



Capacity of train stations in case of a large-scale emergency evacuation

AUGUST 20TH, 2019 | Anna Braun, Dr. Mohcine Chraibi, Dr. Lukas Arnold

Background

- Nature and human made hazards:
 - Hurricanes, floods, wild fires ...
 - Terroristic attacks, incidents in nuclear power plants ...
- Large-scale evacuations carried out with only private / road dependant vehicles:
 - Many people have no access to private vehicles,
 - Not enough bus drivers,
 - Limited road capacity,
 - Large congestions, lack of fuel, accidents
- After the nuclear power plant disaster of Fukushima the 'AG Fukushima' was found (Germany)
- 'AG Fukushima' recommends the use of trains for large-scale evacuations.
- Capacity of train stations for large-scale evacuations is unknown.



www.hs-rottenburg.net

Studies



- **KapaKrit** = Optimising the capacity of train stations in case of large-scale emergency events



- Identification of critical bottlenecks
 - Operational options to increase the capacity
 - Finding the maximum capacity
 - Capacity = evacuees* / hour
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- Field studies at the main station of Dortmund (NRW, Germany)
 - Simulations with JuPedSim

* Evacuees = people who leave a threatened area by train

Field Studies

- Field studies at the main station of Dortmund (NRW, Germany)
 - Entry times for different train types
 - Pedestrian movements inside the station
 - Pedestrian movement and waiting behaviour at the platforms
 - Influence of luggage
- Cooperation with the federal police
 - Accompany special events like the risk football game Dortmund vs. Schalke (April 2019) or other events where a lot of people are using the train station
 - Special barriers and other operational options are used to restrict the inflow or guide the people to the station



Jülich Pedestrian Simulator - JuPedSim



- Developed at the Research Center Jülich
- Free software* for pedestrian dynamics



- Pedestrians = agents
 - Individual parameters (shoulder width, velocity ...)
- Modified floor field router
- Collision-free speed model:
 - No overlapping with other agents or walls
 - Self-organisation phenomena like lane formation or clogging

