IMPROVED DEPARTURE MANAGEMENT THROUGH INTEGRATION OF DMAN AND A-SMGCS

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In order to improve the efficiency of departure processes at large airports, specific decision support systems, so called Departure Manager (DMAN), have been developed in the last decade. At the same time a new generation of Surface Movement Guidance and Control Systems (SMGCS) came into existence, which is designated as Advanced-SMGCS (A-SMGCS). The latter one supports controllers when planning, controlling and monitoring the ground movement traffic. DLR made extensive contributions to the subjects of Departure Management and A-SMGCS. Together with EUROCONTROL DLR developed an operational prototype of a generic DMAN. The Controller Assistance System for Departure Optimisation (CADEO), the DLR DMAN, has been tested and validated successfully at various airports in simulations and field trials. In light of the increasing availability of A-SMGCS, now the integration of DMAN and A-SMGCS comes into the focus of research. This paper discusses several options for improving the adaptability and flexibility of departure management by using A-SMGCS surveillance data and guidance information.

1 INTRODUCTION

In consequence of the fact that airports increasingly turn into bottlenecks of the entire air transportation systems [1], improvements of ground operations became a topic of research for about one decade. Two main research areas were established:

a) The development of Advanced Surface Movement Guidance and Control Systems (A-SMGCS).

b) The development of specific decision support systems for the management of the departure outbound processes, meanwhile consistently termed as Departure Manager (DMAN).

A-SMGCS research was initially safety-driven, supporting an improved situational awareness of the controllers by providing surveillance information of identified targets, i.e. all moving objects displayed on an airport map, allowing also the discrimination between vehicles and aircraft. The detection (and later the prevention) of potential runway incursions, besides the safety-related reduction of airport capacity in bad weather or visibility conditions, was of importance from the very beginning. Since A-SMGCS were rated as safety-critical, they became a matter of standardisation by ICAO [2] and EUROCONTROL, working out definitions of functional levels and an implementation road map [3]. Meanwhile it was proven by several projects [4][5] and real implementations that A-SMGCS contributes to airport safety and efficiency as well as supporting controllers in implementing a fluid ground traffic [6][7].

The new decision support systems for departure management were initially developed with the objective to enhance airport capacity. Based on the experiences gained by using the first Arrival Management Systems (AMAN), like COMPAS [8], the calculation of the departure schedule by DMAN was done also by using optimisation techniques. However there were two main differences. Firstly there was a symmetry break as the DMAN did not support the operations from the event of take off, but from going off-block[1] and secondly – and more important in context of this paper – the assessment of the actual traffic situation could not be based on radar data as they were not available before the development of A-SMGCS[2]. Therefore the DMAN had to be designed as an event driven machine using controllers inputs of given clearances as events to observe the state of the actual traffic situation and to trigger a re-planning of the departure schedule correspondingly.

Within the Airport - Collaborative Decision Making (A-CDM) context [9], the interest was raised to extend the planning horizon of DMAN, in order to have the departure schedule available in a commonly shared information system, for a longer amount of time before the actual off-block event. This would allow other stakeholders at the airport, mainly airlines, airport authorities and ground handlers to re-arrange their resource planning accordingly. The requirement of a pre-departure schedule stimulated the development of Pre-tactical Departure Manager and the Total Airport Management (TAM) concept on the one hand and on the other hand shifted the focus from throughput enhancement to the provision of reliably plans [10]. The issue of pre-tactical departure management will not be addressed in this paper, however the question how to reach a good trade-off between required stability of plans and the necessary flexibility to be able to adapt to unforeseen events and deviations is not only an important question for all planning-based decision support systems in dynamic environments, but is one key driver for the integration of DMAN and A-SMGCS.

Although the new A-SMGCS and DMAN systems support the same team(s) of controllers working in the ATC and/or apron tower(s), the integration of both systems came in the focus of research only recently, as industry is providing both types of systems. This is reflected in launched workshops by EUROCONTROL, Joint Actions Plans of the

[1] It should be emphasised that required separations along the departures routes however are taken into account by DMAN. The task that departure operations from different, closely spaced airports have to be synchronised, has recently also become a topic of research.
[2] SMGCS can only provide radar plots of primer radars without identified targets

European Commission and FAA, and a serious of national, e.g. [11], and European projects [5][12]. All above mentioned decision support systems and their integration is one component of the new SESAR concept [13].

The integration of DMAN and A-SMGCS can be considered from the point of view of human centred automation, combining not only DMAN and A-SMGCS, but the variety of IT systems in an Integrated Controller Working Position (ICWP) or from the algorithm and technical feasibility standpoint. This paper concentrates on the latter aspect.

