Validation Results of Airport Total Operations Planner Prototype CLOU

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TOP
Total Operations Planner

- support tool to optimise usage of airport resources in consideration of stakeholder needs and targets in CDM process
- stakeholders: main airlines, airport operator, local air traffic control
- sometimes opposing preferences and targets
  - high throughput
  - punctuality
  - slot compliance
  - less fuel consumption
- pre-tactical planning horizon (30min to some hours before the event)
- constraints: capacity, demand, operations, weather, tactical systems,...

- output: target times for every flight to fulfil stakeholders’ needs
CLOU
Co-operative Local Resource Planner

- prototype offering first functions of TOP
- built and configured for Frankfurt Main Airport
- national project K-ATM (DFS, DLR, Lufthansa, Fraport, universities, ...)

- planning process is split
  - Operation Mode and Working Point
  - Runway Assignment
  - Target Times

- optimisation to runway
- 3-6 hours planning horizon, 10 minutes intervals
CLOU
Operation Mode and Working Point

- operation modes
  - how arrivals and departures are allowed to use which runway
  - depending on weather and demand

- working point
  - Arrival Prioritisation
  - Demand Ratio
  - to respect Departures
CLOU
Runway Assignment and Target Times

- runway assignment based on operation mode
  - constraints: Wake Vortex Category, stands/gates, ...

- start sequence on today’s “First-Come-First-Served” (FCFS)

- optimisation by Simulated Annealing Algorithm
  - to pursue the “On-Time-Preferred-Served”
  - Planning Adherence deviation from scheduled time
  - Airborne Queue to prevent holdings
  - CFMU-Slot-Violation
  - Control-Window-Violation timeframe of A/C on runway
Validation Restrictions and Preparation
Restrictions

- to reduce complexity and due to data availability
- only two independent runways
- operation direction only 25 and 18
- three independent sequences (ARR25, DEP25, DEP18)
- separations derive from planed throughput
- constant taxi time
- only delays are viewed
- planning occurs once, not continuously
Validation Restrictions and Preparation

Scenarios
- capacity breakdown due to CAT III, headwinds or runway closure
- reduced capacity due to not parallel used runway 25
- normal situation

Validation Parameters

<table>
<thead>
<tr>
<th>Working Point</th>
<th>Baseline</th>
<th>Demand Ratio DR</th>
<th>CLOU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival Prioritisation</td>
<td>Demand Ratio</td>
<td>Demand Ratio</td>
<td>Demand Ratio</td>
</tr>
<tr>
<td>Optimisation</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>
Validation Restrictions and Preparation

Expectations

Sequences created by CLOU (On-Time-Preferred-Served and Optimisation)...

- Hypothesis 1: reduce airborne waiting time (Holdings)
- Hypothesis 2: reduce waiting time (queue)
- Hypothesis 3: increase punctuality
- Hypothesis 4: increase planning adherence

... in comparison with sequences built with FCFS.

- Other items:
  - possibilities to influence single flights by given preferences
  - capacity utilisation
Validation Results
in general

Sequences created by CLOU (On-Time-Preferred-Served and Optimisation)...

- Hypothesis 1: reduce airborne waiting time (Holdings) ✓
- Hypothesis 2: reduce waiting time (queue) ✓
- Hypothesis 3: increase punctuality ✓
- Hypothesis 4: increase planning adherence ✓

... in comparison with sequences built with FCFS.
Validation Results in general II

<table>
<thead>
<tr>
<th>Improvements over all scenarios [%]</th>
<th>Base-DR</th>
<th>Base-CLOU</th>
<th>DR-CLOU</th>
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</thead>
<tbody>
<tr>
<td>Punctuality Total</td>
<td>-3</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Punctuality Arrival</td>
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<td>-2</td>
<td>13</td>
</tr>
<tr>
<td>Punctuality Departure</td>
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<td>26</td>
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<tr>
<td>Planning Adherence Total</td>
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<tr>
<td>Planning Adherence Arrival</td>
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<td>4</td>
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<tr>
<td>Planning Adherence Departure</td>
<td>15</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Queue Total</td>
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<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Queue Arrival</td>
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<td>-27</td>
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<tr>
<td>Queue Arrival Airborne</td>
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<tr>
<td>Queue Departure</td>
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<td>27</td>
<td>4</td>
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Validation Results
Queue Concentration

<table>
<thead>
<tr>
<th>Time</th>
<th>Baseline (ArrPrio, FCFS)</th>
<th>CLOU optimised (with DR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Queue Total 8433 min</td>
<td>Queue Total 8602 min</td>
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<tr>
<td></td>
<td>Queue ARR 3083 min</td>
<td>Queue ARR 5929 min</td>
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<tr>
<td></td>
<td>Queue DEP 5349 min</td>
<td>Queue DEP 2673 min</td>
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</table>

- Arrival Punctuality (15 Min): +44%
Validation Results
Improving Punctuality

Baseline (ArrPrio, FCFS)
- Punctuality Total: 63%
- Punctuality ARR: 88%
- Punctuality DEP: 38%

CLOU optimised (with DR)
- Punctuality Total: 71%↑
- Punctuality ARR: 85%
- Punctuality DEP: 57%↑
Conclusion

- General approach of Total Operations Planner is the appropriate way to achieve future goals like “Vision 2020”.

- Flow planning in consideration of demand ratio improves traffic situation.

- “On-Time-Preferred-Served” optimisation again improves values like punctuality and airborne waiting time.

- Next actions
  - develop a more realistic model with more operational constraints
  - dynamic prototype: react on changes with respect to planning stability
  - generalize the prototype and adapt it to other airports
Thank You.

Questions?