TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Transportation and Traffic Sciences Institute of Logistics an Aviation, Chair of Air Transport Technology and Logistics

TU-Dresden research aiming at CDM output improvements

- passenger expectations vs. handling processes -

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DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

Structure

Chair of Air Transport Technology and Logistics

Dipl.-Ing.

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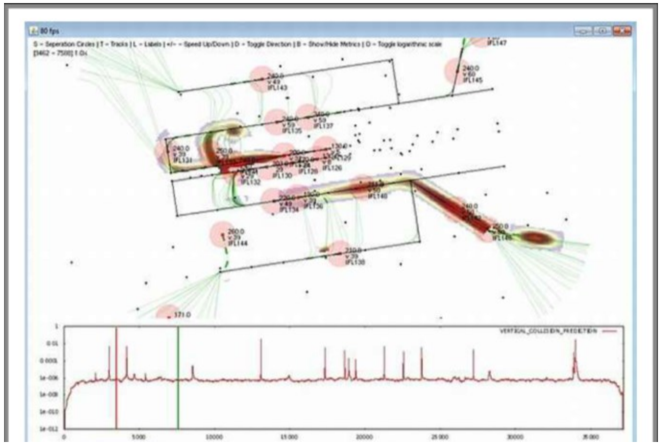
Research Actitvities

- **Trajectory Management**
  - Uncertainty in 4D-Trajectories
  - UTOPIA Project (finished):
    Universal Trajectory Synchronization for Highly Predictable Arrivals Enabled by Full Automation
  - Safety & Security Assessment
  - Simulation Based Risk-Analysis
- **Airport & Terminal Operations**
  - Turnaround prediction and steering
  - Pushback and Deicing Management
- **Other**

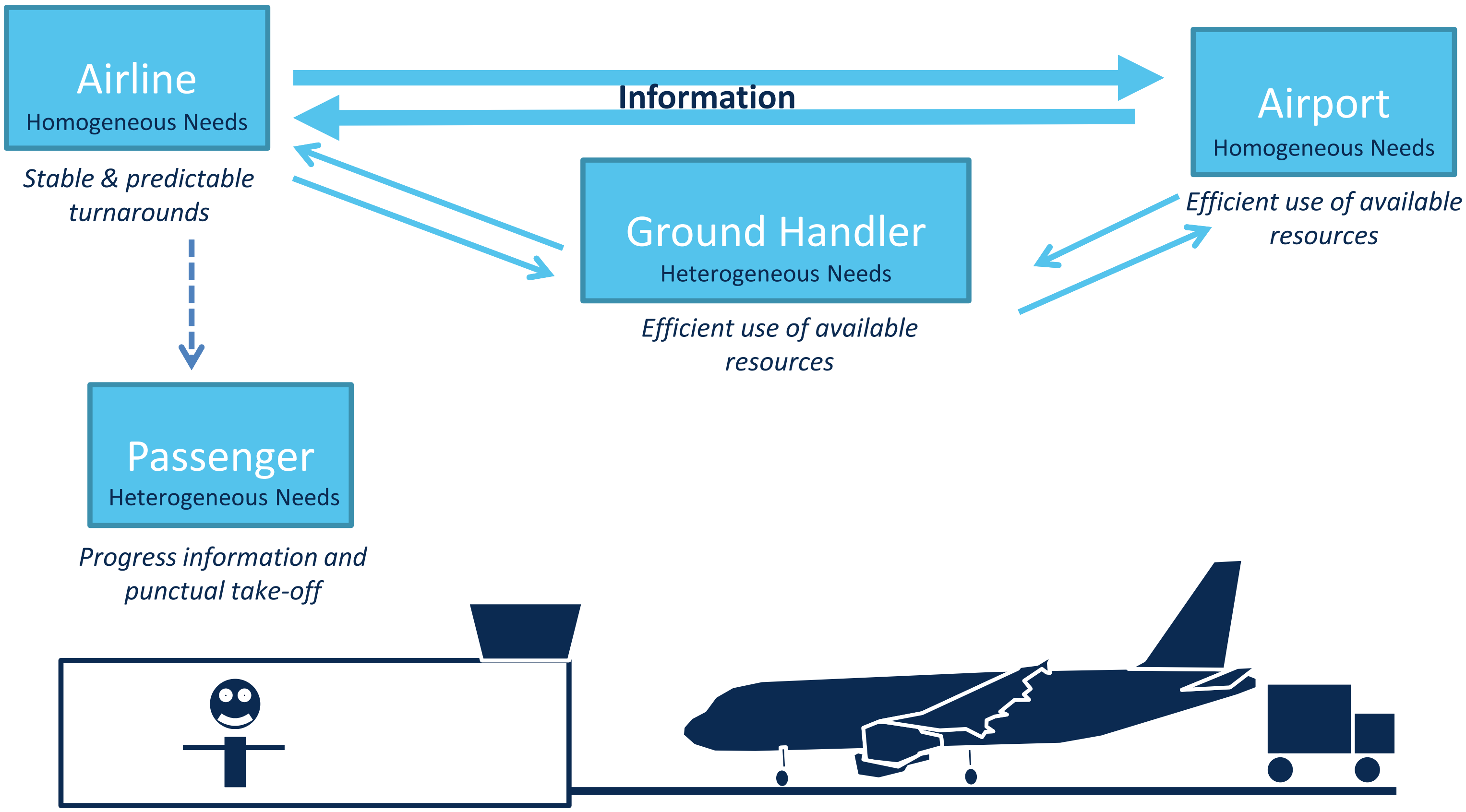
A320 Cockpit Simulator



Safety Analysis in TMA

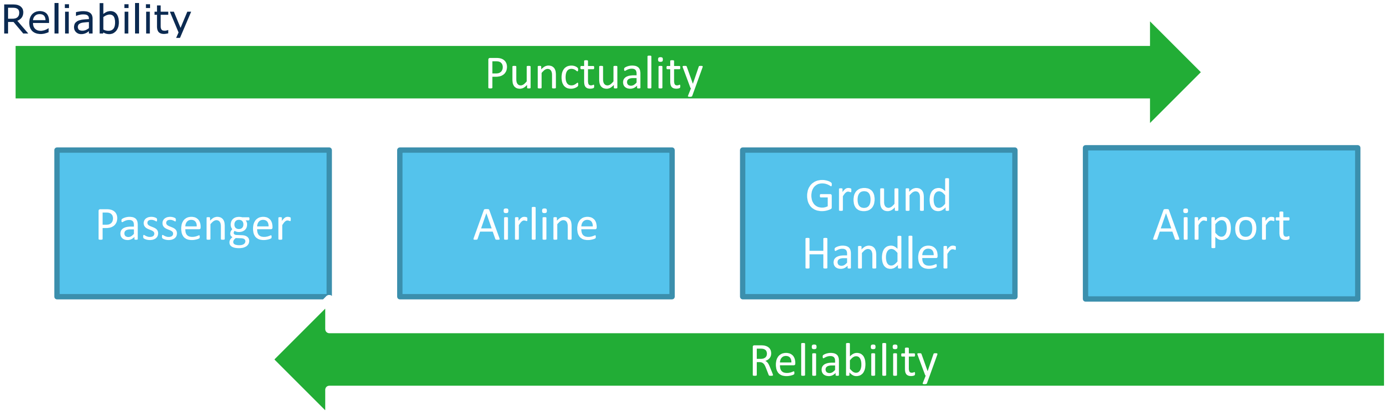
Structure

CDM Costumers – Dependencies & Information Sharing



What is the target – customer satisfaction?