2 BASIC PRINCIPLES OF SUPPORTED DEPARTURE MANAGEMENT

This section outlines basic principles of DMAN planning algorithms and the corresponding operational concepts of use which are relevant to the integration of A-SMGCS and DMAN.

2.1 Technical Solution

Departure planning bases on optimisation, but in keeping the plan adaptive to changes, constant re-planning is necessary.

2.1.1 Scheduling Based on Optimisation

It has already been proven that scheduling the take-off events can be based on optimisation [14]. As departure management shall take into account several objectives, especially

- throughput enhancement,
- CFMU slot compliance improvement,
- stability of plans, and
- taxi-out delay reduction,

the planning task can be formulised as a vector optimisation problem where each objective is expressed by an particular optimisation function:

(1) $$q_i = q_i(\mathbf{t}, \mathbf{t}_i) = \sum_{k \in D} f_{i,k}(t_k - t_{i,k})$$

where **t** is the vector of planned take off times t_k, $\mathbf{t}_i$ is a vector of specific corresponding reference times $t_{i,k}$, D is an index set of all departures considered within the planning process, and $f_{i,k}(\,)$ is a monotonous function assessing for departure *k* any delay of its planned/target take off time (TTOT) with respect to a certain reference time which is specific for the optimisation aspect *i.* It turns out that the design of such functions, the adequately reflecting of the envisioned objectives, is not a trivial task. Equally difficult is the choice of adequate types of reference times for each of the optimisation functions. In order to illustrate this, but to avoid too many details, the reader may assume that for all *i*

(2) $$f(t_k - t_{i,k}) = \begin{cases} (t_k - t_{i,k})^2 & t_k > t_{i,k} \\ 0 & otherwise \end{cases}$$

holds. Furthermore, let $t_{i,k}$ be the actual time as reference time for throughput (i=1), the slot time CTOT as reference time for CFMU slot compliance (i=2), the previous (in last planning cycle) planned take off time as reference time for the measurement of the planning stability (i=3), and finally, which in this context is the most important, the earliest possible take off time (ETT) as reference time for taxi-out delay (i=4). The vector optimisation problem can be formulised finally as follows:

(3) $$\mathbf{t}^* = \arg \min_{\mathbf{t} \in T(C)} Q(\mathbf{a}, \mathbf{q}(\mathbf{t}))$$ and

(4) $$Q(\mathbf{a}, \mathbf{q}(\mathbf{t})) = \mathbf{a}^{\mathrm{T}} \mathbf{q}(\mathbf{t})$$

where **t*** is the vector of planned take off times (Target Take Off Time, TTOT). *Q*( ) is a scalar substitution function, **a** is a vector of weight factors, each of them greater or equal zero, and *T*(*C*) is the solution space restricted by a set of constraints *C*. The set of constraints *C* contains both so called hard constraints which must not be violated by any solution, e.g. no take off while an arrival is landing on the same runway, and soft constraints, e.g. if possible, depart within the CFMU slot. Soft constraints are linked with corresponding reference times and “penalty” functions which are treated similarly as additional objective functions. This results in: The greater the violence the greater the penalty value assigned.

From an operational point of view, constraints result from the necessary separation of an aircraft either to previous departure operations and/or in mixed mode conditions, additionally from the separations concerning previous or following arrivals. In mixed mode the same runway is used for departures and arrivals for take off and landing, or the departure runway crosses or interacts with the runway used for arrivals. The separation itself expresses the necessary “waiting” times due to different safety aspects, e.g.

- required wake vortex separations depending on the pairs of weight categories,
- runway occupancy times for landings and take offs depending on aircraft type and airport layout (geometry) and maybe other environmental factors,
- required separation (in miles and transformed into time) for a pair of consecutive departures which share a certain part of the standard instrument departures routes (SID-constraints).

CADEO (Controller Assistance for Departure Optimisation), the DLR DMAN, provides a set of constraint models which allow a data-based modelling of all relevant operational constraints for various conditions, e.g.

- parallel, crossing or otherwise dependent runways
- segregated or mixed mode operations
- intersection take offs
- SID structures etc.

From a “logical” point of view it is obvious that a somehow estimated earliest time (ETT) should serve as a hard constraint so that no departure can have a TTOT which violates

(5) TTOT >= ETT.

The estimation of the ETT for every particular departure is done with a set of operational models, expressing the necessary times of departure (preparation-) processes, which have to be done consecutively or in some cases can be done simultaneously (like push-back and engine start-up). All "duration" times are also depending on various data, like

- aircraft type
- stand or parking position
- (standard) taxi route from parking (or actual) position to runway etc.

