Potential of Dynamic Aircraft to Runway Allocation for Parallel Runways

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Abstract – **A flexible and demand-driven utilisation of available runway infrastructure plays an important role to meet aviation's future targets regarding capacity, efficiency and environmental sustainability. This paper presents and validates a heuristic algorithm to dynamically allocate arrival aircraft to one of two parallel runways. It considers both ATC regulations and modelled preferences of the airspace user and airport operator. It is designed to balance runway loads to reduce arrival and departure delays, taxi times, resulting fuel consumption and aircraft emissions. Particular focus is also set on ATC controller workload to avoid negative effects on safety. The implemented algorithm was applied in a set of fast-time simulations for the new Berlin Brandenburg International Airport (BBI). It promises significant operational potential, especially but not exclusively for airports with independent parallel runways.**

Keywords: Runway Allocation, Arrival Management, Airport Capacity, Efficiency, Environmental Sustainability.

I. INTRODUCTION

The modernisation of the Air Traffic Management (ATM) system in Europe within the frame of the Single European Sky ATM Research Programme (SESAR) requires an intensified partnership and calls for a collaborative decision making (CDM) between all involved partners. This is a major premise in order to cope with the performance targets for the year 2020, forecasting a 3-fold increase in air traffic demand and promising the reduction of aircraft emissions by 10 percent [1]. It is expected that airports will remain a crucial capacity element in the ATM system. As such, the efficient utilisation of the existing runway infrastructure is a dominant asset. This can be equally as effective as expanding airport infrastructure, without incurring negative financial, societal and environmental costs.

Runways are a vital component within the ATM system for enabling a user-orientated flight trajectory planning and execution [2]. The SESAR Target Concept [3] addresses this requirement in regard to runway management during the execution phase. Improvements in runway throughput, utilisation and safety shall be achieved by implementing operating procedures that balance actual demand and capacity, minimize traffic queues, de-conflict and separate traffic and apply safety nets. The future ATM-system shall combine strategic traffic flow management with tactical air traffic control also within the Terminal Manoeuvring Area (TMA). Although a fixed arrival and departure route structure within the TMA will remain inevitable due to even higher traffic complexity and environmental constraints, the route design shall nevertheless allow for dynamic adaptations according to the actual traffic situation. In that way an efficient and individually adjustable runway allocation scheme can contribute to enabling allocation of traffic demand to the available airport capacity as flexible as possible.

The current paper complements the manifold research performed in the context of arrival and departure traffic optimisation. Currently, focus of according support systems (i.e. AMAN, DMAN) is primarily set to the allocation of target times with regard to flow control measures at airports and the surrounding airspace. The results of several studies (e.g. [4]; [5]) reveal the potential for efficiency benefits. In addition, this paper identifies the potential for a decision support tool that provides specific runway allocation suggestions for arrival traffic. The presented algorithm combines various criteria for each particular flight regarding the current traffic and capacity situation. It is designed to fulfil the above mentioned general objectives for efficient runway management.

II. BACKGROUND

This study is motivated by the planning process for an optimised runway concept for Berlin Brandenburg International Airport (BBI) which is currently under construction. The concept for dynamic runway allocation derives from operational ATC-procedures that are already applied at airports with parallel runways, operated in mixed-mode (i.e. Munich Airport) [6], [7]. However, the concept can also be adapted to the operational constraints of airports with dependent parallel runways (i.e. Frankfurt/Main Airport).

A. *Operational Procedures*

The most prevailing factor for runway allocation of arrival traffic is the geographical origin from where the aircraft enters the TMA. At Munich TMA[1] all aircraft entering via the northern metering fix points follow pre-defined standard

[1] All described procedures of Munich Approach Control derive from personal observation, explanations by ATC-controllers and management of the DFS (German Air Navigation Service Provider) as well as national ATC-regulations.

arrival routes (STAR), if not vectored manually by the Pickup Controller. When reaching the downwind leg, pilots are advised by the Feeder Controller to turn base and intercept the precision (ILS) segment of the northern runway (see Fig. 1). The same procedure is applied accordingly for traffic entering via the southern metering fix points and landing on the southern runway [8], [9].

