VALIDATION RESULTS OF AIRPORT TOTAL OPERATIONS PLANNER PROTOTYPE CLOU

Andreas Pick, German Aerospace Center DLR, Braunschweig, Germany

Abstract

The air transport traffic will grow. The airports have to handle this traffic with their facilities that have limited resources, especially runways, taxiways and stands. Air traffic control has to handle this traffic in the same limited airspace. Airlines have to ensure the punctuality of their flights for the passengers. The only way to get along with the future traffic without building new facilities and under valid safety regulations is to use the existing resources in a more efficient way. Holistic planning systems and information sharing has become a major field of research for the ATM research community. First concepts and prototypes have been developed to understand and handle the complexity. Of course, there are expectations in such systems, and they have to be evaluated and validated: does a holistic planning system improve punctuality and resource use at airports?

This paper will answer this question for the cooperative local resource planner CLOU, a prototype of a total operations planner that was designed and implemented as a decision support tool. CLOU generates target times for each arriving and departing aircraft within the next hours and uses target functions, given by the stakeholders airline, ATC and airport to meet their wishes.

To understand the presented results, the planning process is outlined; the validation scenarios described and special validation results are discussed.

Introduction

The Total Operations Planner (TOP) is a new type of planning system. In terms of Total Airport Management (TAM) and CDM (Collaborative Decision Making) TOP is a support tool, optimising the use of airport resources in consideration of stakeholder needs and targets [5]. The main stakeholders at an airport like Frankfurt are the main airlines, the airport operator and ATC, responsible for runway and TMA operations. The stakeholders have different and sometimes opposing wishes and preferences in special traffic situations, e.g. the airline prefers punctuality and ATC wants to produce a high traffic throughput. However, they are using the same resource: the runway. TOP has to combine these goals and then create a plan that satisfies all stakeholders in the best way.

Until today, arrivals are prioritised in ATC handling. Departure times are depending on intervals where the runways are clear from arrival traffic. Arrivals and departures have the same right and possibility to be handled in a collaborative runway use. To ensure this, it is necessary to consider an extended event horizon and to give early control advisories in order to steer the events at the runways and their previous actions (e.g. turn-around processes). These statements can also be used to fulfil stakeholders' targets.

Therefore, TOP has to respect constraints and target functions given by the stakeholders, which are parameters to the optimisation algorithm. Other integrated constraints are available capacity, the traffic demand, regulations and operation modes from the airport and airspace around it. All these information are needed for the pre-tactical planning horizon that starts at the end of the planning horizon of tactical systems like arrival and departure manager (AMAN, DMAN) and ends at the beginning of the strategic plan of ATFCM. TOP is closing an existing planning gap from about thirty minutes to about one day into the future. Tactical planning results are essential inputs for TOP's optimisation. Therefore, data exchange between either or both, AMAN and DMAN, is necessary to guarantee a smooth transition from pre-tactical to tactical planning tools.

TOP's optimisation results are resource use strategies. Various modes of runway operation, a balanced flow for every interval in the planning horizon, as well as runway allocation and target times for every flight are generated.

Due to the extended planning horizon, TOP is able to show capacity and demand conflicts at an airport, based on actual flight plans and currently available flight updates, at an early stage. The stakeholders' awareness of potential problems is increased and the opportunity to solve conflicts by giving instructions respecting the over-all plan for the airport is enabled. The introduced airport operations plan could be presented to ATFCM for further integration into the overall network plan.

After TOP's plan is calculated, each stakeholder receives it for discussion. The stakeholders are represented by one or more persons and together this group is named the Airport Planner. This representative has the responsibility to assess the potential effects of the airport plan to the internal stakeholder's plans, and to decide about its implementation. If an agent does not agree to this plan, all have to cooperatively coordinate their targets and discuss a possible solution. To support this decision-making process, TOP has what-if-probing functions and is able to show all necessary solution parameters to the Airport Planner using a graphical HMI.