The Target Start-Up Approval Time (TSAT), which can be interpreted as the time the aircraft should go off-block in order to meet its TTOT, can be derived from back-calculation, relaying on the same operational model used for ETT estimation, but adding some buffer time (depending on parameter) to compensate for unexpected delays. This is illustrated in principle in Figure 1. The RTUC (Recommended Time Until next Clearance) is a special result of CADEO to support the controllers implementing the recommended TTOTs and the sequence.

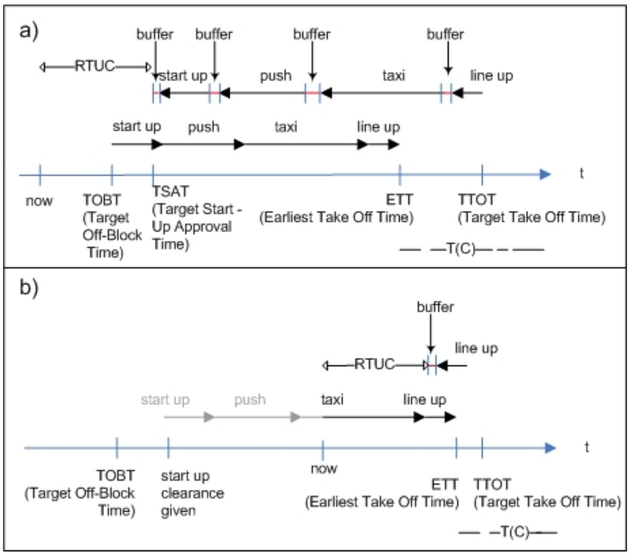

Figure 1: Relations between TOBT, ETT, TTOT, TSAT and RTUC (example): a) before TOBT, b) while taxiing.

It is obvious that the ETT estimation itself depends on the Target Off-Block Time (TOBT), which is considered to be the most important time of the whole A-CDM process [9]. Therefore for the particular case of no buffer time b

(6) TSAT >= TOBT (b=0) holds.

Finally it should be highlighted that for the TTOT calculation the ETT plays a similar key role, since a change of an ETT for one particular departure may result in a change of its TTOT, and in turn may also result in a change of other TTOTs (for other departures). This may or may not lead to sequence changes. This may also occur regardless if the ETT serves as a constraint or not, because of its use as reference time in an optimisation function (equation 1).

2.1.2 Event-Driven Repetitive Planning with Sliding Horizon

After the off-block event, which is in many cases the beginning of the push-back, the aircraft still is subjected to further updates of its TTOT and the derived target times for the beginning of remaining departure processes. Any freezing or fixing of these times seems not to be adequate for a DMAN, which should support all tower and apron controllers, i.e. Clearance Delivery (CLD), Apron/Ground (GND) and (maybe) Runway/Tower Controller as well. The reason for this is that the environment must be assessed as highly dynamic, although an observer may have the impression of rather slow movements of taxiing aircraft. However, on one hand any clearance/command[3], any incoming information of e.g. new flight plans, any information updates and – as this will be explained later – also the absence of an expected clearance must be considered as an event changing the environment. On the other hand the durations of all departure processes vary considerably in a stochastic manner. This is caused by many factors, whereas the behaviour of controllers, pilots, and supporting staff plays a greater role than technical performance parameter of aircraft. For example, a pilot may taxi slower if he is not familiar with the airport layout or may taxi faster if he is aware of being late. In summary the planning task has to be solved under uncertain and incomplete information and for an environment which is highly dynamic. In other words: The compliance of the real world dynamic (traffic situations) with earlier plans over a certain time interval is the exceptional case! Therefore adaptations of the plans have to be done – however, the question is to what degree!

An adequate, well-known technique to cope with such an environment is event-based repetitive planning. The planning horizon is than determined by the TTOT vector **t*** itself and usually will "slide" towards future times as new aircrafts come into the focus of the planning process. The stability of planning, necessary to allow the human operators a mental consideration, can be expressed as similarity between consecutive plans in an additional objective function (equation 1). This allows tuning the behaviour of the DMAN by changing the **a**-vector in equations 3 and 4 according to the accepted compromise between necessary stability vs. flexibility.

2.2 Operational Concepts

Before outlining the corresponding operational concepts of use, which are relevant to the integration of A-SMGCS and DMAN, some remarks to the general conditions are made.

