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, ...)

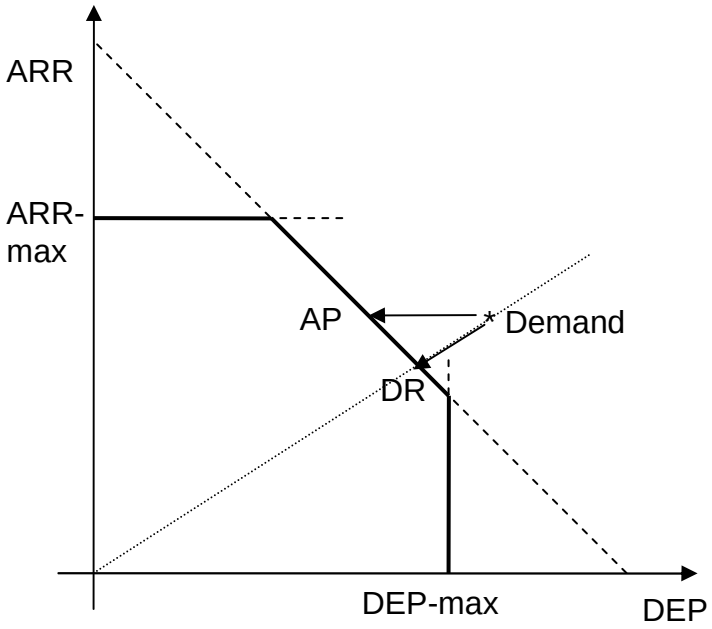
- planning process is split
  - Operation Mode and Working Point
  - Runway Assignment
  - Target Times

- 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, ...

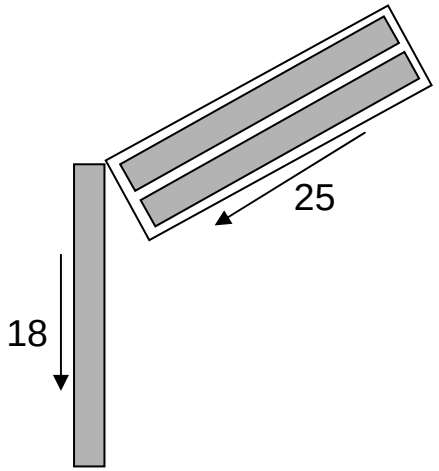
- start sequence on today's "First-Come-First-Served" (FCFS)

- 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
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

	Baseline	Demand Ratio DR	CLOU
Working Point	Arrival Prioritisation →	Demand Ratio	Demand Ratio
Optimisation	no	no →	yes

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 I

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 ☑

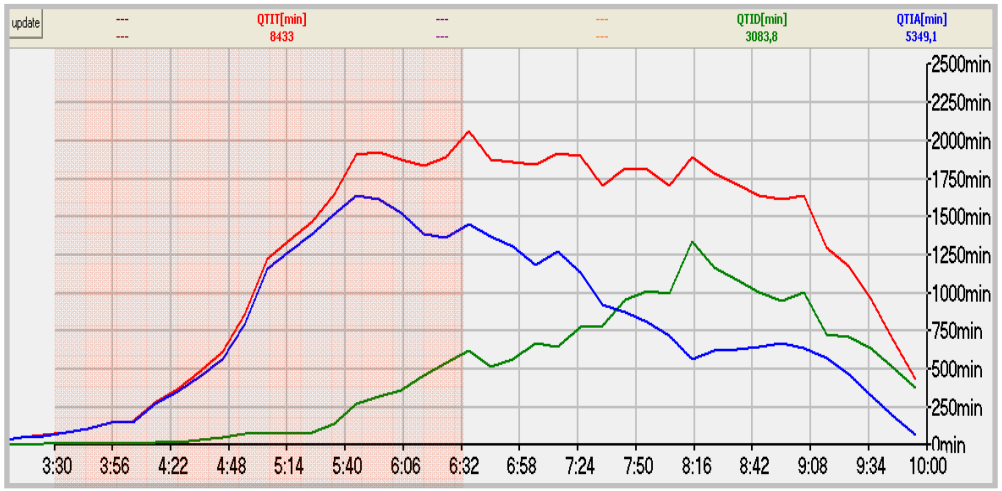
... in comparison with sequences built with FCFS.

