EUROCONTROL

Additional Taxi-Out Time Performance Indicator document

Level 1 and 2 documentation of the Additional Taxi-Out Time performance indicator

Overview

This document is a Level 1 & Level 2 document for the Additional Taxi-Out Time performance indicator.

The approved version of this document is quality controlled as part of the PRU (prototype) Quality Management System.

Edition Number:	00-04
Edition Date:	24/02/2015
Status:	Draft
Intended For:	
Category:	Performance Monitoring and Reporting – Level 1/2

European Organization for Safety of Air Navigation

TITLE		
Additional Taxi-Out Time Performance Indicator document		
	Publications Reference:	
	ISBN Number:	
Document Identifier	**Edition Number:**	00-04
EUROCONTROL PI_descr_ATXOT	**Edition Date:**	24/02/2015

Abstract

This document describes conceptual, informational and mathematical, and platform independent model of the additional taxi-out time performance indicator.

Keywords

Performance indicator

	Responsibilities	Unit
Document Authors	Laura Capelleras	PRU/SQS
Document Reviewer	Arnau Arnaiz	PRU/SQS
Document Approver		

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 General

This document describes the conceptual, logical, and mathematical model of the additional taxi-out time performance indicator.

The indicator is used as part of the performance monitoring and reporting under:

- SES: IR691/2010 and IR390/2013; and
- EUROCONTROL: performance review reporting.

1.2 Purpose of the document

The purpose of this document is twofold:

- To document the concept, underlying information and mathematical modelling of the indicator; and
- To present the processing and use of data for the calculation of the indicator.

1.3 Scope

This document covers the data processing and calculation of the additional taxi-out time performance indicator.

The calculation of this performance indicator is performed according to the Airport Data Flow standard for data collection and processing, under the responsibility of the airports division in the QoS department of the PRU, which is compliant with IR691/2010 and IR390/2013. The Airport Data Flow associated processes and procedures are documented as part of the PRU Quality Management System.

Additionally, this performance indicator is regulated in the Implementing Regulation (390/2013), Annex I, Section 2 Environment, 2.2 (b).

1.4 Summary of the performance indicator information

Additional Taxi-Out Time summary			
Version status and evolution	Conceptual Phase	2008	phase completed
	Technical Development	2008	phase completed
	Prototyping / Validation	2008-2011	phase completed
	Monitoring	2011-today	active
	Target Setting		n/a
	Phase Out		n/a
Context	KPA (SES II Performance Scheme): Environment (RP2) / Capacity (RP1) KPA (PRC/PRU): Efficiency Trade Offs: throughput and ATC local delay. Originator: ATMAP project Supports the SES II Performance Scheme: Implementing Regulation (390/2013), Annex I, Section 2 Environment, 2.2 (b).		
Key Question	What is the effect of the departure queuing techniques applied at the airport? What is the effect of limiting ATC pre-departure delays on queuing departing aircraft?		
Description	This indicator provides a proxy for the average departure runway queuing time on the outbound traffic flow, during times that the airport is congested.		
Formula and Metrics	The indicator is calculated on the basis of data availability for Actual Off Block Time (AOBT) and Actual Take-Off Time (ATOT). The additional taxi-out time per group of similar flights is the difference between the actual taxi-out time and the median unimpeded taxi-out time. Taking the weighted average of the values for all groups produces the taxi-out additional time for the airport		
Units	Minutes per IFR departure		
Used in	EUROCONTROL: Performance Review Reporting SES: IR691/2010; IR390/2013; Annual Performance Report; SES eDashboard		
Uncertainties	a) related to methodology: none in particular - Additional time does not depend on push-back delays. - Additional time does not depend on extra delays before joining the runway queue - ATMAP taxi-out shows a high correlation with local taxi-out measures (LHR and MUC) and with TAAM simulations (Madrid, Palma). - De-icing times can be taken out at least with three different methods. b) related to data - Data accuracy varies depending on the availability of stand/runway configuration and on the accuracy of the recording of the AOBT. The mitigation strategy is to use always the best data source at a given airport among two (airport operators and/or airlines).		
Use of indicator	The purpose of this indicator is to measure the queuing time before take-off. Trade-off can be observed between taxi-out additional time, ATC pre-departure delay and runway throughput.		

Table 1: Performance Indicator summary

1.5 Acronyms and terminology

Term	Definition
AOBT	Actual On-Block Time
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATMAP	ATM Airport Performance project
ATOT	Actual Take-Off Time
AcTXOT	Actual Taxi-Out Time
ATXOT	Additional Taxi-Out Time
ICAO	International Civil Aviation Organization
IR691	COMMISSION REGULATION (EU) No 691/2010
IR390	COMMISSION REGULATION (EU) No 390/2013
KPA	Key Performance Area
KPI	Key Performance Indicator
PI	Performance Indicator
PRU	Performance Review Unit
QoS	Quality of Service
(D)RWY	(Departure) Runway
SES	Single European Sky
(D)STND	(Departure) Stand
TMA	Terminal Manoeuvring Area

Table 2: Acronyms and terminology

2. Conceptual model

2.1 What we ideally would like to measure

This conceptual indicator has been selected to measure the operational inefficiencies associated with the techniques used to manage (i.e. maximise) runway utilisation for the departure flow. This is reflected by the accumulated (i.e. additional) time spent in the departure queue during taxi operations on the apron and taxiway system, including queuing at the runway threshold.

2.2 Concept of runway optimisation

When aircraft cannot fly unimpeded 4D trajectories, there are generally three places at which queuing takes place, as illustrated in the Figure:

- At the departure stand (pre-departure queuing to optimise network performance)
- At the departure runway (take-off queuing, e.g. runway holding)
- In the arrival terminal airspace (arrival queuing in the Arrival Sequencing and Metering Area or ASMA, using speed control, stacks, holding, extension of approach path etc.)

