Boarding Efficiency

How to enter an aircraft – the most efficient way?

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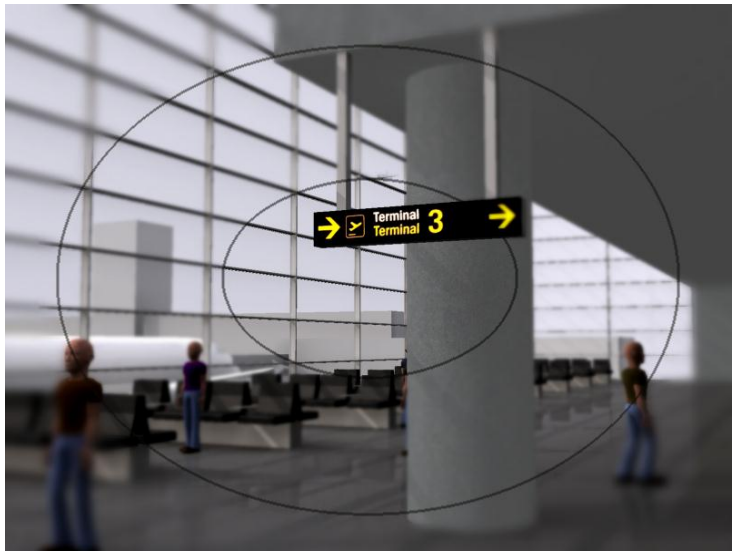
Introduction

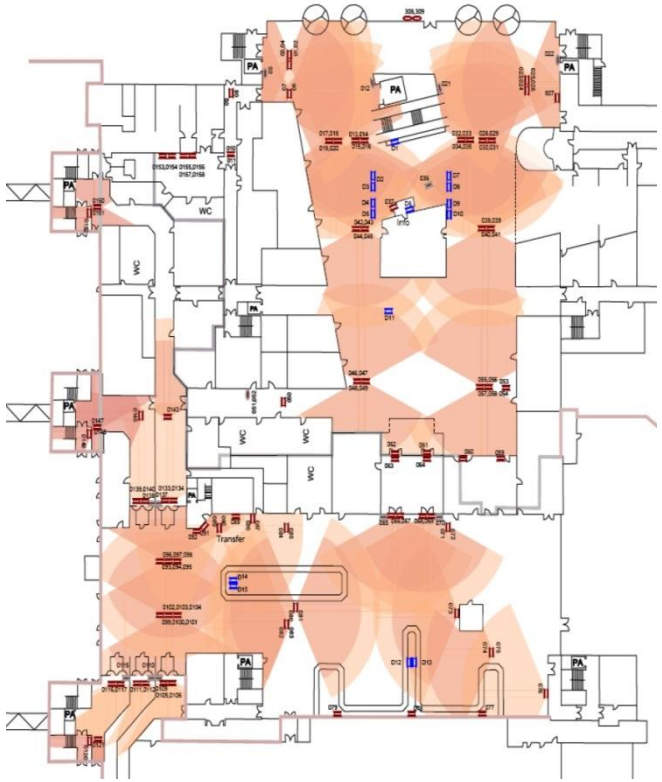
- Michael Schultz
  - Business and Engineering degree (Dipl.-Wirtsch.-Ing.)
  - PhD in Aviation Technologies (Dr.-Ing.)
  - former senior researcher at Institute of Logistics and Aviation, Technische Universität Dresden
  - Currently Heading Department of Air Transportation, Institute of Flight Guidance at German Aerospace Center in Braunschweig
  - Research Topics
    - model-/data based performance assessment of Air Traffic Management (ATM)
    - Performance Based Airport Management (PBAM)
    - advanced ATM concepts
- **Structure of presentation**: research background > tournaround > boarding modell > results

Background - Passengers at Airport Terminals

Considering of visual perception areas

- navigation to unknown locations
- information gathering and processing

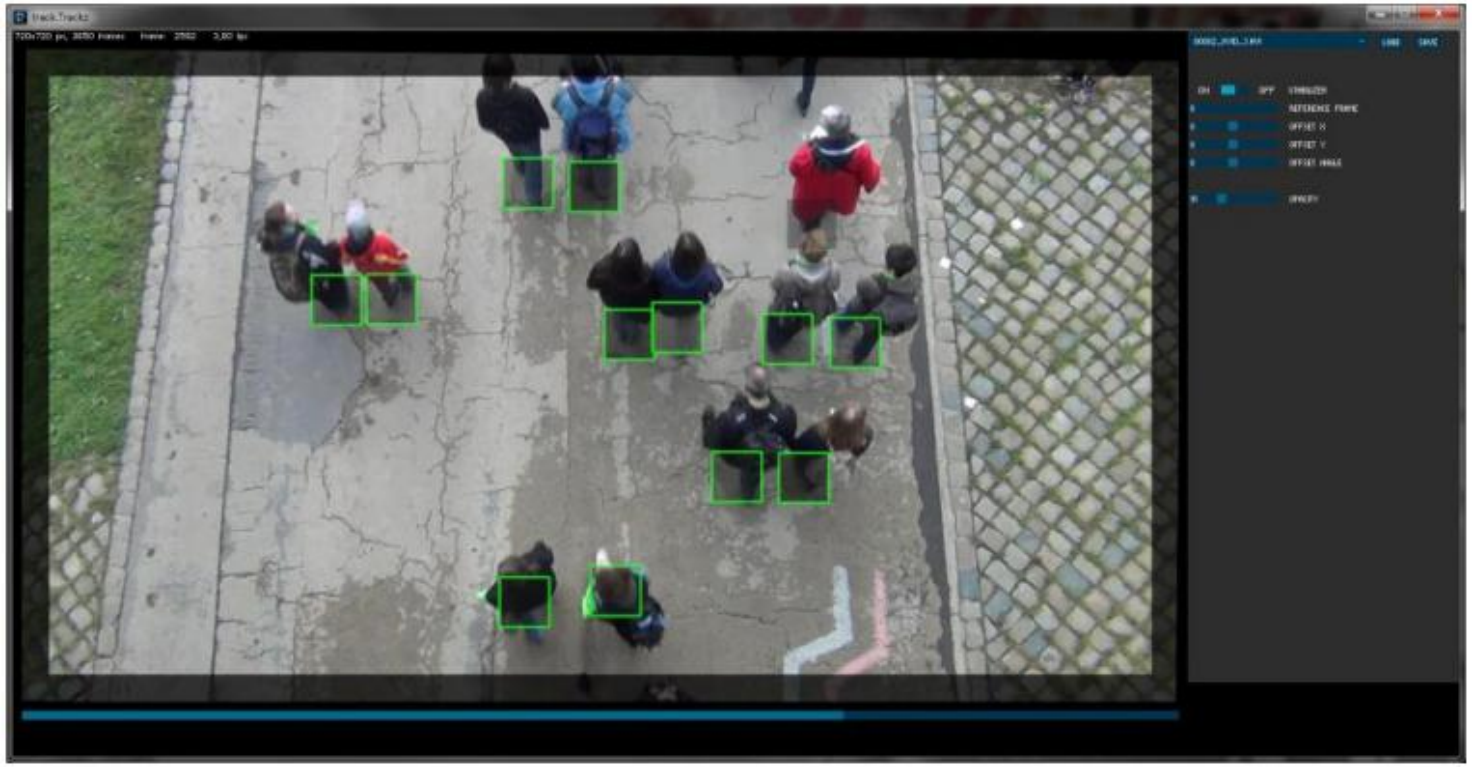




Schultz et al. (2007) *Enhanced Information Flow and Guidance in Airport Terminals using best Passenger`s Visual Perception*
Schultz et al. (2011) *Managing Passenger Handling at Airport Terminal*