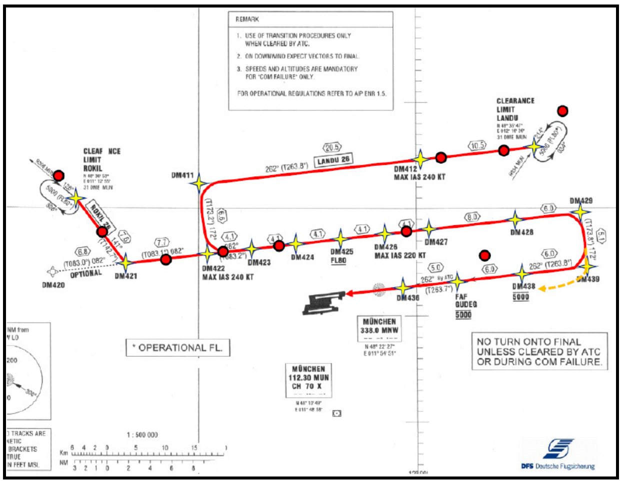

Figure 1. Arrival-Transition for Runway 26R, Munich Airport [9]

In this way conflicting traffic situations on base and on final are vastly resolved. However, the operational practice reveals exceptions to this rule. It can be observed that a minority of flights are being advised by the responsible Feeder Controller to land on an alternate runway. In this case aircraft fly an extended base leg and turn on final of the parallel runway (see dotted line in Fig.1). The analysis of radar flight track data, as shown in Fig. 2, covering an exemplary period of two hours of arrival traffic at Munich Airport, shows that a significant amount of traffic is being allocated to a different runway with the majority of flights still following the standardised approach. At Munich Approach Control one Feeder Controller is responsible for the airspace that covers the downwind, base and final legs of both runways, as illustrated in Fig. 2. He is responsible for separating traffic and establishing an efficient final approach sequence.

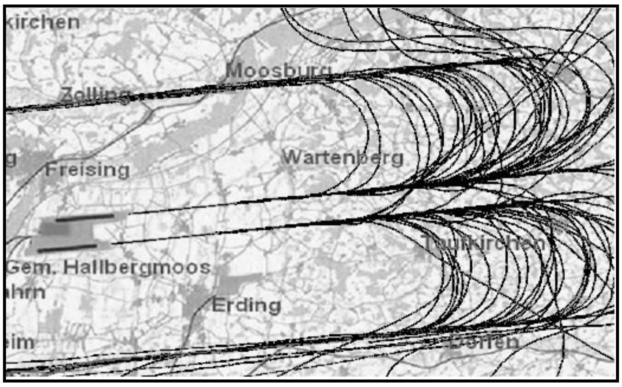

Figure 2. STANLY track data (2h) for arrival traffic at Munich Airport

Most re-allocations are initiated on request by pilots upon entering the TMA in order to reduce taxi time to the expected parking position near a given runway. Moreover, the Feeder Controller takes tactical sequencing decisions, leading to re-allocations, in order to balance the arrival flow for both runways or to create gaps in the arrival sequence for departure traffic on one of the runways. Since this is the responsibility of only one controller, no additional communication workload between ATC units is required. This may change once the responsibility would be shared between two Feeder Controllers for the northern and southern runway.

B. Motivation

The allocation of traffic according to the geographical direction upon entering the TMA complies with the necessity of predefined standard operating procedures for safety reasons, in particular under adverse weather conditions, reduced capacity or emergency situations. However, operating concepts, as described above, provide certain flexibility in the operational process to allocate individual aircraft to routes and runways approximately 30min or 15min at the latest prior landing.

Today's ATC-systems do not systematically provide adequate traffic information necessary for exploiting the full potential of improved capacity utilization. Under these conditions an air traffic controller cannot efficiently consider all factors of traffic flow optimization without increasing his workload. Especially with increasing traffic volumes, it becomes less likely that the potential for traffic flow optimization is recognised by ATC.