- How to measure satisfaction? –> What is satisfaction? Punctuality versus Reliability



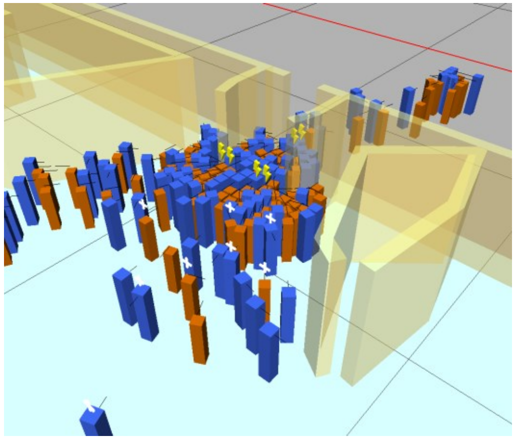
- But today: No Interaction between passengers and process stakeholders
  - passenger expects punctual processes with no restrictions
  - Stakeholder expect reliable processes with controlble Passenger

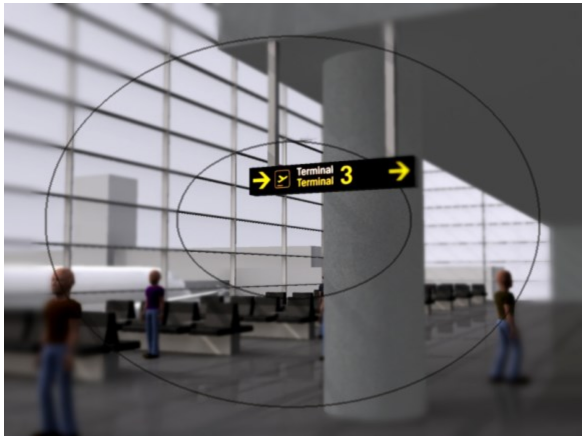
Structure

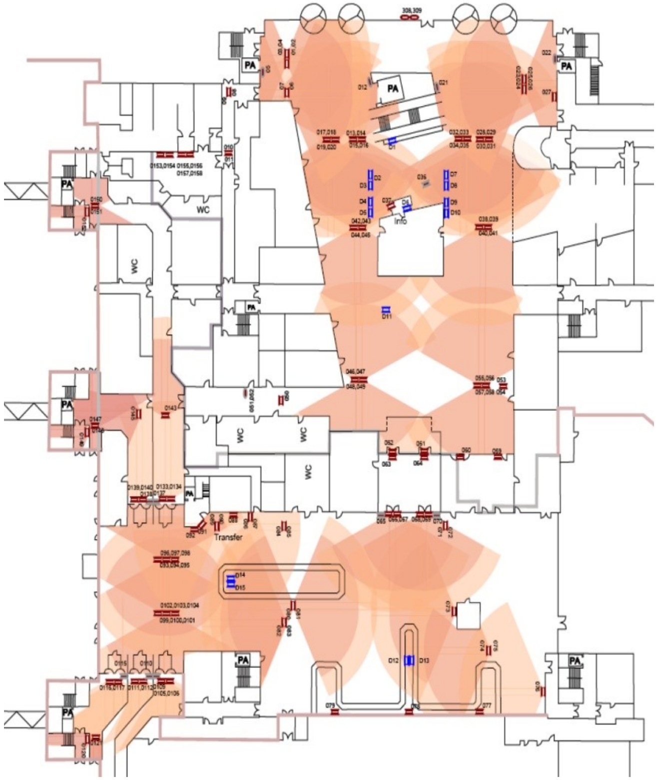
Prior Research – Passenger Dynamics

Individual passenger behavior for microscopic passenger handling

- In Terminal Design
- Security processes