After the commitment of all stakeholders to one plan, this plan can be implemented, e.g. the airlines and aircrafts receive target times and the ATC gets a guideline for capacity and runway use.

CLOU

DLR developed in co-operation with Deutsche Flugsicherung DFS, Lufthansa, Fraport, other companies and universities a concept of such a new planning tool, CLOU [3, 4], which is the abbreviation of "Co-operative Local resOUrce planner". CLOU is the first prototype of a Total Operations Planner (TOP) for Frankfurt airport. Funded by the Ministry of Economics and Technology, the research work is framed within the third national Aerospace research agenda (LuFo3) in the project KATM (Kooperatives Air Traffic Management).

CLOU has a planning horizon from about 30 minutes to about three hours or more into the future. Information is obtained from a central database, which can be fed by special airport databases or other planning systems. The planning horizon is divided into 10-minutes-intervals. For each interval, certain parameters, like capacity or demand, are calculated.

The complex planning problem is split into three solution parts resp. processes:

- Operation Mode and Working Point
- Runway Assignment
- Target Times.

These three parts are representing the planning core. Each process solves a part of the whole problem and gives the solution to the next process. Two modules compute additional information, before the planning starts the gathered data has to be prepared and afterwards metrics from the solutions are derived. The solutions' metrics are presented to the Airport Planner, enabling the agents to decide about that plan.

Operation Mode and Working Point

The first planning core process is responsible for the computation of the runway use strategy. The operation modes show the possibilities to use the airport's runway system under certain constraints. These constraints are weather situation, current arrival and departure demand (based on most recent estimate times) and the availability of the runways.

The second result of this process is a working point for each interval of the planning horizon. The term "working point" describes a proposed traffic flow ratio between arrivals and departures. In most bottleneck situations, the total demand exceeds the total capacity. The working point is calculated under given total capacity forecast, maximum arrival and maximum departure capacity and the demand based on estimates: The capacities, together with the operation mode, build a Pareto-Frontier-Curve (PFC, thick line in figure) [8]. This curve shows possible solutions for dividing the capacity in an arrival and a departure part. Now, the demand is projected onto the Pareto-Frontier-Curve. Different methods have been implemented into CLOU. The most important projections are the projection under arrival prioritisation (AP) and the projection regarding the demand ratio (DR). The demand ratio is the rate between arrival demand and departure demand. The figure below is showing these two projections.

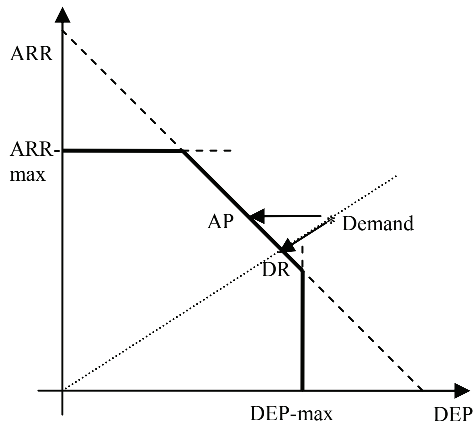

Figure 1. Pareto-Frontier-Curve, Projections and Working Point

In cases of demand exceeding the available capacity the difference is the remaining queue. It is transferred to the next interval and is added to the estimate demand respectively.

Arrival prioritisation is the indirectly used way by ATC today. The projection regarding the demand ratio is the preferred way from the airport operator, leading to a more convenient arrival-departure mix. The second method ensures that even over a short time period a balance between arrivals and departures at the airport is reached.

Runway Assignment

After the decision about runway use and the calculation of maximum flows, every single flight is assigned a specific runway. The runway assignment follows constraints from the airport, i.e. flights with heavy vake-vortex category use a special runway and aircrafts positioned in the north prefer to use the northern runway, as well as from ATC, especially regarding the distribution of the arrival and departure capacities over the runway system.