2.2.1 General Conditions

First of all, the different stakeholders at an airport, in particular the ANSP, the airport owner, the airlines and ground handlers must support at least a first level of CDM, i.e. to provide data to be shared whilst ensuring a certain data quality. Moreover, among the airlines there must be a deeper understanding of how a DMAN is working. Thus

[3] For reasons of simplicity we will use the term "clearance" for both, clearances in an narrower scope (e.g. crossing clearance, take off clearance) and also for all commands (e.g. "hold short") and instructions (e.g. "taxi via ..").

they should understand that a DMAN in general replaces the FIFO-like strategy of requesting and getting the service of take off, for the benefit of overall optimisation, from which all will profit over a longer period. Furthermore, all airlines should agree that on average the introduction of a DMAN will lead to longer waiting times at the gate, but avoiding unnecessary engine running time and fuel burn, while waiting in a queue for take off.

However, a DMAN should provide several options for the controllers to adapt the planning process to a mode which is acceptable for all partners under the particular circumstances of traffic demand, available capacity, weather conditions, and other factors.

2.2.2 Concepts of Use

Although EUROCONTROL and DLR have been supporting the development of DMAN systems by several projects, workshops, and other promotion activities, the DMAN technology was subject to different modifications, as several ANSP or airports launched their own DMAN development. At the same time the same happened to the concept of use. Comparing the different local solutions and test trials, namely Zurich, Frankfurt, Munich, Stockholm Arlanda, Brussels, Prague, and Athens, the different concepts of use may be divided into two classes when the decision support level is used as main classification feature.

CADEO, the DMAN developed at DLR, is based on an operational concept which can be described briefly as follows: As long as controllers have no objections to the advisories they should closely follow the proposed timing of the operational steps. However, whenever controllers have good reasons to deviate from the plan they should do so. In these cases controllers should give clearances sooner or later than planned. CADEO will adapt to any deviations through constant planning (section 2.1.2). This concept implicitly leads to a differentiation between different controller working positions, with respect to the degree of required adherence to CADEO’s planning. For instance, runway/tower controllers, responsible for landing, line up, take off, and crossing clearances, must give a line up and take off clearance, according to their own assessment of the safety level and not according to a target time. Nevertheless they are supposed to maximise departure throughput. In contrast, controllers who are responsible for giving the (engine-) start up clearance, (Apron/Ground [GND] or Clearance Delivery [CLD]) usually have more leeway to closely adhere to the proposed timings without affecting safety. Another implication is the resulting interdependency of planning adherence and stability: On the one hand, controllers contribute directly to the planning stability by close adherence to the plans, on the other hand they are directly affected by any change of the proposed timing, which may in turn result from any caused deviation. In light of these considerations, the integration of DMAN and A-SMGCS shall provide an additional contribution to the stability of an earlier and less erratic adaptation to the actual traffic situation.

An alternative concept of use strives for a minimisation of the impact of the dynamic scheduling on the controller’s work. In this concept the DMAN provides TSAT recommendations only. Furthermore, the TSAT maybe stabilised with the help of filtering, freezing, or other heuristics, or even changed directly by the controllers. Since in this concept controllers do less contribution to the planning stability as they implement their mental plans, the DMAN must adapt constantly. However, in order to reach a considerable enhancement of capacity, reliability, efficiency, and compatibility with environmental requirements, the need to use surveillance data for a timely update of the departure planning seems to be even higher when the DMAN is running in a so called passive shadow mode.

3 INTEGRATION OBJECTIVES AND METHODS

The first section deals with the objectives of the integration derived from the limits of the current, non-integrated solutions first. The second section explains three different methods in detail, differentiated by the levels of A-SMGCS. The last section gives a short glance on an integrated HMI.

3.1 Objectives of Integration

The integration of DMAN and A-SMGCS may either target an improvement of the departure scheduling or the implementation of the schedule. The paper focuses more on the first aspect, i.e. how the departure scheduling can be improved by using A-SMGCS data (section 3.2). The second aspect which is closely related to the concept of an ICWP and has been addressed already [15]. Section 3.3 “Short Glance on an Integrated HMI” will not focus on human factor issues, but rather on which information should be displayed on an ICWP in order to support the implementation of planned departure schedules best.

An improved scheduling should overcome weak points of the non-integrated solution where the DMAN has to assess the actual traffic situation on controllers’ inputs after given and confirmed clearances. This causes an inherent latency when detecting and assessing the deviations of the current traffic situation from the planned one. Particularly when departure processes are delayed or interrupted, “negative” events must be introduced characterising the absence of expected clearances for the start of the following process. In addition, in many cases without surveillance data of the A-SMGCS the DMAN is unable to recognise that a planned sequence cannot be implemented anymore, due to the already established order of taxiing or queued aircraft (Figure 2).