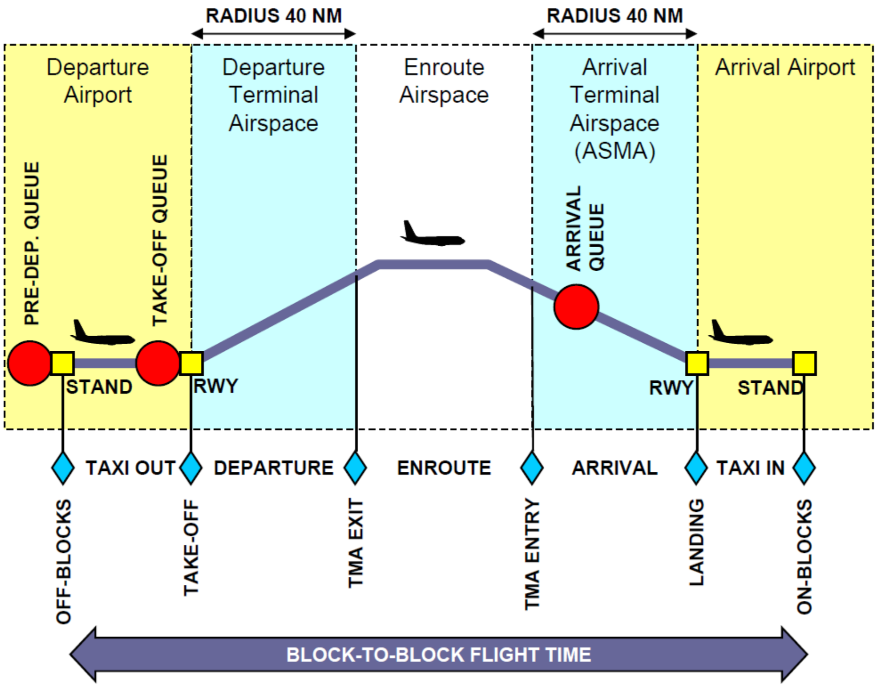


Figure 1: Outbound and Inbound Traffic Queues from a Flight Phase Perspective

In order to ensure continuous traffic demand at runways and maximise runway usage, a minimum level of queuing is required. A certain amount of departure runway queuing is necessary to allow for an optimisation of departure (and arrival) management in terms of runway utilisation when demand is at or near operational capacity. Optimisation of runway utilisation may require:

- Re-sequencing the take-off (and landing) order at the runway; and
- Establishing a buffer of a sufficient number of aircraft in the queue to be able to fine-tune the runway throughput.

In both cases some aircraft will suffer a certain penalty in terms of queuing. Higher runway utilisation targets may require higher levels of departure (take-off) queuing on the taxiway and apron system. This effect can be reduced, if aircraft are delivered to the queue in the right sequence and at the required time intervals.

To reduce cost and environmental impact, the departure queuing time should be kept to the minimum needed to achieve the envisaged runway utilisation objective. Ideally, any departure delay that is needed for other reasons than sequencing should be absorbed at the departure stand through ATFM delays and local ATC pre-departure delay. If this is done properly, then measuring outbound and inbound queuing time allows assessment of the “operational cost” associated with sequencing and metering in function of the selected runway utilisation objectives.

Accordingly, measuring outbound queuing time in terms of additional taxi-out time makes it possible to assess the efficiency of the departure process (i.e. management of departure queue, runway utilisation) and, thus, the operational cost associated with sequencing.

2.3 Conceptual approach

The additional taxi-out time indicator aims to provide a measure of the average departure runway queuing time and inefficiencies on the apron and taxiway system during the taxi-out phase. The additional taxi-out time is a proxy for the level of efficiency (i.e. inefficiency) of the local operations during the taxi-out phase of a flight.

Performance in terms of additional taxi-out time is monitored on the basis of regular reporting in comparison to a nominal reference. Based on regular reporting, metrics are derived for the respective reporting month. The current measurements are compared to a nominal reference to address the level of efficiency. The reference is derived from the statistical analysis of a reference period sample. This approach is depicted in Figure 2. The additional taxi-out time is a measure of the “level of efficiency” to which the actual taxi-out time (actual metrics) exceeds the unimpeded reference (reference metrics).

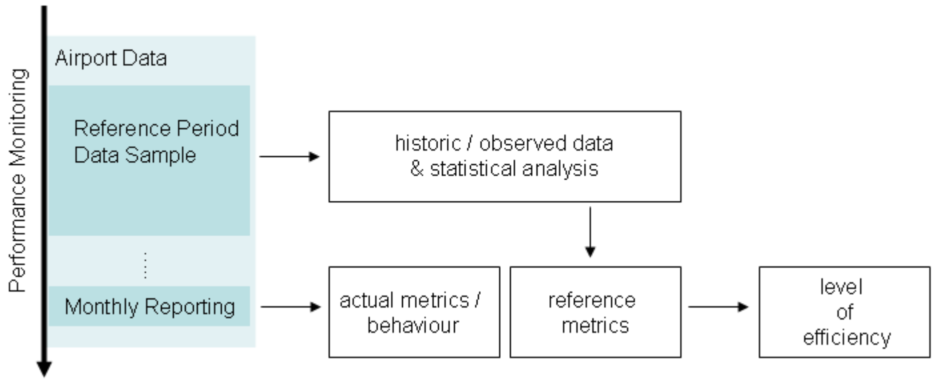


Figure 2: Performance Measurement Approach

The taxi-out additional time is defined as the difference between the actual taxi-out time of a departing flight (taxi-out transit time) and a reference time (‘unimpeded’). The unimpeded reference time is determined based on a statistical analysis of historic data observed at the airport. The performance vision is to reduce the additional time to the extent possible while also paying attention to the trade-off with other performance aspects.

