Managing of Turnaround Priorities for Schiphol Airport

Report by MovingDot and NLR for KDC

Page intentionally left blank

Contents

Page intentionally left blank

Abbreviations & acronyms

ACRONYM	DESCRIPTION
AAS	Amsterdam Airport Schiphol
A-CDM	Airport- Collaborative Decision Making
AIBT	Actual In Block Time
AIP	Aeronautical Information Publication
AirTOp	Air Traffic Optimizer (platform for fast-time simulation of air traffic and airport operations)
ALDT	Actual Landing Time
AOBT	Actual Off Block Time
APC	Apron Control
ASRT	Actual Start-up Request Time
ATA	Actual Time of Arrival
ATC	Air Traffic Control
ATD	Actual Time of Departure
CISS	Centraal Informatie Systeem Schiphol
CPDSP	Collaborative Pre-Departure Sequence Planning system
CTOT	Calculated Take-Off Time
EDD	Electronic Data Display
EIBT	Estimated In-Block Time
EFS	Electronic Flight Strips
GC	Ground Controller
GMS	Gate Management System
KDC	Knowledge & Development Centre
LT	Local Time
LVNL	ATC the Netherlands
MD	MovingDot
MLT	Multilateration (aircraft/vehicle position data)
NLR	Netherlands Aerospace Centre
RASAS	Regulation Aircraft Stand Allocation Schiphol
RETD	Revised Estimated Time of Departure
SID	Standard Instrument Departure
STD	Scheduled Time of Departure
TOBT	Target Off-Block Time
TSAT	Target Start-Up Approval Time
UTC	Universal Time Coordinated
VDGS	Visual Docking Guidance System
VOP	Vliegtuig Opstel Plaats

Page intentionally left blank

1 Introduction

1.1 Background

Traffic growth for Schiphol is predicted to result in 500.000+ movements per year. To accommodate this growth, effective and efficient use of current infrastructure is paramount to ensure continued safe operations. Schiphol has a definite amount of aircraft parking stands, both on aprons and at gates.[1]

Currently available assets are possibly not used optimally, resulting in a perceived shortage. The divergent priorities of the major stakeholders specifically lead to unnecessary inefficient use of aircraft parking stands.

If Schiphol is to grow sustainably and with economic benefit, it must – amongst other things – solve the underutilisation of aircraft parking stand capacity. Smart use of currently available assets will alleviate the impacts of traffic growth, at least in the short term. If unaddressed, the perceived shortage will result in actual shortage as traffic grows. Resolution will require cooperation amongst various stakeholders and consideration for different needs and priorities.

Capacity demand is growing and is expected to continue to grow in the coming years. The issue of underutilisation must be addressed now if it is not to limit the potential growth. Schiphol's position as one of the large airports in Europe is dependent on being able to grow with demand.

1.2 Objective

Being able to process large amounts of movements, requires management of runway, taxiways and gate availability. For a set infrastructure, optimization becomes essential in being able to process the largest feasible amount of movements.

The objective of this project it to, based on the currently available infrastructure, develop a set of priority rules to help optimize the airport throughput, specifically the management of gate availability. This involves identifying several possible priority rules alternatives. Ultimately, a separate Airport-Collaborative Decision Making (A-CDM) initiative will have to come to new priority agreements.

1.3 Scope

The scope of this project is limited to the currently available airport infrastructure and analysed nominal operations.

[1] Aircraft parking stands on the apron and at gates are both considered VOPs. In this research, based on CDM data, when gate changes are mentioned, only ramp (VOP) changes are considered.

1.4 Prerequisites and cooperation

To achieve the objective, adequate participation from the various stakeholders is imperative. The following information was necessary and made available:

- Data on gate allocation (RASAS) and utilisation - from Amsterdam Airport Schiphol (AAS)
- Data on ground movements - from ATC the Netherlands (LVNL)
- Information on internal airline prioritisation – from a legacy airline and a low-cost carrier
- Operational needs and priorities – from AAS, airlines and ground handling service providers
- Operational procedures – from LVNL

1.5 Project consortium

The project was performed by a consortium of two partners: The Netherlands Aerospace Center (NLR) and MovingDot. Both have a long history in airport related research and have several strong points that make the consortium better than the sum of the individuals.

The experts who contributed to the results of the study are:

- Nienke Jester (MovingDot) – Project lead and ATM Expert
- Cornel van Ravenswaaij (MovingDot) – OPS expert – Ground & CDM
- Justin The (MovingDot) – ATM Expert
- Jan-Hein van Dronkelaar (NLR) – ATM & FTS expert
- Robert de Muynck (NLR) – ATM & flight operations expert

Special thanks to Eugene Leeman for facilitating stakeholders contact and all the stakeholders for providing invaluable input.

2 Methodology

Several data and fact collection activities were undertaken, to come to a suggested set of priority rules. The different development steps are described in detail in the following sections. The results of the activities, namely:

- Identification of limiting capacity factor(s);
- Impacts of priority rules;
- Determination of effects of priority rules on throughput.

are presented in chapters 4 and 0.

2.1 Data and facts collection

The data collection process consisted of several steps that together formed the foundation for the study. This activity consisted of the following data and information gathering activities:

- Ground movement data, from LVNL;
- CDM data from AAS;
- Interviews with stakeholders.

Note: A literature study was not deemed of added value given the available data and the input received from the stakeholders through interviews.

2.1.1 Statistical data

2.1.1.1 CDM data

Airport Collaborative Decision Making (CDM) is a concept which aims to facilitate the sharing of operational processes and data to allow for better informed decisions. CDM data at Schiphol contains 37 different information items, including flight information and CDM milestones. The full list of items can be found in 0. For each flight, the first line of data is generated several hours prior to the scheduled arrival or departure. A new line is generated following every modification. Each individual flight has around 30 separate lines.

The CDM data provided to the project team by AAS, covers a period from November 18th, 2015 (day when CDM went live at Schiphol) through October 9th, 2017. CDM data was used both for data analysis, and for visualising flights in AirTOp. Since off-nominal operations are out of scope, the analysis concentrated on a representative month, namely July 2017. That month was selected based on the following characteristics:

- High traffic volume (summer season)
- No major disruptions due to weather, ATC strikes, etc.
- No de-icing operations
- Data is recent

The following CDM data parameters were critical in the performed analyses:

- **Actual In-Block Time (AIBT)** – actual time that an aircraft arrives in blocks
- **Actual Landing Time (ALDT)** – time that an aircraft lands on a runway.
- **Actual Start-up Request Time (ASRT)** – time when a pilot request permission for start-up. At Schiphol, this is the moment when the Outbound Planner generates the Revised Estimated Time of Departure (RETD).

- **Calculated Take-Off Time (CTOT)** – term is allocated by Network Manager Operations Centre (NMOC) for regulated flights.
- **Estimated In-Block Time (EIBT)** – estimated time that an aircraft will arrive in blocks.
- **Revised Estimated Time of Departure (RETD)** – time set manually by ATC when the flight is planned in the active outbound sequence.
- **Target Start-up Approval Time (TSAT)** – time provided by ATC that an aircraft can expect start-up/push back approval. The pilot is required to request start-up within the TSAT window The TSAT window is defined as -/+ 5 minutes from TSAT. If start-up permission is requested prior to the TSAT window, the flight is requested to call again when it is within its TSAT window. If start-up permission is requested after the TSAT-window, the TSAT has expired, and the flight will be denied start-up approval. The pilot is requested to contact its handler to update the TOBT.

  TSAT is calculated based on:
    - TOBT update which is earlier than the previous TOBT or later than the current TSAT
    - (a new) CTOT
    - A change in planned capacity or RWY-usage (for the next planned RWY combination)
    - A change in current capacity or RWY-usage (for the RWY combination in use)
    - Assignment and changes in RETD values by the outbound planner
- **Target Off-Block Time (TOBT)** – time, based on the end of the handling process, an aircraft expects to be ready to leave the stand. It does not take the availability of a pushback truck, when needed, into account.

2.1.1.2 MLT data

MLT (multilateration) data comprises information on the position of a vehicle (e.g., aircraft or tow truck) on the airport. This position information is recorded every second, providing accurate information on the position (and thus speed) and track of any vehicle.

The MLT data, provided by LVNL, covered a full-year period from September 2016 through August 2017. To 'limit' the huge amount of data, only the period between 04:00 and 20:00 (local time) was considered, still yielding files exceeding 900,000 records per single day. An example of the MLT data is given in Figure 1 below.

track_id	flight_id	type	t	x	y	lat	lon
15255157	10512755	OUTB	01-07-2017 4:55:14	26,3	-23,2	5230449	476799
15255157	10512755	OUTB	01-07-2017 4:55:15	26,5	-23,4	5230446	476803
15255157	10512755	OUTB	01-07-2017 4:55:16	26,6	-23,6	5230444	476805
15255157	10512755	OUTB	01-07-2017 4:55:17	26,9	-23,8	5230441	476812
15255157	10512755	OUTB	01-07-2017 4:55:19	26,9	-23,8	5230441	476812

Figure 1 - Example of MLT data provided

track_id *unique identifier for each individual vehicle movement*
flight id *unique identifier for each flight*
type *movement type (INB = inbound, OUTB = outbound, SLP = towing)*
t *date and time (local)*
x *position x-coordinate (airport axis system)*
y *position y-coordinate (airport axis system)*
lat *position latitude (WGS-84 coordinate system)*
lon *position longitude (WGS-84 coordinate system)*

An individual movement consists of the full movement from its start to its end. For inbound aircraft such a movement starts at the landing runway and ends at the parking position; for outbound aircraft they start at the parking position and end at lift-off. It is important to realize that no MLT data is available when the transponder is switched off (e.g., when the aircraft is parked at its gate or parking position). Consequently, no position data is available for aircraft that are parked or aircraft that are being towed. In the latter case, position information of the towing vehicle (tow truck) is available. Tow truck MLT data, however, consists of position data only: no information of the aircraft being towed is available, nor whether the tow truck is towing an aircraft or not.