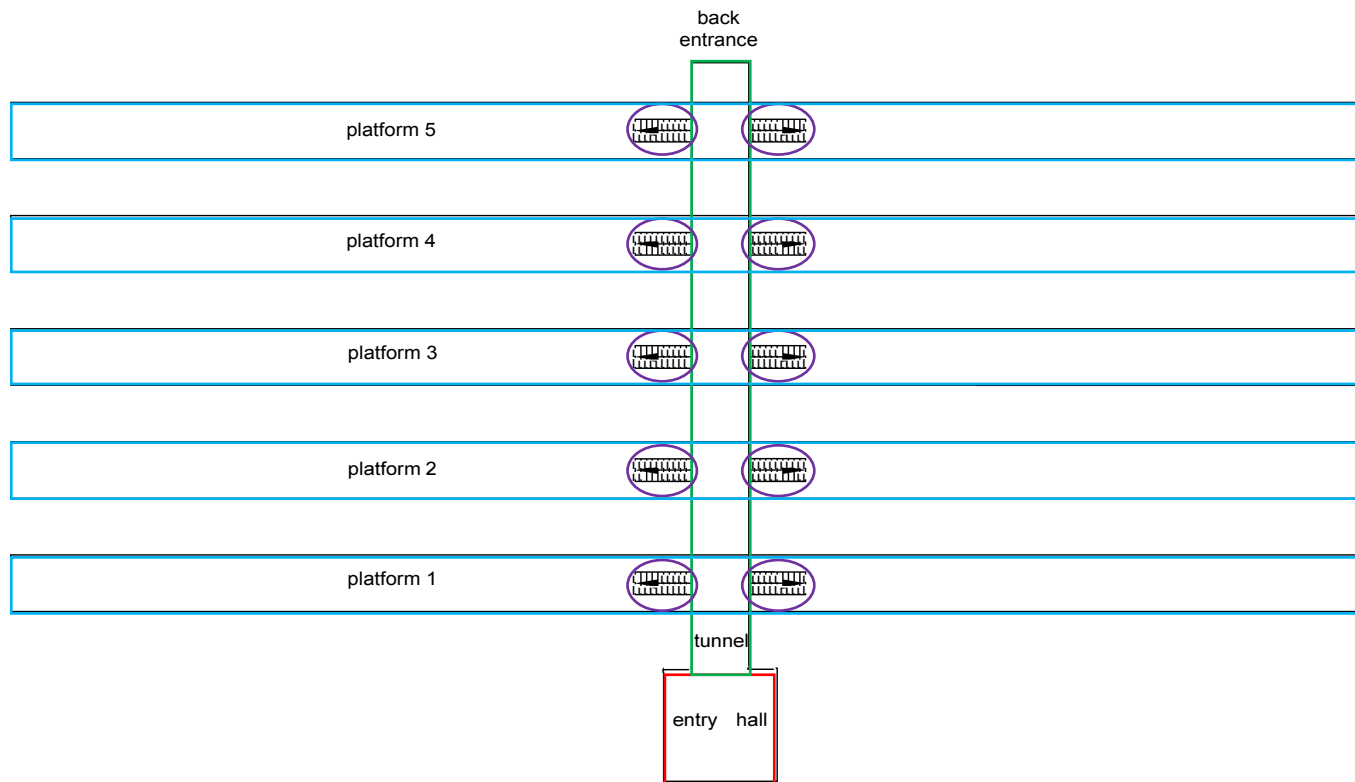
* github.com/JuPedSim

Simulations

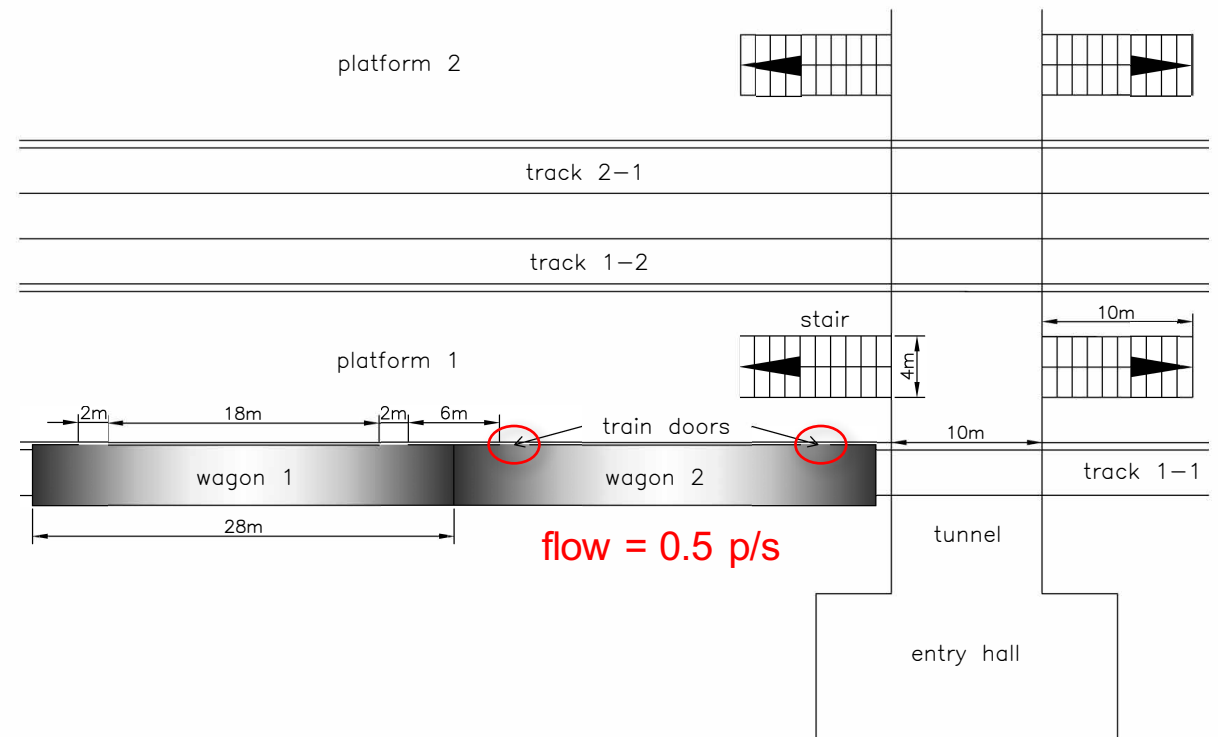
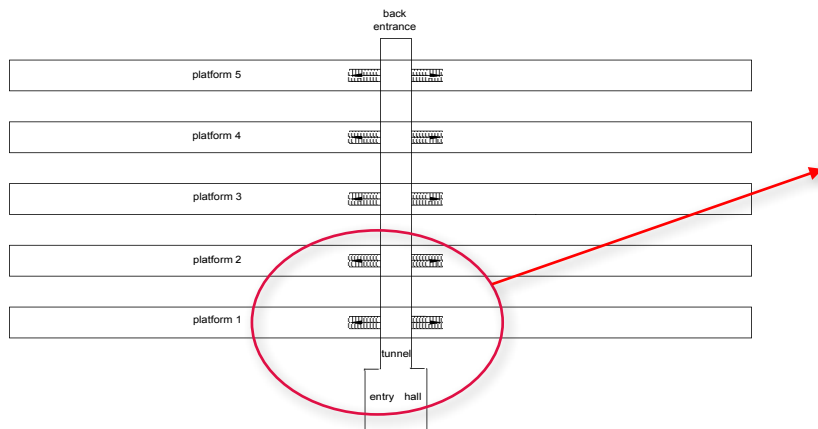