3. Logical model

3.1 Assumptions

The purpose of the **Additional Taxi-Out Time** indicator is to provide a reliable measure of the **average outbound queuing time** during times that the airport is congested.

Considering the temporal efficiency during the departure phase of a flight distinct, sub-phases can be identified as depicted in Figure 3. Taking into account the timestamp data available, taxi-out time is defined as the time elapsing between the Actual Off-Block Time (AOBT) and the Actual Take-Off Time (ATOT). This time envelope covers both systemic durations (e.g. time spans for certain procedures, queuing at runway to ensure flight demand) as well as additional time aspects linked to the actual performance of the operations. This systemic duration of the taxi-out time is captured using statistical analysis for periods of low traffic, referred to as Unimpeded Taxi-Out Time (UTXOT).

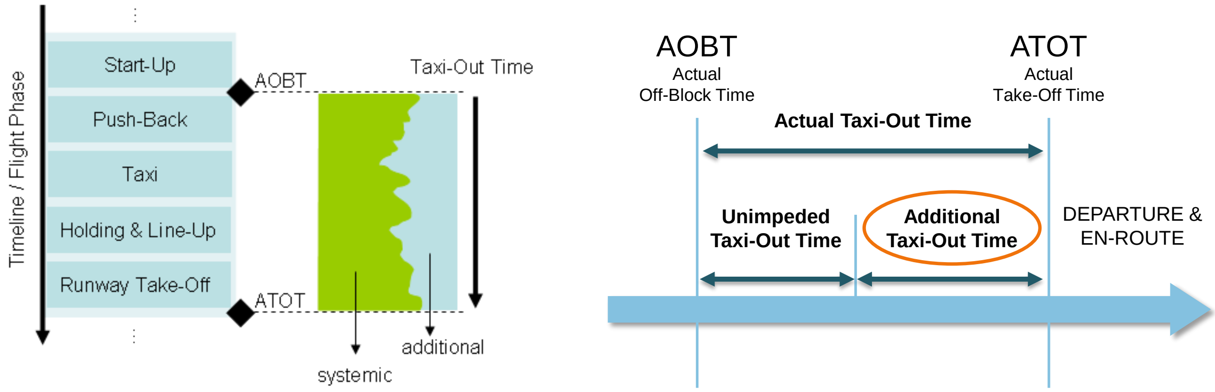


Figure 3: Flight phase temporal mapping (left) and performance indicator definition (right)

Systemic factors are assumed to be captured in the nominal unimpeded reference; they do not significantly influence the metric: including:

- the runway occupancy time during the take-off roll
- the additional time in push-back operations
- the additional time prior to joining the runway queue

3.2 Grouping of flights

The indicator is first calculated at disaggregated level, i.e. for a comparable **grouping** of flights with the same combination of **departure runway** and **stand**. Each grouping of flights has an unimpeded reference associated with it. Taking the weighted average of the values for all groups produces the additional taxi-out time for the airport.

In some airports, the grouping of flights is done for flights with the same combination of departure runway and stand group. The **stand groups** are virtual groupings of departure stands, defined from airport apron area maps with the objective of determining a common unimpeded reference for several stands that are close to each other, so that their average unimpeded times have no statistical difference. In the current calculation, stand groups are defined only on the largest airports (see Section 5.1). In those airports with stand groups defined, grouping of flights is carried out according to departure runway and stand groups (instead of departure runway and stand).

3.3 Overview of the logical model of the Additional and Unimpeded Taxi-Out Times

The aim of this section is to provide an overview the logical algorithm that is defined from the conceptual model.

Additional taxi-out time is calculated as depicted below.

