Note on validation of the baseline airside model for the purpose of performing a capacity assessment of Dublin Airport

1 Background

Under Section 8(1) of the Aviation Regulation Act 2001, the Commission for Aviation Regulation is the competent authority in Ireland for the purposes of Council Regulation (EEC) No. 95/93. Therefore, the Commission is responsible for determining appropriate parameters for slot allocation. To ensure that optimal parameters are set, the Commission has engaged Helios to carry out a full capacity assessment of Dublin Airport with a view to assisting the Commission in declaring the parameters for slot allocation at Dublin airport.

Primary aims of this capacity assessment were set out as follows:

- Assessment of capacity of runways 10 and 28 under a range of parameters.
- Evaluation of stand and apron capacity.
- Identification of pinch points on the taxiway system.
- Assessment of appropriate delay criteria.
- Assessment of the maximum capacity when coordinating to a 10-minute period compared to a 5-minute period.
- Assessment of capacity of terminals 1 and 2.
- High-level assessment of airspace capacity, roads and parking lot capacity.

In order to understand the situation at Dublin airport and to collect the data required for the project, the Helios team conducted a series of stakeholder consultations, either via phone/skype or through a series of meetings. These consultations took place in May 2017. The following stakeholders were consulted:

Organisation	Date of consultation	Means
British Airways	Meeting	03.05.2017
ACL	Meeting	11.05.2017
Lufthansa	Skype call	12.05.2017
United Airlines	Skype call	12.05.2017
City Jet	Meeting	15.05.2017
daa (security)	Meeting	15.05.2017
daa (airside operations)	Meeting	15.05.2017
daa (passenger terminal operations)	Meeting	15.05.2017
daa (planning and regulation)	Meeting	15.05.2017
Ryanair	Meeting	15.05.2017
Stobart Air	Meeting	16.05.2017
Aer Lingus	Meeting	16.05.2017
IAA	Meeting	16.05.2017
CAR	Meeting	16.05.2017
daa (baggage processing)	Meeting	16.05.2017
Customs	Meeting	17.05.2017
Immigration	Meeting	17.05.2017
Swissport handling	Meeting	17.05.2017

2 Methodology

As all elements of the airport airside system are dependent on each other, the optimum approach to evaluate available capacities is through a unified approach that encompasses the interactions between all elements of the airport's infrastructure and services. The most suitable approach is based upon a fast time simulation model.

Instead of modelling different elements of airside infrastructure independently and then assessing their capacities, we created one complete airside model of Dublin airport, that reflects operations on the runway, in the airspace immediately around Dublin airport as well as operations on ground (and their interactions with each other) at the same time. The ability to model all airside elements at ensures that the overall capacity assessment takes into account all interactions between aircraft, airspace and ground infrastructure.

Before the model can be used for the analysis of the impacts of changes in a future schedule it has to be calibrated. The approach taken involves:

- Development of the baseline model. This is a reference model which allows direct comparison against available historic records. After consultation with the daa it was decided that 23 June 2016 will be used as the 'design day' for the purpose of baseline model development. This day was identified as a typical day in terms of number of movements, traffic mix and stand usage. All flights that operated at the Dublin airport at any time between 23 June 2017 00:00:00 and 23 June 2017 23:59:59 were included into the simulation. The model has been built using data and assumptions collated from daa, IAA and any other relevant information disclosed by other parties during the stakeholder consultation period.
- Validation and calibration of the baseline model. Early stages of the baseline model performance have been discussed with CAR, daa and IAA representatives during a model validation meeting held on 28 June 2017 at Dublin airport. As the model calibration is an iterative process, the aim of this meeting was identification of areas where the model showed significant deviations from reality and identification of corrective actions.
- Post-review actions. The model has been updated taking into account deviations identified during the review meeting and performance of the latest version of the baseline model is now being shared with all coordination committee members via this document.
- Development of reference S17 and S18 model. With the baseline model calibrated against available S16 historic data it will be possible to adjust the existing model for simulation of S17 performance. With the S17 model set-up and running it will be possible to evaluate impact of any changes proposed for the S18 flight schedule, be it changes in flight schedule, fleet mix or airside infrastructure.

The fast-time simulation tool used for assessment of Dublin airside capacity is AirTOp. AirTOp has been used worldwide by air navigation service provides, airports and civil aviation authorities for several years, and it has been also used by Eurocontrol and the FAA for airspace analysis.

3 Data and assumptions

This section outlines the key data sources and assumptions used for preparation of the FTS model.