The MLT data was used to produce and visualize the vehicle movements (aircraft and tow trucks) on the airport. The MLT data provided therefore needed to be converted into playback data suitable for AirTOp (Air Traffic Optimizer), the fast-time simulation platform developed by NLR. For this purpose, a special tool was developed, enabling the import of the MLT data in AirTOp. The AirTOp simulation already comprised a detailed airport and airspace model of Schiphol Airport and its surrounding airspace. This enabled an accurate visualisation of all vehicle movements on the airport. A screenshot of such a playback 'simulation' is depicted in Figure 2.

Figure 2 shows (the position of) different vehicles (aircraft and tow trucks) on the airport as well as a selected aircraft ground track (yellow line). The AirTOp playback 'simulations' enable the visualisation of the traffic movements, although a paper document doesn't allow to demonstrate so. The playback 'simulations' allow for quickly visualization and assessment of the trajectories the vehicles have followed and where on the airport aircraft have been stopped, for example, to wait for a gate to become available ('delay absorption').

Figure 2 - Screenshot of a playback 'simulation' with AirTOp (yellow line is selected aircraft ground track).

For the identification of aircraft vs ground vehicles, the MLT data had to be combined with Flight plan data (see below), also provided by LVNL. This allowed the MLT data to be correlated and sorted for aircraft types and type of movement.

2.1.1.3 Flight plan data

To enable the identification of the different vehicles in the AirTOp playback 'simulations', Flight plan data was used. Examples of such a data files are given in Figure 3 and Figure 4, for inbound and outbound flights respectively.

FLIGHT_ID	CALLSIGN	AC_TYPE	REGISTRATION	RW_ARR	ATA	ATA_LT	RW_EXIT	P_POSITIE	AIBT	ARR_GATE
10544076		B788		36C	15-07-2017 3:08	15-07-2017 5:08	W2		15-07-2017 3:18	E07
10544071		A333		36C	15-07-2017 3:11	15-07-2017 5:11	W3		15-07-2017 3:18	F05
10544078		A333		36C	15-07-2017 3:13	15-07-2017 5:13	W3		15-07-2017 3:23	E08
10544088		A332		36C	15-07-2017 3:16	15-07-2017 5:16	W3		15-07-2017 3:26	E18
10544080		B752		36C	15-07-2017 3:21	15-07-2017 5:21	W4		15-07-2017 3:30	S90
10544095		B744		36C	15-07-2017 3:30	15-07-2017 5:30	W2		15-07-2017 3:40	S84
10544097		A332		36C	15-07-2017 3:34	15-07-2017 5:34	W4		15-07-2017 3:42	E22
10544089		B772		36C	15-07-2017 3:37	15-07-2017 5:37	W3		15-07-2017 3:44	F03
10544084		B788		36C	15-07-2017 3:40	15-07-2017 5:40	W3		15-07-2017 3:48	E17
10544082		B772		36C	15-07-2017 3:42	15-07-2017 5:42	W4		15-07-2017 3:48	F06

Figure 3 - Example of flight plan data provided (inbound flights).

FLIGHT_ID	*unique identifier for each flight*
CALLSIGN	*aircraft callsign*
AC_TYPE	*aircraft type*
REGISTRATION	*aircraft registration (information not provided)*
RW_ARR	*arrival runway*
ATA	*Actual Time of Arrival (UTC)*
ATA_LT	*Actual Time of Arrival (local time)*
RW_EXIT	*runway exit*
P_POSITIE	*holding position*
AIBT	*Actual In Block Time*
ARR_GATE	*arrival gate*

FLIGHT_ID	CALLSIGN	AC_TYPE	REGISTRATION	DEP_GATE	AOBT	RW_ENTRY	RW_DEP	SID	ATD	ATD_LT
10544087		B738		D41	15-07-2017 3:02	V4	36L	REN1Z	15-07-2017 3:19	15-07-2017 5:19
10544085		B738		D53	15-07-2017 3:06	V4	36L	REN1Z	15-07-2017 3:22	15-07-2017 5:22
10544092		B738		D55	15-07-2017 3:10	V4	36L	SPY2V	15-07-2017 3:27	15-07-2017 5:27
10544091		B738		C04	15-07-2017 3:10	V4	36L	KDD1Z	15-07-2017 3:29	15-07-2017 5:29
10544256		B738		D12	15-07-2017 3:12	V4	36L	REN1Z	15-07-2017 3:34	15-07-2017 5:34
10544090		B738		C15	15-07-2017 3:20	V4	36L	REN1Z	15-07-2017 3:41	15-07-2017 5:41
10544094		B738		C13	15-07-2017 3:27	V4	36L	KDD1Z	15-07-2017 3:48	15-07-2017 5:48
10544101		B738		D43	15-07-2017 3:33	V4	36L	REN1Z	15-07-2017 3:51	15-07-2017 5:51
10544100		B738		E04	15-07-2017 3:39	V4	36L	ARN1Z	15-07-2017 4:00	15-07-2017 6:00
10544104		B738		D52	15-07-2017 3:42	V4	36L	KDD1Z	15-07-2017 4:04	15-07-2017 6:04

Figure 4 - Example of flight plan data provided (outbound flights).

FLIGHT_ID	*unique identifier for each flight*
CALLSIGN	*aircraft callsign*
AC_TYPE	*aircraft type*
REGISTRATION	*aircraft registration (information not provided)*
DEP_GATE	*departure gate*
AOBT	*Actual Off Block Time*
RW_ENTRY	*runway entry*
RW_DEP	*departure runway*
SID	*SID*
ATD	*Actual Time of Departure (UTC)*
ATA_LT	*Actual Time of Departure (local time)*

The unique Flight ID available in both the MLT data and Flight plan data allows the position information to be connected to a flight and its related aircraft type. The connection with a physical aircraft could not be made using this data as the Registration information was not provided. This information allows to make the connection between an outbound and an inbound flight. However, using the CDM data provided by AAS made it possible to retrieve this information based on the callsign. Note that this operator specific information was only used to correlate and combine all relevant flight information for the anonymous analysis of data.

2.1.2 Interviews with stakeholders

Interviews were held with representatives of the different stakeholders to identify their challenges, needs and preferences with regards to aircraft VOPs and holding positions. The objective was to additionally identify specific improvement wished of the different stakeholders and how these wishes of the different stakeholders compare. The following stakeholder groups were identified:

- *Airlines.* Depending on an airlines' specific business model, what their specific priorities and needs might be. As such, two airlines with significant operations at Schiphol airport were interviewed. One a legacy carrier that operates both short-haul and long-haul international scheduled services, with Schiphol as its primary hub, and provides ground handling for both its own flights, as for other airlines. The second a low-cost carrier, operating domestic and international scheduled services, with a reasonable amount of flights into and out of Schiphol.
- *Airport.* Amsterdam Airport Schiphol (AAS) is responsible for the overall airport infrastructure as well as some movements on the platforms and manoeuvring area. Although ATC is ultimately responsible for every movement on the manoeuvring area, AAS controls tow movements.
- *Air traffic control.* ATC the Netherlands (LVNL) is responsible for aircraft movements with focus on efficient traffic flows.
- *Ground handling service providers.* Providing all ground related activities around the gates, including services such as de-icing, refuelling, towing operations.

Representatives from each stakeholder group were approached.

Two rounds of interviews were held. The first interview sessions were held to obtain insight into current (planning) priorities and corresponding challenges. The second to share examples of notable situations which reflect experienced disruptions and possible mitigation alternatives based on the input obtained during the first round of interviews and identify the stakeholders' pros and cons to each alternative.

First round questions

1) *What is your specific role and corresponding responsibilities with regards to gate occupancy?*
2) *How is current gate occupancy managed?*
3) *Are there gate priority rules, and are you aware of this? (e.g. inbound vs. outbound)*
4) *Is buffer handling acceptable (i.e. connected / buffer / pax handling via bus)*
5) *What are key decision moments? At which stage(s) of the flight?*
6) *What information is available to support decision-making? System, human?*
7) *What info is not available, but would be of help to support decision-making?*
8) *With whom is gate occupancy coordinated? (i.e. which other stakeholders) How: system? Telephone? Human?*
9) *What are known bottlenecks?*
10) *How does (type of) traffic affect workload?*
11) *What are some typical / common off-nominal operations?*
12) *What measures / decisions are taken when flights deviate from their schedule (and a gate is not yet / no longer available). Is the process transparent, efficient?*
13) *What are some wishes / recommendations for optimizing gate occupancy?*

Second round questions

Following the consolidation of the information obtained from the different stakeholders and the processing of available data, five research questions were developed with corresponding hypothesis for outcomes. During the second round of interviews initial analysis finding were/will be discussed. The main question being whether the initial findings align with their experiences and whether they are open to the project team's initial recommendations.

2.2 Simulation

One of the tools used in this study is the AirTOp (Air Traffic Optimizer) fast-time simulation platform. For the data analysis part of this study, AirTOp was used to visualize past operations, namely playback 'simulations' based on the MLT data provided. These playback 'simulations' allow to quickly assess vehicle (e.g., aircraft, tow trucks) trajectories and vehicle behaviour on Schiphol Airport.

For inbound aircraft, trajectories immediately reveal when an aircraft made use of a holding position (P-holding or R-holding), before being allowed to taxi to its assigned parking position (see Figure 5 and Figure 6).