Consequently, a system support tool is needed combining information on specific flight data as well as traffic demand and calculating an optimized solution for allocating each specific flight respectively. This system shall help minimizing arrival and departure delays, balance traffic demand and reduce taxi times on the ground. The potential for such a system is certainly depending on local airport infrastructure as well as air space and traffic conditions. Within this paper first a system design is developed and then applied to the specifications of Berlin Brandenburg International Airport (BBI) including the following conditions.

- The expected traffic pattern for BBI reveals 55% of flights originating from the south and 45% originating from the north, resulting in a disparity of about 100 movements per day between the two runways. This leads to high loads and so potential arrival or departure delays on the southern runway and unused capacity on the northern runway.
- The airport layout has two independent parallel runways and a midfield concept. Parking positions near the terminal building have partly been designated to the major airlines using this airport. This creates advantages and disadvantages concerning taxi routes for certain flights.
- Due to cargo and military facilities on the north side of the airport, runway crossings become necessary for cargo and military flights arriving and departing

at the southern runway, and the risk of runway incursions may increase.

Concerning the findings from Munich Airport, it is assumed that operational ATC structures provide flexibility to introduce dynamic runway allocation procedures that help optimizing runway utilisation. However, operational constraints have to be considered.

C. Operational Constraints

Due to the operational requirements of departure route design and ATC responsibilities, a dynamic runway allocation for departure traffic is not taken into consideration for the present study: Independent simultaneous departures from parallel runways require a strict separation of utilised departure routes in order to leave the TMA geographically towards the destination airport without conflicts. A takeoff from an alternate runway requires more coordination and may lead to increased workload and reduced capacity. As such, this aspect must be considered in future research.

The predominant constraint for dynamic runway allocation of arrival traffic is the maximum approach sector capacity, which is mainly limited by the controller workload. Controller workload is mostly determined by the number of flights, the traffic-mix, and traffic activities within the sector (descent, climb, and cruise). On top, conflicting traffic situations lead to a significant increase in workload [10]. As such, the amount of deviating runway allocations is limited due to potential traffic conflicts within the responsibility of the Feeder-Controller. Thereby runway allocation requires adequate communication procedures with the cockpit crew, so that procedural adaptations have to be completed at least 10 to 15 minutes prior landing.

Finally it is emphasised that a system support tool is not fully automated so that the controller shall remain responsible for the runway allocation

III. METHODOLOGY

A significant amount of research has been performed by others in the field of runway capacity optimisation, mostly motivated by preventing traffic congestion and delays. Operations research models such as integer, linear or dynamic programming can be used for optimal allocation of inter-dependent arrival and departure runway system capacity to expected demand. In [11] Mixed Integer Linear Programming (MILP) was applied for optimising the allocation of flights to multiple runways over a period of one year. Apart from total delays, a multi-objective function minimises the external risk and aircraft noise to the environment. However, this concept is balancing the amount of traffic on a strategic level without focusing on the actual allocation of individual flights. A heuristic concept in [12] is allocating runway capacity in a way closely reflecting procedures of ATFM operators which makes it easier for controllers to comprehend and implement. Although this concept is based on a tactical level, it is not suited for selecting the best choice for a specific flight on the operational level. Also other factors affecting traffic efficiency, such as taxi times, schedule delay and environmental costs should be considered for individual flights.

Similarly to the concept described in [12], a heuristic algorithm is used in this study to evaluate an optimised runway allocation under actual traffic conditions for each specific flight without considering the result of previous allocations. This implies the assumption that any locally optimised solution produces a global benefit, without inevitably reaching the optimum solution.

Arrival flights are allocated to the runway about 35 NM to 40 NM (app. 15 min) prior landing. The algorithm compares all options for runway allocation by accumulating a range of criteria for each runway. The criteria are measured in time units and valued with specific cost factors, which are based on previous studies on aircraft operating costs and airline delay costs ([13]; [14]). Results have been adapted for this particular study with regard to aircraft category, the relevant operating phase and the magnitude of delay. All cost factors represent marginal direct operating costs for an additional time unit of flight operation or delay, i.e. fuel, maintenance, crew and a limited amount of passenger compensation costs. In order to incur the costs of environmental pollution, CO_2-Emissions are calculated based on fuel consumption and valued according to the price of EU-Allowances for CO_2-Emissions (EUA) under the European Emission Trading Scheme (ETS), which will be launched for air traffic in 2012 [15].