The impracticability of a planned sequence not only may confuse the controllers, but in addition may result in an inadequate timing of consecutive departures, as separations between aircrafts depend on the order of take off operations. This effect increases in mixed mode operations where departures fill the gaps between landing aircrafts. In order to mitigate these effects the current version of CADEO offers additional means of enabling controllers to input interruptions of processes and allowing the establishing of additional sequence constraints for the scheduling.

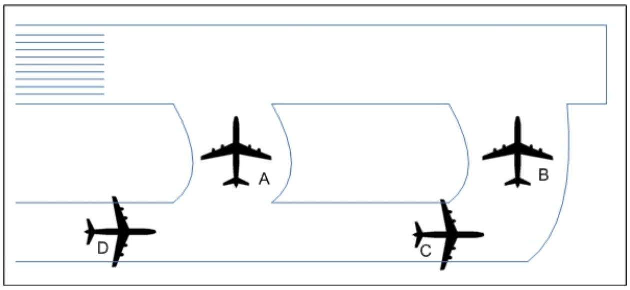

Figure 2: Generic example of constraints for possible departure sequences which are caused by the current traffic situation (example of impossible sequences: (A, **C**, **B,** D), (**C**, B, A, D), (A, D, **C, B**), (**D**, **A**, **B**, C))

As it will be shown in the next section from the point of view of an improved scheduling the A-SMGCS output data should be used to

- estimate the earliest time for take off (ETT) more precisely and
- update the ETT earlier (when necessary)
- identify automatically sequence constraints

whilst taking into account

- the taxi speeds
- planned or estimated taxi paths
- visibility, congestions level, and other environmental conditions
- taxi and queuing sequences.

Under the aspect of a “better” ground movement management, with respect to the implementation of the planned schedules, DMAN results should be used to improve the mental ground movement management by the apron and taxi controllers:

- Generate a better, consistent, and permanent situational awareness of the target schedule (ground movement management by target schedule).
- Immediate anticipation of consequences of taxi plans on take off schedule. This will decrease the frequency of too late arrival at runway threshold and in consequence either slot violations or returns to gate (or any other parking position) with the necessity of slot re-negotiation.

Overall the efficiency will be enhanced with all the positive side effects of a better harmonisation of planning and implementation of ground movements and departure schedules.

3.2 Integration Methods

The integrations methods will be differentiated by the levels of A-SMGCS whereas level 1 and 2 are summarised as well as level 3 and 4.

3.2.1 A-SMGCS Level 1 and 2

A-SMGCS Level 1 and 2 support surveillance data, which contain frequently reported positions of aircraft.

The positions reports can be used for

- analysis of the movement status,
- updating remaining taxi times, and
- derivation of sequences.

For the analysis of the movement status the position data is sufficient, knowledge of either the topography or topology is not necessary. With two succeeding position reports the movement speed can be calculated. If the speed than is less e.g. 5 km/h, the aircraft is supposed as not moving. This affects directly the ETT, so DMAN gets notice of the delay immediately when the aircraft holds, even before the next expected clearance is delayed (Figure 3).

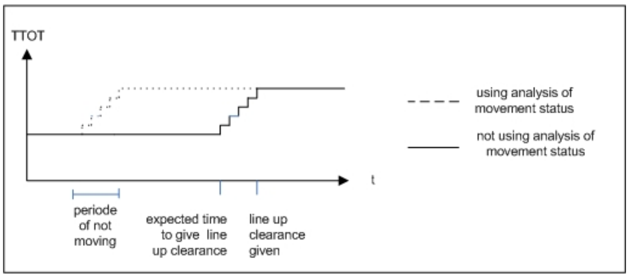

Figure 3: ETT and TTOT gradient using analysis of the movement status.

For both, to update the remaining taxi time and to derive sequences, the knowledge of the topography is necessary. Both actions will be triggered when an aircraft crosses a so called Virtual Gates (VGate). This could be imagined similar to crossing a light barrier. The VGate is defined as segment **s** through two coordinates, subtending the taxiway. If the vector **v**, build out of two consecutive positions, subtend the segment **s**, which is the VGate, the aircraft passed the VGate (Figure 4).