Background - Group Dynamics

- Common group behavior also valid for airport environment

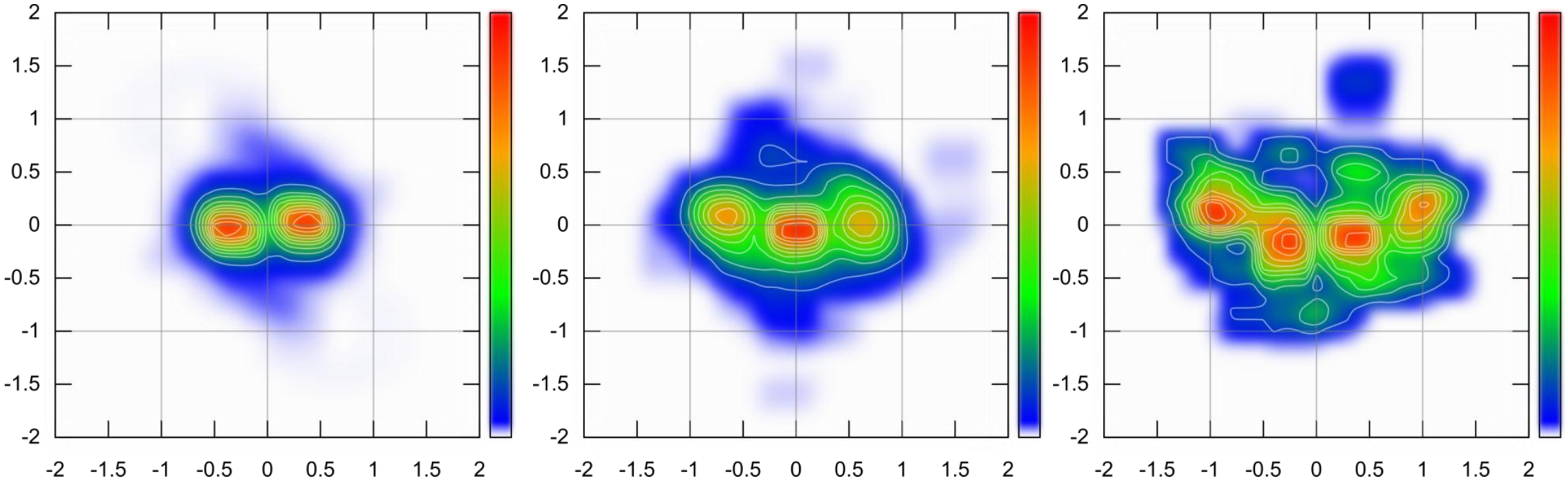


Group Size	Business	Tourist
1	73%	19%
2	23%	55%
3	4%	26%

Schultz et al. (2011) *Group dynamic behavior and psychometric profiles as substantial driver for pedestrian dynamics*
Schultz (2010) *Entwicklung eines individuenbasierten Modells zur Abbildung des Bewegungsverhaltens von Passagieren im Flughafenterminal*

Background - Group Dynamics (2)

- Common constellation of pedestrians walking in groups (size of 2, 3, and 4 pedestrians)

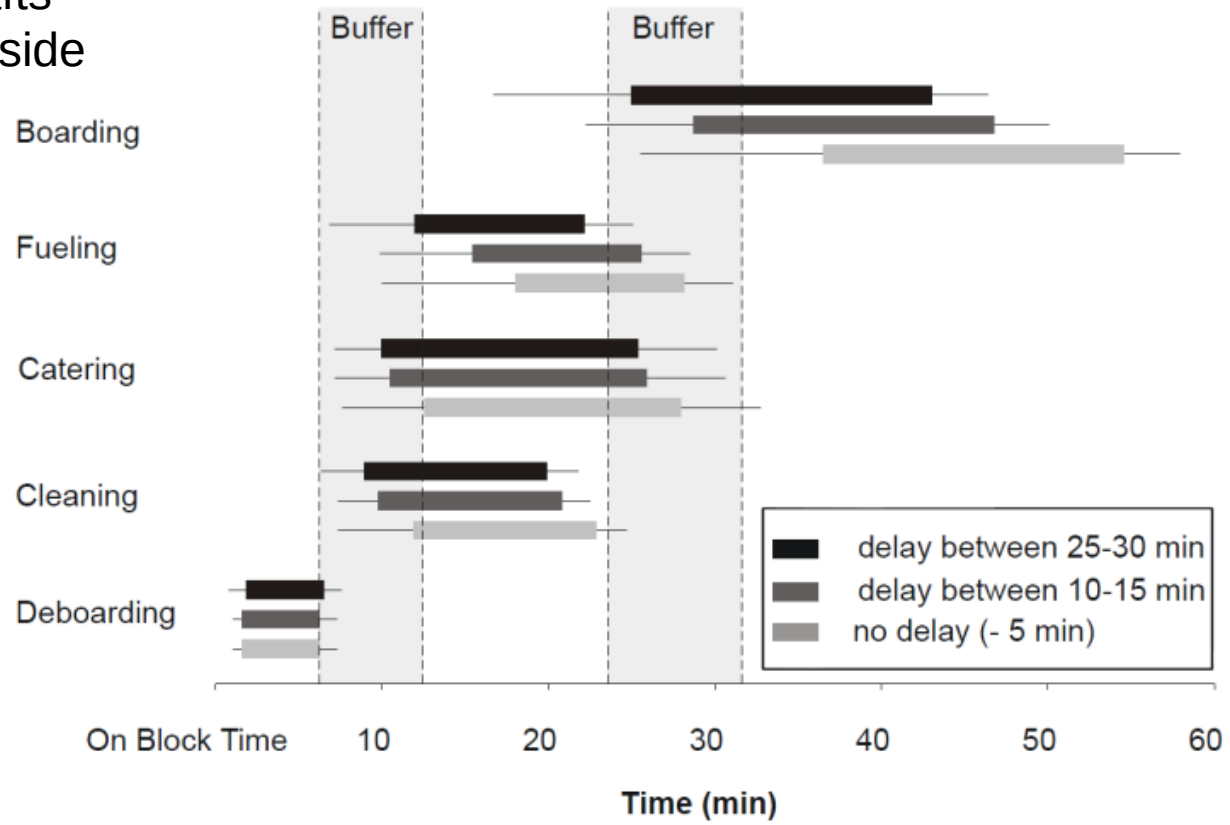


Schultz et al. (2011) *Group dynamic behavior and psychometric profiles as substantial driver for pedestrian dynamics*, Presentation at Pedestrian and Evacuation Dynamics Conf.

Airt Transportation - Turnaround

- Connect research topics: passenger dynamics, turnaround optimization
  - increasing passenger transport capacity of aircrafts
  - demand for efficient connection between land/airside
  - ATM significantly depends on a reliable turnaround progress