- Boarding processes







Aircraft Boarding

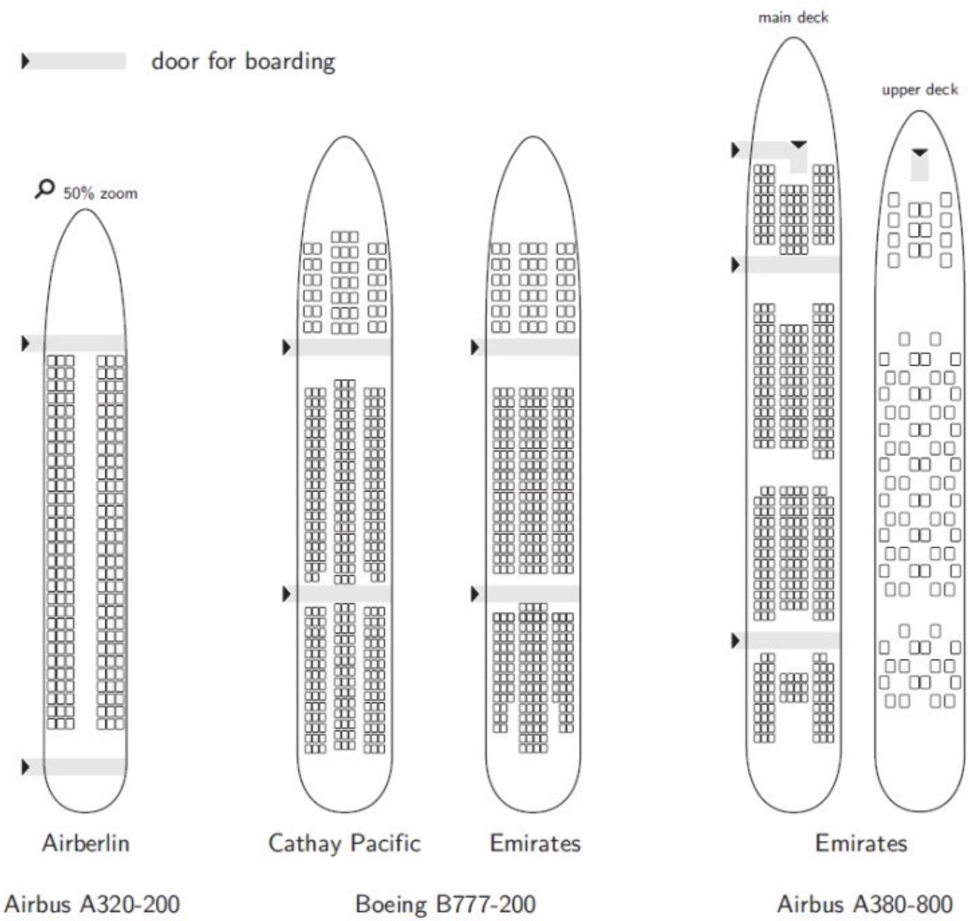
A320 as a reference layout

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



Boarding – Motion Model and Parameters

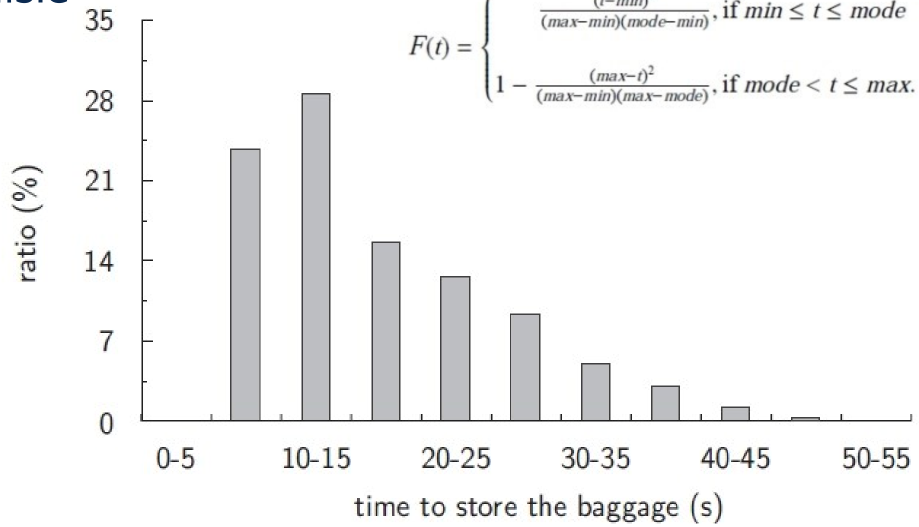
Asymmetric simple exclusion process (ASEP)

- 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

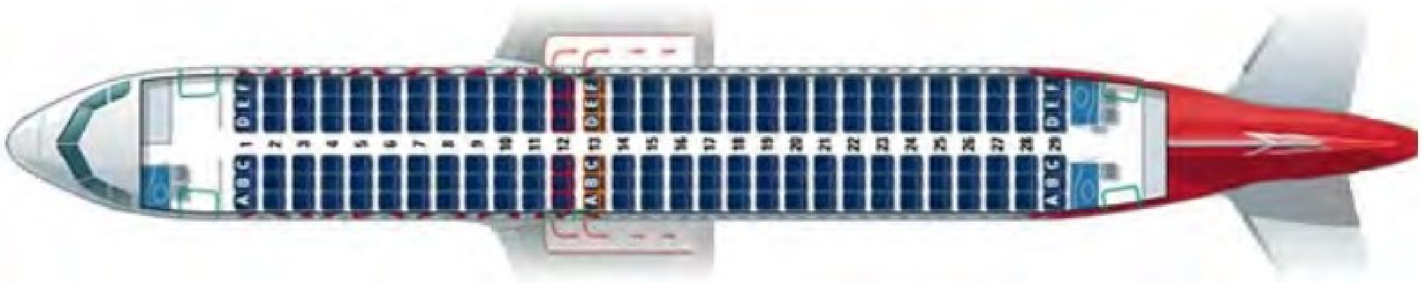
Additional parameter

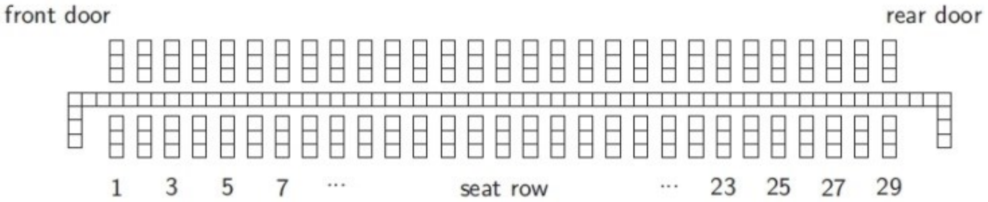
- individual amount **baggage**
- interaction during seating (**seat shuffle**)
- boarding **strategy**