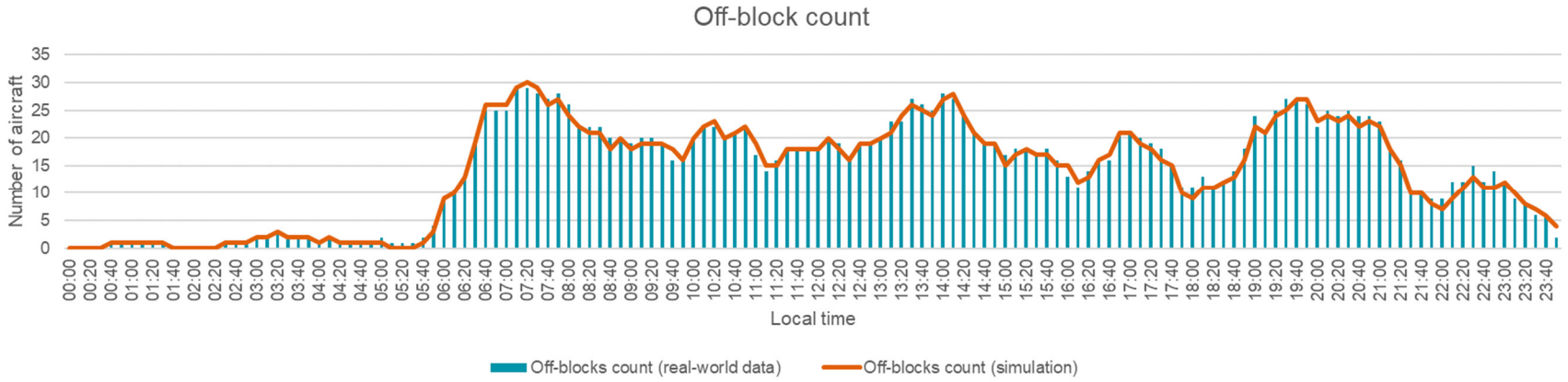
Item	Type	Source
CAD drawings of landside layout on the design day	Data	daa
Flight by flight historic data for full S16 season	Data	daa
List of infrastructure changes planned between S16 and S18	Data	daa
List of stands not available for commercial operations	Data	daa
S16 stand allocation guide	Data	daa
S17 stand allocation guide	Data	daa
Approved unescorted towing routes	Data	daa
Flight by flight historic runway occupancy data for full S16 season	Data	IAA
SIDs and STARs used by flights on the design day	Data	IAA
Description of arrival and departure procedures	Data	eAIP
Stand usage restrictions	Data	eAIP
Stand size restrictions	Data	eAIP
Tug release points (TRP)	Data	eAIP
Commonly used taxi routes from each runway end to each pier	Assumption	IAA
Taxiway F-inner used mostly for departures	Assumption	IAA
Taxiway F-outer used mostly for arrivals	Assumption	IAA
Cul-de-sacs operational rule: “one in, one out” (code C aircraft only)	Assumption	IAA
Aircraft pushed back from stand and towed to the TRP. From there it continues on its own power.	Assumption	IAA
Parallel operations of two (up to) code C aircraft on taxilanes D-north and D-south possible	Assumption	IAA
Operation of only one code D/E aircraft possible on taxilane C	Assumption	IAA
R28 departures from Pier 1 and Pier 2 queue on R16-34	Assumption	IAA
R28 departures from Pier 3 and Pier 4 queue on taxiway F	Assumption	IAA
Taxiway A closed when R28 is in operations	Assumption	IAA
Aircraft performance as per AirTOp performance tables	Assumption	AirTOp
Departure-departure separation set to minimum of 84 seconds	Assumption	IAA
Arrival-Arrival separation set to minimum of 3.5 NM	Assumption	IAA
If arriving aircraft is closer than 2NM from 28 threshold the departure on the R28 holding point cannot be cleared to enter the rwy/take off	Assumption	IAA
Arriving aircraft needs to be on taxiway B to be clear of runway (no other aircraft can land until then)	Assumption	IAA
Departing aircraft needs to be above the opposite runway threshold before the following aircraft can land	Assumption	IAA

Item	Type	Source
Taxi speeds on long and straight taxiway segments increased to 25kts.	Assumption	Helios
Delay between tug release and the time when aircraft starts moving on its own power set to 3 minutes for narrow body and 4 minutes to wide body aircraft.	Assumption	daa
Speeds in point merge (R28): ▪ Outer arc: 230kts ▪ Off-arc: 210kts ▪ LAPMO: 190kts ▪ MAXEV: 165kts	Assumption	IAA

4 Calibration and validation of FTS results

This section provides a comparison of the key metrics from the baseline model against their real-world equivalents measured on the design day. Real-world metrics were calculated from the flight by flight data provided by daa and IAA. Each sub-section contains explanatory note on how the metric is calculated within the simulation software and how the corresponding real-world metric was calculated.