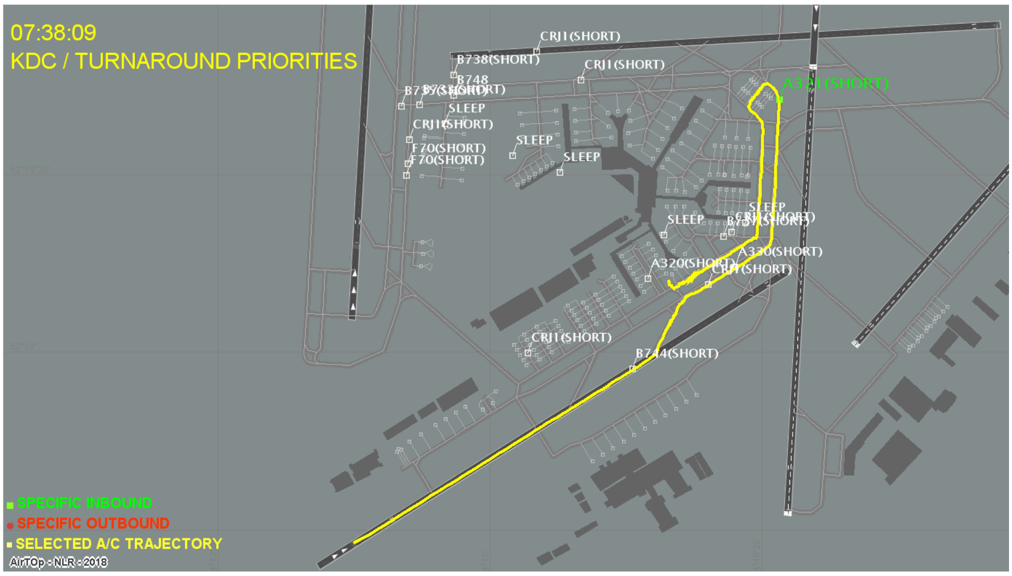

Figure 5 - Example of inbound flight using P-holding position while waiting for gate to become available.

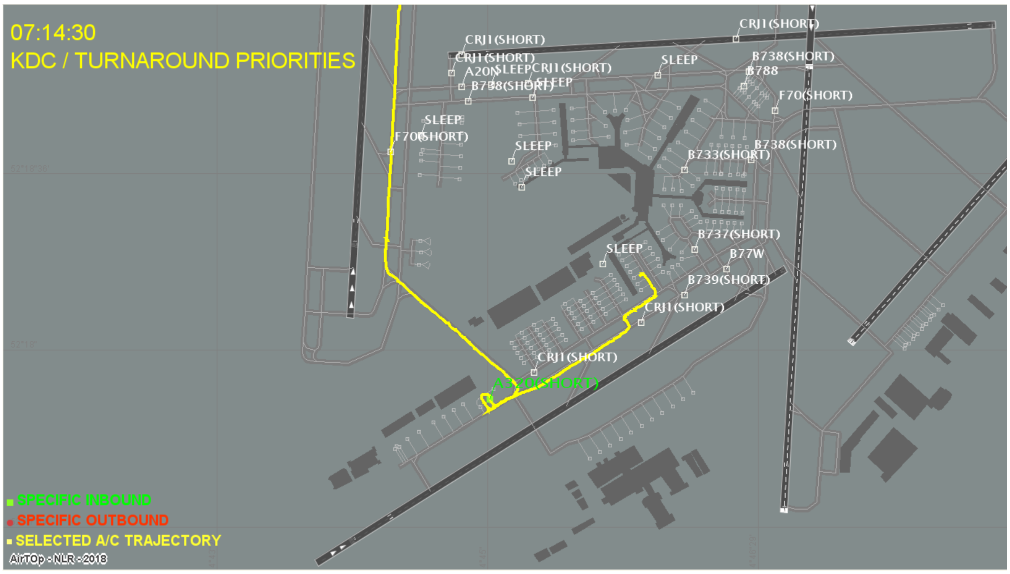

Figure 6 - Example of inbound flight using R-holding position while waiting for gate to become available.

When running the playback 'simulation', the tool can also help to quickly identify locations, other than the holding positions, where an aircraft has stopped to absorb the necessary delay before being able to taxi to the assigned parking position. Additionally, other techniques used to make an aircraft wait for its parking position to become available and at the same time avoiding delays for other traffic, can be easily visualized (see Figure 7).

Figure 7 - Example of inbound flight making a slight detour to absorb minimal delay before the gate becomes available.

Figure 5, Figure 6, and Figure 7 give an initial insight into the impact of a temporary gate unavailability on airport operations. *Note: Videoclips of these and other occurrences have been prepared to be presented to the KDC during the presentation of the results of this study.*

2.3 Establishing a set of priority rules

The current priority rules for stand allocation (gates, remote stands, buffers) are principally governed by the regulations as laid out in the RASAS document. This document describes the priorities that are applied for the allocation of gates or stands to aircraft, depending on many factors.

Each day, based on the winter or summer season planning and fine-tuned by the input from the ground handling agents and airlines on exact aircraft types and passenger counts for the next day, a one-day-ahead operational gate planning is created by AAS using the Gate Management System and released between 19-20h LT.

Gate allocation must consider the aircraft size (9 categories, with a range of narrowbody and widebody aircraft), flight with Schengen/non-Schengen origin or destination, as well as other security considerations. Furthermore, aircraft stands and gates are divided into located in the “central transfer zone” or the “common use zone”. The central transfer zone is dedicated to flights with transfer passengers. The common use zone is used for predominantly point-to-point flights without transfer priority, for example for low cost carrier operations.

Specifically, the priority rules contained in the RASAS document consider the following principles (in order of importance) for the allocation of stands at Schiphol Main Terminals:

1. *Airlines with primarily transfer passengers will be allocated gates in the Central Transfer zone.*
2. *Airlines with few or no transfer passengers will be allocated outside this zone.*
3. *Minimum 20 minutes separation is planned between a departing aircraft and the next arriving aircraft. This value is reduced for aircraft being towed in/out or may be increased based on available time.*
4. *Aircraft should be moved from an allocated pier gate in case of delay > STD + 20 min.*

5. *Pier handling is prioritised over remote handling.*
6. *Aircraft are allocated stands that best fit their size and may be allocated a stand for a larger aircraft only if available.*
7. *Passenger numbers determine the priority to allocate gates/stands with larger waiting areas.*
8. *If the use of remote aircraft stands is required due to unavailability of gates, passenger numbers will determine the priority.*
9. *Widebody aircraft with ground time during turnaround > 3.5hrs should be towed away if capacity requires, for narrowbody this applies if > 2h50.*
10. *Flights handled by a given handling agents are preferred to be clustered for handling efficiency.*
11. *Agreements can be made with airlines/handling agents on preferred use of pier gates.*
12. *Dual status flights (Schengen changing to non-Schengen and vv) should be handled at a dual status gate. Other gates required special handling of arriving or departing passengers.*
13. *Nightly stopovers should be able to stay at their arrival pier gate.*
14. *Aircraft at adjacent stands should not depart/arrive at the same time.*
15. *Shuttle bus gates are allocated in the relevant border area (Schengen/non-Schengen).*
16. *Last minute changes of flights (aircraft type, delayed STA/STD) after daily ahead planning may lose the assigned gate if capacity requires.*
17. *Occupied pier gates may require allocating a different gate, remote holding upon arrival, or remote handling depending on available stands.*
18. *Low cost airlines with short turnaround times are offered the H/M pier. Generally, this requires a turnaround within 30 minutes and a reduced separation time of 10 min between dep/arr flights.*

Under normal day-to-day conditions gate and stand allocation is based on the daily planning created the day prior using the Gate Management System (GMS). During the day, with usual disturbances due to earlier/later arrivals, technical delays and ATC arrival and departure sequence changes, the gate planning is continuously updated by AAS based on inputs from handling agents, airlines and flight updates.

With the application of the priority rules contained in the RASAS (see bullets 1 through 18 above), the rules and procedures still leave some room for alternate solutions towards achieving the daily planning and absorbing disturbances. Depending on the day and general operational circumstances, disturbances or traffic situations are handled differently. Daily trade-offs are made based on, amongst others:

- preferences with regards to taxiway and gate occupancy times
- preferences with regards to inbound and outbound traffic flows
- preferences with regards to towing movements

Based on the stakeholder interviews, analysis of data obtained for the project (MLT, CDM, flight plan), and the assessment of the research questions, different priority rules and solutions will be discussed and evaluated.

2.4 Expected results

This study will provide KDC with insights into the limiting factors for efficient use of aircraft stands at Schiphol airport and, if applicable, a recommendation for priority rules modification.

3 Data and interview findings

3.1 Stakeholder roles and interests

Through the interviews the specific stakeholder roles and interests with regards to gate management were identified. They are summarized in the bullets below.

Airlines

Legacy carrier

- Provides passenger connect operations.
- Is both an airline, ground handling agent, and provides maintenance.

Low-cost carrier

- Provides 'in & out' operations, no transfer of passengers.
- Quick turnaround required for business model.
- Priority is outbound aircraft (on-time departure).
- Expansion at Schiphol is (also) limited by available slots.
- Gate management and handling is delegated to a ground handling service provider.

Amsterdam Airport Schiphol (AAS)

- Owns and manages VOPs.
- Responsible for gate planning and management, using Gate Management System (GMS).
- Gate allocation is coordinated with handling agents through Centraal Informatie Systeem Schiphol (CISS).
- Provides capacity analyses and forecasts (up to 5 yrs.) and season planning.
- Daily planning, one day ahead plus last-minute updates.
- Transfer of passengers to/from aircraft, by means of passenger boarding bridge or bus.

LVNL

- LVNL is responsible for guiding a specific flight to and from a VOP allocated by AAS.
- VOP allocation is made know to ATC through the generation of a flight strip in the AAA-system about 30 minutes prior to an aircraft landing. A gate change will trigger re-issuance of a flight strip.
- Ground Controller (GC) is responsible for providing aircraft with taxi instructions.
- Although LVNL is ultimately responsible for every movement on the manoeuvring area, AAS controls tow movements.

Ground handling service providers

To low-cost carrier and limited Schiphol-use operators

- Provides ground handling services for several Schiphol users, with a relatively large low-cost carrier being its largest customer.
- Ground handling in the morning hours is focussed at H-pier, and later during day also more distributed over other locations.
- To keep available equipment and personnel manageable, aim is to concentrate handling operations at H-pier or grouped gates.