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



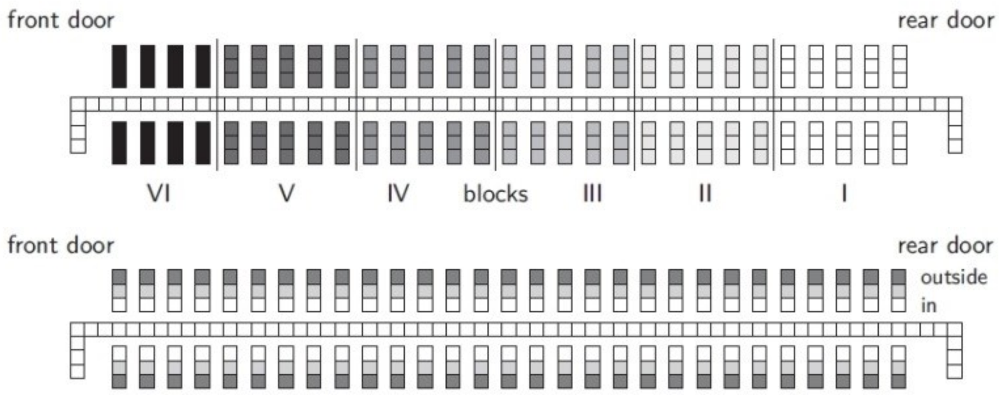
Boarding – Gridded Layout





Boarding Strategies

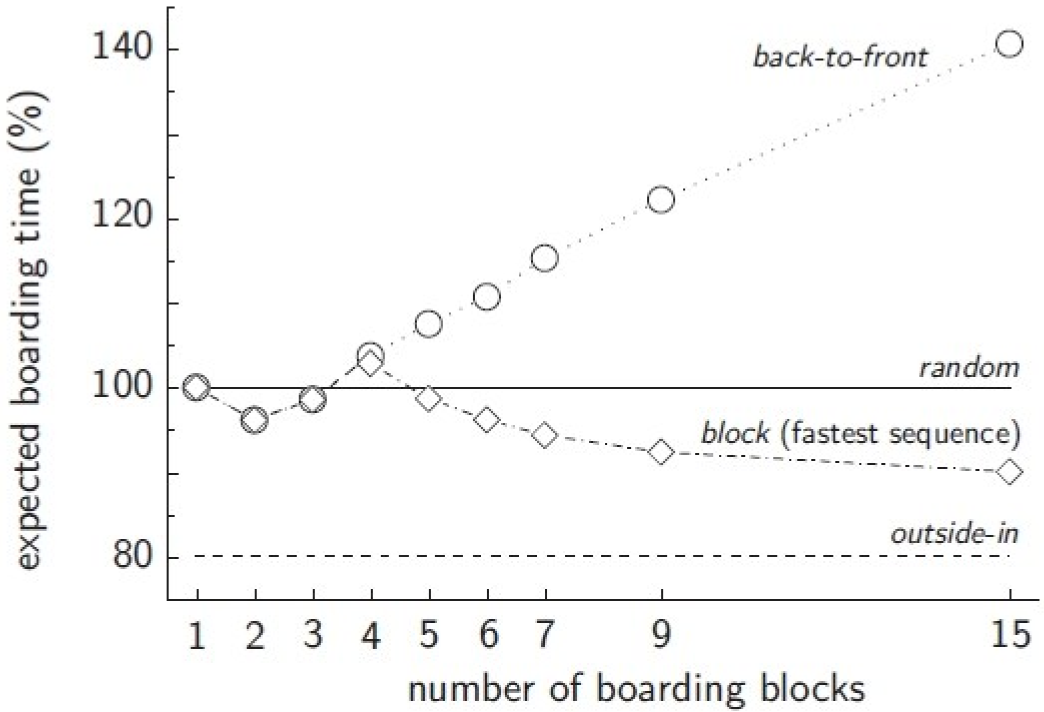
Random (reference), *Block*, *Back-to-Front*, *Outside-In*



Crucial remarks which have to be appropriate covered

- 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

Boarding Results – Block Size (A320)



At a Glance – Recap

Reliable boarding progress and delay compensation during the turnaround

- **additional door** for the boarding process (20 - 25 % savings)
- change of the **boarding strategy** (10 - 15 % savings)
- different **seat layouts** (3 % savings).

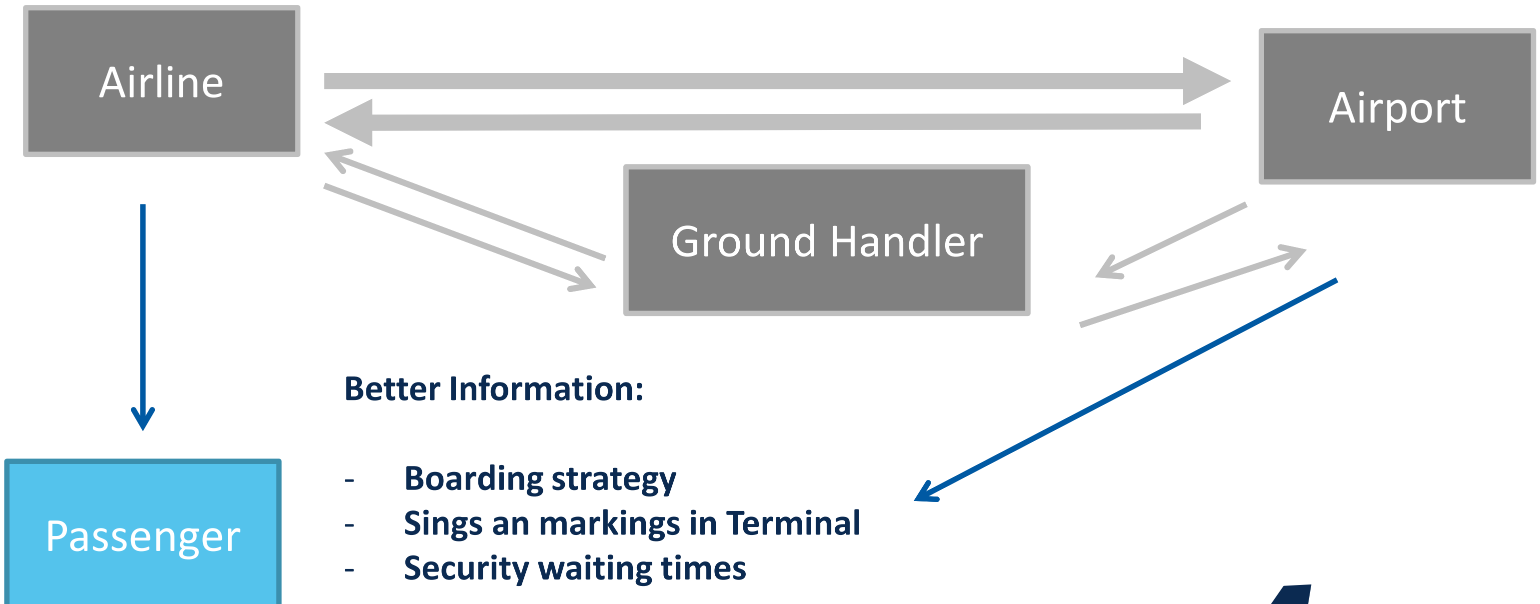
Validation checks are performed (field trials with Air Berlin)

- **high reliability** of the proposed stochastic aircraft boarding model
- adapted seating procedure is **planned to be introduced**
- measurements for further improvements (**reducing variance**)

Microscopic process description

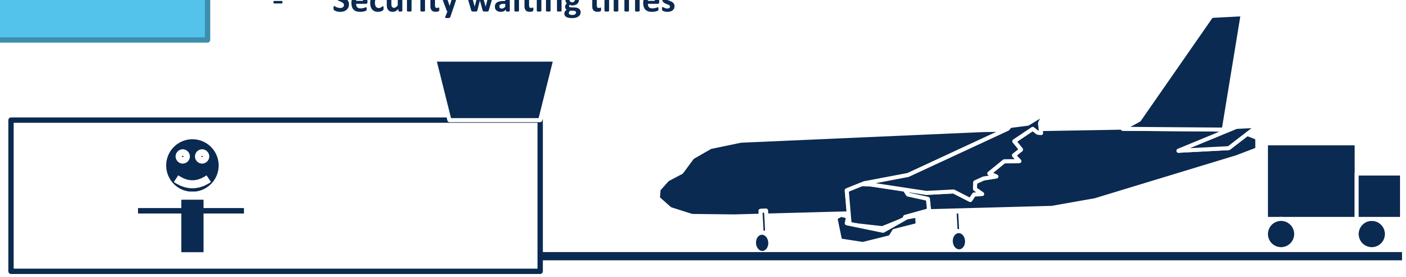
- potential of **optimization** of existing processes
- application for all turnaround processes, derive **benchmark**
- test of **dynamic** interactions

CDM Costumers – Dependencies & Information Sharing



Better Information:

- **Boarding strategy**
- **Sings an markings in Terminal**
- **Security waiting times**



Structure

Prior Research – Turnaround

Study in cooperation with an aircraft manufacturer looking for enhancements of **technical aircraft design**

Field measurements on different German airports

Interviewing of **ground handling companies**

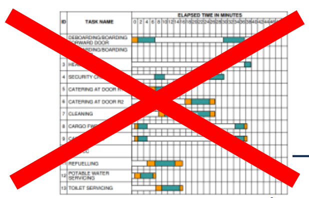
Evaluation of **dynamic buffers strategies** to compensate arrival delay