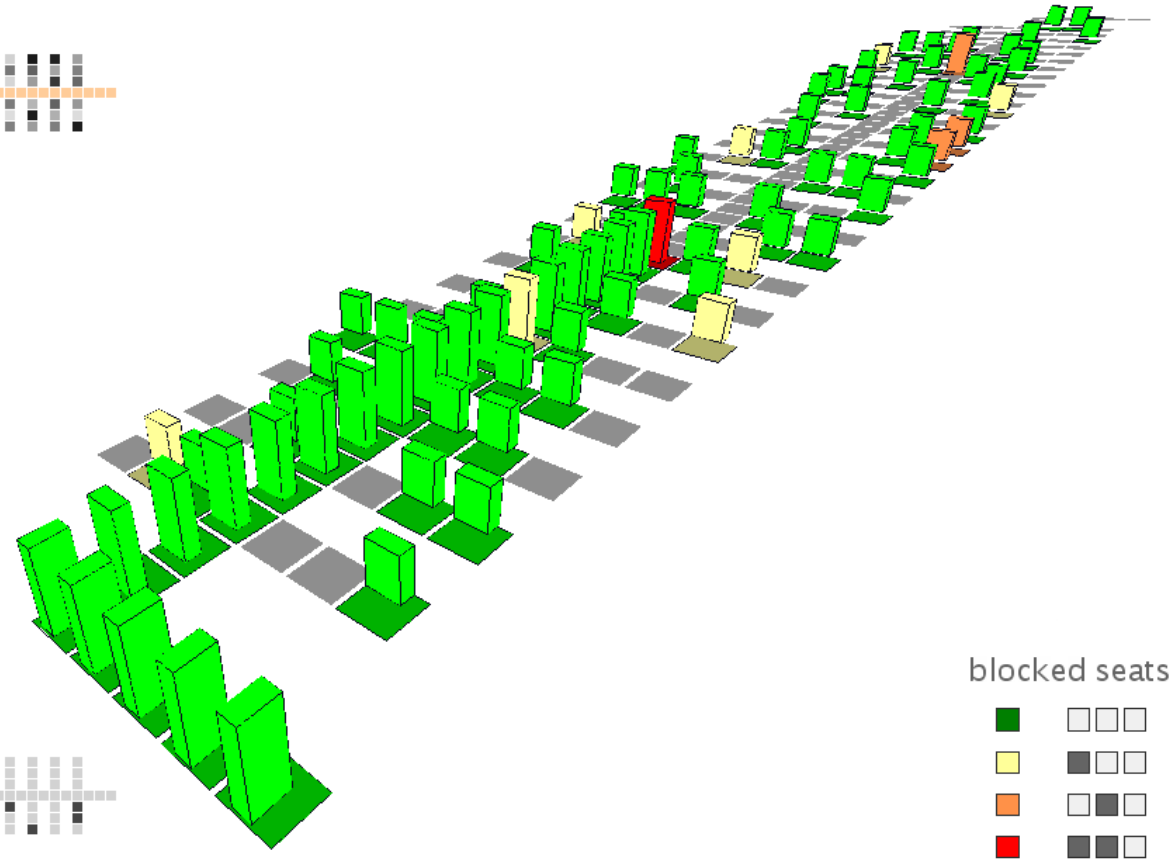
- Boarding
  - always on the critical path
  - high potential of disruptions
  - robust strategies vs. highly optimized procedures
  - Passengers own the process, individual behavior drives the boarding progress



Fricke and Schultz (2009) *Delay Impacts onto Turnaround Performance*

How boarding looks like?

Szenario: Random – 1 Door

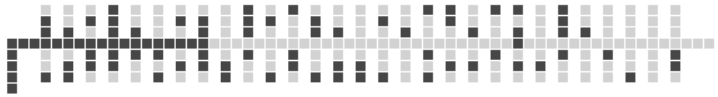


Results:

Boarding efficiency: +0 %

Boarding stability: +0 %

Boarding Progress: 30 %

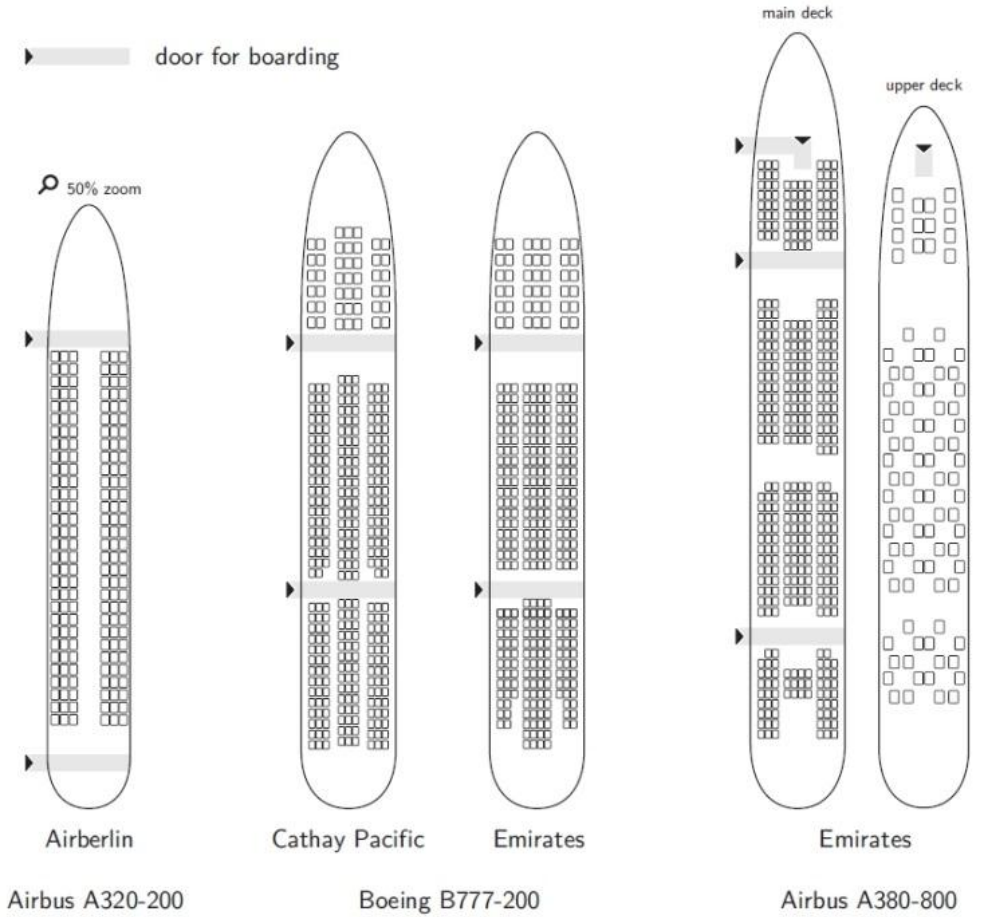


blocked seats

see http://video.air-transportation.org

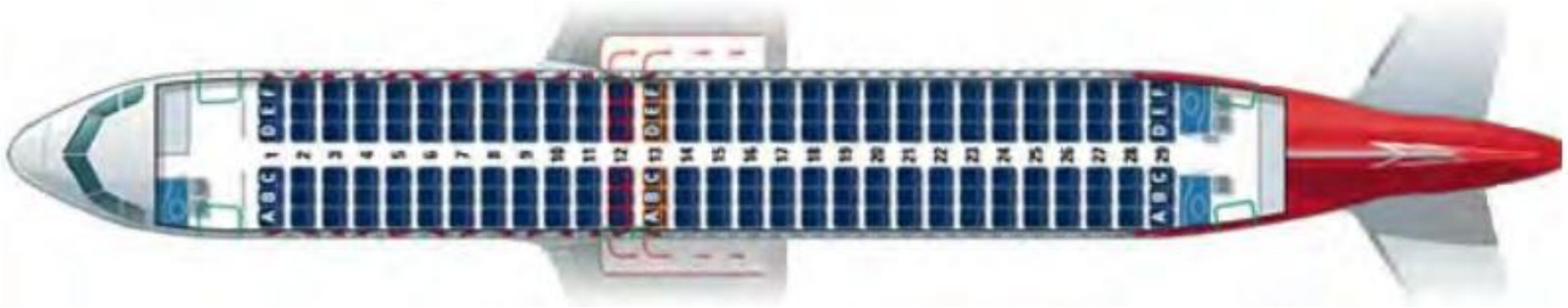
Aircraft Layout

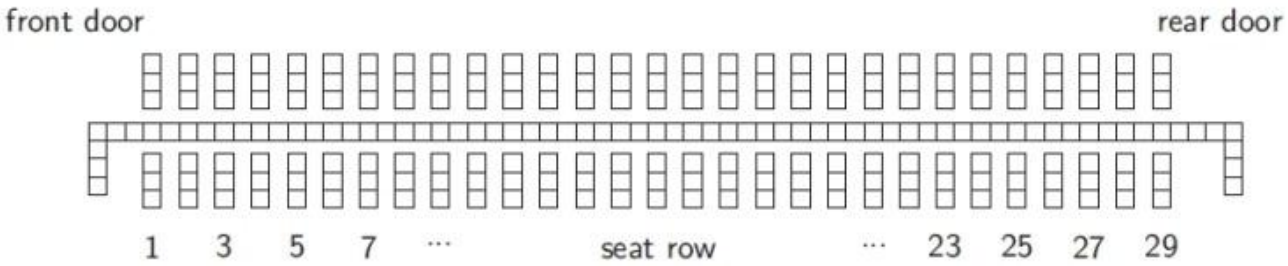
- A320 as a reference layout
- Layouts differ
  - amount of passengers
  - number of aisles
  - config: 1st, business, eco
- Passenger process
  - enter aircraft
  - get correct aisle
  - walk to assigned seat
  - store baggage
  - seating interaction