A. Evaluation Criteria

For an arrival flight all factors are accumulated concerning operating costs during approach and landing as well as the consequences of this arrival flight on delay costs of departure traffic. This is repeated for all runway allocation options after which the option with minimum total costs is chosen. In this way the individual flight execution and the overall traffic flow with reduced arrival and departure delays can be improved. Fig. 3 illustrates the flow chart of the described algorithm.

The following criteria are evaluated: First, the flight distance is predicted from the point of optimization to the runway threshold without considering any traffic interdependencies.

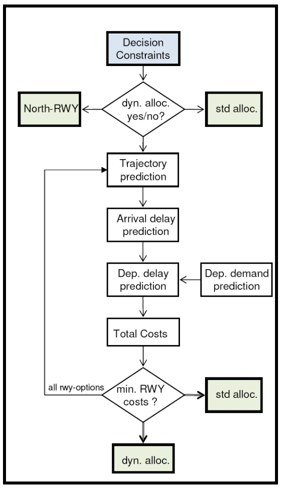

Figure 3. Flow chart of the runway allocation algorithm

This requires the knowledge of a median transition length as it is similarly used in Arrival Management (AMAN) systems. With a pre-defined speed profile a minimum flight time can be calculated and valued with a corresponding cost factor. The cost factor includes marginal operating costs for the specific aircraft category, mainly consisting of fuel and maintenance costs. Since a comprehensive approach of estimating operating costs was already undertaken by the Westminster University of London, commissioned by the Eurocontrol Performance Review Unit [14], this study refers to these results.

Second, a landing sequence is estimated based on the preceding traffic in order to predict potential arrival delays. The additional flight time is valued with a higher cost factor that also takes a low level of extra costs for flight crew and passenger compensation into account.

Third, the taxi-in time resulting from the distance between runway exit and the parking position is calculated and valued with a cost factor for aircraft ground operations. This includes a low level of fuel and maintenance costs. For reasons of simplification the taxi time does not include any traffic conflicts and waiting time on the ground.

Finally, the on-block-time can be predicted by accumulating the preceding processes. If the on-block-time deviates more than 15 min from the Scheduled Time of Arrival (STA), the resulting delay is valued additionally with a higher cost factor for crew costs and passenger compensation.

The last decision criterion values the consequences of a runway allocation for a specific flight by predicting the possible delay on departure traffic that is holding short of the relevant runway and is required to wait for runway clearance from the preceding landing. In that way the algorithm balances the costs that a specific flight induces to the traffic, taking into consideration arrival and departure demand. This requires a highly precise prediction of departure demand at the time of arrival of the allocated flight, as well as a realistic estimation of the expected delay. The delay time is then multiplied with a cost factor which includes operating costs on the ground and costs for crew and passenger compensation.

B. Delay Prediction

Delay prediction is based on the traffic demand and the required separation between two successive aircraft movements. These minima derive from radar- or wake turbulence separation minima [8]. For arrival delay determination, the predicted arrival time of two successive arrivals is compared with the required separation minima of following flights. If the time difference is less than the required separation, the subsequent flight must be delayed accordingly. This additional delay time is then used for arrival delay cost determination.

Departure delay prediction is based on a departure sequence which provides an estimated time of departure for each flight. The delay calculation for flights that would be affected by an additional landing derives from the capacity model by Newell [15]. It is assumed that arrivals are always prioritised over departures. The departure rate is therefore a function of the arrival rate. This function provides the minimum time separation between two successive departures. The resulting departure rate is calculated with minimum time separation between two successive aircraft movements which is mostly depending on the aircraft category. This model uses a median traffic mix which is specific for BBI. Variations in wind conditions and final approach speeds are yet not considered.