- No daily business – only evacuation trains
- Particularities:
 - Passengers carry a lot of luggage → walking speed decreases, space increases
 - Empty trains and huge number of passengers → increased boarding and dwell times
 - Limited capacity/space in the building and on the platforms → inflow restrictions and waiting areas
 - Departure only in specified direction → limited tracks → increased waiting times
- Assumption:
 - Passengers act rational at any time
 - No panic or similar occur
 - Enough trains and train drivers for the evacuation

Setup



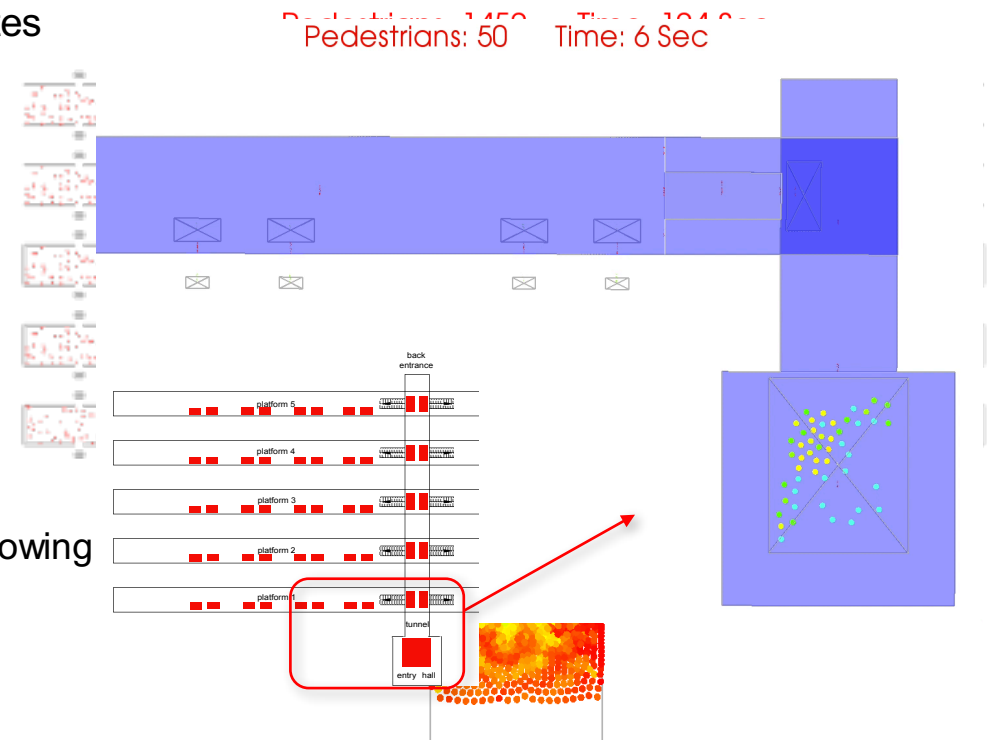
Setup - Detail



First Studies

Critical bottlenecks

- One train at each of the five platforms every 5 – 10 minutes
- 3200 agents → 640 agents/train
- Three setup variations:
 1. Usage of both entrances
 2. Only main entrance
 3. Main entrance and waiting areas
- Bottlenecks:
 1. Bidirectional flow → huge congestion inside the tunnel
 2. Congestion at the first platform accesses → blockage of following agents
 3. Congestion at transition between entrance hall and tunnel
- Capacity = 19000 agents / hour