Target Times

The third step of the planning core is the optimisation of sequences in order to use the runway system in a most efficient way. This process generates event times for each arrival and departure flight in consideration of the constraints computed by previous processes. A simulated annealing algorithm is used to compute solutions. The initial solution or sequence is equivalent to sequence obtained by a "First-Come-First-Served"-Method (FCFS). In FCFS, the aircraft with the earliest estimate is assigned the first position in the sequence, followed by the aircraft with the second earliest estimate and so on.

The optimisation regards given optimisation targets and uses valuation functions that have been defined by the stakeholders. To evaluate the optimisation criteria, the calculated target time is compared with a reference time, i.e. the schedule or the estimate time. CLOU has four weighted target functions:

- Planning adherence,
- Airborne-Queue,
- Slot-Violation,
- Control-Window-Violation.

Planning adherence measures the deviation from the schedule time. This difference is among the important quality criteria for the passengers.

Airborne-Queue is the accumulated time flights spend in holdings, the goal is a reduction of this time.

The Slot-Violation-Function affects the certainty to reach an ATFCM-slot and is used to steer the computation of the target time into the slot.

The Control-Window is a time interval around the estimate time of a flight. It describes the earliest time and the latest acceptable time where a flight can perform a runway operation. It takes into account the status of the flight and the remaining time until the runway event occurs.

The last two functions allow a violation of this interval, but also try to avoid it.

Necessary results from previous processes are the runway assigned flights, arrival and departure capacities for each runway based on the airport working point for each interval, and if available, tactical target times as planning results from other tactical planning tools (AMAN or DMAN).

The optimisation functions and parameters are chosen to pursue the "On-Time-Preferred-Serve"-target. Punctual flights are handled with preference. It follows that late flights could be more delayed if they hinder an on-time flight. Well-balanced choices of the target functions' parameters have to be set to avoid extreme delays.

Validation Restrictions and Preparation

In order to reduce the computational complexity and due to data availability, there are some validation restrictions regarding the CLOU validation for Frankfurt Airport.

The runway system at Frankfurt is modelled by two independent runways and three independent sequences, one for arrival and two for departures. For instance, due to the low distance between runway 25/07L and 25/07R they grouped as one runway. In reality the runway system consists of three runways with dependencies between them.

The main operation direction for the parallel runway system in Frankfurt is 25 and the validation scenarios have been created for that direction. Runway 26 and direction changes to 07 were not in focus yet.

As the planning horizon of CLOU extends over several hours, a reduction of complexity is also sustainable in separation compliance. The concerned stakeholders decided to derive separations from the given capacity and the calculated working point, instead of applying the official safety separation regulations. The capacity forecast predicts values under certain constraints. These values are based on historically reached traffic flows with the same regulations in place and depending on the weather and traffic mix.

Because some given times in the flight plan and some validation aims are related to the on/off-block event, a conversion between runway and block times is necessary. This is done by using a constant taxi time.

The optimisation's target functions are used to evaluate delays and earliness. An early arrival or departure causes only in some situations a problem, in CLOU only delays are viewed.

The validated first CLOU-Prototype is a static planning system. The planning result has no effect on the traffic, in simulation or reality, and therefore no estimate times are updated. The validation is done for one planning cycle.

Although real traffic scenarios are used, the results CLOU obtained cannot be compared with the real traffic, because of all the above described simplifications and restrictions to CLOU.

In preparation of the CLOU validation runs a validation plan [1] was created. The plan follows MAEVA [6] guidelines, which is the basis of today's E-OCVM [10]. The validation scenarios and hypotheses were described by all stakeholders in this CLOU validation plan.

Validation Scenarios

CLOU is a TOP-Prototype for Frankfurt Airport. To validate it, two sets of traffic scenario solutions are needed: the baseline and the CLOU results.

The validation baseline is the result of CLOU under constraints which produce the traffic today. Today arrivals are prioritised and no pre-tactical optimisation is done. That means that today traffic is handled by arrival prioritisation and "First-Come-First-Serve" principle.