C. Decision Tree Constraints

A range of constraints triggers the algorithm.

- All flights with designated parking positions on the north side of the northern runway will be allocated to the northern runway in order to avoid runway crossings for arrival traffic when taxiing.
- Arrival traffic is excluded from dynamic allocation when the limit of controller workload is reached. A simplified workload model is implemented by allowing a maximum of 10 aircraft within the sector for dynamic runway allocation at the same time. Any additional flight is allocated to the runway according to its geographical origin.
- The calculated cost difference between two runway options must exceed a minimum cost benefit to initiate a runway re-allocation (a minimum gain requirement).

IV. RESULTS

The algorithm was implemented and tested with a JAVA-based fast-time simulation, developed at the Chair of Air Transport Technology and Logistics at Technische Universität Dresden. The traffic environment was designed according to the future infrastructure and a given traffic forecast for BBI in 2011. The results of two scenarios were compared. At first a static reference scenario allocated the arrival traffic according to its geographical origin. The second simulation run applied the algorithm for dynamic runway allocation to assess the potential benefits. TAB. II summarises the main findings for both scenarios.

TABLE I. COMPARISON BETWEEN REFERENCE AND DYNAMIC SCENARIO

scenarios:	reference		dynamic	
	abs.	rel.	abs.	rel.
aircraft movements (sum)				
north-rwy (25R)	509	43%	596	50%
south-rwy (25L)	678	57%	591	50%
re-allocations (abs. and share of total arrivals)	0	0%	**249**	42%
delays (sum and relativ reduction)				
Arrival (25L/R)	10:12:43		4:02:02	-60%
Departure (25L/R)	25:13:40		16:11:22	-36%
taxi-in time (sum and rel. reduction)	46:51:23		42:28:35	-9%
main-apron crossings (sum and rel. red.)	157		118	-25%

The analysis of the simulation results reveals that dynamic runway allocation creates an equalised traffic distribution on both runways. The unbalance between the two runways of 100 movements per day is resolved. Major peaks with more than 50 movements per hour on the southern runway are reduced to 45 to 47 movements per hour (see Fig. 4). However, the arrival-departure ratio shifted from 50-50 % to 57-43 % with a higher share of arrivals on the northern runway and more departures on the southern runway. Especially during periods of extensive departure demand on one runway, arrivals are allocated to the alternate runway (i.e. departure peak at 6:00).

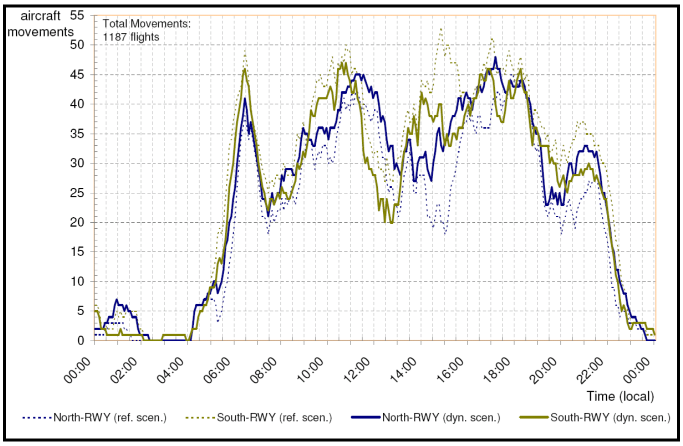

Figure 4. Comparison of total movements as rolling hour for North and South runway

Fig. 5 illustrates the accumulated delay of arrival and departure traffic on both runways. Overall delays can be reduced on the northern runway by 13.6 % (-1.8 h in total per day) and on the southern runway by 60.4 % (-13.4 h in total per day). On average, arrival delays are reduced by 37 s per flight. Delays for departure flights are reduced by 55 s per flight. Especially during times of equally high arrival and departure demand (i.e. 9:00 to 12:00 and 16:00 to 18:00) delays can be reduced significantly.