Analysis regarding to the influence of **airport categories** (regular hub, non-hub, and supply-base)

Identification of varying level of **staff skills** due to different training principles and expertise resulting in further major reason for distinct process characteristic

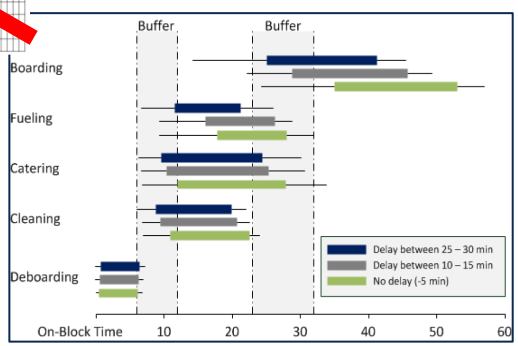
Turnaround Research findings by TU-Dresden

- Field measurements and data analysis on several airports (MUC, FRA, STR, HAM, DRS, LEJ) show a discrepancy between scheduled and actual times:
  - Actual Turnarounds don't fit fixed plans
  - Process durations and buffers influenced by
    - Delays
    - Airport (category) => Staff Skills

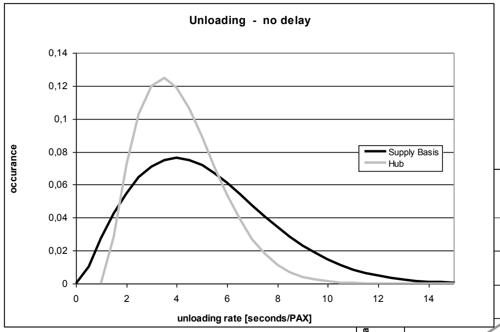


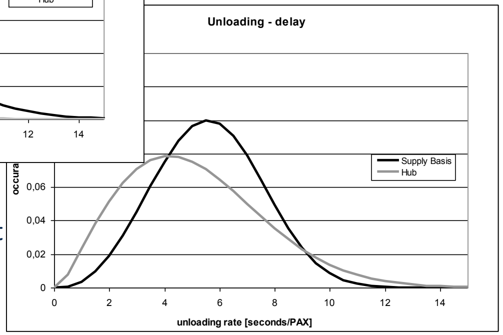
A319 Turnaround Plan, source: Airbus SAS

Reality



Delay influences on process durations & buffers

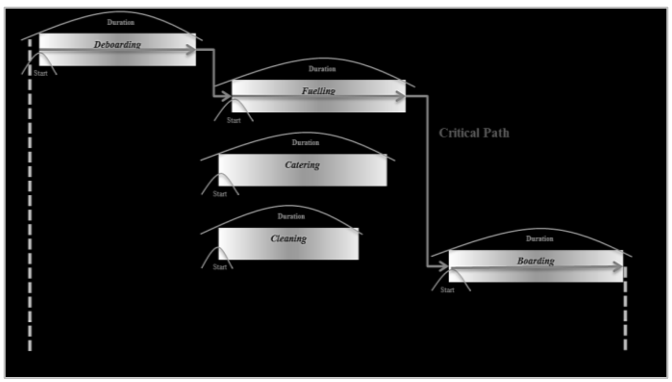




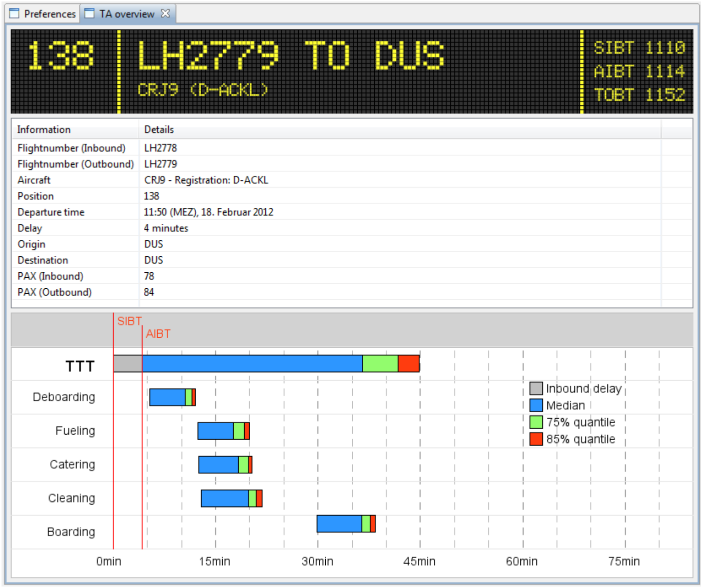
Example Process Variations due to Airport Category & Delay - Unloading

Turnaround modeling for higher predictability

- The traditional “best-guess” for turnaround time / TOBT prediction will not meet A-CDM and 4D system targets and TU-Dresden research shows:
    - Process duration can be more precisely represented stochastically than deterministic and can be used for better prediction