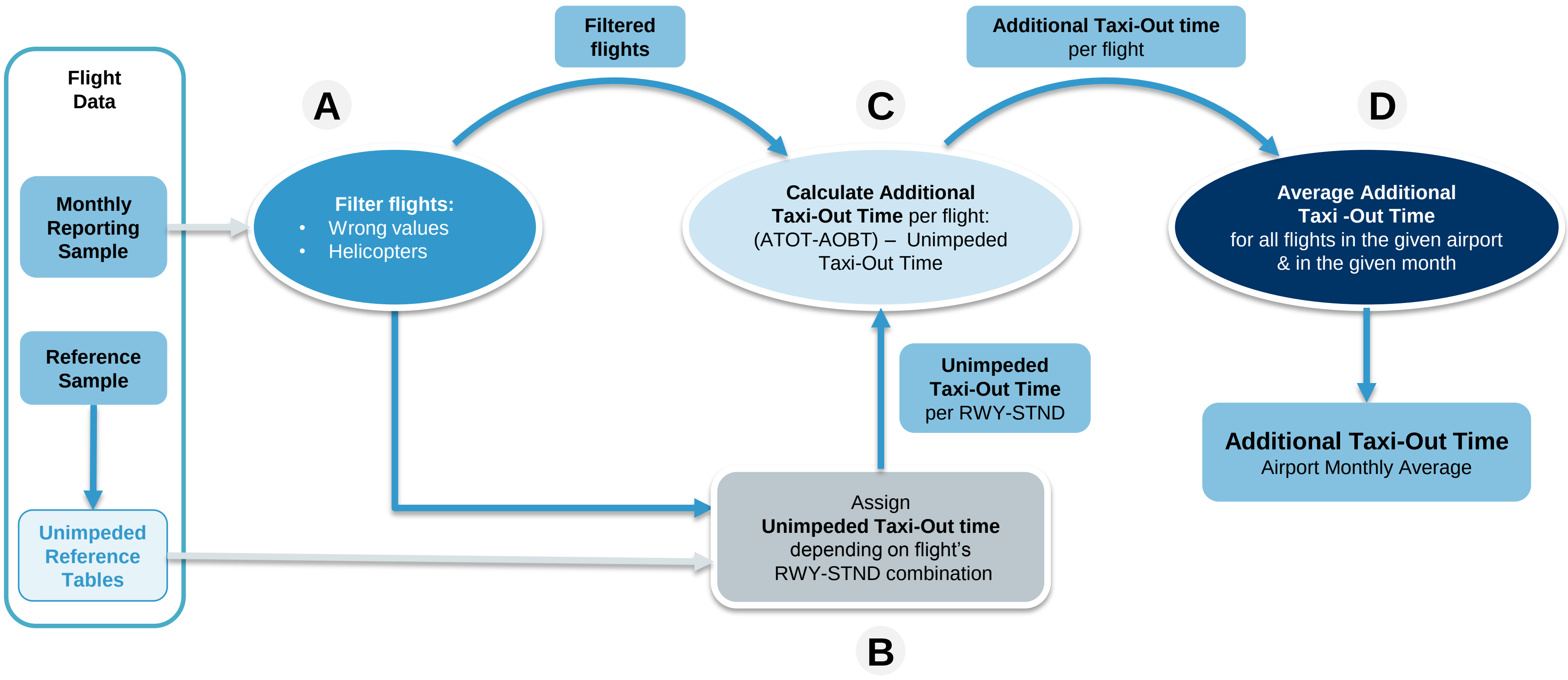


Figure 4: Logical steps in Additional Taxi-Out Time calculation

Unimpeded taxi-out time is calculated as depicted below.

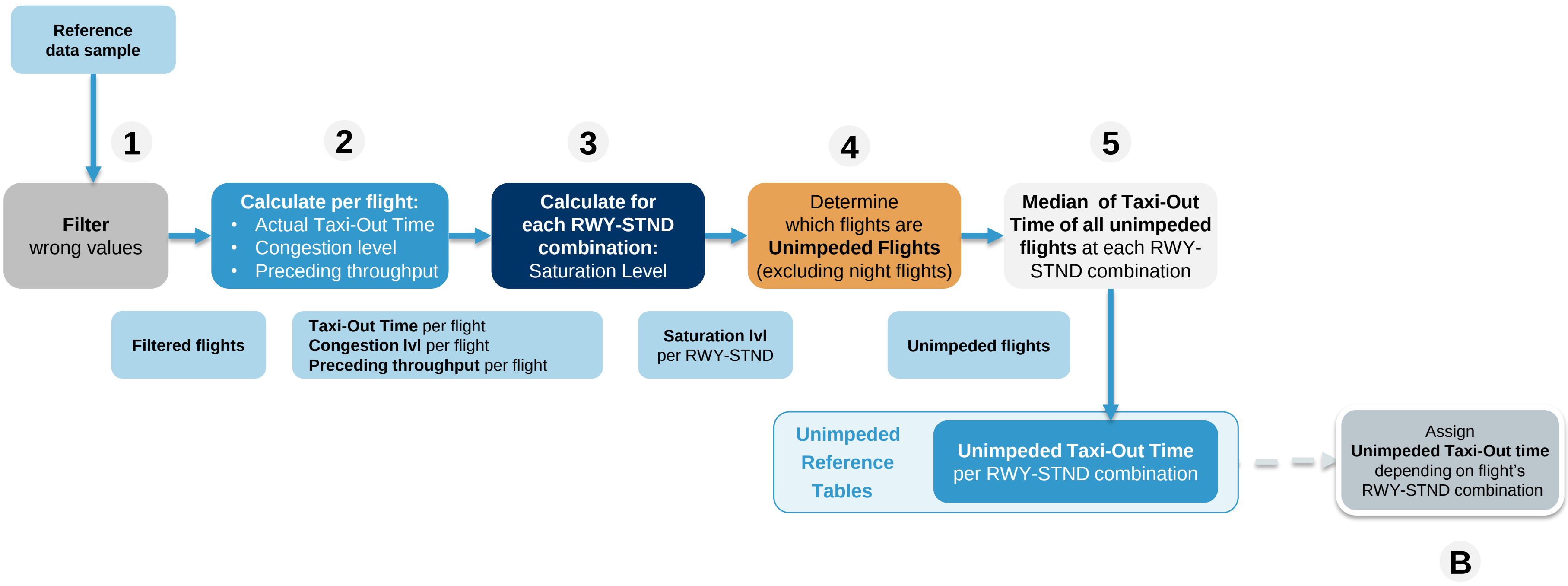


Figure 5: Logical steps of Unimpeded Taxi-Out Time calculation

3.4 Logical approach to Additional Taxi-Out Time calculation

This section focuses on the algorithm for the calculation of the additional taxi-out time indicator from a logical point of view. The computation of the indicator is based on four consecutive steps:

A. Filtering out of the flights with erroneous data and helicopters.

B. Assignment of an unimpeded taxi-out time of the unimpeded reference tables, calculated from a reference dataset in a separate process that is explained in the next section, with their values being constant for groups of similar flights (same departure stand, same departure runway).

C. Calculation of the average additional time for each group of similar flights by calculating the additional time for each flight through subtraction of the group's unimpeded time from the actual time each aircraft spent on the taxi-out phase.