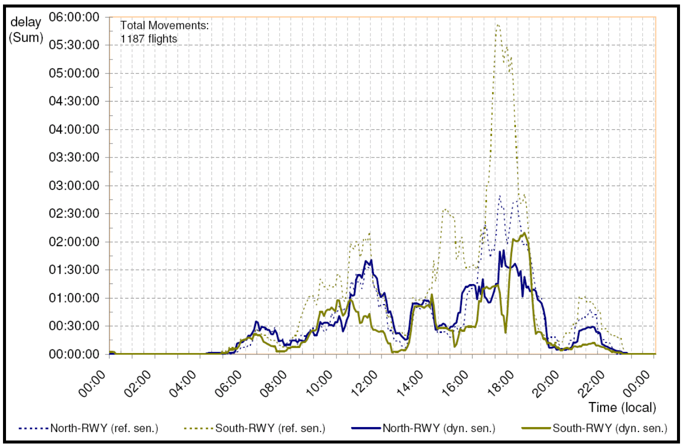

Figure 5. Sum of delay in floating hour for North and South runway with comparison of both scenarios.

Taxi times are reduced by 9.4 % in total (-4.4 h per day) which corresponds with a reduced taxi time of 26 s on average per flight. Extremely high individual taxi times in the static scenario (up to 12 minutes) can be resolved completely. The maximum recorded taxi-in time during the dynamic allocation scenario is 8.5 minutes. For some flights taxi-in times are reduced by more than 8 min, whereas some flights have extended taxi-in times by 1 min to 5 min. This is due to the integration of all decision criteria in one optimisation function where one criterion might overvalue other criteria. In this case extended taxi-in times might be accepted for reduced arrival delays or resolved departure queues.

The re-allocation of arrivals for reasons of reduced taxi time has direct consequences on the complexity of ground traffic and potential conflicts. Due to the airport layout of BBI aircraft taxi routes cross the main apron when landing on the south runway but parking on the northern apron and vice versa. The usage of these taxi route relations is reduced by 25 %.

Fig. 6 illustrates the arrival traffic flow, the share of re-allocation (orange line) and the distribution to both runways (blue and green line) over 24 h. In total a share of 42 % of all arrivals (249 flights) is re-allocated to the opposite runway.

In 43 cases the workload limit of the Feeder-Controller prevented a re-allocation (see red line in Fig 5). Additionally, 33 flights did not exceed the minimum cost benefit limit, so that these flights remained on the standard approach. Especially in periods of high arrival demand, the potential of airspace conflicts increases because of crossing traffic.

The reduction in arrival and departure delay as well as taxi times leads to a reduction in fuel burn of app. 19 tonnes. This leads to potential savings of 8.143 € for airlines and about 60 t less CO_2-Emissions.

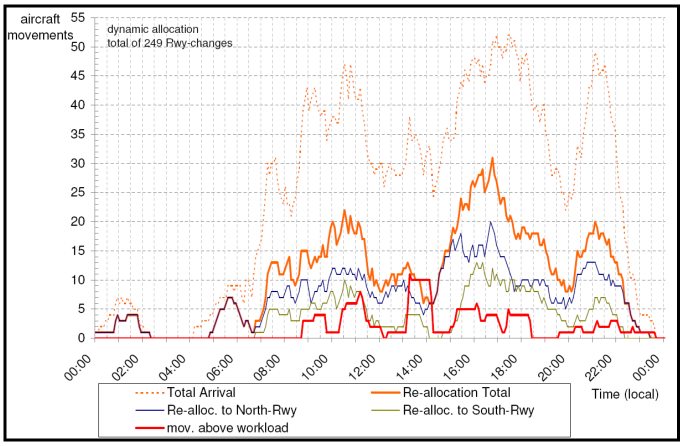

Figure 6. Arrival movements with Re-allocation to North and South runway and blocked allocations due to workload limitations.