Actual studies

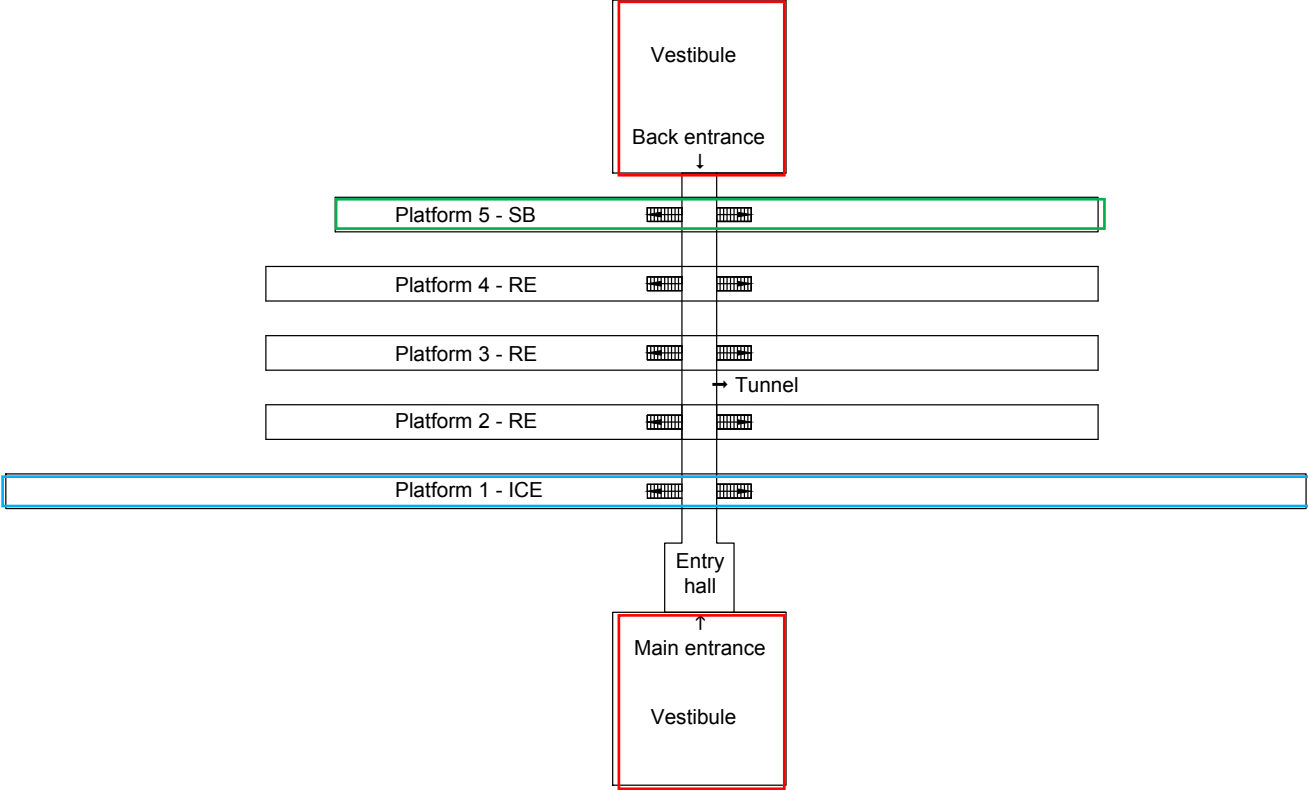
- Three different train types:

Train type	Capacity [agents]	Length [m] door ₁ - door _n	Door width [m]	Agents / door	Door flow [s ⁻¹]
ICE (Intercity Express)	1170	372.9	0.9	45	0.45
RE (Regional Express)	1350	236.2	1.9	75	0.95
SB (City Express)	1440	195.2	1.3	40	1.10