4.1 Off-block count

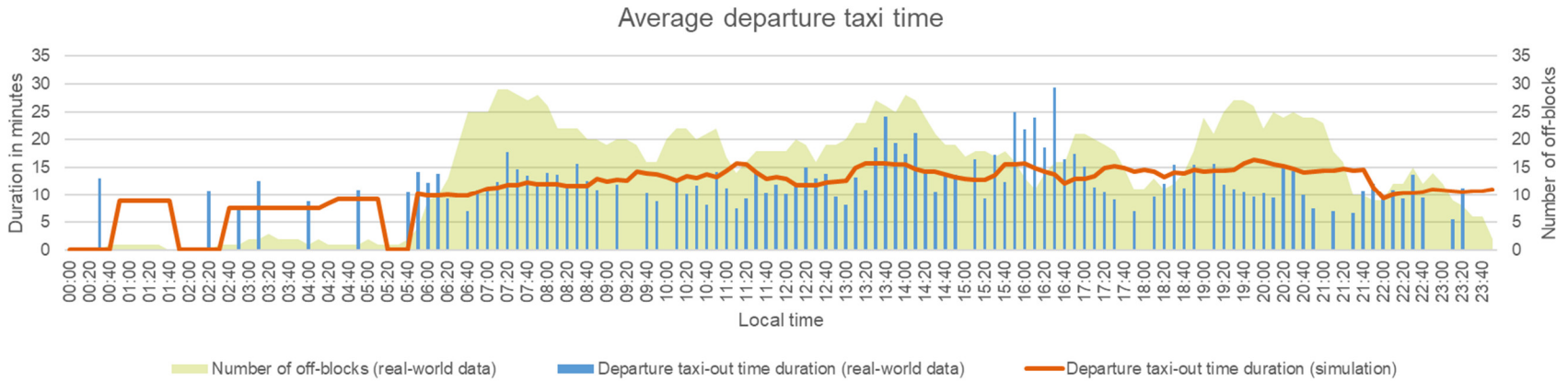


* This graph is presented as a rolling 60-minute average (value for each time period has been calculated as average of values of all events occurring within the T+60 minutes window from the start of the measurement).

Metric definition (simulation): The number of aircraft that have been pushed back in the last rolling period. The count is incremented when the Aircraft leaves its departure parking position (either being pushed back at gate or taxiing / pulled away from a parking position).

Metric calculation (using real-world data): Calculated as count of off-blocks in the last rolling period measured on the BLOCK_TIME_LOCAL field (provided by the daa).

4.2 Average departure taxi-out time

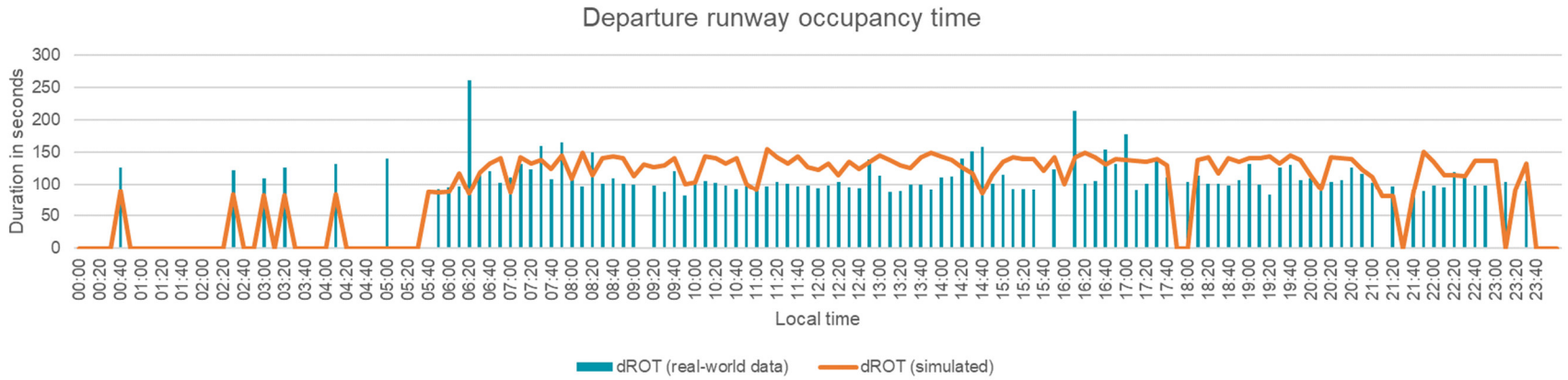


*This graph is presented as a rolling 10-minute average (value for each time period has been calculated as average of values of all events occurring within the T+10 minutes window from the start of the measurement).