To be able to assess the advantages of single steps in CLOU planning, two validation results were created. First, the "First-Come-First-Serve"-Sequence basing on flows which were calculated with the demand-ratio working point (DR). This result shows the advantages of capacity deviation in consideration of existing demands. Second, same working point is taken and optimisation is done to show the total effect of CLOU.

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

Table 1. Validation Parameters

Depending on two real traffic days at Frankfurt, two master scenarios were created. Different scenarios for specific traffic situations were derived from these master scenarios:

- Capacity breakdown due to CATIII,
- Capacity breakdown due to headwinds at runway 25,
- Capacity breakdown due to runway 18 closure,
- Closed runway 25R,
- Normal operations.

The capacity breakdowns have different durations and remaining time until they will occur. The demand in all scenarios is almost the same.

The scenarios consist of flight plans, weather information, capacity forecasts and target function parameters.

The target functions are weighted and their form can be adjusted by parameters. For validation purposes, all parameters are kept constant. To obtain function weights that create results acceptable by the stakeholders, repeated trial runs have been done [7]. These weights were then fixed to all scenarios.

- Planning Adherence 0.1
- Airborne-Queue 0.4
- Slot-Violation 0.3
- Control-Window-Violation 0.2

Validation Expectations

In the validation concept [1] some expectations to CLOU are addressed.

Hypothesis 1

Sequences created by CLOU (On-Time-Preferred-Serve and Optimisation) reduce the airborne waiting times (holdings, airborne queue) in comparison with sequences built with FCFS.

This goal is measured by solution parameters number and time of airborne arrivals in queue. A flight is counted into the queue, if its target time is behind its estimate time.

Hypothesis 2

Sequences created by CLOU (On-Time-Preferred-Serve and Optimisation) reduce the waiting times (queue) in comparison with sequences built with FCFS.

To validate this, the number and time of all aircrafts in any queue is viewed.

Hypothesis 3

Sequences created by CLOU (On-Time-Preferred-Serve and Optimisation) increase punctuality in comparison with sequences built with FCFS.

To satisfy the punctuality criterion of Vision 2020 [9], a flight has to be less than 15 minutes behind its scheduled time. The reference point is the block.

Hypothesis 4

Sequences created by CLOU (On-Time-Preferred-Serve and Optimisation) increase planning adherence in comparison with sequences built with FCFS.

Planning adherence is the average delay at block measured in minutes.

Other Validation Objectives

CLOU additionally had to be validated regarding possibilities of specific influences to single flights, capacity utilization, runtime behaviour and potential system improvements.

Validation Results in general

Hypothesis 1

An improvement of the general situation was shown in all scenarios. Due to the demand ratio projection to the working point, departures are more regarded in runway use. Therefore, the arrival queue increases a little. The optimisation calculates target times to the airborne part of these arrivals, improving their time in queue and their over-all number.

Hypothesis 2

The CLOU-Optimisation reduces the waiting time for departures, but also deteriorates it for the arrivals. Overall, the waiting time and respectively the queue was improved.

Again, the improvement of the departure queue based on the calculation of the demand related working point. Therefore, the departure flow increases as well. It was shown that with arrival prioritisation, sometimes too much capacity is reserved for arrivals.

Hypothesis 3

The number of punctual flights increased. The arrival values decreased due to the chosen working point, but the optimisation increased them again. Unfortunately, they are not as good as the baseline values (2% worse). Departure punctuality became approximately 40% better.

Hypothesis 4

Planning adherence was increased. Due to the choice of the demand-ratio working point, arrival planning adherence deteriorated, but after the optimisation increased again.

The table below shows the percentage changes in validation solutions over all scenarios due to the done planning steps. First column shows the viewed solution parameters regarding the hypothesis. Second column shows changes, which are the results of changing the projection of the demand from arrival prioritisation to demand ratio working point, sequencing by FCFS. Third column shows the effect of the optimisation of the sequences in addition to changing working point. Fourth column declares the effect reached only by optimisation and same demand ratio working point. Negative values are deteriorations.