Schultz (2013) *Boarding on the critical path of the turnaround*

Aircraft Layout - Modell





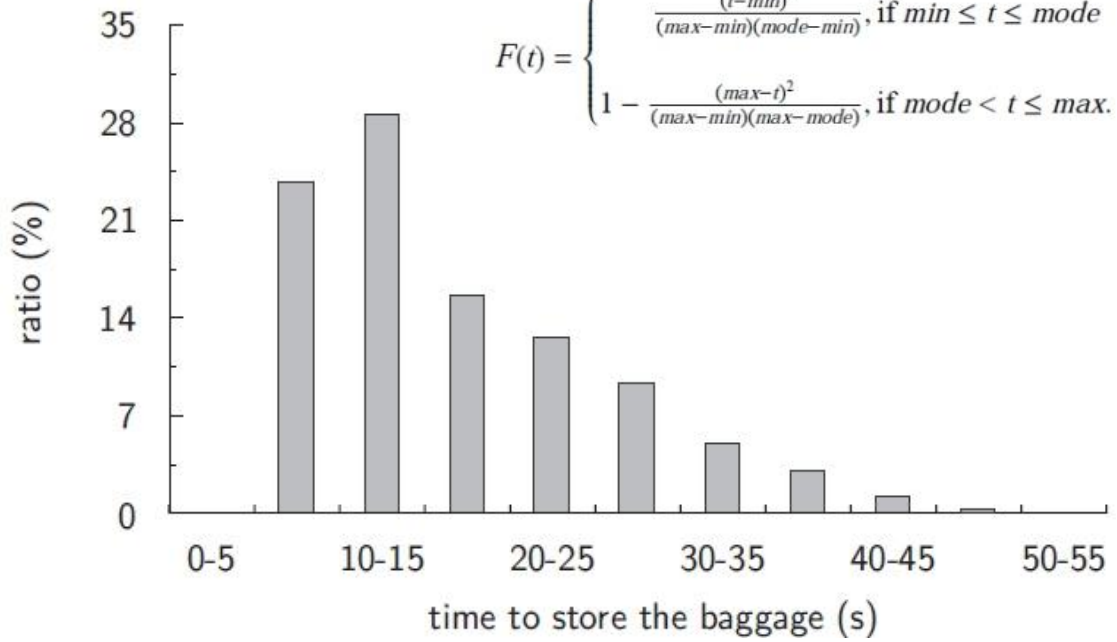
Schultz (2010) *Entwicklung eines individuenbasierten Modells zur Abbildung des Bewegungsverhaltens von Passagieren im Flughafenterminal*

Motion Model and Parameter

- Asymmetric simple exclusion process (ASEP)
  - stochastic, forward directed, one dimensional, and discrete
  - shuffled sequential update of positions at each time step
  - regular grid consists of equal cells with a size of 0.4 x 0.4 m^2
  - v_{max} = 1 model (max 1 cell per time step)
  - pax speed of 0.8 ms^{-1} at the aisle
  - time step of 0.5 s

- Additional parameter
- individual amount **baggage**
- interaction during seating (**seat shuffle**)
- boarding **strategy**

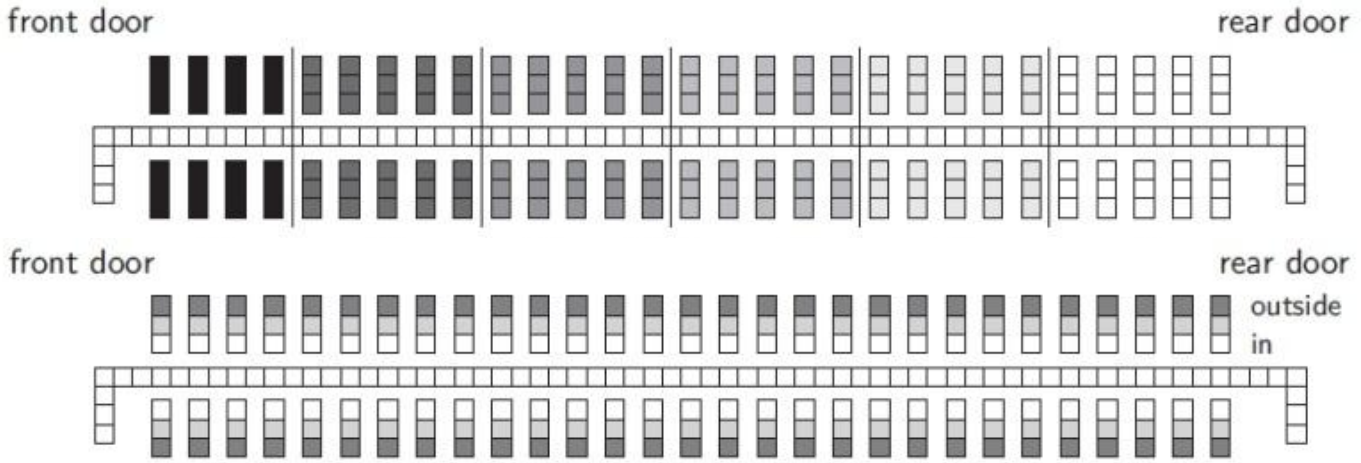
$$F(t) = \begin{cases} \frac{(t-min)^2}{(max-min)(mode-min)}, & \text{if } min \le t \le mode \\ 1 - \frac{(max-t)^2}{(max-min)(max-mode)}, & \text{if } mode < t \le max. \end{cases}$$



Schultz (2013) *Boarding on the critical path of the turnaround*

Boarding Strategies

- *Random* (reference), *Block*, *Back-to-Front*, *Outside-In*



Schultz (2013) *Boarding on the critical path of the turnaround*

- Remarks:
  - tourist with clear trend of groups with 2 or more members (81%)
  - business travelers often travel alone (73%)
  - passengers are not altruistic (non-conformant behavior)
  - fast processes need considerable pre-sorting effort

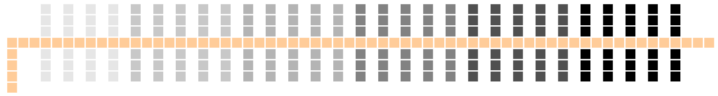
Simulation Scenarios – Sensitivity Analyses