Metric definition (simulation): The time duration the aircraft has been taxiing for departure on the ground of its departure airport. This value is updated every second of simulation time when the aircraft is taxiing for departure even if the aircraft is stopped on ground. This metric is defined to be the time period between off-block and the time the aircraft reaches its stop bar for runway entry.

Metric calculation (using real-world data): Calculated as a difference between START_LINEUP field (provided by IAA) and BLOCK_TIME_LOCAL field (provided by daa).

4.3 Average departure runway occupancy time

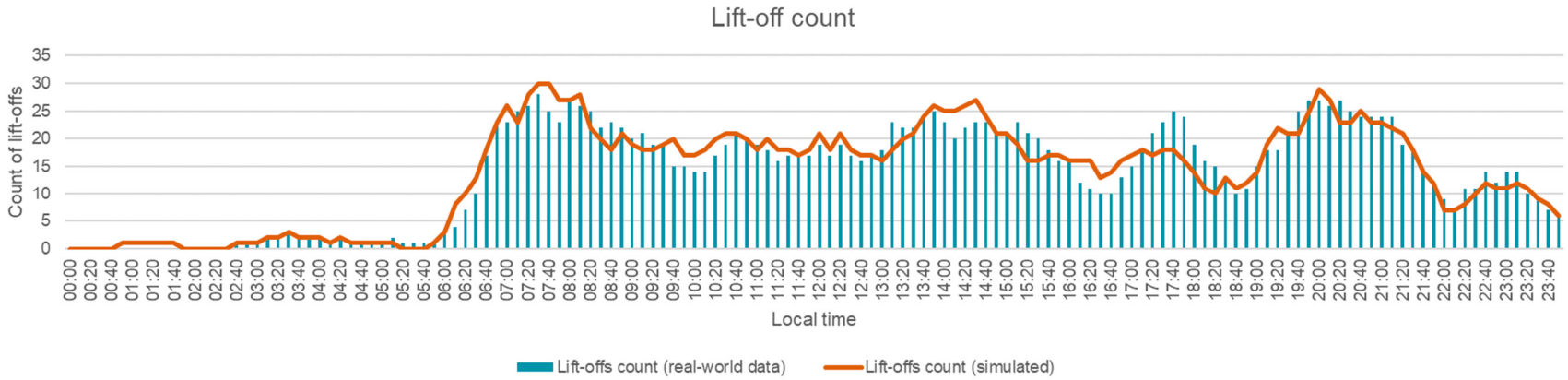


*This graph is presented as a rolling 10-minute average (value for each time period has been calculated as average of values of all events occurring within the T+10 minutes window from the start of the measurement).

Metric definition (simulation): The time duration the aircraft has been occupying the departure runway of its departure airport. This value is updated every second of simulation time once the aircraft is starting to line-up (has passed the runway stop bar) until it has passed the opposite end of the runway.

Metric calculation (using real-world data): Calculated as a difference between OFF_RUNWAY field and START_LINEUP field (both provided by IAA).