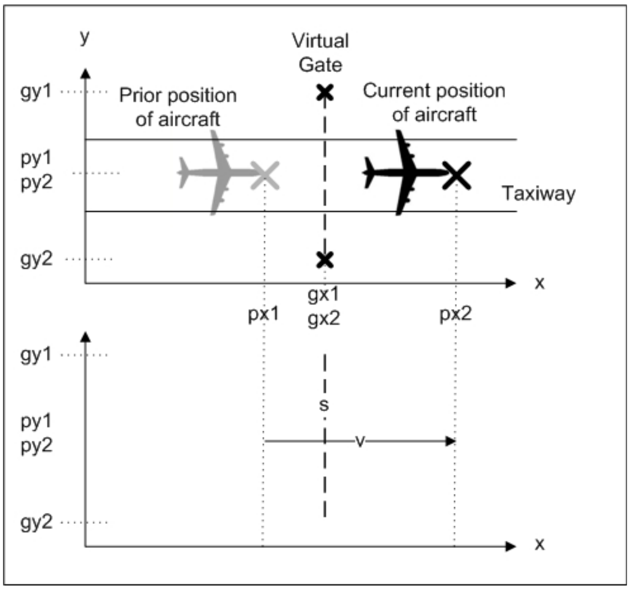

Figure 4: Basic principle of Virtual Gates.

The event of passing a VGate may trigger either the update of the remaining taxi time, the deriving of sequences or both. Updating the remaining taxi time when passing a VGate while taxiing, improves the ETT sooner than waiting for the next clearance event (Figure 5).

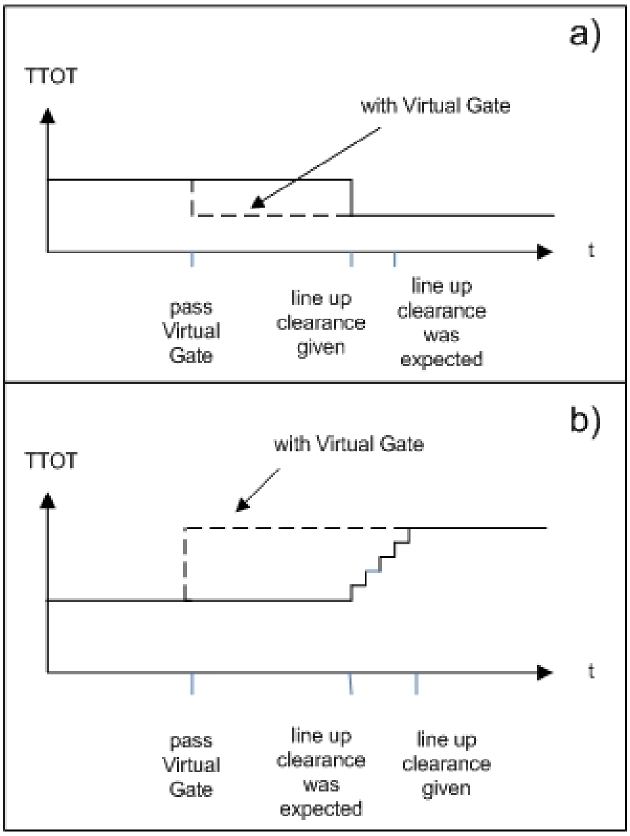

Figure 5: ETT gradients with and without using remaining taxi time updates. a) The remaining taxi time is less than estimated. b) The remaining time is more than estimated.

Deriving sequences or even sub-sequences will lead to quicker detection of deviations from the planned sequence. Especially if DMAN is used at an airport where sequence changes at the runway head are not possible, this may improve the departure scheduling a lot. Figure 6 shows the last taxiway segment and the runway entry. The VGate is placed on the taxiway directly behind the last merging point, after that sequence changes will not be physically possible any more. Deriving the sequence within the DMAN makes the planning from the human point of view more realistic and from the technical point of view shortens the width of the solution space, stabilizes the schedule of sequences and the sequences itself.

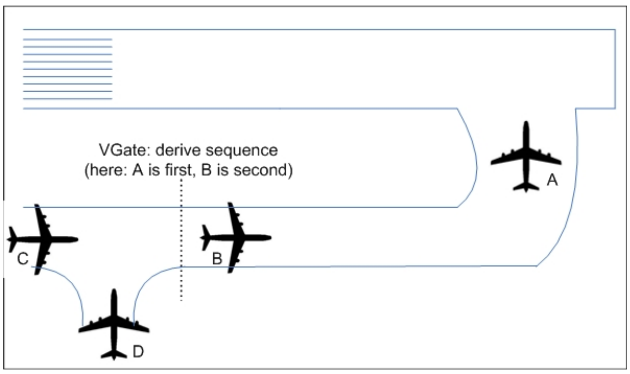

Figure 6: VGate for deriving sequences at a runway with one entry.

Sub-sequences could be derived if VGates were placed at the runway entries directly behind the last merging point and the last branch, after that sequence changes will not be physically possible any more (Figure 7). In this example a sub-sequence can be derived within the DMAN with the same advantages described above.