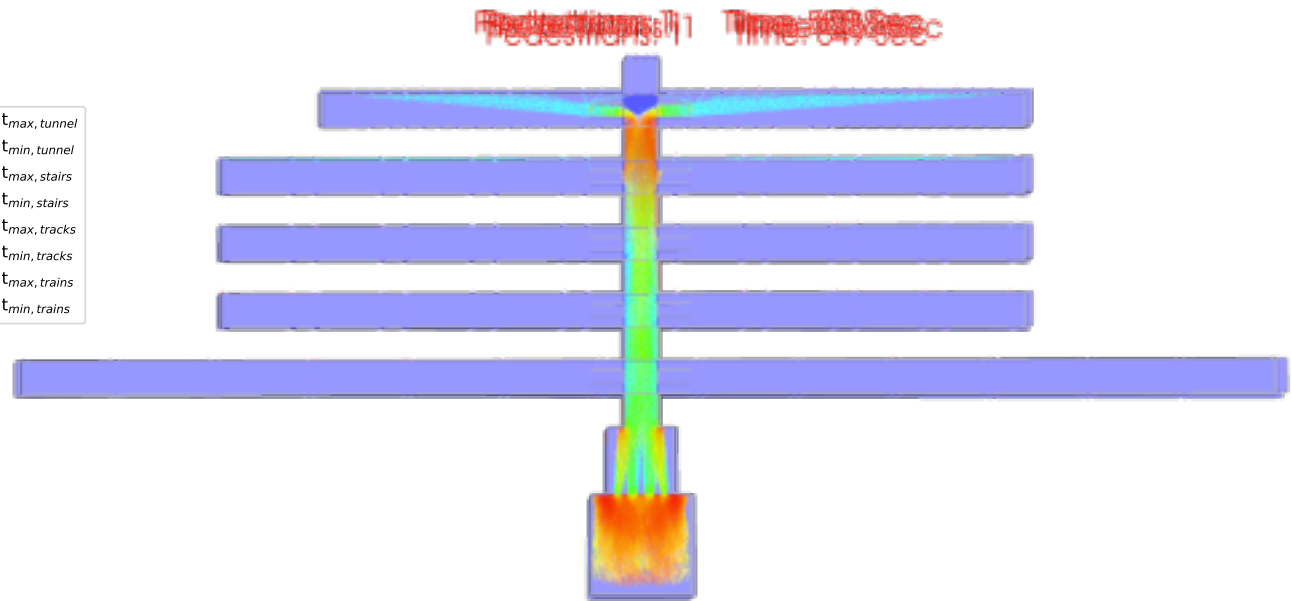
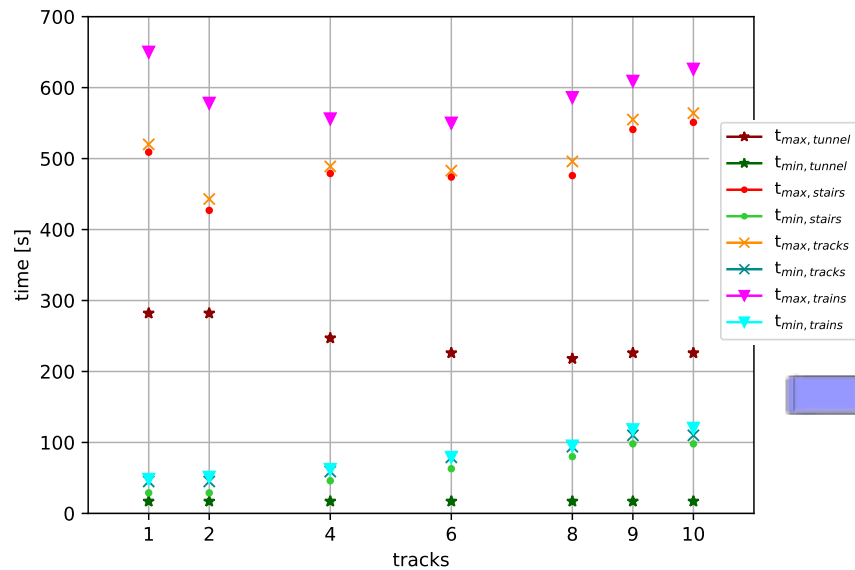
- Different time schedules for each platform:

- How long does it take to refill the single platforms? → Train arrival time
 - How long does it take to fill the trains? → Dwell time
 - When do the last agents enter the tunnel and the staircases? → Inflow restriction to avoid congestion
- } Departure time

Adapted Setup



Transition times



- Track 1 & 2: Short distance to the platform → congestion in front of the stairs influences the flow inside the entrance hall
- Track 4 & 6 : Mean distance to the platform → only a small influence on the flow inside the entrance hall
- Track 8 – 10: Longer distance to the platform → no tailback to the entrance hall

Time schedule

- Minimum and maximum times of the transition between tunnel and staircases
 - First agents < 2 minutes
 - Difference between first to last agents 6.5 minutes (track 8) – 8 minutes (track 1)
- Train arriving interval = 7 minutes
- Usage of both entrances (main: platform 1+2, back: platform 4+5, both: platform 3)
- Dwell time = 3 minutes

Platform 1		Platform 2		Platform 3		Platform 4		Platform 5	
Track 1	Track 2	Track 3	Track 4	Track 5	Track 6	Track 7	Track 8	Track 9	Track 10
21*		13		7 _{main}			7		14
	35		28		21 _{back}	28		35	
56		49		42 _{main}			42		49

} 21150 P/h

* Time in minutes

Conclusion and Outlook

Conclusion:

- Operational options like inflow restrictions are necessary
- A good time schedule can increase the capacity

Outlook:

- Investigation of the influence of luggage and group behaviour like staying together (e.g. families)
- More detailed investigation of operational options like barriers and inflow restriction in and around a station to increase the train departures per hour
- Detailed modelling of trains

Questions?

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