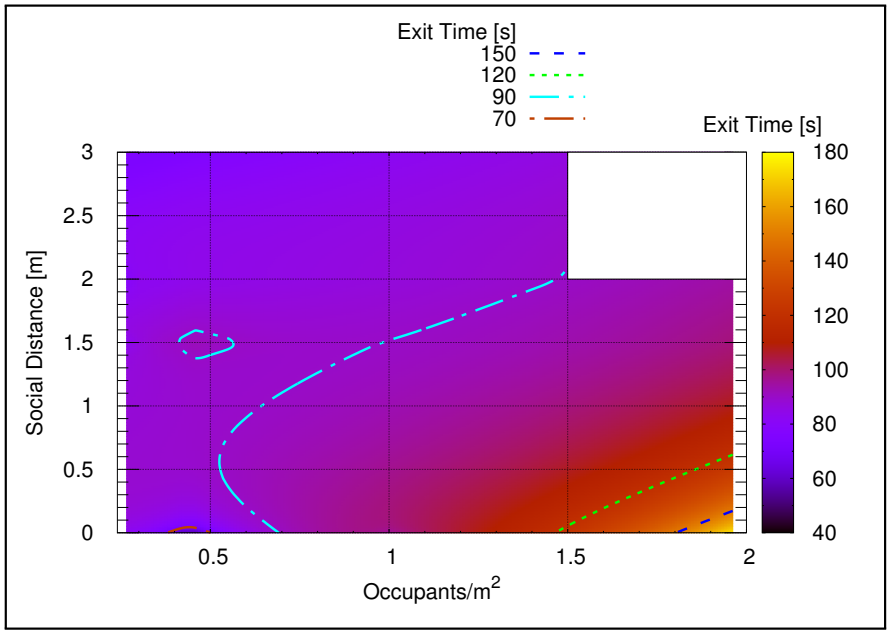
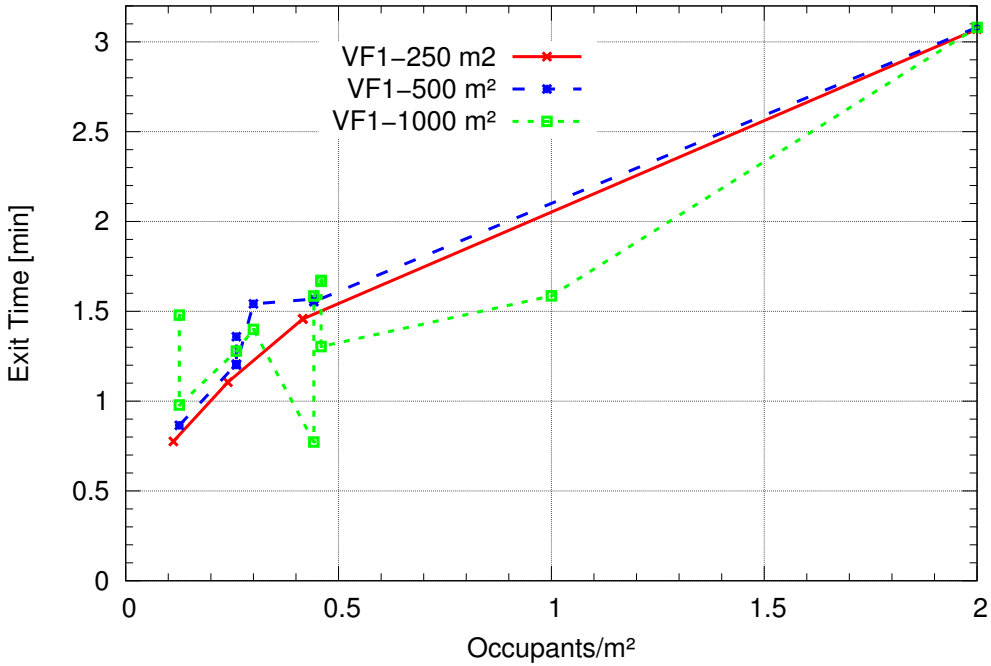
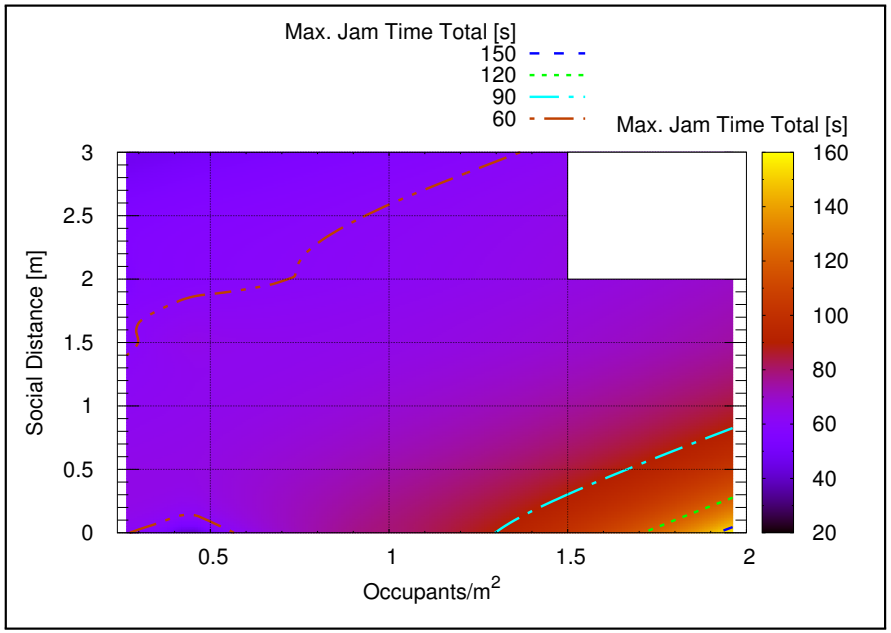
Exit time as a function of social distance (sd) vs. global density

