Turnaround prediction concept: proofing and control options by microscopic process modelling

GMAN proof of concept & possibilities to use microscopic process scenarios as control options

Bernd Oreschko, Thomas Kunze, Tobias Gerbothe and Hartmut Fricke
Chair of Air Transport Technology and Logistic, Technische Universität Dresden, Germany

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Research Activities

• Trajectory Management
  • Uncertainty in 4D-Trajectories
• Safety & Security Assessment
  • Simulation Based Risk-Analysis
• Terminal Operations
• Expert knowledge exchange
• Airport & Terminal Operations
  • Turnaround prediction and steering
  • Pushback and Deicing Management
• Other
Motivation & Background

2. Research Review

3. Turnaround Prediction Modell GMAN

4. Process Controlling by Microscopic Modelling

5. Conclusion & Outlook
Background - ACDM

EUROCONTROL Airport Collaborative Decision Making
Improves situational awareness and rises efficiency by
- Better information connection and sharing for all airport partners
- Therefore better capacity use when information is used correctly

⇒ Establishing Milestone concept

Impacts for the Turnaround:
- Prediction of
  - Target Off Block Time (TOBT) & Turnaround Time (TTT)

HOW? => knowing process characteristics for all process and interconnections and control options
Motivation Turnaround Uncertainty

Uncertainty of start and duration cause of several factors, e.g. delays, extended sub-process duration, airport type or staff skills.

Deterministic TA-Planning does not work

Best Guessing by Ramp and Ops Agents does not fit in 4D/ACDM Environment
Motivation – Modelling for DST

The Turnaround within adjacent ATM-tools inline with EUROCONTROL perspective:
AMAN – Arrival Management Tool
DMAN – Departure Management Tool
SMAN – Surface Management Tool

Turnaround Modell Output useful for SMAN and DMAN
Motivation – new DST for Turnaround - GMAN
Motivation – new DST for Turnaround - GMAN

The GMAN output may be used in ramp operations control or schedule planning the following ways:

• Perform **Critical path** analysis of TA process
• Analyze **expected buffers** between processes constituting a TA event
• Identify non-achievable **target times** at earliest times
• Identify **excessive process durations**.
Motivation & Background

Research Review

Turnaround Prediction Modell GMAN

Process Controlling by Microscopic Modelling

Conclusion & Outlook
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

Example Process
Variations due to Airport Category & Delay - Unloading

Delay influences on process durations & buffers

A319
Turnaround
Plan, source: Airbus SAS

Reality
TUD Turnaround Researches

- The sub-processes comprising a TA should be modeled stochastically as they have uncertainty associated with their processes duration.

- The TA process is dependent on various parameters like airport category and operational factors (e.g. passenger number, airline, aircraft type), and these information can be obtained from different sources.

- **Incoming delay** has an important influence on the individual sub-process duration and process interaction times (buffers).

- See ICRAT Contributions of last years – and others: www.ifl.tu-dresden.de
TTT Prediction and Controlling – Two Step Approach

1. Prediction of TTT and Process Duration with stochastics
   • => comparison with other target times (e.g. TSAT)
2. Control Options by microscopic task simulation
   • => possible handling options

Dipl. Ing. Bernd Oreschko

GMAN
TTT Prediction

Mircoscopic
Process
Simulation

Target Time
comparison
e.g.: cTTT = TSAT ?

Control Option 1
Control Option ..
Control Option n
GMAN – Process Description

• Prediction is based on single process description and their interaction results

• **Described Processes:**
  • deboarding, catering, fuelling, cleaning, boarding, unloading, loading (other possible)

• **Processes description:**
  • Each of these process duration and Start time is stochastically described

• **Description source:**
  • empirical data from aircraft operators, airports and ground handling companies are used

- influence of the following parameters:
  • Aircraft type
  • Airline
  • Airport inbound and outbound
  • Airport where the TA is processed
  • Flight distance to destination
  • Flight type, i.e. low cost or legacy
  • **Incoming delay** (on gate)
  • Number of passengers inbound and outbound
  • Type of aircraft stand
GMAN – Critical Path Calculation

Repeated n-times

Critical Path

GMAN critical path calculation for one run out of $n$ - with stochastic process start times and duration description
GMAN – Stochastic Process Description

• Finally, probability distribution functions can be fitted to the collected/empiric data. The Turnaround Modell is designed to allow using any distribution functions, while
  • Deterministic (fallback level) and
  • Weibull distribution fit best.