Critical path calculation with stochastic process start times and durations

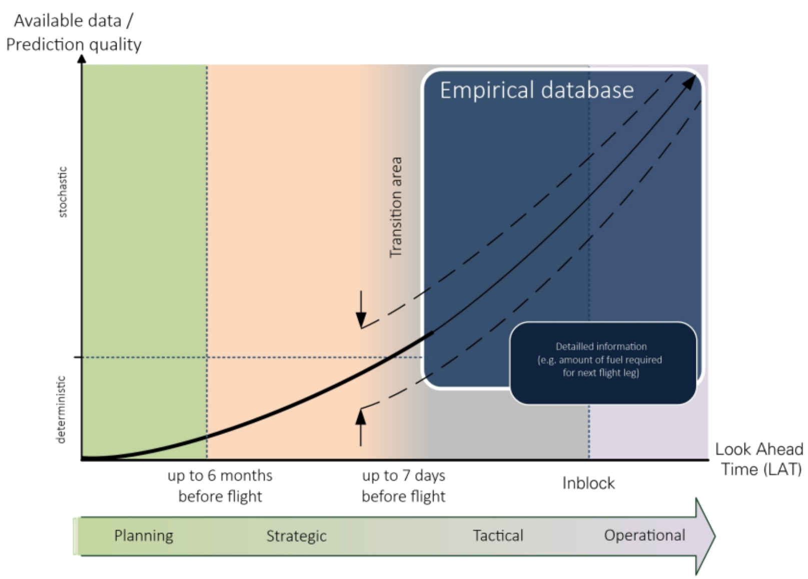


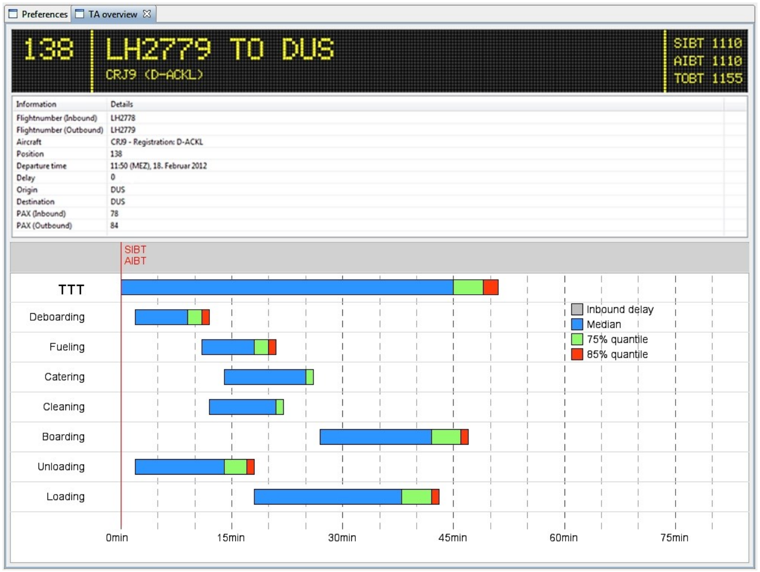
TU-Dresden Turnaround Predictor Prototype

Aggregated Turnaround Model & Application

Macroscopic process description, considering

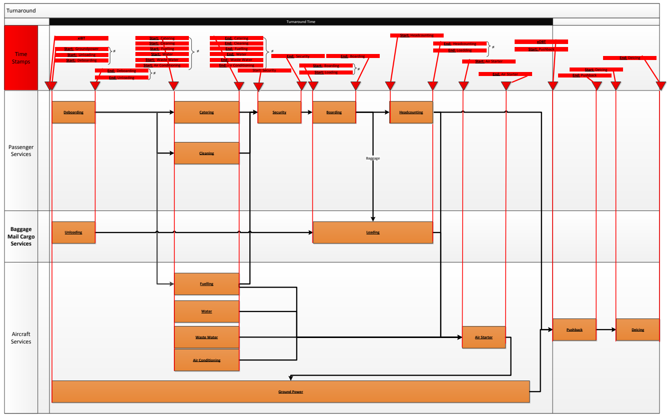
- real turnaround data, measurements at field
- stochastic nature of input data
- different look ahead times (data quantity and quality)





Turnaround – Process Charts

Developing process chart to cover all elementary steps of turnaround processes



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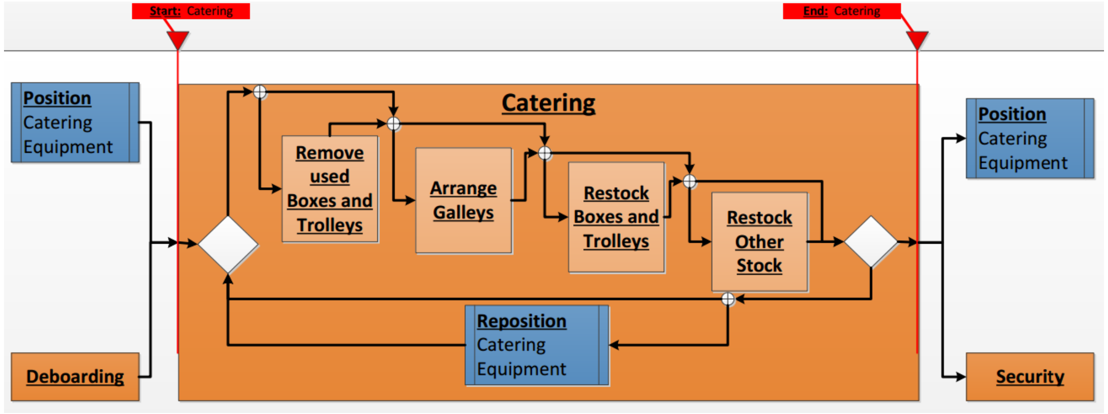
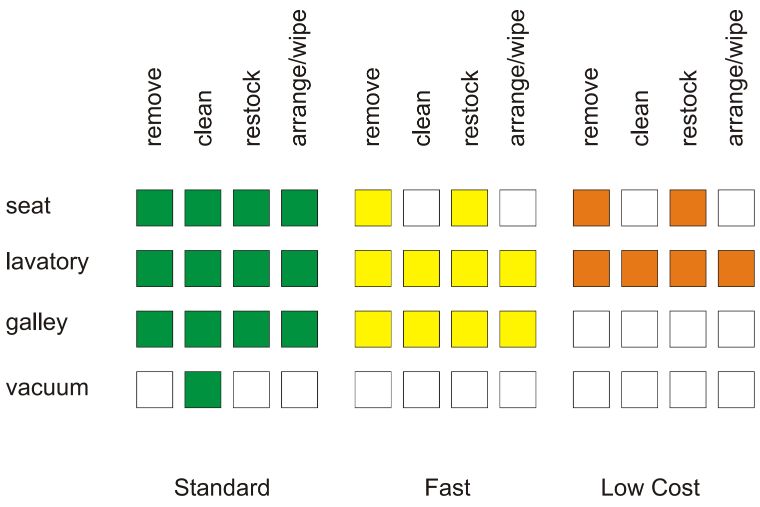


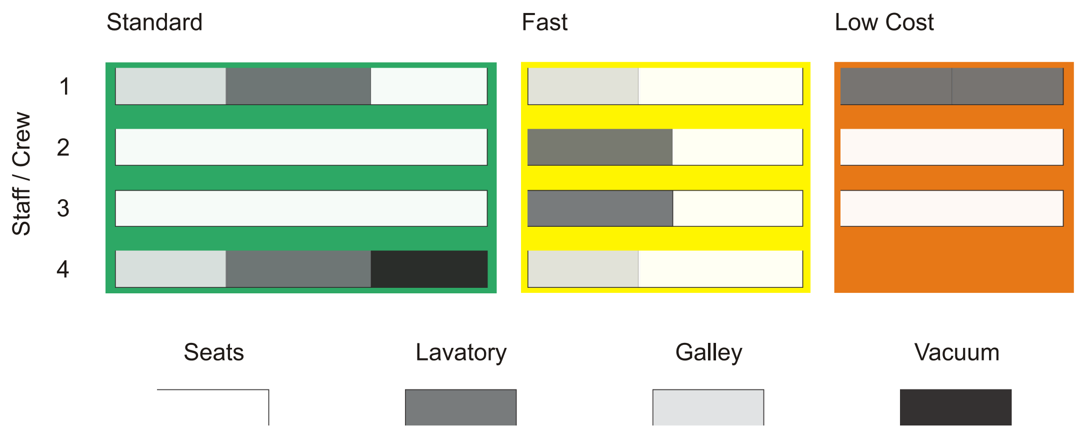
Overall TA → Relevant steps of aircraft catering