By legacy carrier

- Airline and ground handling agent, and provides maintenance.

3.2 Stakeholders experienced bottlenecks

Through the first round of interviews with the stakeholders, various experienced factors limiting efficient ground movement and efficient utilisation of aircraft parking stands were identified:

Airlines

Legacy carrier

- Early arriving aircraft, sudden capacity peaks/changes.
- Unstable TSAT information resulting in start-up delays.
- Updating TOBT information is often not done due to cumbersome process. CDM does not assist in this.
- Insufficient gate capacity requires use of (undesired) buffer handling.[2]

Low-cost carrier

- Aircraft access to H-pier is an issue (single taxiway, cul-de-sac, wide-body pushback from G-pier).
- Availability of gates is insufficient.
- Turnaround at locations other than preferred gates at H-pier takes longer than 30 min target.
- Presented TSAT information is too dynamic.

Amsterdam Airport Schiphol (**AAS**)

- Increasingly limited availability of gates and buffer positions.
- Information exchange between stakeholders, reasons for delays are not always explained
- Expansion of pier infrastructure is highly needed.
- Availability of gates during winter operations due to shifting of inbound/outbound flows.

LVNL

- ATC is dependent on (timely) available VOP allocation of a flight to ensure a smooth and efficient taxi process.
- The slot coordinator uses declared runway capacity for issuing slots. Bunching of actual flights occurs when (multiple) operators schedule (multiple) flights for one particular time.
- Networkmanager issued restrictions on regulated flights have a direct impact on a flight's CTOT and as such affect VOP occupancy. LVNL has no control over these issued restrictions.
- Only ~15 minutes prior to landing does a flight become visible on the EDD of the ground controller, leaving little time for planning.
- Conflicting AAS vs. LVNL priority, with AAS preferring to vacate a gate as quickly as possible and LVNL preferring to limit the number of idle aircraft in the manoeuvring area.
- ATC is presented with list of TSATs as calculated by the CPDSP, however this is not necessarily equal to the order in which flight crews initiate communication with ATC.
- CPDSP does not take parking positions into account. It is possible that flights on adjacent parking positions may receive similar TSATs, and call ATC at the same time. However, it is often operationally not possible to push back two adjacent flights simultaneously.
- Runways-in-use changes have an impact on gate occupancy.
- Platforms are tight and easily blocked.

Ground handling service providers

to low-cost carrier and limited Schiphol-use operators

- Gate planning at H-pier is controlled by AAS, however, operations might be more efficient if the ground handler would be responsible or more directly involved in local gate planning and allocation.
- Last minute gate changes require active monitoring of CISS and are typically not coordinated by phone between AAS and the ground handler, only by courtesy. Coordination by phone is not laid down in procedures.

---

[2] The home carrier chooses to have three flights per day scheduled at a buffer platform, such that the home carrier can steer which aircraft type is handled remotely. However, in the experience of the home carrier, this strategy does not result in improved gate availability.

- No insight into reasons for (last minute) gate changes in CISS.
- Cautious to provide TOBT updates, concern for large CTOT changes.
- TOBT changes should be entered at the gate instead of only through the ops office. Removing this additional layer would speed up the TOBT update process.
- Different handling / No pre-boarding in case of gate changes away from H-pier.

Legacy carrier

- Unpredictable planning due to fluctuating TSATs: difficult to coordinate push-back resources.
- Unpredictable planning due to early arrivals: often no ground team scheduled to handle the aircraft.

3.3 Stakeholder recommendations

During the first round of interviews with the stakeholders, they were asked for specific recommendations for possible solutions to improve VOP handling. The following recommendations were made:

Airlines

Legacy carrier

- When two flights of their own are ready for pushback, the carrier would like the possibility to request their preferred sequence.
- Improve TSAT calculations (less fluctuations).
- Improve quality of buffer handling (passenger boarding steps with canopies, improved waiting rooms).

Low-cost carrier

- Operations (taxi-in/out) not to be hampered by wide-body push-back.
- Reduce cul-de-sac issues at H-pier.
- Buffer handling: covered aircraft stairs for better passenger experience.
- Alternating Schengen/Extra-Schengen operations at H-pier to be improved, with their different security and immigration procedures.
- Possibility to push back more than one aircraft at a time at H-pier.
- Remote de-icing at dedicated remote spot to reduce time at gate.

Amsterdam Airport Schiphol (**AAS**)

- Airport capacity seems to be determined by runway capacity. Slots are allocated based on this. However, gate capacity appears to become more limiting factor.
- Slots should also be allocated based on gate availability, instead of runway capacity only. Slot allocation and gate availability are presently not balanced.
- All stakeholders to provide up to date and reliable information. Claim free culture should be created.
- Handheld terminals for TOBT updates.

LVNL

- TSAT is available to controllers, but presentation of information could be made more intuitively.
- TOBT is indirectly available to controllers, but presentation of information could be made both directly and intuitively.
- Currently CPDSP does not take gate location into account. For optimal sequence, adjacent gates or stands should not be given the same TSAT as it would give pushback conflicts.
- Current CPDSP uses a TSAT window of 10 minutes (-/+5 min from TSAT). A larger window would allow for filling gaps more frequently.
- Tow planning information is not available to ATC. This information provides additional insight into gate availability.
- Information on gate availability is not directly available to ATC. This information may be useful when an aircraft was due to be ready but is still occupying the gate. Currently, gate management needs to be consulted on how long a situation will last.

Ground handling service providers

to low-cost carrier and limited Schiphol-use operators

- Last minute gate changes are not actively coordinated between AAS and the ground handler. This requires continuous monitoring of CISS since no notification is being generated. Reasons for changes are therefore not always known to the ground handler.
- AAS to provide clear triggers when gate changes occur to the concerned parties, instead of requiring active monitoring.
- TOBT updates are presently done centrally at operations. Local updating at the gate could make the process more efficient.
- De-icing not at the gate but at a remote spot (similar to J-platform). Platforms need to be cleaned following each de-icing to accommodate passengers for disembarking/boarding. This takes time and effort not required at remote deice location.
- When ground handling preparations are initiated, inbound holding is preferred instead of a last-minute gate change.

Legacy carrier

- Buffer handling aircraft should not result in gate capacity being occupied by competitors.
- Buffer handling: should be more passenger friendly, covered aircraft stairs, waiting rooms.
- Faster narrow body boarding in combination with boarding via rear entrance using stairs, to better achieve turnaround within allocated time.
- TSATs should be more reliable.
- More aircraft parking positions (gates, buffers) are needed.
- Airlines making use of handling of the legacy carrier to better coordinate / share information.

3.4 Data derived observations

Following the consolidation of the information obtained from the different stakeholders and the processing of available data, five research questions were developed. In the following sections they are presented individually, including the initial findings.

3.4.1 Gate changes

Research Question

During what flight phase do most gate changes occur, and does the traffic peak (inbound-, outbound peak, 2+2, 1+2) play a role?

For this research question, both the K- and B-platform were excluded as ramp changes for the sake of convenience are common on these platforms.

Hypothesis

The closer an aircraft is to a gate, the fewer gate changes take place.

Findings

Figure 8 shows the average gate change progress during a single day. Peaks are also indicated in the figure. Most gate changes occur in the morning.

As depicted in Table 1, Gate change decisions are routinely made during the taxi-phase (contrary to expectations). Possible reason: TOBTs are adjusted late (or not at all), hence gate planner notices gate mismatch in a late stage.

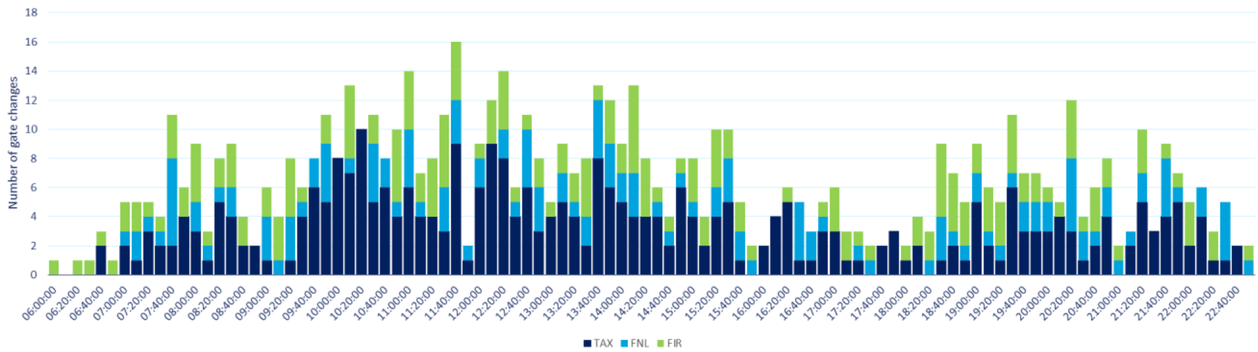

Figure 8 – Gate changes for arrivals in July 2017 between 6:00 and 23:00 UTC

Table 1 – Daily averages for gate changes based on arrivals in July 2017 between 6:00 and 23:00 UTC

	Total	TAX	FNL	FIR	AIR
Absolute numbers	44.6	3.2	1.4	1.9	38.1
Percentages	100.0%	7.5%	3.2%	4.5%	84.9%

3.4.2 Taxi delays due to occupied gates

Research Question

a) When there is a taxi delay due to the intended gate still being occupied, how is this resolved?
b) In case of a consequent gate change: how long until the gate change was initiated and is there a relation with delay?

Hypothesis

In case of a gate change: the longer it takes to make the gate change decision, the longer the delay.

Findings

All possible inbound taxi delay possibilities (slow taxi, re-routing, stopping on taxiway, placed in holding area) were detected and visualized. Figure 9 provides an overview of the frequency and duration of taxi delays for flights during July 2017. Since most gate changes occur in the morning (see Section 3.4.1), the overview also includes values for the period 7h-13h LT, since flights during this time bracket appeared to suffer most from delays and gate changes.