D. Calculation of the monthly average of additional taxi-out time for the airport, which is the weighted average of the average additional taxi-out times of all groups of similar outbound flights. [min/IFR flight].

3.5 Logical approach to Unimpeded Taxi-Out Time calculation

The unimpeded taxi-out time corresponds to the taxi-out time that an aircraft of a given Departure Runway – Departure Stand (RWY-STND) combination would spend if no additional sequencing time was added, i.e., if the operation was unimpeded. The unimpeded times are calculated from a reference data set, and their values are constant for each combination.

The unimpeded taxi-out time for each flight is taken from the unimpeded reference tables. These are calculated by averaging the actual taxi-out time for the unimpeded flights from a reference sample (e.g. one year worth of data). The basis of the algorithm is to determine which flights are unimpeded.

The process steps are described below:

1. Filtering out of the flights with no data or with wrong data.
2. Calculation of actual taxi-out time and congestion level for each flight
3. Calculation of saturation level for each flight and flight groupings having same departure runway – departure stand combination;
4. From these flights, determination of which flights are unimpeded by comparing congestion level and saturation level, for each grouping of flights with a different departure runway – departure stand combination;
5. Calculation of unimpeded time is made as the median of all unimpeded flights in the grouping for each departure runway – departure stand combination, for groupings that have at least 10 unimpeded flights. No unimpeded time is calculated for the groupings that have less than 10 unimpeded flights. Night flights are excluded.

4. Mathematical model

The aim of this section is to describe how the logical model is modelled mathematically:

4.1 Mathematical model of the Additional Taxi-Out Time performance indicator

The actual taxi-out time is defined as the time elapsing between the Actual Off-Block Time (AOBT) and the Actual Take-Off Time (ATOT). Mathematically, the additional taxi-out time performance indicator is calculated as the difference between the actual taxi-out time, and a previously computed taxi-out time reference.

Units for each variable are shown in [ ] brackets.

4.1.1 Step A: Filtering

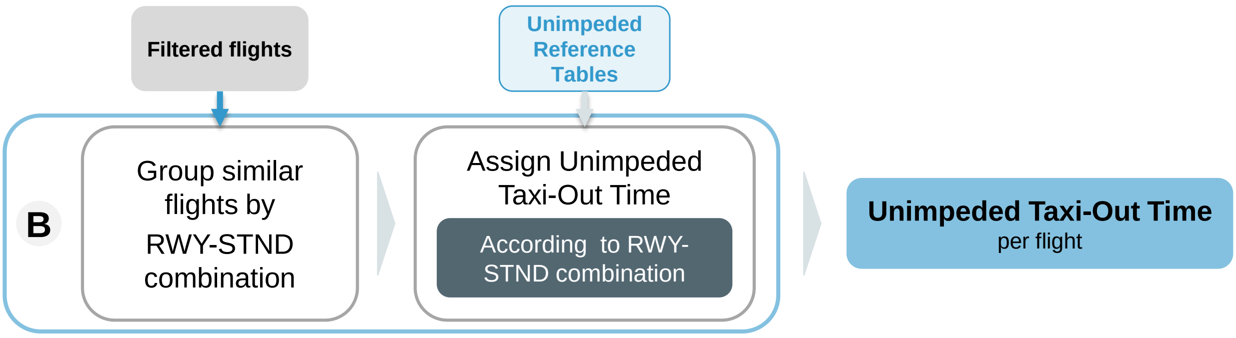
Calculation of the additional taxi-out time performance indicator is done with the flight data reported by airports as monthly reporting.

The following filter criteria apply:

- flights with no actual taxi-out time or an actual taxi-out time of more than 5 hours are excluded, i.e. flights with $AcTXOT < 300min$ are taken into account;
- Helicopters are also excluded from the calculation.

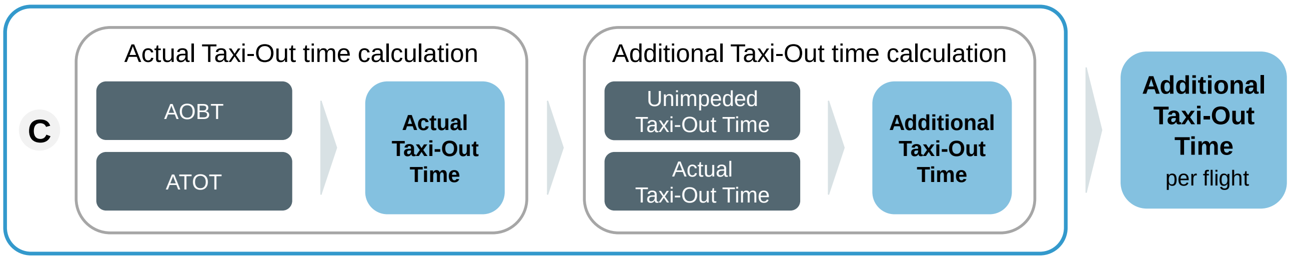
4.1.2 Step B: Determination of unimpeded time by RWY-STND combination

In this step, flights are assigned a reference unimpeded taxi-out time from the unimpeded reference tables, according to the grouping of flights they belong. The **Unimpeded Taxi-Out Time** $UTXOT(c_i)$ is a calculated constant for each grouping c_i (for calculation see section 4.2) [min]. The unimpeded taxi-out time is the taxi-out time in non-congested conditions at the departure airport.



Flights are grouped by c_i, or **grouping of flights** with the same departure runway (direction of runway, i.e. 12 or 30r) and departure stand, at each airport j (j=1-n, being *n* the total number of airports affected by regulation IR390/2013). For example, if there are two departure runways and 20 stands, there will be 40 c_i groupings of flights.