4.4 Lifted-off count

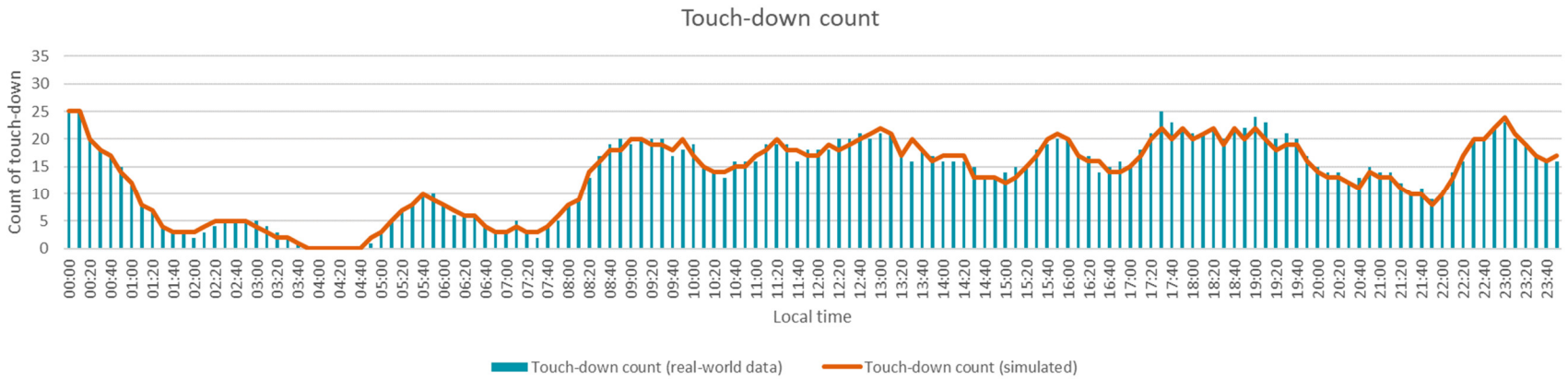


*This graph is presented as a rolling 60-minute average (value for each time period has been calculated as average of values of all events occurring within the T+60 minutes window from the start of the measurement).

Metric definition (simulation): The number of aircraft that have lifted off in the last rolling period. The count is incremented when the aircraft passes over the opposite end of runway.

Metric calculation (using real-world data): Calculated as count of lift-offs in the last rolling period measured on the ATOT field (provided by the IAA).

4.5 Touch-down count

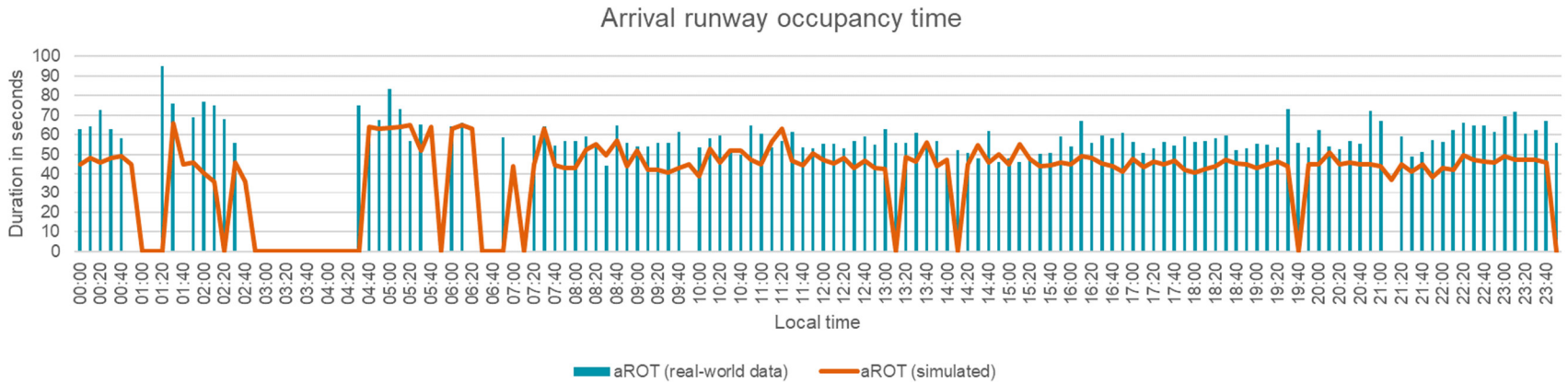


*This graph is presented as a rolling 60-minute average (value for each time period has been calculated as average of values of all events occurring within the T+60 minutes window from the start of the measurement).

Metric definition (simulation): The number of aircraft that have touched down in the last rolling period.

Metric calculation (using real-world data): Calculated as count of touch-downs in the last rolling period measured on the ALDT field (provided by the IAA).