Cleaning – Model

Identification of significant cleaning steps: remove, clean, restock, arrange

Define sequence of steps using different scenarios

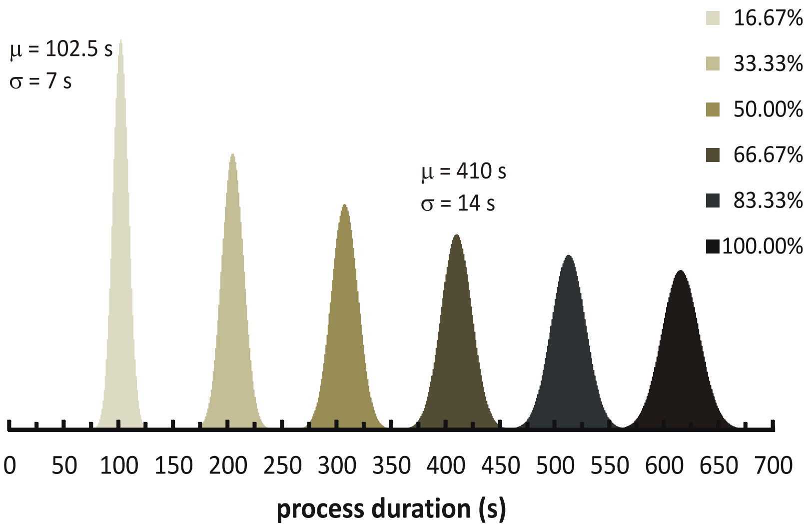


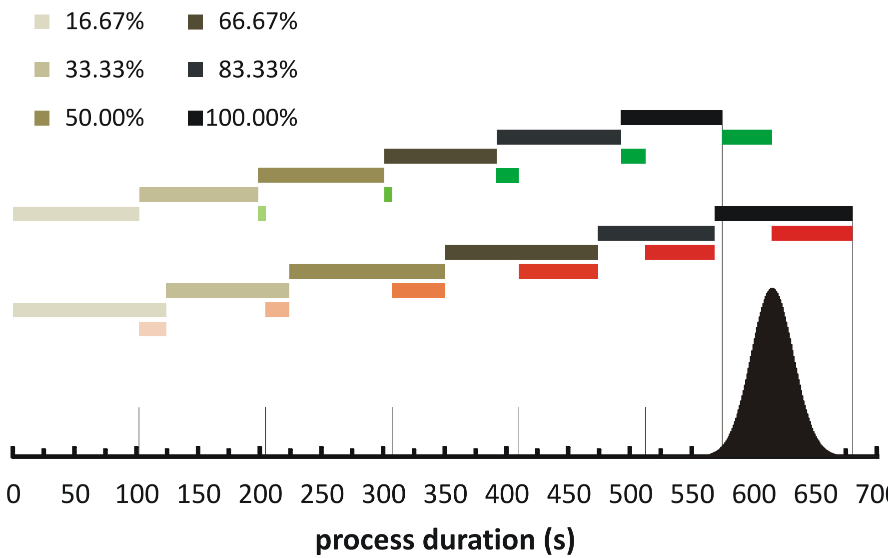


Cleaning – Stochastic Description

Assumption of normally distributed behavior at each step

Example: μ= 4.1 s per seat and cleaner, σ = 1.4 s, 1 cleaner, 150 seats to clean, 6 points to monitor/control the process