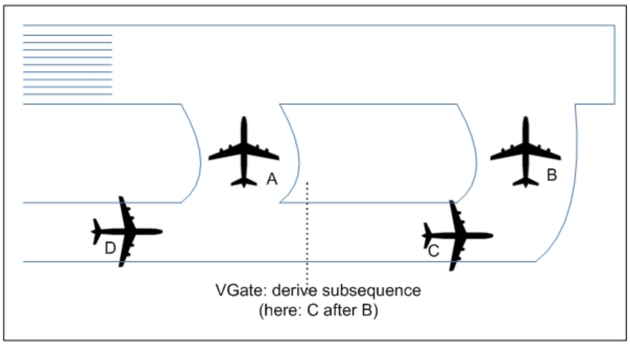

Figure 7: VGate for deriving sub-sequences (example).

To improve the departure scheduling and sequencing through the usage of VGates, not only the topography is needed, but also knowledge of the operational procedures. Only well chosen combinations of the VGate's position and attached actions executed, when the VGate is crossed, will improve the departure scheduling.

Example: The VGate L in Figure 9 is a good example of a well placed VGate. Taxiway L is used for departures and arrivals as well. If a departure has to wait e.g. on taxiway M, to give way to an arrival, the VGate functionality updates the taxi time much more in advance than waiting for the other VGates or the line up clearance or, to be more precise, the delay of the line up clearance.

3.2.2 A-SMGCS Level 3 and 4

A-SMGCS Level 3 and 4 contain a surface management system (SMAN), which either plans taxi routes and updates repeatedly the taxi times or, at minimum, makes taxi time predictions, which are also updated repeatedly. The taxi time prediction or planning may include several factors, e.g. manual inputs to set and modify the taxi route, take into account congestions, day and night regulations, visibility conditions, de-icing constraints, e.g. particular taxi ways must not be used by de-iced aircrafts.

When integrating DMAN and SMAN it has to be taken into account if aircraft are already taxiing or not.

Before the aircraft starts taxi

1 SMAN calculates the taxi route, taking into account constraints, optimisation criteria, conflicts, dead lock situations etc. The ETT will be calculated, taking into account the taxi route.

2 DMAN uses the ETTs of the departure to calculate the TTOTs as described in sections 2.1.1. TTOT will be greater or equal ETT.

3 SMAN calculates the TSAT, knowing the TTOT and optimises the taxi route. TSAT will be displayed to the controllers. If new route constraints are required, the procedure starts again with step 1.

If the aircraft is taxiing, the ETT will be updated cyclic using A-SMGCS surveillance data, which again influences the calculations of the departure schedule by DMAN.

Another idea, which is outlined here only, is to do hot spot analysis at particular crossings on taxiways and derive recommendations for the sequence the aircraft shall cross. This will have impact on the ETT and the sequence on the taxiways [16].

3.3 Short Glance on an Integrated HMI

This section will give a short glance on the benefits controllers get, if DMAN and A-SMGCS information are integrated into one HMI, an integrated controller working position (ICWP). Figure 8 shows an example of an HMI prototype which is in development at DLR. The aircraft positions are shown on the map and the electronic flight strips contain detailed information, including TSAT, TTOT and RTUC from the DMAN (here: CADEO).

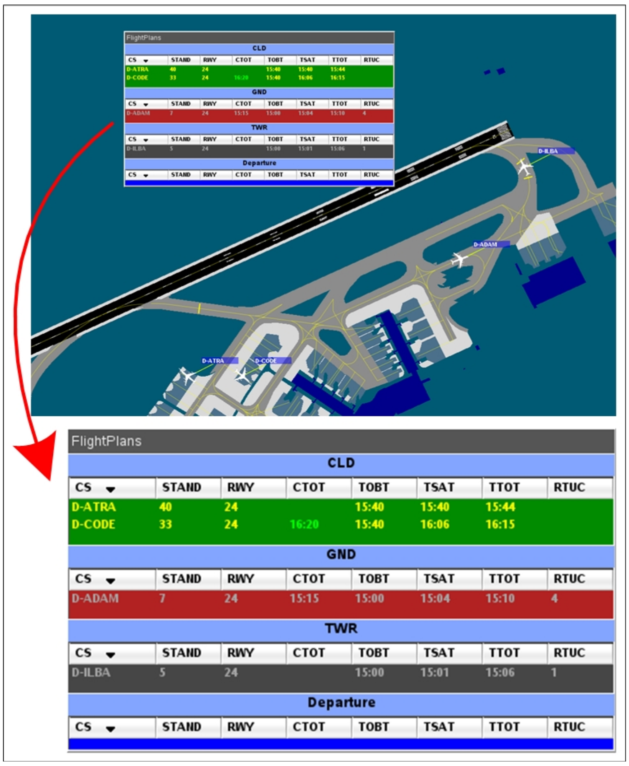

Figure 8: HMI showing aircraft positions and information provided by CADEO to support the implementation of planned sequences (TSAT, TTOT, sequence number, RTUC).