4.6 Average arrival runway occupancy time

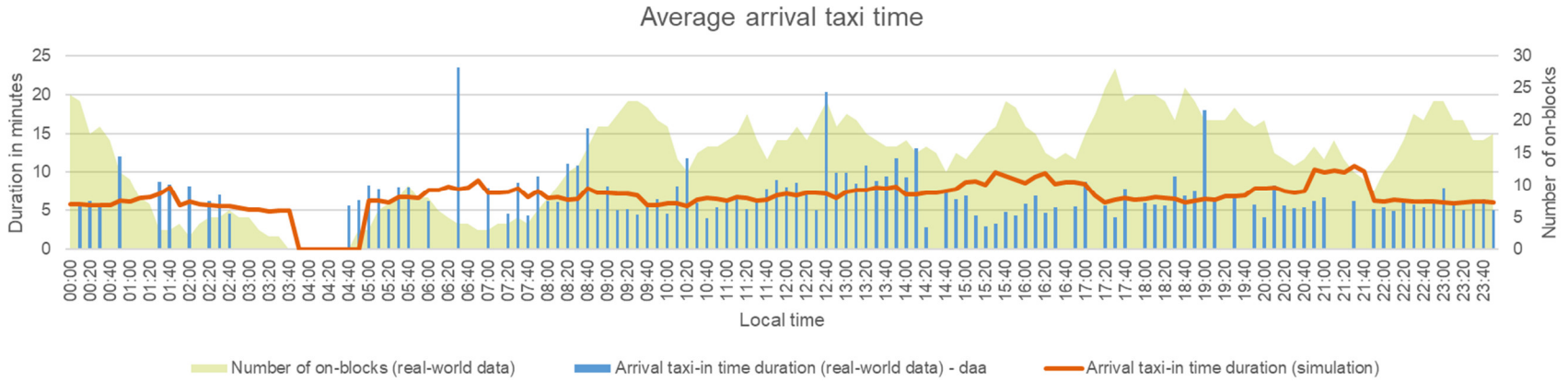


*This graph is presented as a rolling 10-minute average (value for each time period has been calculated as average of values of all events occurring within the T+10 minutes window from the start of the measurement).

Metric definition (simulation): The time duration the aircraft has been occupying the arrival runway of its arrival Airport. This value is updated every second of simulation time once the aircraft has touched down until it has left the runway safety zone.

Metric calculation (using real-world data): Calculated as average of ROTA field (provided by IAA) in the last rolling period.

4.7 Average arrival taxi time

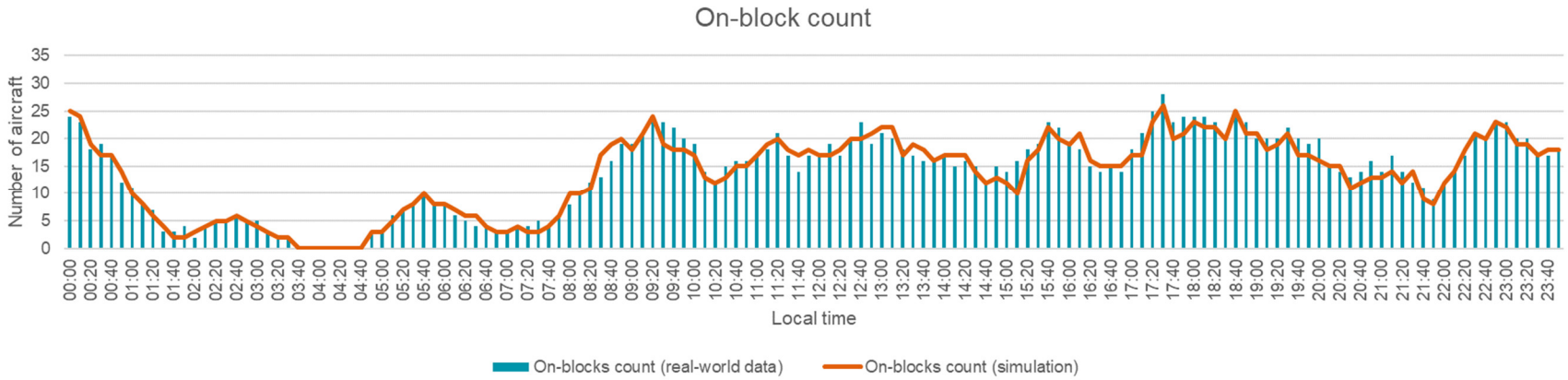


*This graph is presented as a rolling 10-minute average (value for each time period has been calculated as average of values of all events occurring within the T+10 minutes window from the start of the measurement).

Metric definition (simulation): The time duration the arriving aircraft has been taxiing on the ground of its arrival airport. This value is updated every second of simulation time when the arriving aircraft is taxiing even if the aircraft is stopped on ground. Arrival taxi time is defined to be the time period between exiting the runway safety zone and on-block.

Metric calculation (using real-world data): Calculated as difference between ALDT field (provided by IAA) and BLOCK_TIME_LOCAL field (provided by daa) decreased by value of ROTA field (provided by IAA) to account for the time period between touchdown and exiting the runway safety zone.