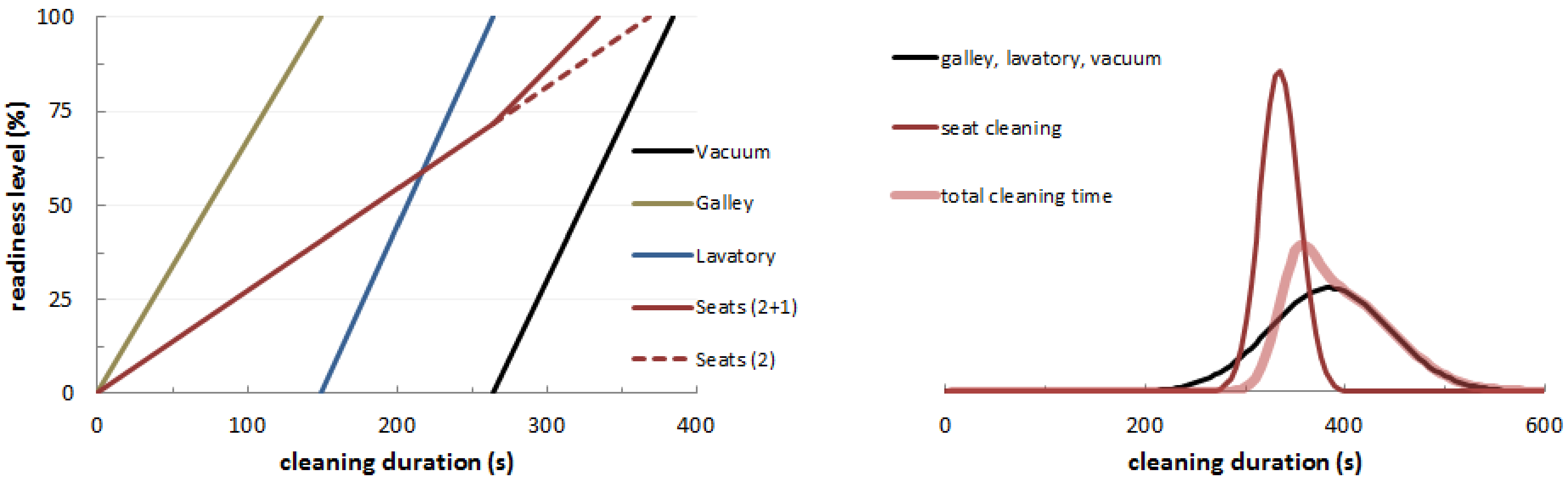




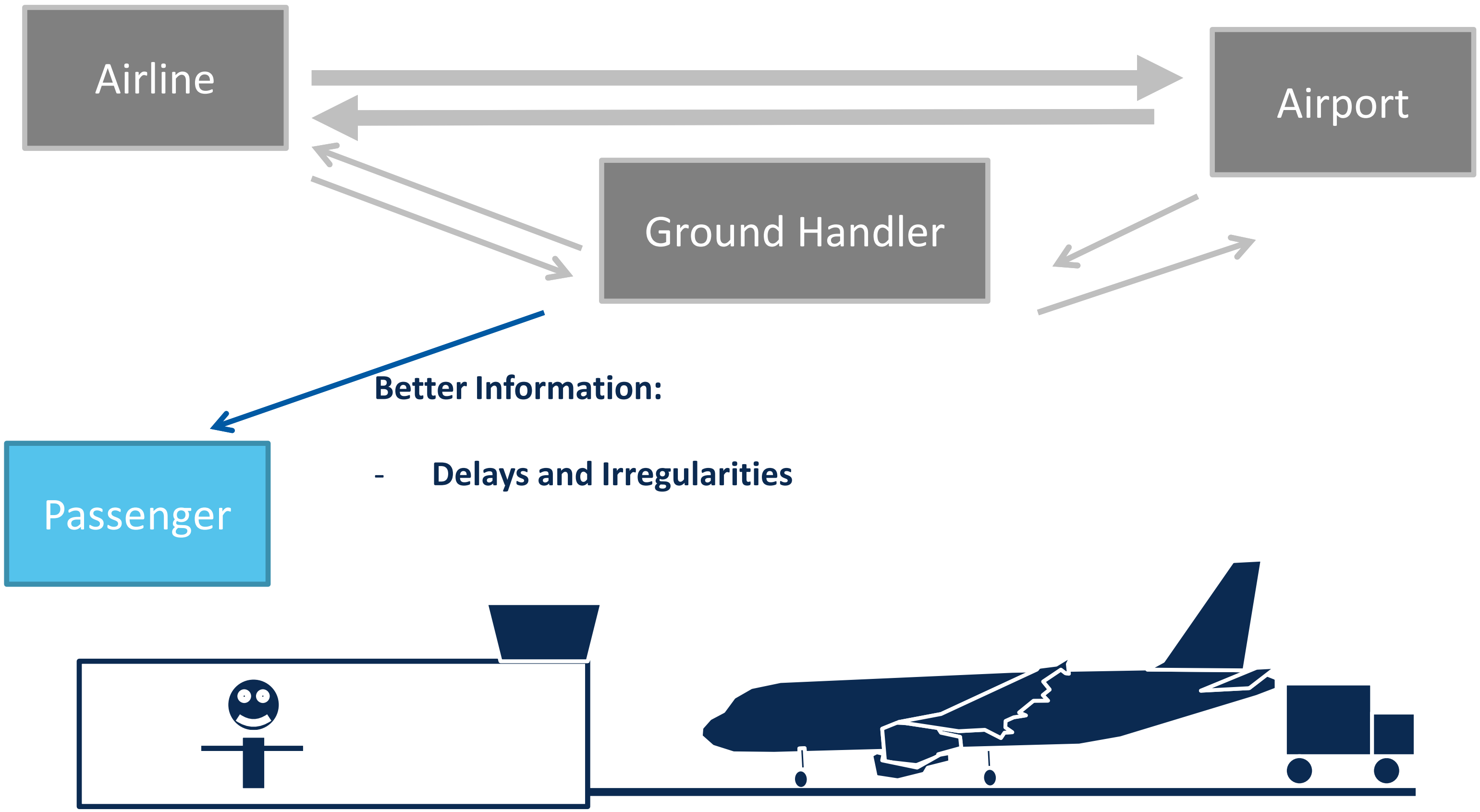
Cleaning – Progress

Progress of each cleaning step using expected value of duration

Remarkable inter-process dependencies, not easy to cover with analytical description

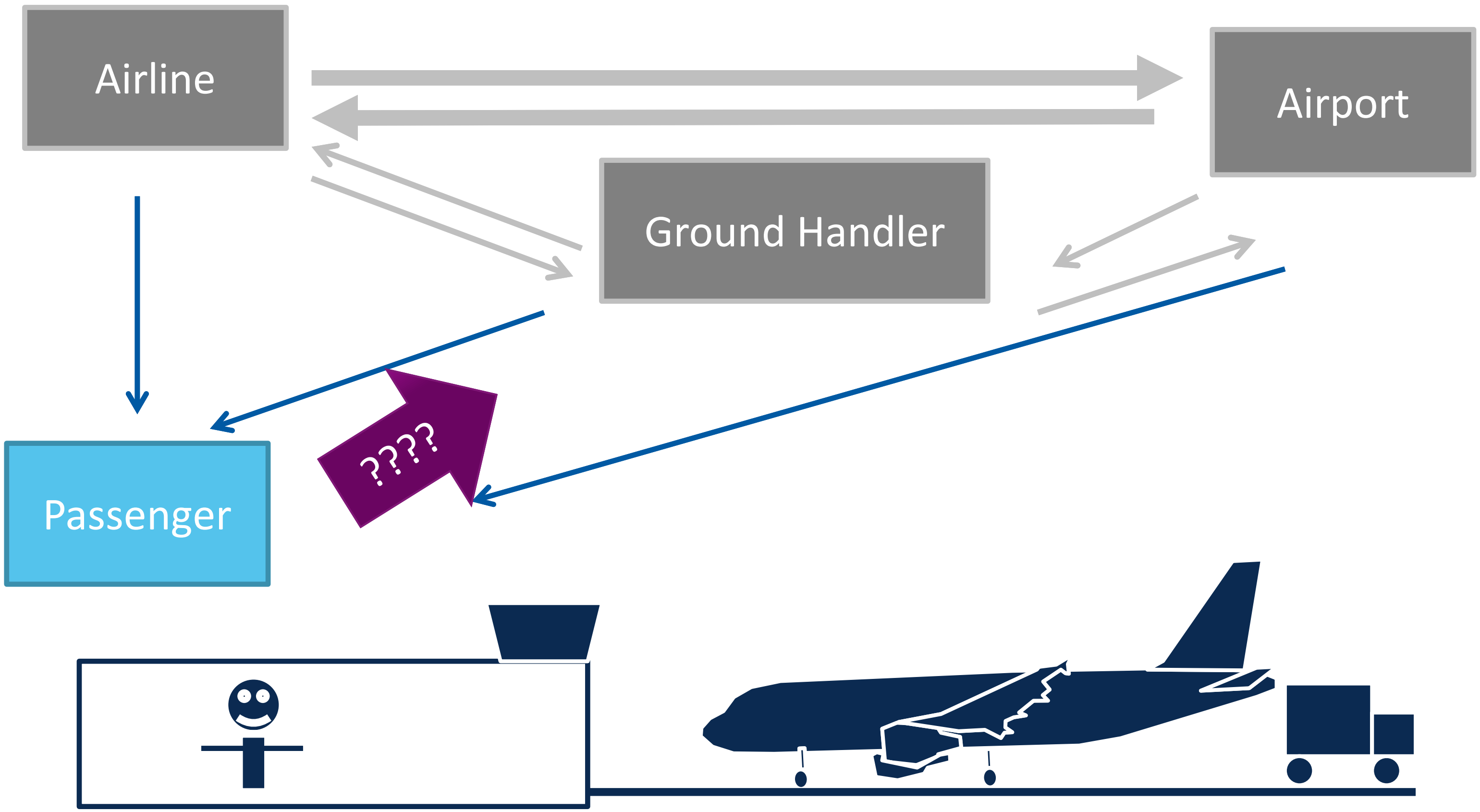


CDM Costumers – Dependencies & Information Sharing



Structure

CDM Costumers – Dependencies & Information Sharing



Thank you for your attention