[%]	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

Table 2. Validation Results

The most outstanding values are the improvements of departure punctuality (39%) and airborne arrival queue (55%). The last one is a result of the target function and its weight in optimisation.

Some selected Results

This chapter describes some interesting scenarios and their optimisation results in detail. The values are calculated in a moving average with an interval length of one hour. Because scenarios were defined only for the shown planning horizon, the values of the last hour do not have to be noted. The curves show arrival (A), departure (D) and total (T) values.

Queue Concentration

The following figures show the time in queue [min] for the baseline (arrival prioritisation and FCFS), and the CLOU optimisation. The capacity breakdown occurs from 3:30 h to 6:30 h.

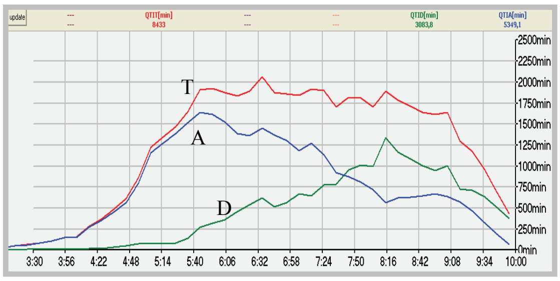

Figure 2. Waiting Time - Baseline

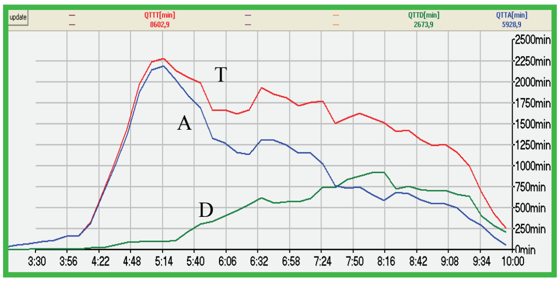

Figure 3. Waiting Time - CLOU optimised

In the baseline, the queue raises due to the bottleneck. With the optimisation result, the queue time is extremely extended. The reason is that a few flights, especially arrivals, received a target time far behind their estimate time. The optimisation concentrates the planned delays on these few flights to reach a better overall plan. Particularly flights with estimates at the beginning of a bottleneck are delayed. This results in queues and long waiting times. The total queue minutes increase from 8433 to 8602 (2% worse). Arrival punctuality is about 44% increased in this scenario.

Improving Punctuality

The figures show punctuality improvement of the baseline situation by changing capacity utilisation and by optimisation. The curves are from top: arrivals, total and departures. The scale in the middle shows the percentage of punctual flights regarding all related movements.