Further more arrays of single notifiable times can be used

• Output for GMAN: Qantiles

Possible Output for DST-Tool GMAN: Qantiles

Reliability ⇔ Accurateness
A higher prediction accuracy level requires more reliable information for better stochastic process description.

As the LAT decreases, more accurate trigger information is expected to become available, and therefore a more specific stochastic process description out of the empirical database can be gathered and fitted.
GMAN Prototyp

![Ground Handling Prototype](image)

**Simulation runs:** 1000
**Controller type:** None

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 min</td>
<td>40%</td>
</tr>
<tr>
<td>30 min</td>
<td>45%</td>
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<tr>
<td>45 min</td>
<td>50%</td>
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<tr>
<td>60 min</td>
<td>55%</td>
</tr>
<tr>
<td>75 min</td>
<td>60%</td>
</tr>
<tr>
<td>90 min</td>
<td>65%</td>
</tr>
</tbody>
</table>

**Deboarding**

- Mean: 3.1654561301447182
- Median: 3.0007030070300704
- 75% quantile: 3.5007030070300704
- 95% quantile: 4.0007030070300704
Proof of Concept (POC) at LEJ Airport

- LEJ is a medium sized airport with mainly domestic and European flights
- Modification of the GMAN model due to the lack of necessary date (no Timestamps at the a/c)
  - start and end times of deboarding, fuelling, unloading, loading and boarding were adjusted, s/aIBT and s/aOBT also available
  - => adoptions to GMAN model
- No catering and cleaning process (minimum amount of occurrences of these processes on the critical path in LEJ)
- Aim of POC:
  - Does the GMAN gives a usable TTT prediction

Overview LEJ Airport PAX Facilities
Source: airportzentrale.de
POC at LEJ Airport – Empiric Data Source

Preparation of Empiric Data (>10.000 data) from IFL Database

1. all TA with a scheduled TTT (SOBT-SIBT) above 2 hours were skipped => # 8.150
2. Data class preparation by trigger information:
   • airline => main, charter and low-cost classes
   • aircraft type by the maximum seats available =>
     eg. ac100- (up to 100 seats), ac156 (101 up to 156 seats)
   • passenger numbers inbound / outbound by cluster of 2:
     eg. pax25 (0 -25 passengers), pax50 (26-50 passengers)
3. creation of classes for start times and durations, regarding the trigger information
   • boarding, deboarding, loading and unloading:
     1. aircraft type
     2. corresponding passenger number class
   • Fuelling
     1. aircraft type
     2. the destination airport
POC at LEJ Airport

- GMAN connected to the local airport information network
  - Only final trigger information => no intermediate steps => no LAT analysis

- Data analysis for 600 turnarounds in 09/2013

- Output of the GMAN:
  - stochastic values of TTT for a single TTT
  - Mean, $\mu$, $\delta$

- Manual match of predicted TTT and ATTT by operational staff

=> Questions:

- Does the prediction cover with the reality?
- Indications to what should be the target values for the GMAN output?
POC at LEJ Airport - Output

Deviation of ATTT to GMAN TTT prediction, all flights

- No clustering by trigger information
- No good prediction
  => Clustering necessary
POC at LEJ Airport – Output

Deviation of ATTT to GMAN TTT prediction, A319 to CGN and STR

- Lowcost Turnaround (25 min)
  => Simple/stable TA, acceptable prediction
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Turnaround – Process Charts

- Developing process chart to cover all elementary steps of turnaround processes
- Dividing process into tasks,

Overall TA → Relevant steps of aircraft catering
Example: Microscopic Cleaning Model

- Identification of significant cleaning steps: remove, clean, restock, arrange for seats, lavatories, galleys, vacuum

- Define sequence of steps using different scenarios (sequence, staff usage), as different control options
Cleaning – Progress

Progress of each cleaning step using expected value of duration

Remarkable inter-process dependencies, not easy to cover with analytical description
TTT Simulation with Microscopic Processes

- Simulation shows anticipated behavior
- Next step is to prove the usability in live environment
Motivation & Background

Research Review

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Process Controlling by Microscopic Modelling

Conclusion & Outlook
Conclusion and Outlook

• Proof of concept of TTT Prediction is confirmed
• The different levels do not generally imply that the TA process time prediction will get smaller by default (or even show a smaller variation)
  • But the reliability of the results increases

• **GMAN principle proofed:**
  • Identify non-achievable target times (at earliest times)
  • Identify excessive process durations
  • Output with quality information

• **Next Step:**
  • Test and Validation of control options (in LEJ)
Bernd Oreschko
Chair of Air Transport Technology and Logistic
Technische Universität Dresden, Germany
oreschko@ifl.tu-dresden.de