4.1.3 Step C: Calculation of Additional Taxi-Out Time per flight



Let:

- f (departing) flight;
- f_{c_i} flight belonging to combination c_i;
- $AOBT(f_{c_i})$ actual off-block time of flight f_{c_i};
- $ATOT(f_{c_i})$ actual take-off time of flight f_{c_i};

The $AcTXOT(f_{c_i})$, the **Actual Taxi-Out Time** for a flight f_{c_i}, is defined as the elapsed time between the actual off-block time $AOBT(f_{c_i})$ and the actual take-off time $ATOT(f_{c_i})$,

$$AcTXOT(f_{c_i}) = ATOT(f_{c_i}) - AOBT(f_{c_i}), \text{ [min]}$$

A filter is applied at this point so that only flights with actual taxi-out time $< 300min$ *are* taken into account.

Then, the **Additional Taxi-Out Time per flight** $ATXOT(f_{c_i})$ is calculated for each flight f_{c_i} as the difference between the actual Taxi-Out Time $AcTXOT(f_{c_i})$ of the flight and the Unimpeded Taxi-Out Time $UTXOT(c_i)$ for the Grouping c_i to which the flight belongs.

$$ATXOT(f_{c_i}) = AcTXOT(f_{c_i}) - UTXOT\ (c_i), \text{ [min]}.$$

4.1.4 Step D: Calculation of the Additional Taxi-Out Time per airport

- N_j is the total number of IFR arrivals in the data set used for calculation of the additional taxi-out time performance indicator, [count].

The **Additional Taxi-Out Time for a given airport** $ATXOT_j$ is the weighted average of the Additional Taxi-Out Time $ATXOT(f_j)$, for all the flights f_j at that airport that have an unimpeded reference, in the sample N_j.

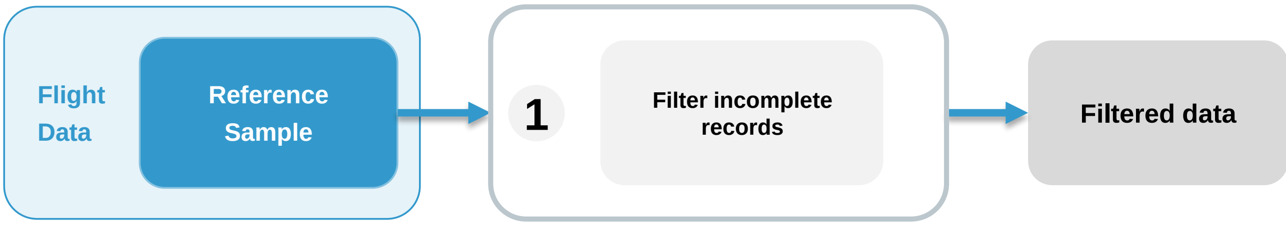
$$ATXOT_j = \frac{ATXOT(f_j)}{N_j}, \text{ [min/IFR arrival flight]}.$$

4.2 Mathematical model of the Unimpeded Taxi-Out Time

The unimpeded taxi-out time is the median of all the taxi-out times in non-congested conditions at departing airports. The following section details the calculation done as part of each step.

Units for each variable are shown in [ ] brackets.

4.2.1 Step 1: Filtering



Reference sample for calculation of unimpeded times for all airports is one year, from (and including) January 1st until 31st December of a chosen year.

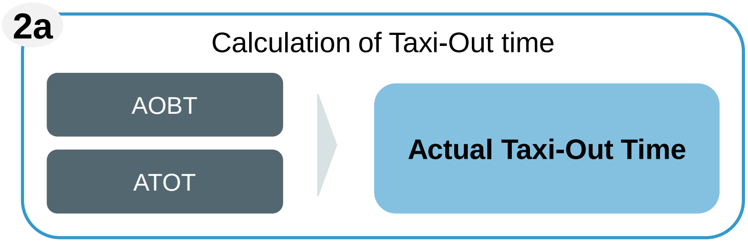
A filter is applied so that only flights with $AcTXOT(f_{c_i}) < 300min$ are taken into account.

Incomplete records will not be taken into account for the calculation, that is, records with no take-off or off-block data.

4.2.2 Step 2: Computations at flight level: Actual Taxi-Out Time, Congestion level

At flight level, there are two parallel computations that lead to two calculation outputs: The actual taxi-out time (Step 2a) and the congestion level (Step 2b).

Step 2a: Calculation of the Actual Taxi-Out Time per flight



Let:

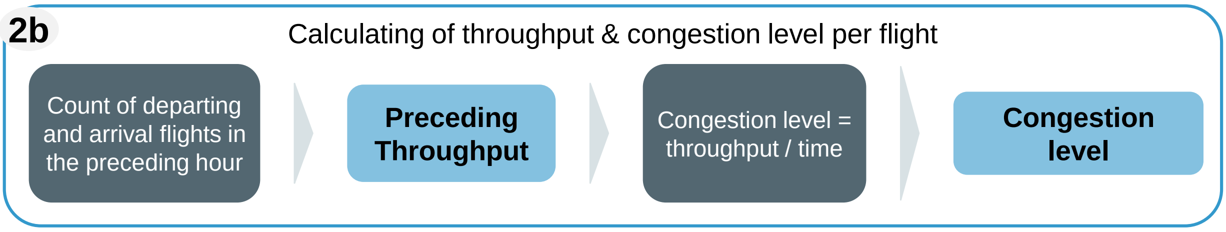
- f (departing) flight;
- f_{c_i} flight belonging to combination c_i operated between 0600-2200hrs local time;
- $AOBT(f_{c_i})$ actual off-block time of flight f_{c_i};
- $ATOT(f_{c_i})$ actual take-off time of flight f_{c_i};

The $AcTXOT(f_{c_i})$, the Actual Taxi-Out Time for a flight f_{c_i}, is defined as the elapsed time between the actual off-block time $AOBT(f_{c_i})$ and the actual take-off time $ATOT(f_{c_i})$,

$$AcTXOT(f_{c_i}) = ATOT(f_{c_i}) - AOBT(f_{c_i}), \text{[min]}$$

Step 2b: Determination of Congestion Level per flight

For each flight f_{c_i}, a **congestion level** $seq(f_{c_i})$ can be determined [count].