4.8 On-block count

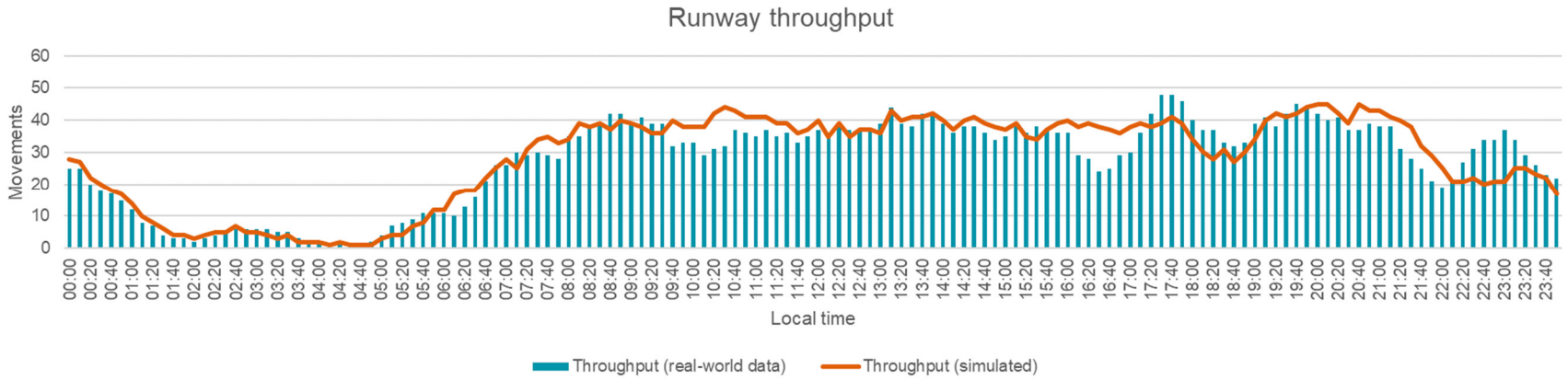


*This graph is presented as a rolling 60-minute average (value for each time period has been calculated as average of values of all events occurring within the T+60 minutes window from the start of the measurement).

Metric definition (simulation): The number of aircraft that have reached their arrival parking position in the last rolling period. The count is incremented when aircraft reaches its in-blocks position.

Metric calculation (using real-world data): Calculated as count of on-blocks in the last rolling period measured on the BLOCK_TIME_LOCAL field (provided by the daa).

4.9 Runway throughput



*This graph is presented as a rolling 60-minute average (value for each time period has been calculated as average of values of all events occurring within the T+60 minutes window from the start of the measurement).

This metric is combination of metrics presented in section 4.4. and 4.5.

Metric definition (simulation): Sum of all aircraft touching down and lifting-off in the last rolling period.

Metric calculation (using real-world data): Sum of all aircraft touching down and lifting-off in the last rolling period.

5 Conclusions and next steps

As the metrics calculated through the FTS model closely match the real-world data, both in terms of the magnitude and the shape of profile throughout the day, the baseline model can be considered as a satisfactorily representation of reality for the purpose of evaluating the impact of changes in flight schedules. It should be noted the model is considered to be valid if it is a sufficiently accurate representation of the corresponding real-world problem from the perspective of the intended uses of the model. "Valid" for a simulation does not mean the same as “indistinguishable from the real-world system”, even though in this case there is a close match.

The baseline model will be now updated with traffic schedules for the S17 design day (11 August 2017) and airside performance on this day will be simulated and recorded as a reference case scenario. Subsequently, this S17 design day will be adjusted with anticipated S18 changes in the flight schedule. This alternative S18 scenario will be compared against the reference S17 case in order to ascertain the impact of proposed changes to the flight schedule.

Results from this comparison will be presented on the 17 August 2017 during the Coordination Committee pre-meeting to better inform stakeholders’ voting decision. The remainder of the capacity analysis will be completed and shared with all stakeholders on Monday 25 September 2017.

6 Feedback received

The table below provides overview of comments received on the airside model together with indication of actions taken to address these comments.