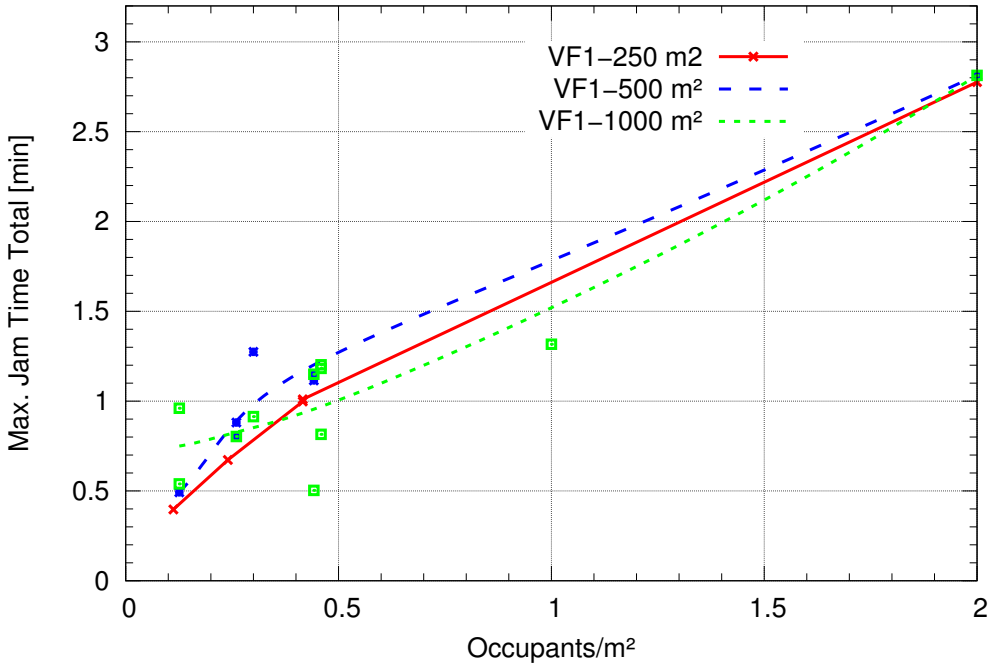




The bigger the social distance ⇑ in the same room the smaller are density ⇓ and exit time ⇓ .

Max. total jam time as a function of social distance (sd) vs. global density





The bigger the social distance $\Uparrow$ in the same room the smaller are density $\Downarrow$ and max. total jam time $\Downarrow$.