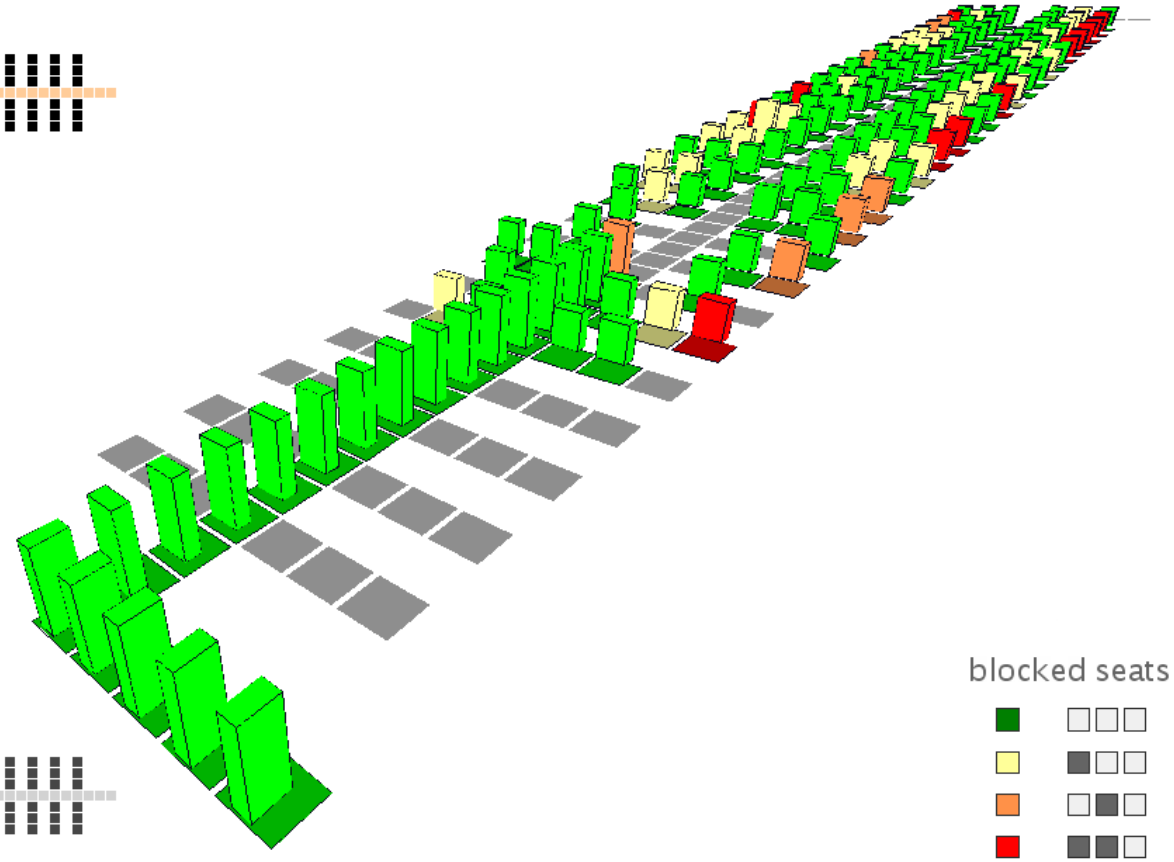
- Input
  - time to store baggage
  - seat shuffle: response time, interaction time
  - seat layout of aircraft: A320, B777 (2-5-2, 3-4-3, 3-3-3), A380

- Variation of input factors
  - boarding strategy/passenger sequence (default: *random*)
  - seat load factor (SLF) - ranging from 20% to 100% (default: 85%)
  - conformance rate (CR) - ranging from 20% to 100% (default: 85%)
  - arrival rate at aircraft (AR) - ranging from 1 to 40 pax per minute (default: 14 pax per minute)
  - one door and two door configuration (default: one)

Results (1) - Video

Szenario: Back to Front





Results:

Boarding efficiency: -11 %

Boarding stability: -12 %

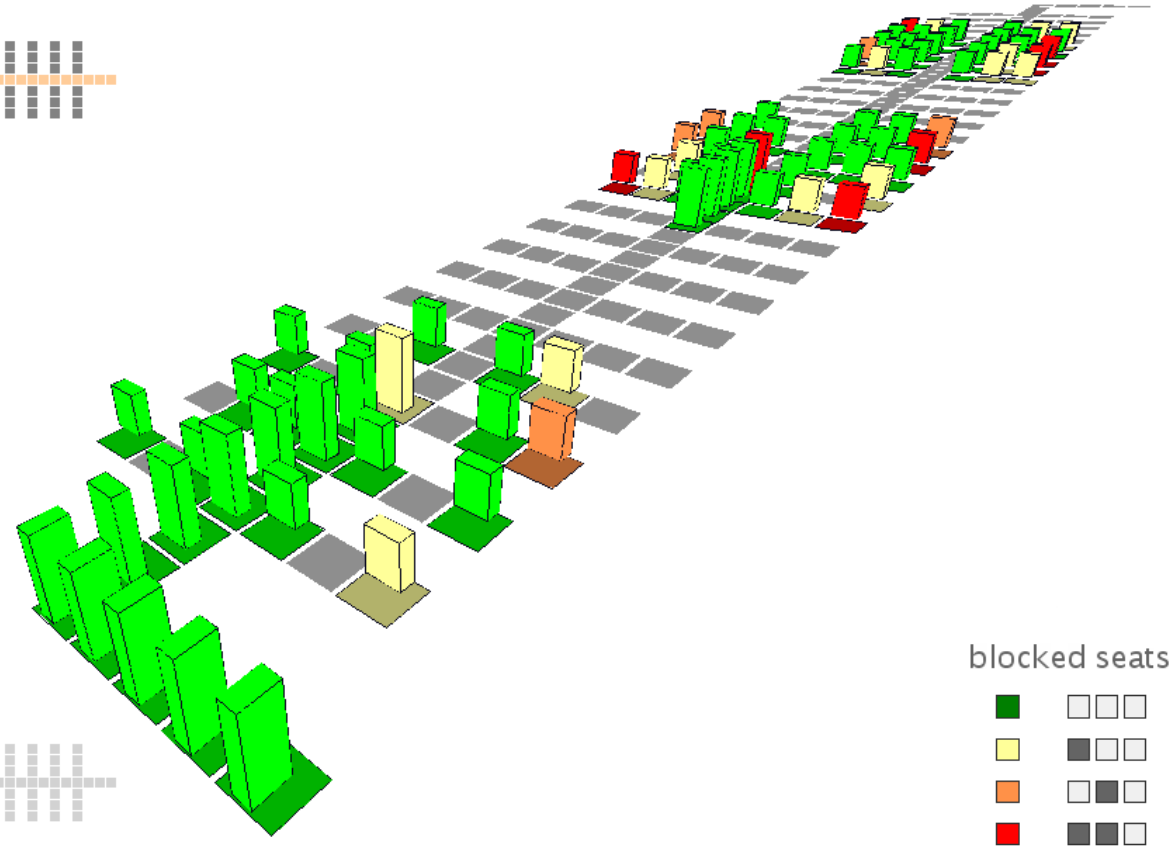
Boarding Progress: 74 %

blocked seats

see http://video.air-transportation.org

Results (2) - Video

Szenario: Block-Boarding



Results:

Boarding efficiency: +4 %

Boarding stability: +4 %

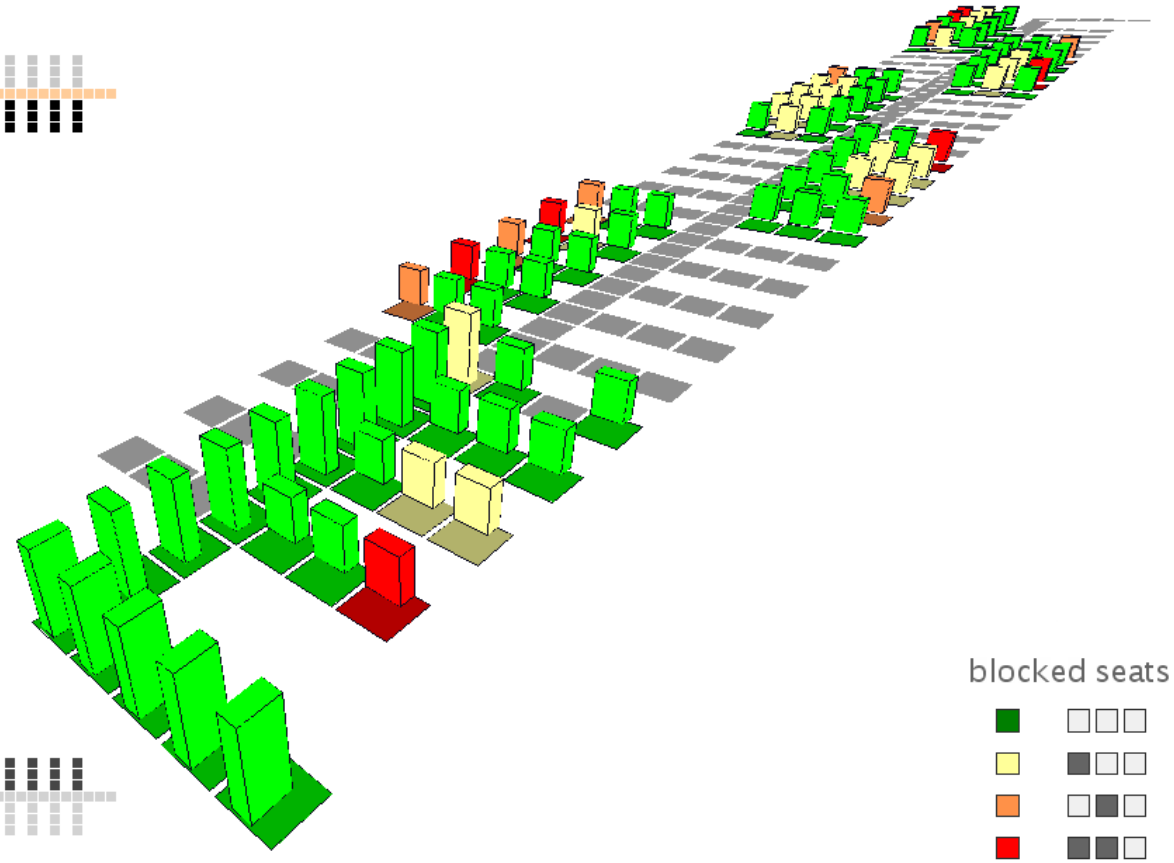
Boarding Progress: 36 %

blocked seats

see http://video.air-transportation.org

Results (3) - Video

Szenario: Block Boarding – Alternating

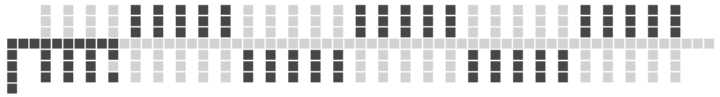


Results:

Boarding efficiency: +16 %

Boarding stability: +14 %

Boarding Progress: 51 %

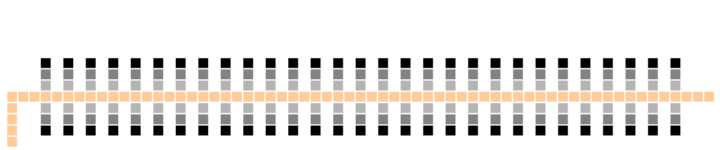


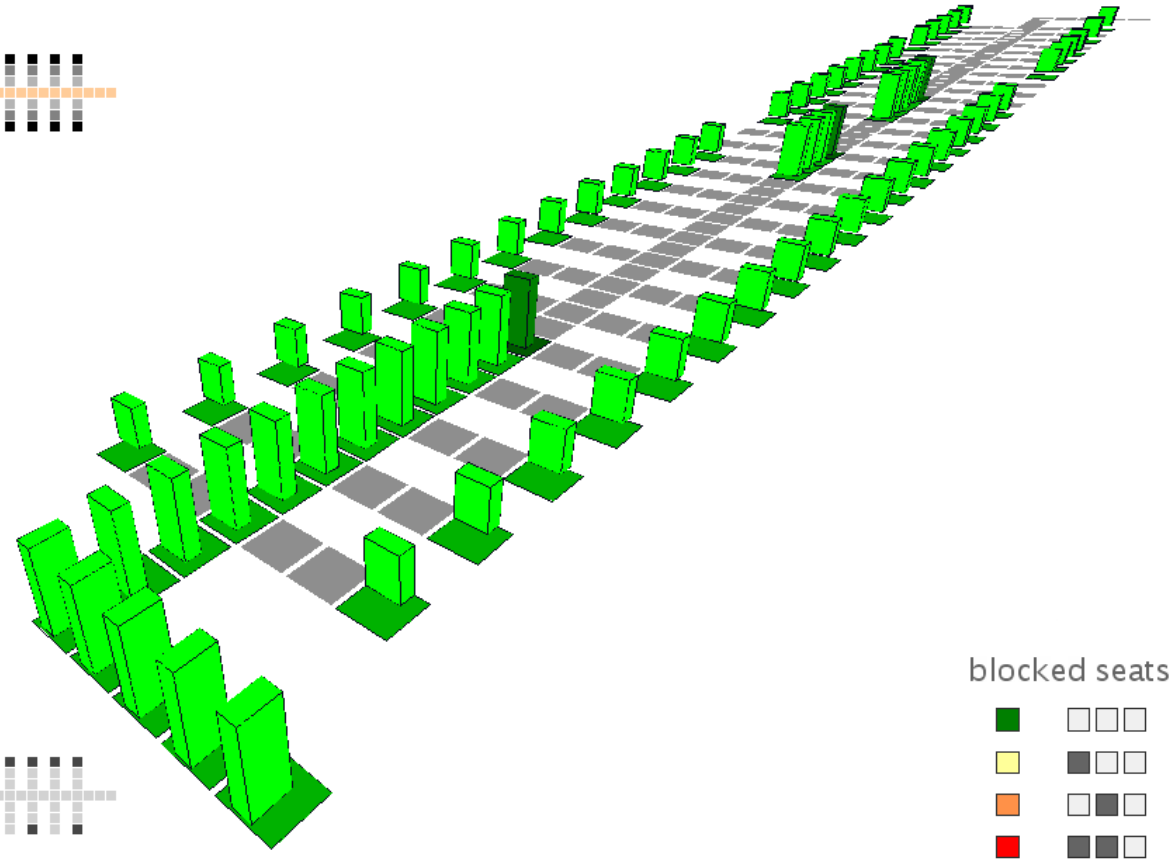
blocked seats

see http://video.air-transportation.org

Results (4) - Video

Szenario: Outside-In





Results:

Boarding efficiency: +19 %

Boarding stability: +22 %

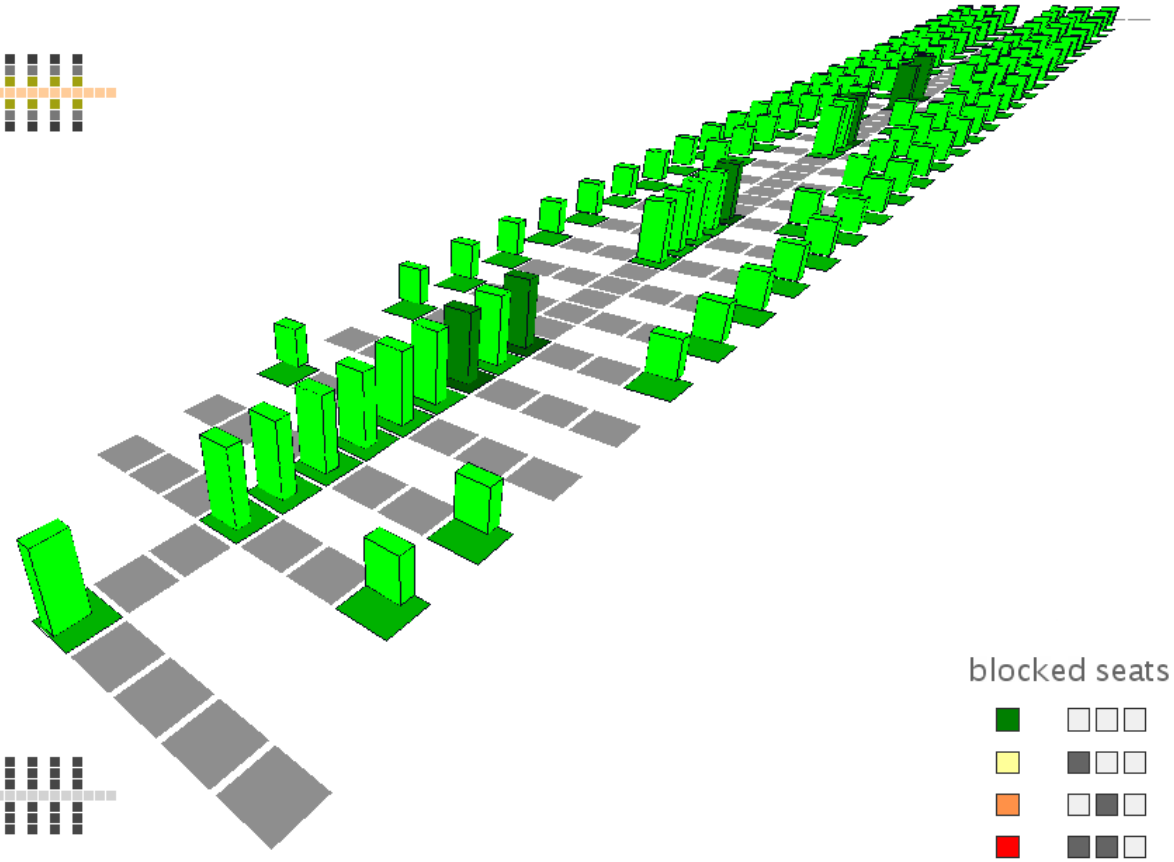
Boarding Progress: 34 %

blocked seats

see http://video.air-transportation.org

Results (5) - Video

Szenario: Reverse Pyramid

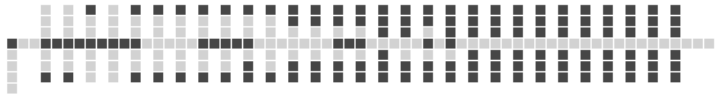


Results:

Boarding efficiency: +23 %

Boarding stability: +28 %

Boarding Progress: 60 %

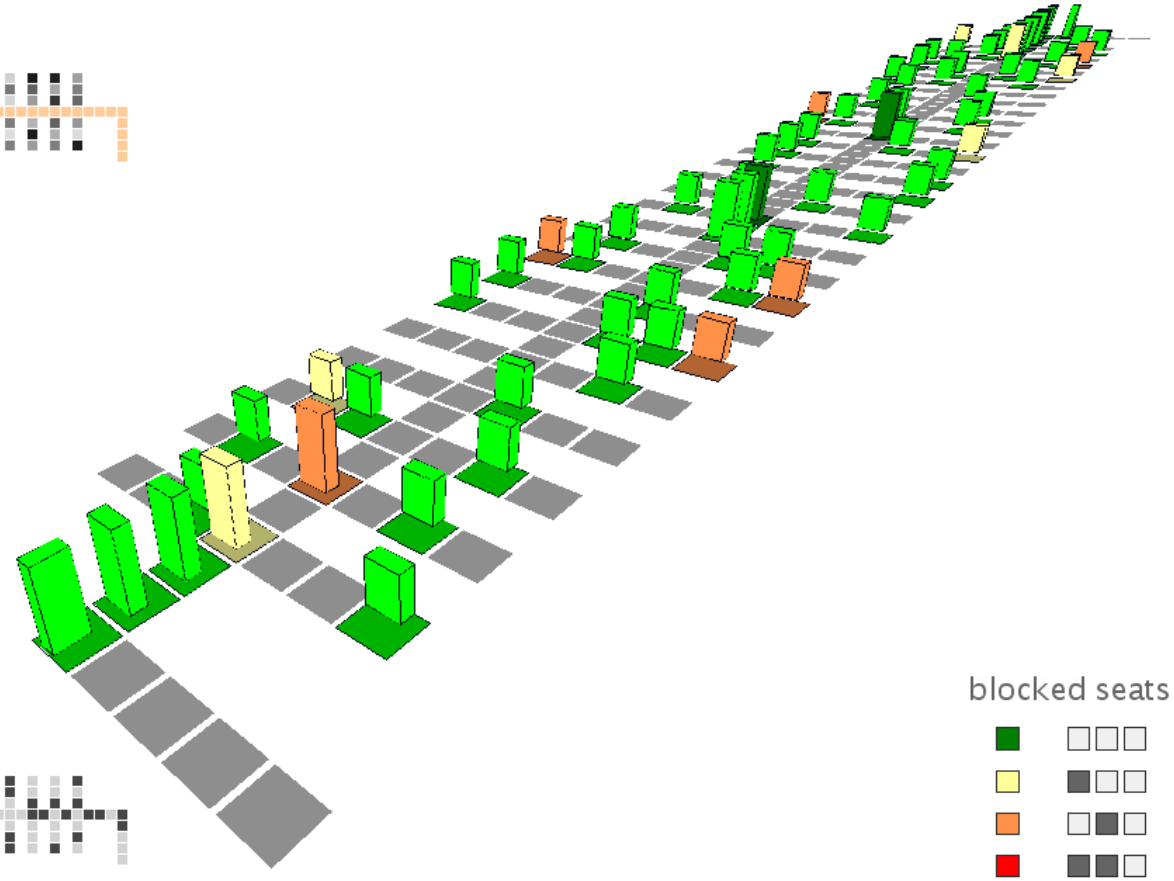


blocked seats

see http://video.air-transportation.org

Results (6) - Video

Szenario: Random – 2 Doors



Results:

Boarding efficiency: +26 %

Boarding stability: +34 %

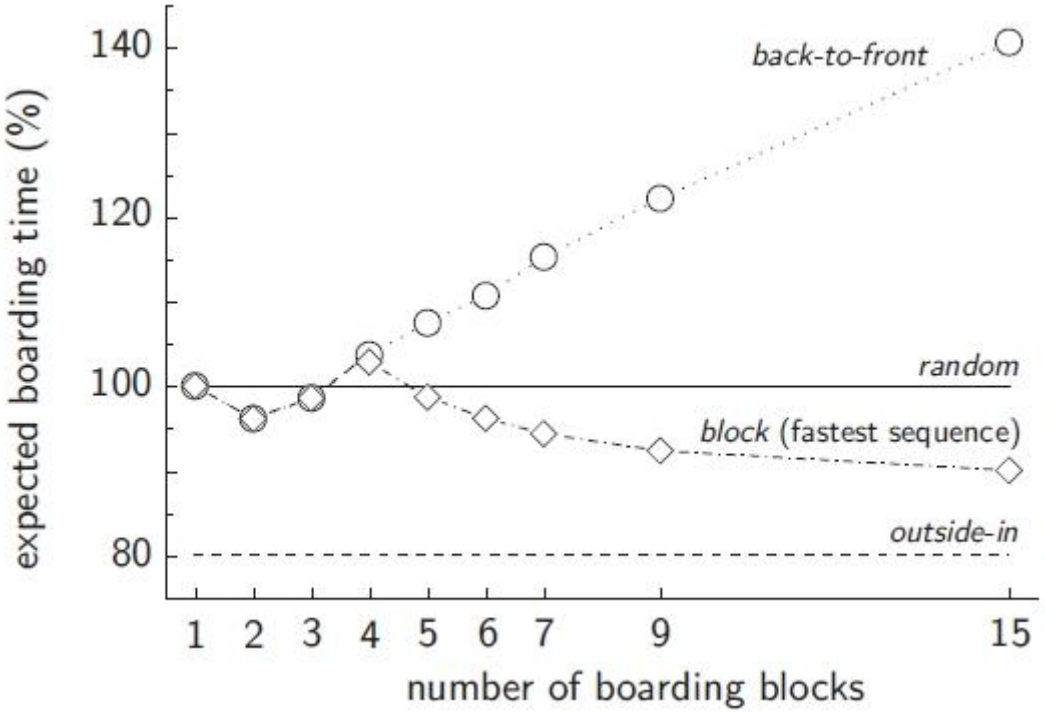
Boarding Progress: 29 %

blocked seats

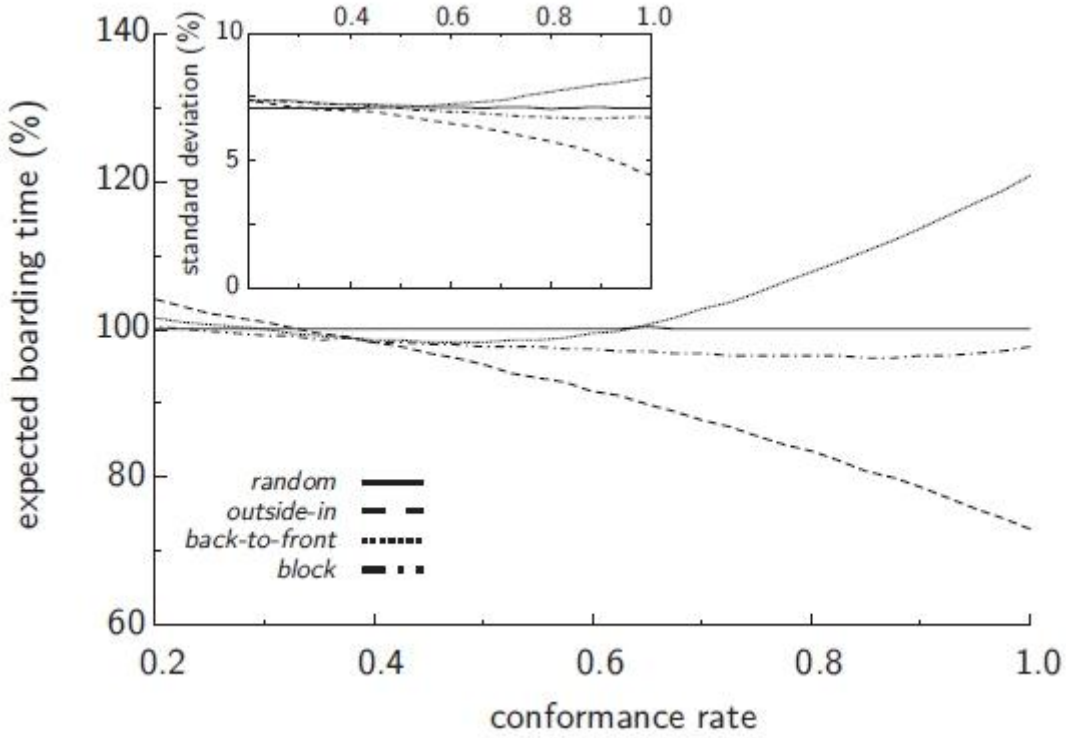
see http://video.air-transportation.org

Results (A320 Sample)

Block – Sequence



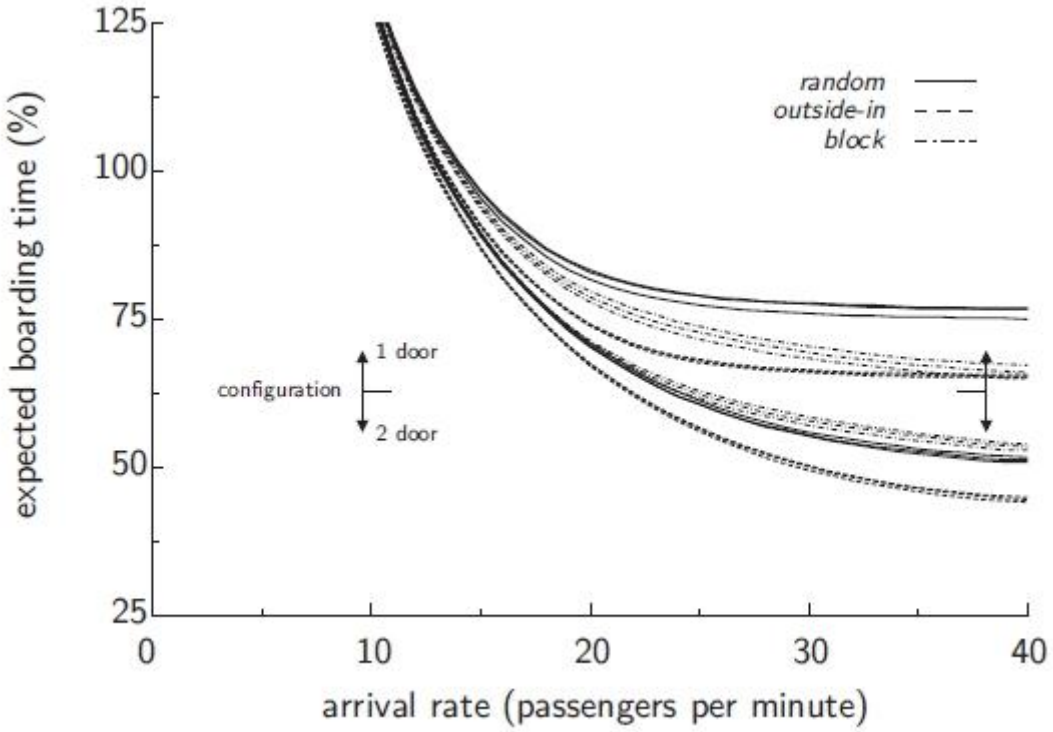
Acceptance of Boarding Sequence



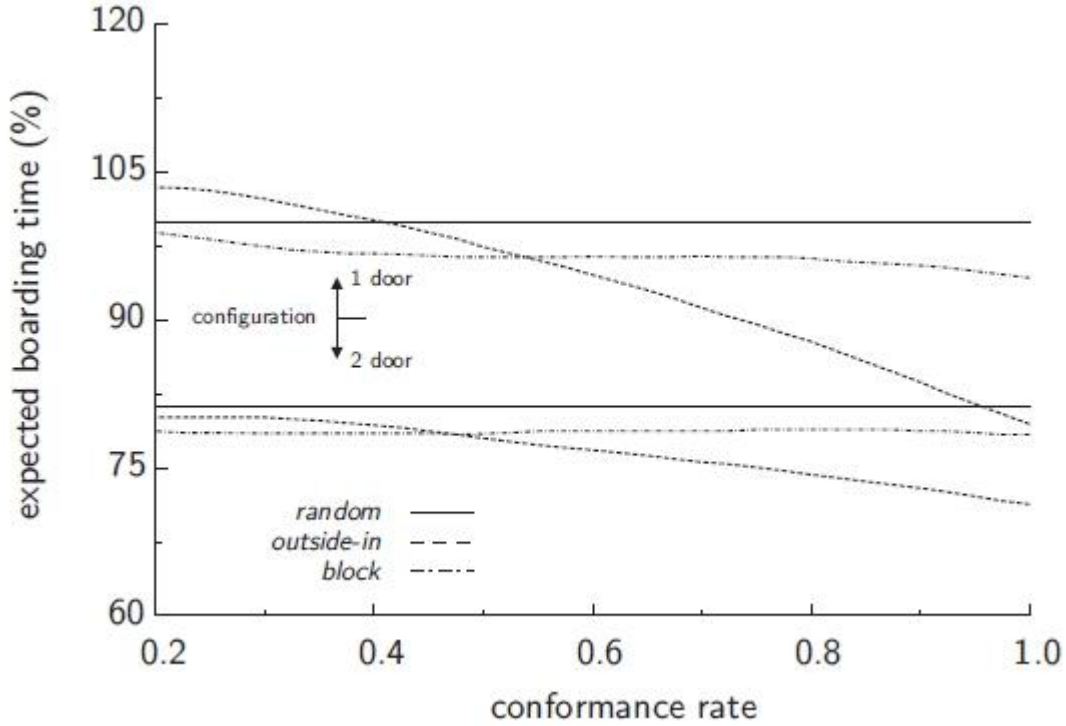
Schultz (2013) *Boarding on the critical path of the turnaround*

Results (B777, A380 Sample)

Arrival Rate (B777)



Acceptance of Boarding Sequence (A380)



Schultz (2013) *Boarding on the critical path of the turnaround*

Summary of Research Results

- Reliable boarding progress and delay compensation during the turnaround (A320, B777, A380)
  - **additional door** for the boarding process (20 - 25 % savings)
  - change of the **boarding strategy** (10 - 15 % savings)
  - different **seat layouts** (3 % savings)

- Verification/Validation
  - **field trials** done with Airberlin for validation of input parameters
  - **reliability** of the proposed stochastic aircraft boarding model against common observations
  - measurements for further improvements needed (**reducing variance**)

- Microscopic (individual-based) process description results in
  - identification of **optimization potential** of existing processes
  - stochastic boarding model to derive a **benchmark** methodology
  - coupling of **infrastructure** and **procedure** requirements

Next Step – New Infrastructure?

- Side-Slip-Seat - @molonlabedesigns

first simulation results using new slide seats
(preliminary results! procedures not yet verified)

- *random* boarding (0%, 0%)
  - efficiency + 16%
  - stability + 4%
- *block* boarding (16%, 14%)
  - efficiency + 25%
  - stability + 11%
- *Random* boarding, 2 doors (26%, 34%)
  - efficiency + 31%
  - stability + 40%

Boarding Efficiency

How to enter an aircraft – the most efficient way?

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