It appears that taxi delays correlate to the time necessary to come to a gate change decision. This effect is less for traffic from 18R (Polderbaan) due to the buffering function of the longer taxi-length. See Figure 10 for a depiction of the distribution.

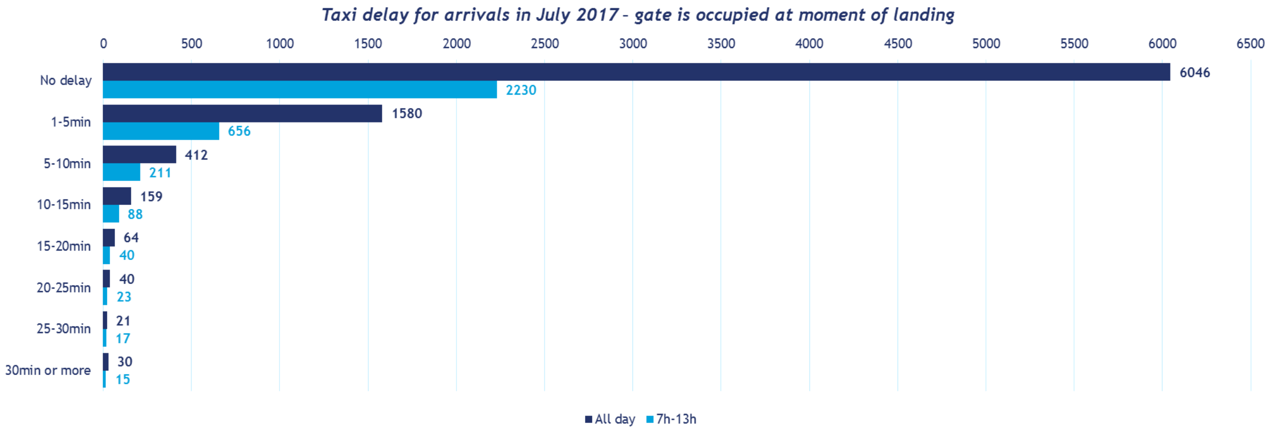

Figure 9 - Taxi delay for arrivals in July 2017 - gate is occupied at moment of landing

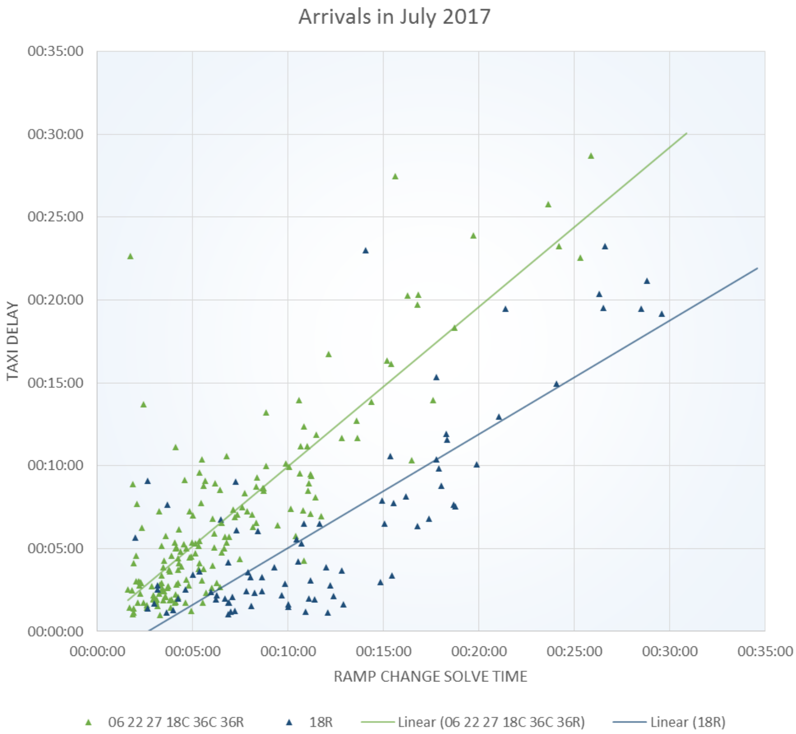

Figure 10 – Correlation of taxi delays to the time necessary to come to a gate change decision

Taxi delay absorption

In case no parking position is available yet for an arriving aircraft, the aircraft must wait and 'absorb delay' while taxiing until its position becomes available.

Different 'delay absorption' techniques have been observed while analysing the MLT data received, each technique having its own characteristics and possibilities. Typical delay absorption techniques are:

- Path stretching / diversion / re-routing;
- Stop and wait on through taxiway (A or B);
- Stop and wait on secondary taxiway;
- Holding.

Combinations of the above techniques also occur. They are briefly discussed and illustrated below.

Path stretching / diversion / re-routing

Instead of following the shortest route from runway exit to the parking position, a longer route is selected. A longer route requires a longer taxi time and thus delay can be absorbed. This technique allows only small delays to be absorbed. Ground controller workload is affected, as the ground controller must identify a longer route and the duration the aircraft is under control of the ground controller is longer. An example of this technique is given in Figure 11.

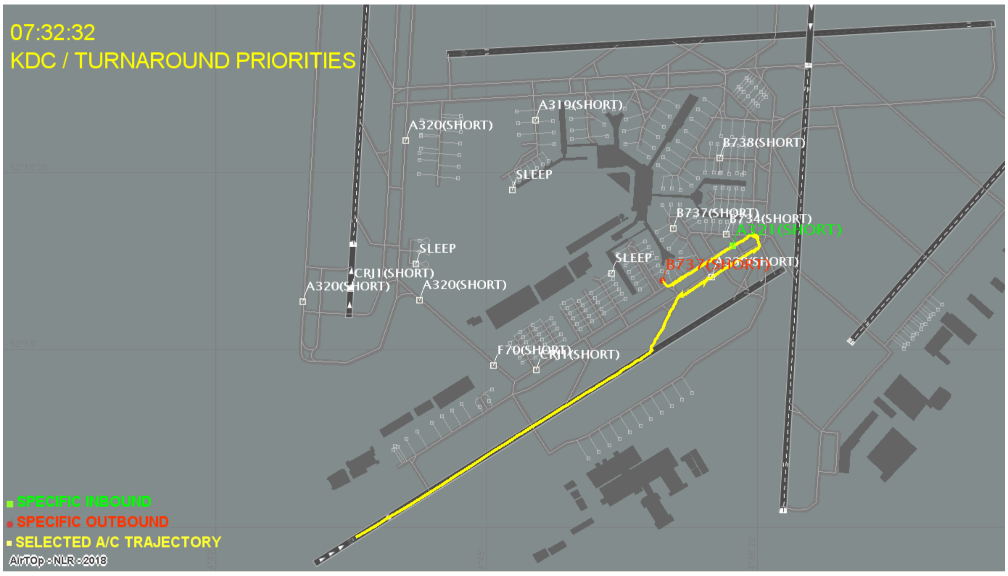

Figure 11 - Example of path stretching / diversion / re-routing for A321 aircraft to absorb delays.

Stop and wait on through taxiway (A or B)

A second technique observed is making the aircraft stop and wait on the main, through taxiway until the parking position assigned becomes available and/or can be reached. Due to blocking of the through taxiway, this technique will only be used to absorb small delays and traffic permitting. Ground controller workload is affected, as the ground controller must assess the possibilities taking into account other traffic and the duration the aircraft is under control of the ground controller is longer. An example of this technique is given in Figure 12.

Figure 12 - Example of A319 aircraft stopping and waiting on through taxiway B to access its parking position H1.

Stopping on a through taxiway, however, can affect other taxiing traffic. Additional measures may be required not to block other traffic. The aircraft concerned can be instructed to temporarily leave its position to allow other aircraft to proceed. This has an additional impact on the ground controller workload, as is apparent from Figure 13.

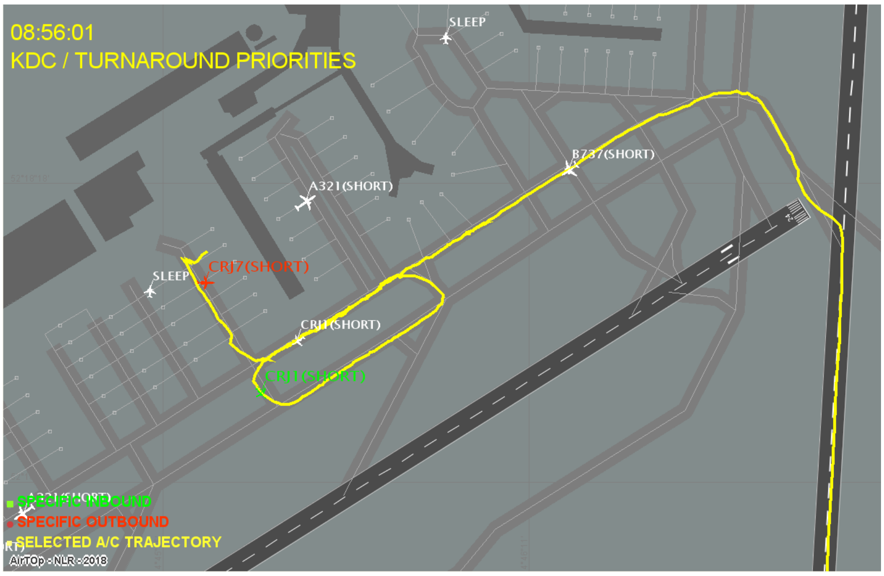

Figure 13 - Trajectory of CRJ1 aircraft before being able to park at its position.

Stop and wait on secondary taxiway

Stopping on a through taxiway may easily obstruct other taxiing traffic and therefore is not always a favourable solution. Making an aircraft stop and wait on a 'secondary' (non-through) taxiway largely prevents this problem, allowing aircraft to absorb somewhat larger delays. Ground controller workload is affected, as the ground controller must assess the possibilities taking into account other traffic and the duration the aircraft is under control of the ground controller is longer. An example of this solution is given in Figure 14.