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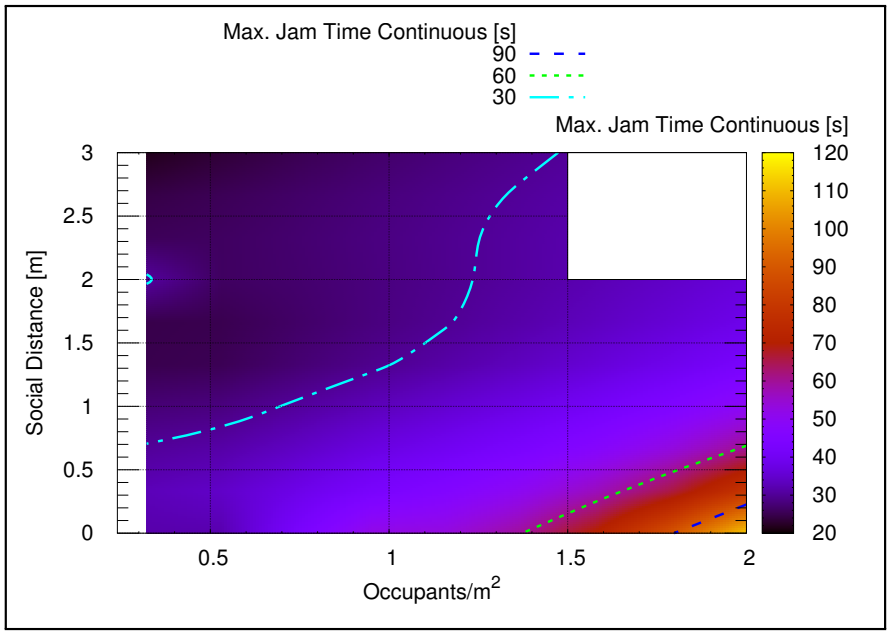
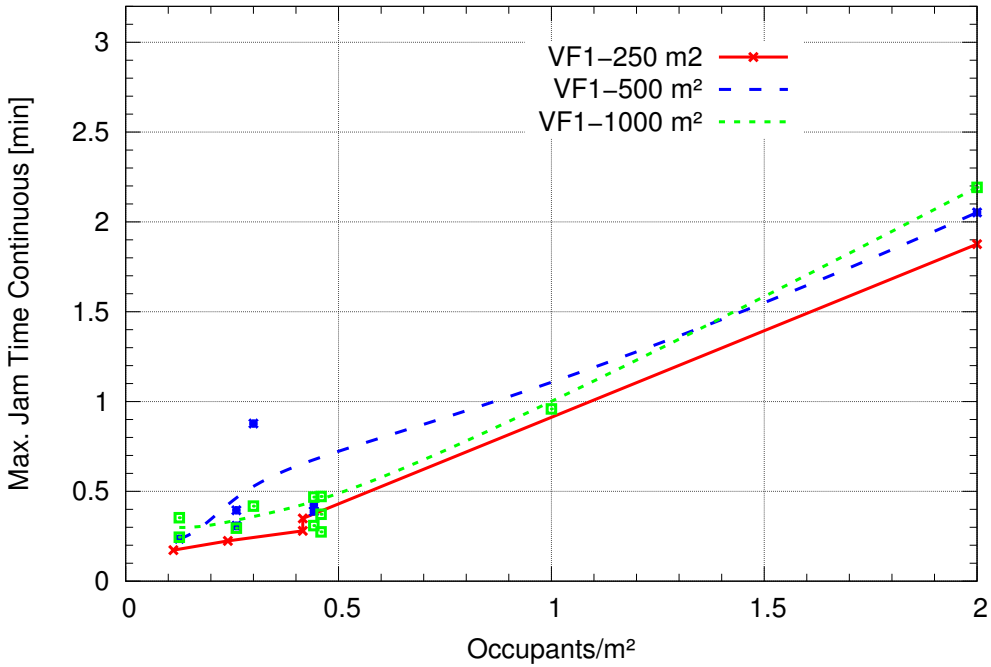
Max. jam time continuous as a function of sd vs. global density





The bigger the social distance ⇑ in the same room the smaller are density ⇓ and max. jam time continuous ⇓ .

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Times Normalised by Number of Occupants

$$t_{exit,n} = \frac{t_{exit,max}}{P}$$

$t_{exit,n}$	...	Normalised exit time
$t_{exit,max}$	...	Max. exit time
P	...	Number of Occupants

The normalised exit time per occupant with a social distance (sd):

- of 1,5 m is 2.3 times bigger,
- of 2,0 m is 3.0 times bigger,
- of 3,0 m is 4.5 times bigger than without sd.

The normalised jam times per agent is increasing $\Uparrow$ with an increasing social distance $\Uparrow$.

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Conclusion

For evacuation simulations with social distances in Pathfinder

- Density and social distance have an influence on exit times and total jam times.
- The bigger the social distance $\Uparrow$ in the same room with the max. possible number of occupants, the smaller are exit $\Downarrow$ and jam times $\Downarrow$.
- The normalised exit times per agent are increasing $\Uparrow$ with an increasing social distance $\Uparrow$ by factor 2.3 - 4.5 and for jam times by factor 1.8 - 3.0.
- There is no significant difference between a constant social distance to a uniform distribution for the same density.

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Thank you for your attention.

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Thanks to:

- Katharina Schwab (Bachelor Thesis, OTH Regensburg, 2020)

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