ID	Comment	Action taken
#1	General modelling – it's difficult to understand what is happening in the model. Would it be possible to see the airline operating code and perhaps flight number of origin/destination?	Video from the latest version of the model now contains aircraft labels which include ICAO codes of origin and destination. Colour scheme has been adjusted to allow better readability of aircraft labels.
#2	7 Narrow body aircraft on West Apron at 5:30 – these aircraft should be on X1-X13 stands	Stands X1 to X13 were missing in the previous version of the model. These stands have been added to the latest version and are used for overnight parking of aircraft that were parked on West Apron in the previous version of the model.
#3	7:30 showing departures from West Apron. This can't happen – only cargo and transit operations allowed. These should have been towed to Pier 3/4 first for a subsequent departure	See the comment above. No more operations on the West Apron with the exception of aircraft that operated from this apron on the Design Day (e.g. military C17)
#4	9:04 a/c Code E aircraft towed onto but onto Code D stand – not allowed	Aircraft size stand restrictions have been revised.
#5	Looks like MRO stands 101-104 are being used for commercial operations – not allowed	Stands 101-104 have been closed for commercial operations. The only exception relates to flights that actually operated from stands 101 and 103L on the design day.
#6	It looks like the dimensions of the stands on 5G and some of the adjacency rules need to be changed. If 143C is in use, then 143L/R can't be used but this happens several time in the model. Also, there are ATRs parking on 143C – this would never happen as that is the largest stand in the Airport!	Aircraft size stand restrictions have been revised. Moreover, smaller aircraft have been prevented from unnecessarily using the large stands.
#7	Could you provide a towing log from the model so we can understand where aircraft are being towed to/from	The towing log from the simulation shows that 55% of tows happened in line with the data we have available. Unfortunately, AirTOp software does not provide many options to give us detailed control over towing operations. As it is not the purpose of this model to focus on towing operations, we do not consider this being an issue for the future scenarios, especially given the fact that there is a really good match in all of the key metrics we used to validate the model performance.
#8	No passenger operations allowed on West Apron, stands 101-104 are MRO only	See response to #5
#9	4.4 – data in chart seems skewed after 13:40. Is there a reason for this?	This is caused by differences in actual and simulated taxi out durations.
#10	As 23rd June 2016 was a RWY28 operation day, is it planned for the	Yes, the model will be used to assess both RWY28 and RWY10 operations.

<table>
<tr><td></td><td>RWY10 operation also to be assessed once this methodology is validated?</td><td>Our intention is to crosscheck performance of the S16 model in RWY10 direction with the data we have available from the IAA.</td></tr>
<tr><td>#11</td><td>It is quite rare for Category D aircraft (B-772, A-330, etc.). to vacate the runway via B7 (less than 5%). The model seems to allocate the full-length for all arrivals of this category as well as B-757 and A-321??</td><td>The model now includes % use and estimated aROT for each runway exit. The assumptions we used were based on available IAA data and are as follows:<table><tr><td>Exit</td><td>% of ARR</td><td>aROT (s)</td></tr><tr><td>E5</td><td>16.5%</td><td>51</td></tr><tr><td>E6</td><td>73.7%</td><td>60</td></tr><tr><td>E7</td><td>5.3%</td><td>63</td></tr><tr><td>B7</td><td>4.5%</td><td>70</td></tr></table></td></tr>
<tr><td>#12</td><td>Assumption: “Departing aircraft needs to be above the opposite runway threshold before the following aircraft can take off or land” - True for landing following departure but a departure following another departure cannot be given take-off clearance until the first aircraft reaches 1.0NM from the departure end of the runway. It is this that gives the minimum departure interval of 84 seconds (typically) – however, it is not clear from the video that this distance/time is being respected – please confirm</td><td>The model has been amended to ensure the separation between two subsequent departures is at least 84 seconds.</td></tr>
<tr><td>#13</td><td>Another method of (easily) validating the figures in 4.4 and 4.5 would be to provide an aggregate of the two graphs which then would show total runway throughput. These should give rolling values of the order of 40-50 movements per 60m.</td><td>Please see graph in section 4.8.</td></tr>
<tr><td>#14</td><td>Stand allocation needs improvements</td><td>Stand allocation improved. 99.3% of all aircraft in the simulation use exactly the same stand as in reality.</td></tr>
<tr><td>#15</td><td>TWY B2 is not part of a standard tow route</td><td>B2 has been closed for all tows.</td></tr>
<tr><td>#16</td><td>A gridlock situation occurs in the simulation at 17:05, which lasts for 18 minutes.</td><td>Gridlock has been resolved.</td></tr>
<tr><td>#17</td><td>No use of F-inner permitted by aircraft with wingspan >36m</td><td>F-inner has been closed for aircraft with wingspan >36m.</td></tr>
<tr><td>#18</td><td>Widebody tow locations should prioritise the use of 411C, 119C/120C/203C/205C and stands 137C-143C</td><td>Appropriate rule has been implemented</td></tr>
</table>