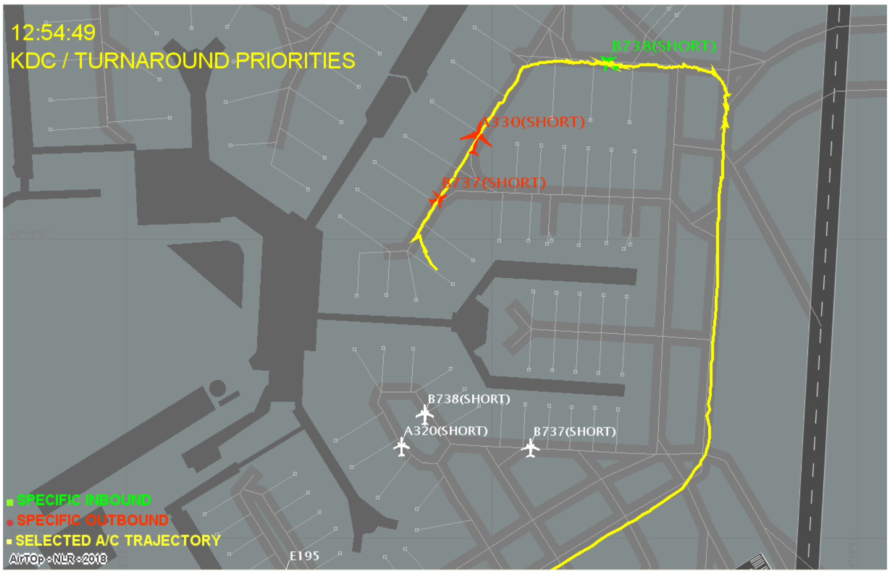

Figure 14 – B738 aircraft waiting on secondary taxiway before being able to park at its position.

<u>Holding</u>

All previous delay absorption techniques only allow limited delays to be absorbed, otherwise other traffic will be affected. In case larger delays must be absorbed, use is made of holdings, where the aircraft can be ‘parked’ without affecting other taxiing traffic. Two such holding areas are available at Schiphol: the R-holding, south-west of the terminal facilities, with two positions (limited aircraft wing span) and the P-holding, north-east of the terminal facilities, with a maximum of 5 positions (depending on aircraft wing span). Using the holdings will affect the ground controller workload, although this will be limited as aircraft once parked on a holding position do not affect other traffic. Examples of the use of holdings are presented in Figure 15, Figure 16, and Figure 17.

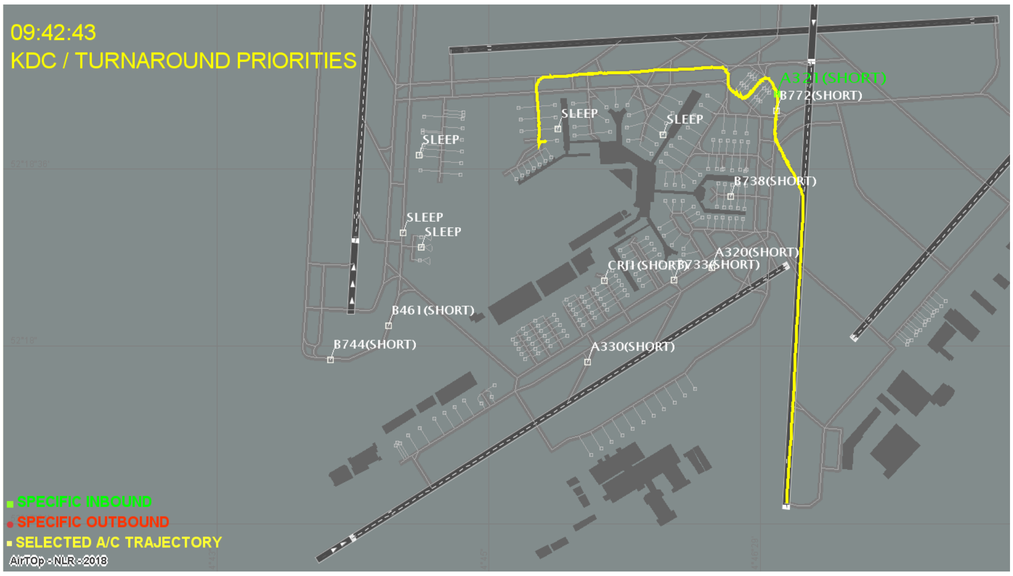

Figure 15 – A321 aircraft using remote holding platform P before accessing its parking position.

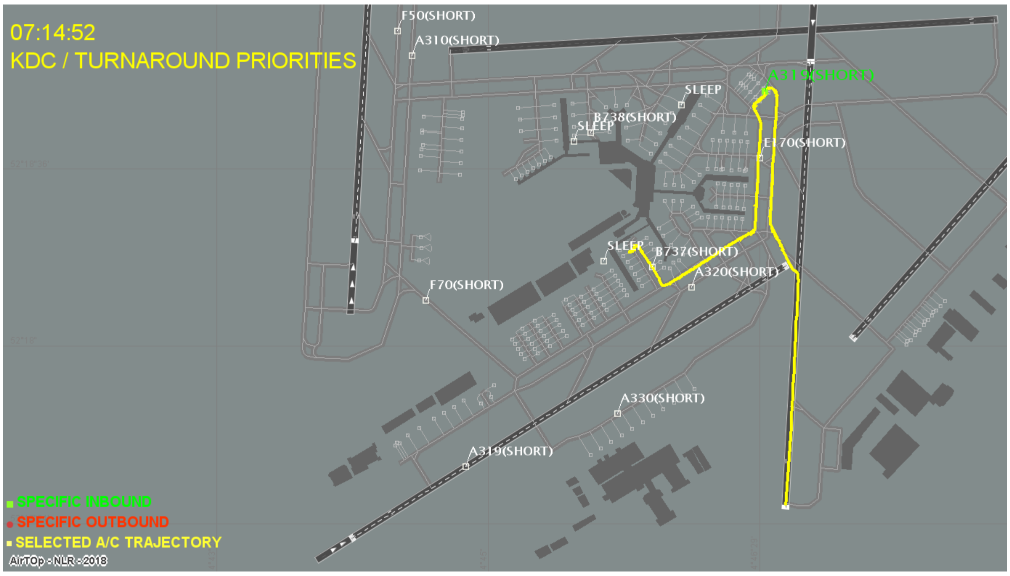

Figure 16 – A319 aircraft waiting on remote holding platform P before accessing its parking position.

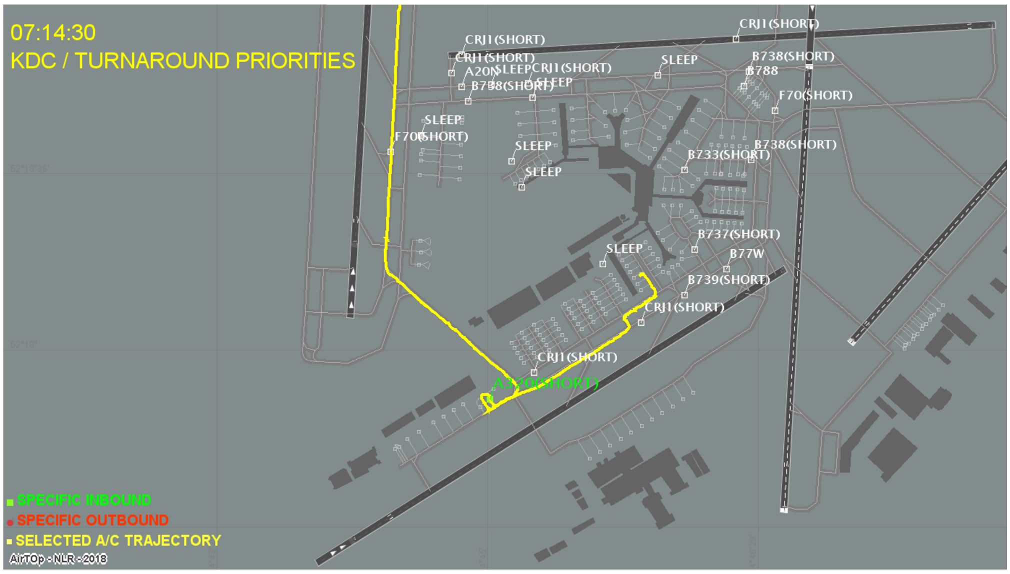

Figure 17 – A320 aircraft waiting on remote holding platform R before accessing its parking position.

3.4.3 Occupied gates: occupancy duration based on TSATs

Research Question

When an aircraft is on 10 mile final and its allocated gate is still occupied: How great is the time difference between the EIBT of the inbound aircraft versus the TSAT of the outbound aircraft?

Hypothesis

Handlers that handle both inbound and corresponding outbound flight will not let the difference increase as often.

Findings

The difference between the EIBT of the inbound aircraft and the TSAT of the outbound aircraft is larger when both aircraft are serviced by different handlers.

Table 2 - July 2017 - ARR EIBT vs DEP TSAT (at ARR FNL)

	Between Legacy Carrier aircraft	Between Legacy Carrier and another carrier	Between low-cost carrier aircraft	Between different ground handling service providers
3-5 min	75	29	16	14
6-10 min	74	28	21	22
11-15 min	27	14	15	11
16-20 min	19	9	7	11
Total	195	80	59	58

3.4.4 TSAT and TOBT change

Research Question

How many TSAT changes are there per flight, and how often is the TOBT adjusted?

Hypothesis

TOBTs are not adjusted often; TSATs fluctuate a lot.

Findings

- TSATs indeed fluctuate (often).
- TOBTs are not adjusted frequently by any of the handlers. Hard to differentiate between handlers.
- The number of TOBT changes seem limited but appear to affect TSAT changes.

Table 3 provides a summary of values for the points above.

Note: The project team is aware that LVNL is exploring the possibility of acquiring a replacement planning tool to stabilize the issuance of TSATs.