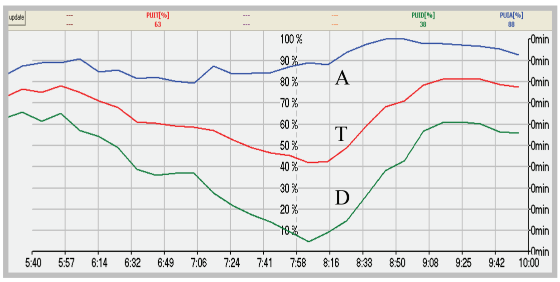

Figure 4. Punctuality - Baseline

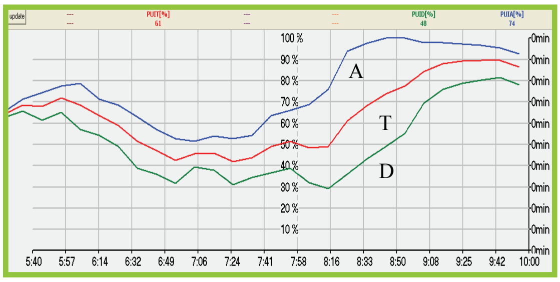

Figure 5. Punctuality - Demand Ratio and FCFS

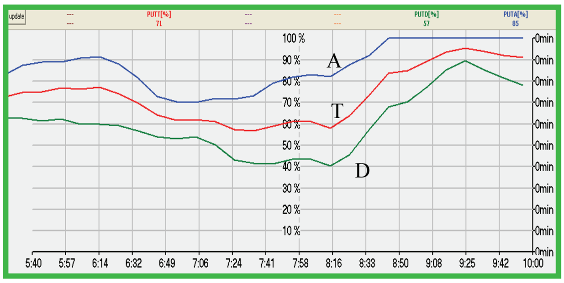

Figure 6. Punctuality - CLOU optimised

Trough change of the working point, and therefore reserving more capacity for departures, departure flow and punctuality increases, while arrival punctuality decreases. Due to optimisation, punctuality again improves. The total punctuality increases by about 13%, the departure punctuality increases by about 50%.

Even in a normal situation punctuality improvement of about 11% was shown.

Planning Adherence and Punctuality

The following two figures display an effect caused by the three steps of the planning core and the definition of punctuality.

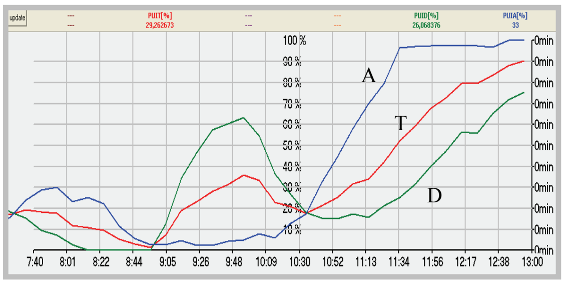

Figure 7. Punctuality - Baseline

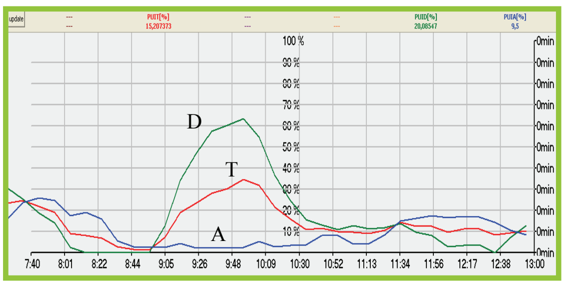

Figure 8. Punctuality - Demand Ratio and FCFS

The figures represent punctuality as described in the above chapter. Figure 7 shows the baseline with a capacity reduction due to a runway closure. This runway is used for departure operations only. Because of the change of the working point from arrival prioritisation to demand ratio projection, the solution parameters change dramatically. The peak from 9:00h to 10:30h depends on the reopened runway. Departures reach relative good values. Because the arrival demand is exceeding the available arrival capacity, arrival punctuality is bad. After the peak, due to over-demand and the calculated demand ratio working point, capacity is reserved for departures. Therefore, arrival capacity is less than the demand, and punctuality decreases. Due to the runway assignment, done strictly before sequence generation, departures from the closed runway, which are not handled before closure, remain fixed on it. Now these departures are added to the normal demand and this exceeds the capacity. Because the other runways (25L and 25R) are used for arrivals, the departure capacity part of these remains less than needed for departure handling. The departure punctuality decreases as well.

A reason for this problem is the definition of punctuality. Frequently, and for CLOU, a punctual flight is defined if its operation takes place within 15 minutes around scheduled time. If a flight is 14 minutes and 50 seconds late, it is punctual. Only eleven seconds later, the flight is considered unpunctual. In this special scenario solution (Figure 8) many flights have a delay a few seconds more than the 15 minute barrier. The planning adherence, the average positive differences from target time to schedule, in this solution is better than the baseline: total average delay decreases from 39 to 35 minutes and departure average delay decreases from 52 to 36 minutes. The graphs are shown in the following figures below.