V. Operational Implementation

According to the objectives of SESAR and considering the recommendation to establish a centralised and demand-orientated resource-management at airports, it is advised to implement a dynamic runway allocation system at an Airport Operation Center (APOC) under the responsibility of the airport authority in close partnership with the local ATC-Tower services. The core principle for operational decision making within an APOC environment is Airport Collaborative Decision Making (A-CDM) process which provides a structured and frequent data exchange between airport operators, Air Navigation Service Providers (ANSP), airlines and handling agents. Access to updated operational flight plan data is a vital requirement for reliable trajectory and delay prediction.

Traffic predictions and workload models are best done by ATC-services and provided as input data for the algorithm. The final calculations for runway allocations should be done according to the CDM philosophy within the APOC and sent to the operational ATC-controller via an appropriate data-link. Other research projects have identified practical means to present the suggestion for runway allocation to the controller so that the information is easy to comprehend and does not disturb basic controller tasks. In [17] it is suggested to include the allocation information within the aircraft label on the radar screen of the approach controller. The system should allow the user to interact and accept or disregard the information.

This concept for dynamic runway allocation is based on operational procedures used by ATC and flight crews. The system support is designed in a way that the controller is not limited in his current work tasks. Any runway advice can be rejected or ignored without any consequences for traffic safety. Compared to subjective evaluation by the controller, the system support is clearly decreasing workload by providing a runway suggestion that includes a range of criteria by combining data from various sources. Without a system support this is too much information for a human being to be able to process at a given time especially with increasing traffic volumes. The harmonised traffic flow also reduces the coordination between Tower and Approach Control, because the allocation of arrival traffic already considers departure traffic demand. However, a potential increase in conflicting airspace situations, and the necessity for more radio communication, can limit the usability of dynamic runway allocation under high traffic demand.

VI. CONCLUSION AND FURTHER RESEARCH

The designed algorithm in this paper is based on the integration of several criteria in a total cost function which is used for the evaluation of runway options for specific arrival flights. The architecture of the algorithm is sequential and not iterative so that a total optimum for the entire arrival and departure traffic is not inevitably achieved. A sequential optimisation provides the necessary foundation for further research. However, with this method it is possible to control and allocate arrival traffic according to the actual traffic condition and capacity situation and to create overall improvements in the traffic flow.

The implementation within a simulation tool showed clear benefits for the traffic flow at BBI. The utilisation of both runways was well balanced and delays were reduced by 55 seconds per departure and 37 seconds per arrival. Taxi-in times were reduced by 26 seconds per arrival on average. Crossings of the main apron, which can produce potential ground conflicts, were cut by 39 movements. This leads to potential savings of more than 8.000 € in fuel costs and 60 t of CO_2-Emissions per day.

A range of improvements for the algorithm was identified. Data analysis has shown that under high traffic volumes the predicted departure sequence is not stable enough and provides an over or under estimation of departure delays. This has direct consequences on the reliability of the departure delay prediction which is an important criterion for the runway allocation. Therefore, the departure sequence should be updated frequently in order to take into account the actual rate of arrivals.

Further improvements could be made by introducing a limited iteration process for the runway allocation in order to compare the cost benefit of the preceding and consecutive flight, and to adapt the runway allocation if necessary. However, it is vital that only one final suggestion for runway allocation is presented to the ATC-controller well in advance, so that the controller and the flight crew are not confused by changing allocations. For this purpose, the internal calculation process should begin at least 30 min or 100 NM and stop latest 10 min or 30 NM prior landing.

Additionally, the workload model used in this algorithm should be extended so to consider potential airspace conflicts as well. This requires a precise trajectory prediction and sequence planning for arrival traffic.

For implementation purposes further research must be done on data exchange and technical data-link solutions between the APOC, ATC-controllers and the cockpit crews. Special attention should be drawn to an appropriate human-machine-interface for the controller. A collaborative development and operation of such a system is best done on the basis of a common decision-making platform with all partners involved.

REFERENCES

[1] SESAR Consortium, *The performance target D2*, EUROCONTROL, December 2006.

[2] Episode 3 Consortium, *Runway Management E1 D2.2-034*, Version 1.0, European Commission, January 2009.