Table 3 - July 2017 - TSAT & TOBT changes

	TSAT MODs / FLT	TOBT MODs / FLT
All flights	15.7	2.5
AIRLINES		
Legacy carrier	16.8	2.6
Legacy carrier – regional	15.7	2.7
Foreign carrier – SPL-based code share	14.3	2.3
Foreign carrier – other	15.5	2.5
Low cost carrier	16.7	2.6
GROUND HANDLING SERVICE PROVIDERS		
Handler-A	15.8	2.6
Handler-B	16.5	2.9
Handler-C	15.6	3.0
Handler-D	14.6	1.7

3.4.5 TSAT expirations

Research Question

How often to handlers let a TSAT expire?

Hypothesis

Handlers monitoring CDM-milestones closely, will try to avoid a TSAT expiration and timely adjust their TOBT.

Findings

Legacy carrier handler (Handler-A) allows TSATs to expire less often than other handlers. Table 4 provides a summary of TSAT expirations for the different handlers.

Table 4 – Departure with TSAT expirations in July 2017

GROUND HANDLING SERVICE PROVIDERS	TSAT Expirations [%]
Handler-A	0.5
Handler-B	1.0
Handler-C	1.2
Handler-D	1.3
All	0.7

3.5 Additional findings

While performing the data analyses, combined with the second round of interviews with the stakeholders, additional noteworthy findings were made. They are presented in the following sections.

3.5.1 TSAT fluctuations

TSATs are calculated by the Collaborative Pre-Departure Sequence Planning system (CPDSP)[3] . The stable zone is defined as the window between 5 minutes prior to the TSAT and the TSAT itself. In the stable zone, the TSAT will not change, given that the TOBT is not adjusted. Every stakeholder confirmed that TSAT fluctuations often cause start-up delays. This may indicate that the current stable zone may not be sufficient. LVNL is aware of this and are currently assessing possibilities for a system replacement.

The reason for start-up delay, however, is not always clear for each individual stakeholder. This is especially experienced as frustrating when the handler achieves the TOBT.

When the data shows that the ASRT has passed the TSAT, evidently, the TOBT is not achieved. Even though the ground handler has finished its process, there is still the possibility that the flight crew still needs to finish up their pre-flight checks.

Another factor affecting TSAT allocation which may not be under control of the airport stakeholders is the implementation of flow control measures on certain outbound flights. Such measures can impact gate availability for subsequent flights if the outbound aircraft at the gates become subject to slot regulation.

When a flight needs to go through regulated airspace, a CTOT will be allocated by the NMOC. If the CTOT is pushed into the future, the TSAT will be pushed into the future as well, resulting in start-up delay. Since start-up approval is not given, the aircraft is not able to leave the aircraft stand. This means that the next inbound flight allocated to that stand may have to wait. In RASAS is documented that after a certain amount of time the aircraft will be towed to a holding stand. However, this means that a tow needs to be arranged, which also requires logistical challenges. In rare occasions, the aircraft will get special approval to taxi to a holding stand on its own power.

3.5.2 Parking and holding positions

Aircraft on the ground are assigned a VOP for aircraft handling. Different types of VOPs are available for this purpose:

- Gates (or contact stands), where the aircraft is directly connected to the terminal building by means of a passenger boarding bridge;
- Remote stands, where aircraft handling takes places, but where there is no direct connection with the passenger terminal and passengers are transported to/from the aircraft by bus.

The (remote) holding positions, are not suitable for aircraft handling and thus not used for these purposes. Aircraft temporarily positioned on a holding position must proceed to either a gate or a remote stand before passengers can (dis)embark. Figure 18 gives an overview of some examples of gates, remote positions and holdings at Schiphol.

[3] Schiphol A-CDM Operations Manual

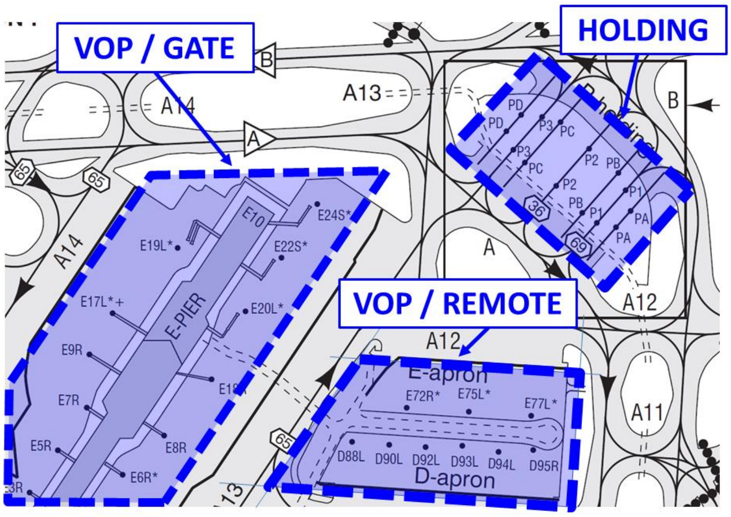

Figure 18 - Example of gates, remote positions and holdings at Schiphol Airport Amsterdam.

In addition to the above, more parking positions are available, but these are beyond the scope of this project. Examples are the different aprons, each with a specific purpose, like the J-apron for long-term parking and de-icing, R and S aprons for freight, K apron for general aviation et cetera.

4 Limiting capacity factor(s)

During the study several limiting factors affecting the management of gate turnarounds were identified. Corresponding improvement opportunities were determined. They are presented in clusters based on the following topics:

- Available VOPs vs. a/c types
- Taxiway bottlenecks
- Interpretation and processing of information
- External factors
- Factors impacting workload

Availability of VOPs vs a/c types

There is a perceived shortage of gate VOPs, as indicated during the interviews.

- Based on the day-before gate allocation and the planned ARR/DEP times, there is no shortage in gates/VOPs;
- During the day of operation, disturbances create a shortage of available gates/VOPs at specific times – when aircraft arrive or depart at times other than initially planned. Specifically, unavailability of gates for widebody aircraft has resulted in more frequent use of remote stands.
- Schedule disturbances (aircraft being early/late) require either (last minute) gate reallocation or the allocation of a parking or holding position until the originally assigned parking position becomes available.

There is room for an enhanced short-term gate planning tool to tackle structural operational disturbances during the day of operation.

Taxiway bottlenecks

Taxiway capacity is not a general limiting factor, though a few bottlenecks have been identified, e.g. access to H-pier, or taxiway Q under certain circumstances:

- H-pier: widebody push-back and start-up at G-pier may block access to the H-pier for up to 15 min.
- Above item also applies to a lesser extent to some other piers
- Taxiway Q is a single taxiway, restricting capacity in case taxi movements are preferred from both directions.

The already planned infrastructural changes for the coming years will solve most of the taxiway bottlenecks.

Interpretation and processing of information

During the study several disconnects with regards to information interpretation and processing were identified, namely:

- Aircraft handlers (agents/handling airlines) not always work towards the TOBT.
- TOBT changes are not always (timely) updated in the CDM portal. Reasons include too long of a communication chain or being confident that TSAT can still be met.
- Updates on progress of handling is not always shared effectively, resulting in less than efficient use of gates
- LVNL GC aims at controlling aircraft based on their TSAT, with no knowledge of handling progress and other CDM times. TOBT information is not readily available to ATC.
- Reasons of delays at the gate, and possible subsequent TOBT/TSAT changes, is not known to ATC controllers.
- Flight crew may not be aware of specific CDM parameters and corresponding communication initiation with ATC, e.g. ATC may be called up to 5 min <u>before</u> TSAT already instead of starting from TSAT.

- Aircraft towing movements are primarily coordinated between AAS and ground handling, while ATC GC needs to authorise these movements. This may at times lead to less than optimum situation awareness for ATC planning and ground control.

More customized information for the individual parties is necessary. Additionally, parties need to have more insight into each other's processes to be able to make better decisions.

External factors

During the study several external factors affecting gate capacity management were identified, namely:

- Weather induced disruptions (specifically strong winds, poor visibility, snow/icing conditions). Sudden changes in start/landing capacity have significant impact on gate management.
- Strikes (either at Schiphol or outstation – either ground handler, airline or ATC)
- Individual disruption (e.g. maintenance, passenger event).

There is little to no control over preventing above types of events. How these types of events can be dealt with, depends on the actual event.

Factors impacting workload

Several workload increasing factors that affect handling capacity were identified, namely:

- AAS does not actively communicated gate changes to affected handling agents (only at discretion and if time permits). It is up to the handling agents to actively monitoring CISS updates for changes.
  An improved CISS interface for handlers would facilitate more effective communication.
- Late/no updates of TOBT by aircraft handling agents:
  - Updating TOBT requires additional coordination if performed away from the gate.
  - Updating TOBT increases risk of obtaining a later TSAT, while the original TSAT might still be achieved.
  - Concern of potentially losing a departure slot.

  An improved CDM interface for handlers, with regards to TOBT input, would facilitate more effective communication. Alternatively, an advanced CDM planning tool, accompanied by an awareness campaign to enhance trust in CDM could be deployed.
- No advance knowledge of aircraft towing movements to ATC ground controllers:
  - Towing is coordinated and communicated between AAS and aircraft handlers.
  - Towing movements are not known in advance to ATC, e.g. by means of a "flight plan".
  - ATC ground control lacks overall picture of planned towing movements.

  Closing the gap between the taxi and towing processes would greatly improve mutual efficiency and effectiveness.
- Gate changes are made aware to ATC GC by the generation of updated flight progress strips, not through active coordination or information provision.
  Here too would closing the gap between the taxi and towing processes improve mutual efficiency and effectiveness.
- TOBT data are not readily available to ATC GC. Information can be obtained by contacting outbound planner, adding to regular work activity.
  Implementation of Electronic Flight Strips (EFS) would serve as an enabling technology for making relevant CDM data more readily available to ATC GC.