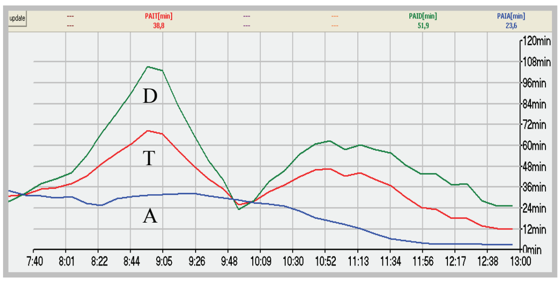

Figure 9. Planning Adherence - Baseline

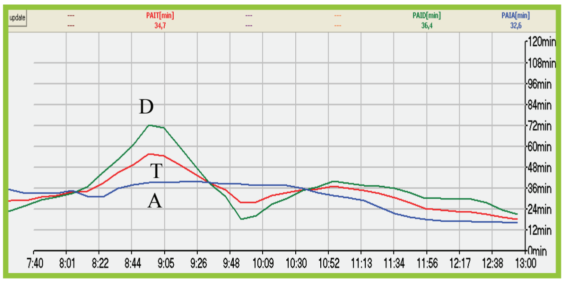

Figure 10. Planning Adherence - Demand Ratio and FCFS

This example shows problems in reducing system complexity. Suggestions how to handle this, have to be developed.

Other Results

The validation contains some low-level objectives; one is capacity utilization. CLOU uses the given capacity better than in the baseline, because projection of working point considering the demand ratio reserves more capacity for departure operation.

Possibilities in influencing single flights regarding their planning adherence are giving preferences for each flight. The validation shows, important flights obtained a better place in sequence if the effect on following flights, i.e. new delay, is less than the improvement for the whole system. Therefore, a higher preference does not guarantee a higher punctuality for this flight, but often results in it. The following figure shows the delay seconds of flights in a scenario grouped by their preference (left 1, middle, 2, right 3). Flights with higher preference have less delay in the optimised solution than in the reference, shown by the red arrows.

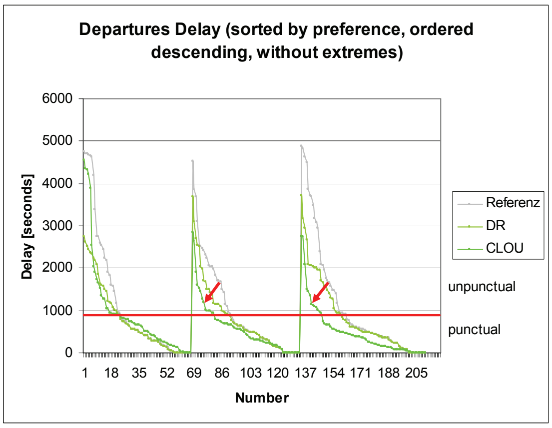

Figure 11. Preferences and Delay

The validation proves the expectations of the concept regarding simplification of the model and the resulting effects. System improvements are suggested.

Conclusion

Validation has shown that the general approach of a Total Operations Planner is the appropriate way to create a plan, which respects stakeholder needs. Prototype design gave an insight into problem complexity and offered a first solution of how to handle it.

CLOU is able to improve the traffic situation. Especially departures are handled more punctually, while arrivals have to accept very little impairments. This results from changing capacity use from arrival prioritisation to in a demand related way.

An additional optimisation again improves the values like punctuality and airborne waiting times.

The optimisation of capacity use trough generating sequences regarding airport needs, airline punctuality wishes and ATC operation modes is the right way to achieve future goals as shown in Vision 2020.

Outlook

The complex decision processes and their support possibilities have to be investigated further. More operational constraints have to be analysed to specify the underlying model and its optimisation.

Also, problems in modelling were shown. These problems like the integration of runway assignment with target time optimisation have to be investigated. A description of situation based target function weights could be discussed.

While the first prototype of TOP is a static tool, which means that only one planning cycle is done, the next step is to bring it to a dynamic and automated planning and a more operational status. In addition, the HMI has to be improved based on first findings from working with the TOP prototype in validation trails.