The congestion level aims at capturing the level of traffic encountered by a departing flight during the taxi-out phase. It is a flight-specific value; it will be used later to – statistically – determine whether the respective flight has experienced non-congested traffic conditions.

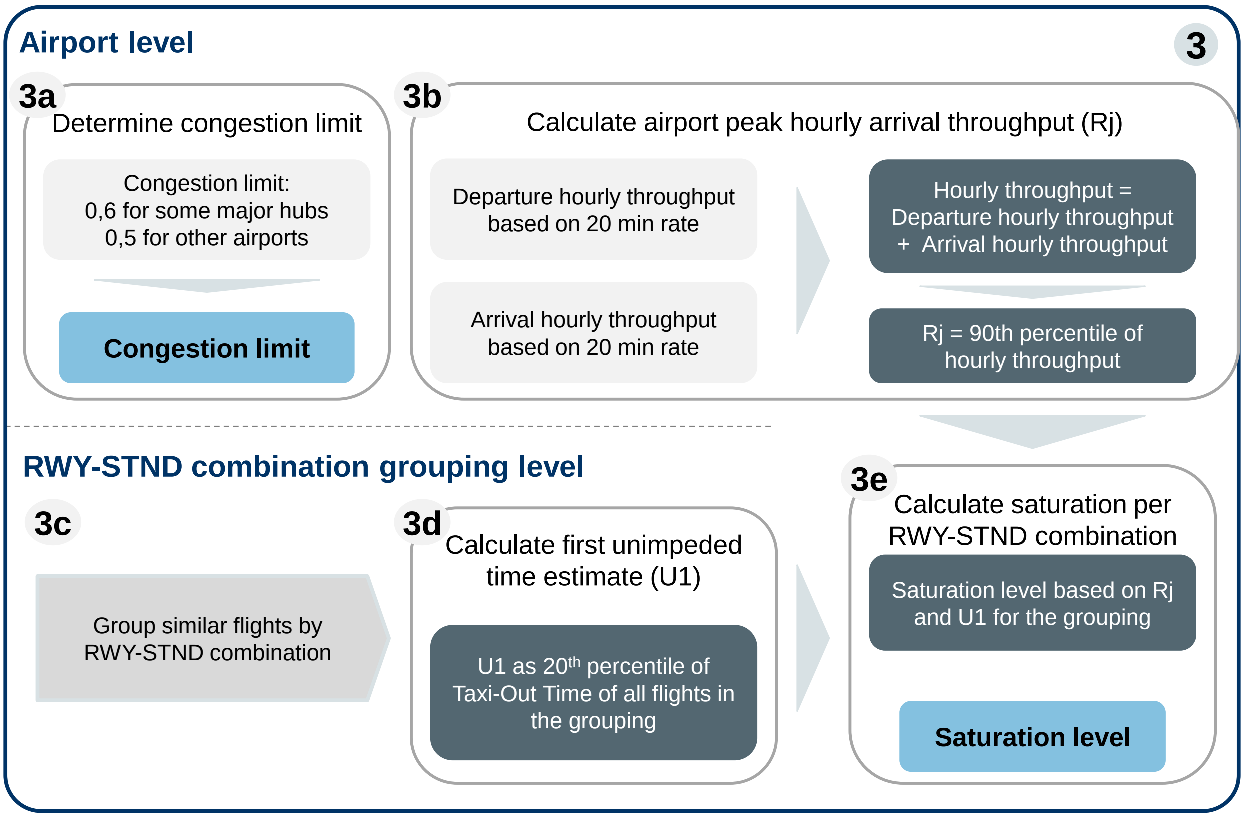
The congestion level is defined as the number of movements (i.e. arrivals and departures) within the taxi-out transit time (i.e. time between off-block and take-off) of the respective flight.

$seq\left(f_{c_i}\right) = count(departures\ and\ arrivals\ during\ taxiout) = count(f)$ for all flights f such that:

$AOBT(f_{c_i}) \leq ATOT(f) \leq ATOT(f_{c_i})$ for take-offs, or $AOBT(f_{c_i}) \leq ALDT(f) \leq ATOT\left(f_{c_i}\right)$ for landings.

4.2.3 Step 3: Computation of the Saturation level

Computation of the saturation level requires the previous determination of the airport congestion index (Step 3a) and airport arrival throughput R_j (Step 3b). The grouping of flight according to their AC-RWY-SEC combination (Step 3c) allows the calculation of the first unimpeded time estimate U1 (Step 3d) and latter determination of the saturation level based on the results from each one of the computations (Step 3e).