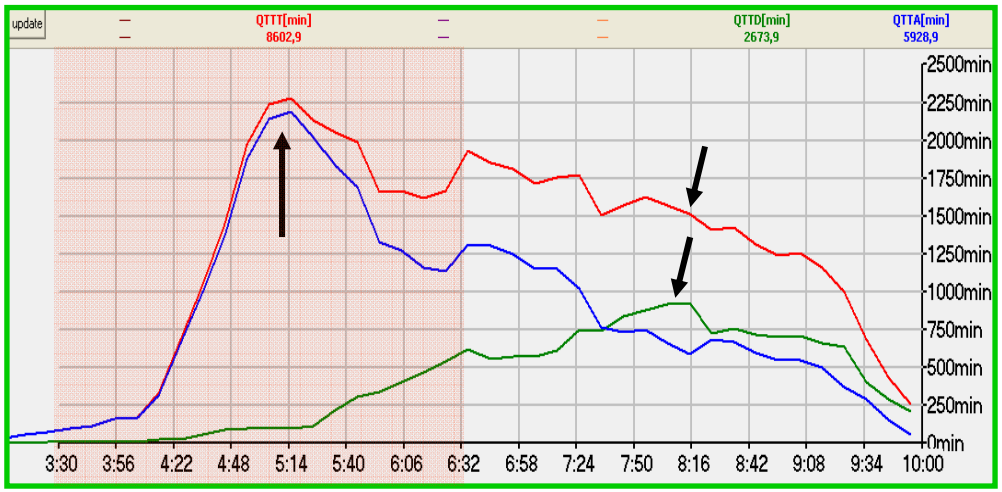
Validation Results
in general II

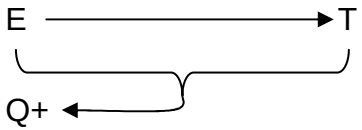
Improvements over all scenarios [%]	Base-DR	Base-CLOU	DR-CLOU
Punctuality Total	-3	15	19
Punctuality Arrival	-13	-2	13
Punctuality Departure	11	39	26
Planning Adherence Total	4	9	5
Planning Adherence Arrival	-20	-16	4
Planning Adherence Departure	15	19	5
Queue Total	6	9	3
Queue Arrival	-30	-27	2
Queue Arrival Airborne	-23	55	64
Queue Departure	24	27	4

Validation Results

Queue Concentration







Baseline (ArrPrio, FCFS)

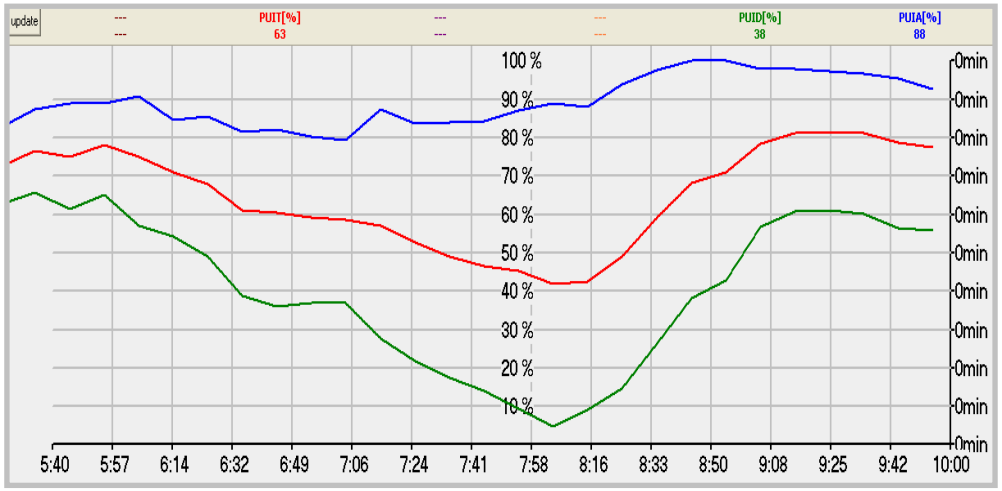
Queue Total	8433 min
Queue ARR	3083 min
Queue DEP	5349 min

CLOU optimised (with DR)

Queue Total	8602 min
Queue ARR	5929 min
Queue DEP	2673 min
Arrival Punctuality (15 Min)	+44%

Validation Results

Improving Punctuality

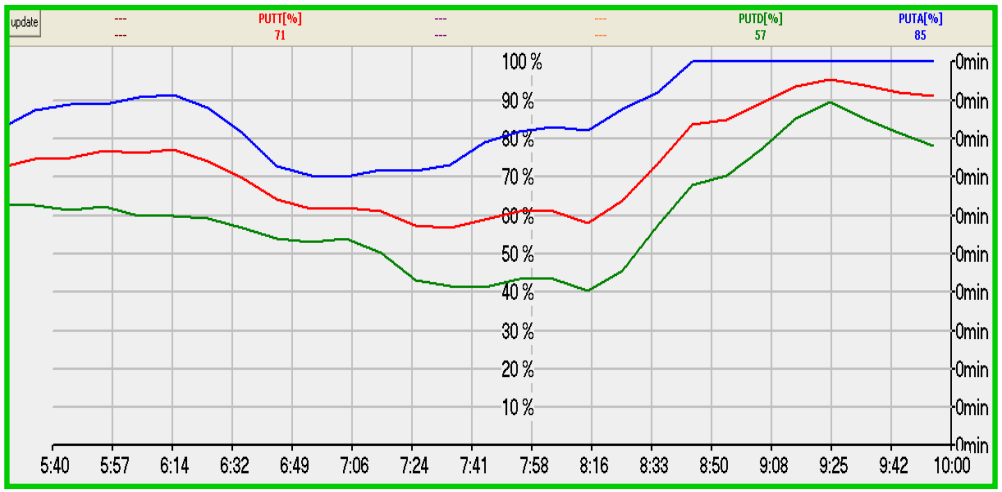


Baseline (ArrPrio, FCFS)

Punctuality Total 63 %

Punctuality ARR 88 %

Punctuality DEP 38 %

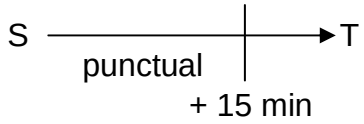


CLOU optimised (with DR)

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 ?