Furthermore, the collaborative decision making process of a TOP, as pre-tactical planner, and both tactical systems like AMAN and DMAN, and strategic ATFCM planning systems have to be forwarded.

Due to the specific implementation of CLOU for Frankfurt Airport, a generic TOP is needed to adapt it to other airports.

TOP and all other systems will be brought together in DLR APOC for simulating and validating the work with a TOP.

References

[1] Helmke, Hartmut, Oliver Albert, Dec. 2005, *IB 112-2005/44, Dokumentation zum Planungssystem CLOU A2210 CLOU Validierungskonzept,* 1.20, DLR/DFS, Braunschweig, Germany, internal paper

[2] Pick, Andreas, Florian Piekert, Meilin Schaper, Michael Hahn, May 2006, *IB 112-2006/09, Validierung des Planungssystems CLOU, D5.1 CLOU Nutzenbewertung und Validierungsbericht,* 1.02, DLR, Braunschweig, Germany, internal paper

[3] Kaufhold, Rainer, Andreas Pick, Christoph Meier, Florian Piekert, Feb. 2006, *IB 112-2006/05, Dokumentation zum Planungssystem CLOU, A2210 CLOU Basis- und Betriebskonzept*, 1.10, DFS/DLR, Braunschweig, Germany, internal paper

[4] Pick, Andreas, Florian Piekert, Gerald Siol, Christoph Meier, Rainer Kaufhold, Dec. 2005, *IB 112-2005/38, Dokumentation zum Planungssystem CLOU, A2200 CLOU funktionales Konzept*, 1.00, DLR/DFS, Braunschweig, Germany, internal paper

[5] Günther, Yves, Antony Inard, Bernd Werther, Marc Bonnier, Gunnar Spies, Alan Marsden, Marco Temme, Dietmar Böhme, Roger Lane, Helmut Niederstrasser, 2006, *Total Airport Management, Operational Concept & Logical* Architecture, 1.0, DLR/Eurocontrol EEC, Braunschweig, Germany/ Paris, France

[6] Revuelta J. (2004), *MAEVA, A Master European Validation Plan, Validation Guideline Handbook*, European Commission, Brussels, Belgium

[7] Hahn, Michael, July 2006, *IB 112-2006/17, Untersuchung eines computerbasierenden Planungssystem zur kooperativen Planung von An- und Abflügen für den Flughafen Frankfurt/Main*, 1.00, TU Dresden/DLR, Braunschweig, Germany, internal paper

[8] Gilbo, Eugene, Sep. 1993, *Airport Capacity: Representation, Estimation, Optimisation*, IEEE Transactions on Control Systems Technology, Vol. 1, No. 3, pp. 144-145, United States of America

[9] Busquin, Philippe et al., Jan. 2001, *European Aeronautics: A Vision for 2020*, Luxembourg

[10] Eurocontrol, Jun. 2005, *"European" Operational Concept Validation*

Methodology, www.eurocontrol.int, Brussels, Belgium

Abbreviations

AMAN	Arrival Manager
AP	Arrival Prioritisation
APOC	Airport Operation Centre
ATC	Air Traffic Control
ATFCM	Air Traffic Flow and Capacity Management
ATM	Air Traffic Management
CATIII	Category III Flight Conditions
CDM	Collaborative Decision Making
CLOU	Co-operative Local Resource Planner
DMAN	Departure Manager
DR	Demand Ratio
FCFS	First-Come-First-Serve
HMI	Human Machine Interface
KATM	Kooperatives Air Traffic Management
MAEVA	Master European Evaluation Plan
PFC	Pareto-Frontier-Curve
TAM	Total Airport Management
TMA	Terminal Movement Area
TOP	Total Operations Planner

Biography

Andreas Pick has been a scientific employee at German Aerospace Center DLR since 2002. He got his diploma in computer science in economics at Halle-Wittenberg University. At DLR, Andreas Pick works in Total Airport Management and CDM investigation and implementation. In the KATM project, he was responsible for the functional and technical concept of CLOU.