4 CASE STUDY OF PRAGUE AIRPORT

Within the EMMA2 (European Airport Movement Management by A-SMGCS, part 2) project simulations of the airport Prague Ruzyne took place with A-SMGCS and DMAN integrated. The main goal of the EMMA2 project is the holistic, integrated air-ground approach, considering advanced aircraft with pilot assistance systems in a context of tower and apron controllers, supported by A-SMGCS ground systems. One factor is also the integration of A-SMGCS and DMAN and a validation through real time simulations and shadow mode trials at the airport Prague Ruzyne.

4.1 Description of the Trials

In June 2008 simulation trials took place at DLR site in Braunschweig with an electronic flight strip system (EFS), showing also planning information from CADEO, and an A-SMGCS HMI next to it. The trials were performed by Prague controllers within a tower simulation supported by pseudo pilots.

4.2 Preliminary Findings

Even if the validation will only be finalised in October 2008, first conclusions can be given: The output of CADEO, departure schedule planning and the recommendations to implement them, shown within the EFS, were supporting the controllers work. By using the VGates shown in Figure 9 improved planning results were achieved, in comparison to former tests without these VGates.

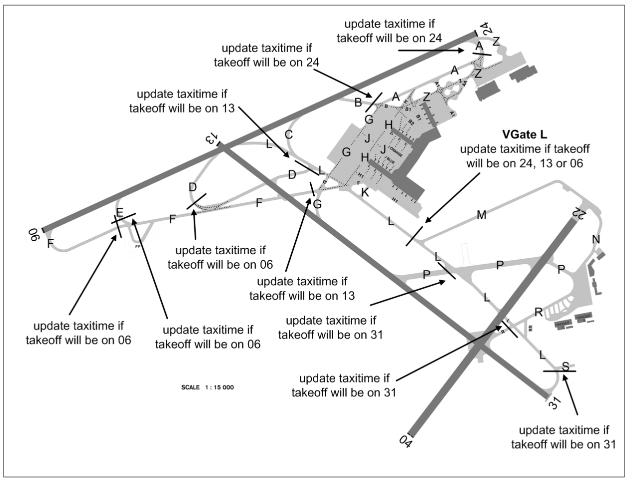

Figure 9: VGates used in simulations trials at airport Prague.

5 SUMMARY AND OUTLOOK

A-SGMCS and DMAN may be integrated under the aspect of algorithms and technical features as well as under the aspect of HMI design and functionality. This article focuses on the former and describes how movement status analysis can advance DMAN planning. The VGates are introduced and it is presented how taxi time can be updated early and sequences can be derived. If a SMAN is available, it is suggested how the surface movement planning and the departure schedule and sequence planning shall be integrated. Different solutions need different know-how. The movement status analysis is low level and needs only frequent position data. The VGates require knowledge of the topography and the operational procedures. Integrating SMAN needs A-SMGCS level 3 or 4.

The more A-SMGCS and DMAN features will be developed, a higher level of integration will be achieved. To start using position data is quite an easy way to improve the departure planning, without increasing the workload of the controllers.

6 ABBREVIATIONS

A-CDM	Airport CDM
ANSP	Air Navigation Service Provider
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATC	Air Traffic Control
CADEO	Controller Assistance for Departure Optimisation (i.e. the DMAN from DLR)
CDM	Collaborative Decision Making
CFMU	Central Flow Management Unit
CLD	Clearance Delivery
CTOT	Calculated Take Off Time
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
DMAN	Departure Management System
EFS	Electronic Flight strip System
EMMA	European Airport Movement Management by A-SMGCS
ETT	Earliest possible Take off Time
FIFO	First In First Out
GND	Ground/Apron Control
HMI	Human Machine Interface
ICAO	International Civil Aviation Organisation
ICWP	Integrated Controller Working Position
IT	Information Technology
RTUC	Recommended Time Until next Clearance
SID	Standard Instrument Departure Route
SMAN	Surface Management System
SMGCS	Surface Movement Guidance and Control System
TAM	Total Airport Management
TOBT	Target Off-Block Time
TTOT	Target Take Off Time
VGate	Virtual Gate

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