- Unstable TSAT times lead to uncertainty for flight crews and handling agents.
  An advanced CDM planning tool, accompanied by an awareness campaign to enhance trust in CDM could be deployed, thus providing more stable TSAT times and decreasing uncertainty among flight crews and handling agents.
- Foreign operators often arrive flight crews that do not frequently visit Schiphol. Unfamiliar with the remote holding procedures at Schiphol, these flights can pose additional workload for ATC ground controllers

During the study it was determined that runway capacity is not truly a limiting factor with regards to gate management, namely:

- Airport operations are aligned to runway capacity (i.e. slot allocation/coordination)
- Gate capacity/availability is more challenging when actual times differ (significantly) from allocated/schedule times.

Page intentionally left blank

5 Priority rules

While the priority rules for stand allocation (gates, remote stands, buffers) are principally governed by the regulations as laid out in the RASAS document, it is apparent from the stakeholder interviews and assessment of the research questions, that there are areas for improvement. Both strategic and tactical adjustments in handling of (daily) disturbances are discussed in the sections 5.1 and 5.2 respectively.

5.1 Strategic adjustments

CDM related information management

Many comments were received regarding the many TSAT changes per departing aircraft. This not only creates uncertainty for the aircraft handling agents, but also for flight crews preparing for departure. Determination of the planned departure queue should be made more stable, in order to provide less volatile TSAT information presented to crews and ground handling personnel. The project team is aware that AAS is exploring the possibility of acquiring a replacement planning tool to stabilize the issuance of TSATs.

Aside from the desired increased TSAT stability, it is worthwhile to better inform ground handling personnel of the relevance of and adherence to TOBT and TSAT times in the overall process. While both TOBT and TSAT are indicated on VDGS (or separate) displays, the TOBT should be leading when preparing an aircraft for flight, which does not always appear to be the case. Allowing a TSAT to expire is more likely to lead to additional delay than (timely) updating the TOBT. Handling agents are currently cautious about updating TOBT times, sometimes due to the process of generating an update being time consuming. An improved means to quickly update TOBT information for all handling providers should improve time and VOP management. A possible option could include portable equipment at the ramp location itself in addition to the currently available CISS interfaces. Besides that, the CDM HMI can be improved to give signals to handlers when TOBT and TSAT are about to expire.

Airline / Aircraft handler

From the interviews it has become clear that aircraft handling service providers see potential for further benefits in the use of CDM data, gate management tools, and data allocation, specifically:

- More room for specific requests from aircraft handling service providers
- More insight for handlers in the (short term) decisions on gate allocation by gate management
- Preferred use areas with limited authority to reallocate gates under own responsibility

Above items will require well defined arrangements between aircraft handling service providers and AAS gate management on mutual responsibilities.

Strategic infrastructure decisions concerning disruptions

Based on the seasonal planning, sufficient capacity exists to provide all scheduled aircraft movements parking positions during the day. This is still the case when the gate planning is finalized the day before the operation. However, on the day of the operation, deviations in the planning always occur. Inbound flights may arrive early (e.g. due to favourable wind conditions, runway change, or expeditious flight crew) or outbound flights may depart with delay (e.g. due to delayed passenger, required baggage removal, shortage of staff/ground equipment, CTOT restrictions, traffic peaks). When for a certain gate either occurs, or both, this may result in conflicting gate allocations, with the possibility of a snowball effect on subsequent flights. This may even result in an insufficient number of available (and suitable) gates for certain periods during the day.

When buffer capacity is frequently used during nominal planning, the ability to absorb strategic deviations is steadily decreased. The interviewed stakeholders indicated that they are currently experiencing this effect.

5.2 Tactical adjustments

Late gate changes on the ground typically require a lot of coordination between ATC Ground Control, Outbound Planning, Apron Control, flight crew and ground handling. Based on the available (CDM) data, direct communication and position of the inbound aircraft (final approach, taxi), a decision needs to be made how to solve any necessary delay. In particular the availability of information regarding the reason and duration of a possible departure delay will influence the decision process. Independent of the specific situation, any delayed outbound flight will occupy an aircraft stand which eventually has to be vacated before any next aircraft can be accommodated. This implies that any delay primarily will need to be absorbed by looking at delaying or reallocating gates for the next planned.

Current tactical adjustments

Depending on the required delay to be generated for an inbound aircraft to arrive at an available VOP, ATC GC and AAS have the following options:

- *Slow taxi* – In case of sufficient taxi distance and no conflicting traffic behind, an aircraft may be notified of occupied gate and be requested to reduce taxi speed.
- *Temporary holding* – a few options are available:
    - Close to the assigned gate. Waiting for push back of the occupying aircraft may result in temporarily blocking the taxiway, which is only workable traffic permitting.
    - At a remote holding. Depending on the position relative to the gate, to be absorbed delay at remote holding will vary.
    - On the taxiway. This can only be done if no other taxi traffic is affected for the required holding time.
    - Performing a racetrack pattern using parallel taxiways. This may be required when other aircraft are following the inbound aircraft that needs to be delayed.
- *Reallocation to other available gate* – This solution is only feasible if the gate is compatible with the respective inbound aircraft and if personnel and equipment can be made available (timely).
- *Reallocate handling to buffer stand* – This is only feasible if personnel, handling equipment and buses can be (timely) made available at the buffer stand. It must be noted that not every airline allows remote handling and buffer handling may be experienced of a lesser quality by passengers.
- *Push-back and hold delayed outbound aircraft* – Clearing the aircraft stand or gate by towing the delayed outbound aircraft away until ready for departure or departure slot time reached. This requires aircraft doors to be closed and ready for pushback.

Reassignment of a VOP can be done at different moments in time for an inbound aircraft, namely:

- Before FIR entry:
    - Aircraft handling has time to take measures in terms of moving people and equipment.
    - Aircraft can be informed on VOP allocation (change) by ACARS or VHF.
- Within FIR
    - Aircraft handling has time to take measures in terms of moving people and equipment.
    - Aircraft can be notified on VOP allocation change by VHF (handling agent flight watch).
- On 10NM final
    - Depending on VOP and available equipment, no or limited delay in subsequent handling.
    - Usually notification of gate change after landing by ATC GC.
- During taxi

- Gate change requires coordination between different stakeholders.
- Aircraft are notified by ATC GC.

Recommended tactical adjustments

The following recommendations may improve decision making on a tactical level:

- Increase the ability of gate management to handle last minute gate changes
- Improve the provision of information by gate management to all relevant stakeholders (ATC and handlers) in the final flight phase (FIR entry up to in blocks). This will improve decision making of all relevant stakeholders.
- Provide priority rules for situations where holdings are exceeded. For example, prioritize outbounds such that gate availability is created for inbounds.
  - This may especially work when 36L is used for take-off. Traffic is directed away of the center area.
  - Rules must be clear and must be communicated to all relevant stakeholders.

Page intentionally left blank

6 Conclusions and recommendations

There is currently no common or shared view of VOP management challenges and/or corresponding solutions amongst the different stakeholders.

One concern is with regards to the current CDM processes and pertains to the (timely) provision of information. While the handling agents have limited confidence in the CPDSP presented times (fluctuating TSATs are perceived as unreliable), TOBTs are not always (timely) adjusted, not only further exacerbating the TSAT changes, but also impacting efficient use of VOPs.

Note: The project team is aware that LVNL is exploring the possibility of acquiring a replacement planning tool to stabilize the issuance of TSATs.

A second concern pertains to the number of VOPs. While several stakeholders indicate that there are insufficient VOPS, when making the planning the day before the operation, the number of (suitable) VOPs is sufficient. Bottlenecks arise due to deviations from the planning. Additionally, sometimes aircraft – though ready for departure - are held at the gate in order not to burden the flow of traffic on the manoeuvring area. In essence, while the nominal planning fits all inbound and outbound flights, there is very limited room for non-nominal situations and disturbances, that arise during the day.

In addressing specific challenges regarding gates and stands occupancy, there are various trade-off options available to the different stakeholders, namely:

- Implement a new A-CDM outbound planning tool which generates TSAT's that are more stable than now
- With the new planning tool in place, provide better means to update TOBT's to handlers. Furthermore, enhance the way pending TOBT and TSAT expiries are presented to handlers and cockpit crew.
- Enhance sharing of gate management information between parties involved
- Develop a CDM cell which guards the CDM process, in particular the adherence to TOBT and TSAT, and plays an active role.
- Develop sets of rules on gate management which will be put in place during structural disruptions of the gate management process on the day of operation. Impose these rules on all parties involved when necessary.
- Enhance the gate management tools to handle structural disruptions on the day of operation better.
- Allow handlers to have more influence on gate management in their designated gate areas. Make rules like RASAS but specified for handler needs in their designated areas.

It is recommended a follow-up study be performed to determine whether daily deviations in the planning are structural and predictable. As part of such a study it should be assessed what delay duration is 'acceptable'. This will allow to determine if there is a (structural) shortage of (suitable) VOPs during specific times, and whether buffers between flights should be adjusted. Additionally, it might be worthwhile to assess what the effects are when aircraft - when ready for departure - are cleared off the VOP to allow handling of another aircraft, specifically:

- How often does this opportunity present itself?
- Does this provide enough additional gate availability?
- How much delay is reduced?
- How does this affect manoeuvring area congestion?
- Does this result in queues for runways?

Page intentionally left blank

Appendix A CDM Data columns

FLTDATA_MODIFIED
SDATE
ARRDEP
SDATETIME
CALLSIGN
FLTNR
AIRLINE
CONNFLTNR
CONNFLTDATE
ACREG
ACTYP
HANDLER_PAX
HANDLER_FREIGHT
CDMFLTSTATE
RUNWAY
RAMP
GATE
ELDT
EIBT
ALDT
AIBT
EOBT
TOBT
TOBT_SOURCE
TSAT
TSAT_STATE
AOBT
EXOT
TTOT
TTOT_TARGET
ASRT
ATOT
CTOT
AIRPORTOFDEP
AIRPORTOFDEST
MODIFICATIONS
ICAOSID