[3] SESAR Consortium, *The ATM Target Concept D3,* EUROCONTROL, September 2007

[4] Günther, T., Fricke, H., *Potential of Speed Control on Flight Efficiency*, in Proceedings of the 2nd International Conference on Research in Air Transportation, Belgrade, June 2006.

[5] Günther, T., Hildebrandt, M., Fricke, H., Strasser, M., *Contributions of Advanced Taxi Time Calculation to Airport Operations Efficiency*, Air Transport and Operations Symposium 2010, in press.

[6] International Civil Aviation Organization, *Annex 14, aerodromes,* vol. 1, 4th ed., Chapter 3, November 2004.

[7] International Civil Aviation Organization, *Manual on simultaneous operations on parallel or near-parallel instrument runways (SOIR),* Doc 9643, 1st ed., Appendix, 2004.

[8] Deutsche Flugsicherung GmbH, *Betriebsanweisung Flugverkehrskontrolle (BA-FVK)*, DFS, Langen, March 2007.

[9] Deutsche Flugsicherung GmbH, *Aeronautical information publication Germany – Luftfahrthandbuch Deutschland*, *aerodromes (AIP-AD)*, DFS, September 2006.

[10] Mensen, H, *Moderne Flugsicherung, Organisation, Verfahren, Technik,* 3rd ed., Springer Verlag, Berlin, 2004.

[11] Heblij, S., Wijnen, R., *Development if a runway allocation optimisation model for airport strategic planning*, Transportation Planning and Technology, vol. 31, no. 2, pp. 201-214, April 2008.

[12] Janic, M., *A heuristic algorithm for the allocation of airport runway system capacity*, Transportation Planning and Technology, vol. 30, no. 5, pp. 501-520, October 2007.

[13] International Civil Aviation Organization*, Cost tables of CNS/ATM planning and evaluation tools*, *base-line aircraft operating costs*

(appendix), 4th Meeting of the ALLPIRG/Advisory Group, February 2001.

[14] Transport Studies Group, *Evaluating the true cost to airlines of one minute of airborne or ground delay*, University of Westminster, May 2004.

[15] European Environment Agency, *Air pollutant emission inventory guidebook*, Technical Report no. 6, 2009.

[16] Newell, G. F., *Airport capacity and delays,* Transportation Science, vol. 13, no. 3, pp. 201-241, 1979.

[17] Lee, K., Sanford, B., *The passive final approach spacing tool (pFAST), human factors operational assessment*, 2nd USA/Europe ATM R&D Seminar, Dec. 1-4 1998, Orlando, 1998.

AUTHOR BIOGRAPHIES

Martin Fritzsche studied traffic engineering at Technische Universität (TU) Dresden where he received his Diploma in 2010. In his study he worked on different projects regarding ATM and environmental sustainability of air traffic. The present investigation is part of his diploma thesis supervised by TU Dresden and Flughafen Berlin-Schönefeld GmbH between 2009 and 2010.

Thomas Günther works at Technische Universität Dresden, Chair of Air Transport Technology and Logistics as a scientific assistant. Within his PhD thesis he is currently working on the assessment of efficiency improvements under consideration of ATM network effects. The development and application of a proper methodology shall contribute to a better understanding of according potentials regarding lateral, vertical and speed profiles as well as queue management and surface movement aspects. Thomas studied traffic engineering at TU Dresden where he received his Diploma in 2004.

Hartmut Fricke studied Aeronautics and Astronautics at Technische Universität Berlin from 1985–1991. From 1991 to 1995 he was a research fellow in Flight Operations, Airport Planning, and ATM at TU Berlin, where he completed his doctor thesis in ATM (ATC-ATFM Interface). In 2001 he finished his Habilitation on “Integrated Collision Risk Modeling for airborne and ground based systems”. This included HIL experiments with an A340 full flight simulator in co-operation with EUROCONTROL Experimental Centre (EEC). Since December 2001 he has been Head of the Institute of Logistics and Aviation, and Professor for Aviation Technologies and Logistics at TU Dresden. In 2006 he was appointed Member of the Scientific Advisory ”Board of Advisors” to the Federal Minister of Transport, Building and Urban Affairs in Germany.