Step 3a: determination of airport congestion index

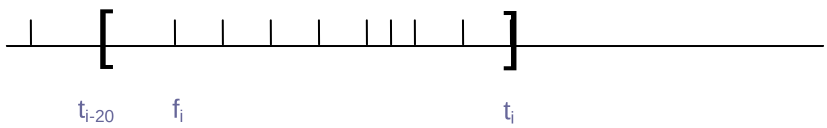
At airport level, a constant known as the **congestion limit** cl is chosen as:

- 0.6 for major hubs
- 0.5 for all other airports

Step 3b: Calculation of Airport Peak Hourly Throughput

The next step is defining the airport peak hourly throughput, which is a theoretical hourly rate based on the truncated 20min window prior to the departure*.* The – theoretical – maximum airport throughput during the taxi-out phase of a flight is seen as determinant of the level of traffic saturation and, thus, the threshold at which effects of congestion can be observed.

Based on the data sample, the theoretical hourly throughput of both departures and arrivals at the airport is determined as the hourly rate of movements observed within 20 minutes prior to the departure truncated to the observed departure or arrival times. For each aircraft departing from airport A, the number of aircraft that took-off and landed in the previous 20 minutes is counted.



Let t_i be the take-off time of the aircraft i, n be the number of take-offs and landings in the window $[t_i - 20, t_i]$ and f_i the take-off/landing time of the first aircraft in the window. Then, the arrival rate during this period is given by

$$hourlyMaxRate = \frac{n-1}{t_i - f_i}$$

The numerator of the fraction is expressed as n – 1 to denote that the aircraft *i* is excluded for the calculation of the rate.

Therefore, the airport throughput for each flight f_j in the airport *j* is calculated as:

$$\forall_{f_j}: \begin{cases} count\left(f \mid ATOT(f_j) - 20\,min \le ATOT(f) \le ATOT(f_j) \\ \quad \wedge ATOT(f_j) - 20\,min \le ALDT(f) \le ATOT(f_j)\right) \\ base = ATOT(f_j) - min(ATOT(f) \vee ADLT(f)) \\ \quad |ATOT(f), ADLT(f) \in [ATOT(f_j) - 20, ATOT(f_j)] \\ hourlyMaxRate(f_j) = \dfrac{count - 1}{base} \end{cases}$$

For example, for a flight departing at 07:04:00hrs, the first preceding departure is observed at 06:45:04. The resulting rate base is hence 18:56 minutes. Assuming 4 departures and 5 arrivals would be observed in this window (without counting the 07:04:00 flight itself), this yields a (theoretical) hourly throughput of: $hourly\ dep.throughput(flight) = \frac{(4+5)\ fligthts}{18{:}56\ min} = 0.4754 \frac{flights}{min} = 28.52 \frac{flights}{hr}$

The peak hourly arrival throughput of the airport, R_j, is calculated as the 90[th] percentile of all values of the $hourlyMaxRate$ in the reference sample

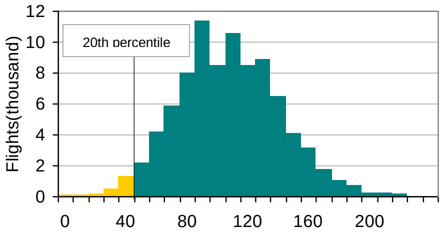
$$R_j = 90th\ percentile\ (hourlyMaxRate), \text{[flights/hour]}$$

Step 3c: Grouping of similar flights by RWY-STND combination

Flights are grouped by c_i, or **grouping of flights** with the same departure runway (direction of runway, i.e. 12 or 30R) and departure stand, at each airport j (j=1-n, being *n* the total number of airports affected by regulation IR390/2013).

Step 3d: Calculation of the first Unimpeded Taxi-Out Time estimate

For the respective departure stand (group of stands) and departure runway a first approximation of the unimpeded taxi-out time is calculated based on the observed distribution of departure flights and their actual taxi-out times.



$U_1(c_i)$ is defined as the **first Unimpeded Taxi-Out Time** estimate for each grouping of flights c_i, being the 20th percentile of all the actual taxi-out times of the flights belonging to that grouping [min].

$$\mathrm{U}_1(c_i) = 20th\ percentile\ (AcTXOT(f_{c_i}))$$

Step 3e: Determination of the Saturation Level per grouping

While the congestion level is a measure for the traffic encountered by an individual flight, the saturation threshold describes the maximum traffic level served under non-congested traffic conditions. As an upper bound for the saturation threshold, the saturation level can be estimated as the maximum number of aircraft operating under non-congested conditions (expressed by the first estimate of the unimpeded taxi-out time).

Dependent on the previous steps 3b and 3d the saturation level is calculated by multiplying the estimate of the unimpeded time U1 with the peak hourly throughput R_j, to provide an estimation of the (theoretical) maximum number of aircraft per hour (arrivals and departures) served by the airport without congestion. The result is rounded to the next unit.

$L(c_i)$, the **saturation level** of the grouping c_i, is calculated as:

$$L(c_i) = round\left(\frac{R_j * U1(c_i)}{60}\right)$$

4.2.4 Step 4: Identification of unimpeded flights

To ensure that a flight is unimpeded, its congestion level needs to be sufficiently smaller than the saturation level. Departing flights are considered as non-congested, if their congestion limit is equal or below the saturation threshold.

However, it needs to be ensured that the data sample is big enough to produce a statistically relevant sample for the chosen stand/runway combination and robust estimate of the unimpeded time.

To limit the impact of any congestion effect (and to address the sample size), the saturation threshold is estimated as a fraction of the saturation level. This limitation is achieved with the definition of the **congestion limit** cl, a constant defined in Step 3a.

Based on the previous outputs, the identification of the unimpeded flights is done: the saturation level, corrected with the congestion limit, is compared to the congestion level.

Congestion level per flight

Congestion limit (0,5 or 0,6)

Saturation level per RWY-STND

4

If flight congestion level is lower than (congestion limit) * (saturation level) for its RWY-STND combination

Flight is unimpeded

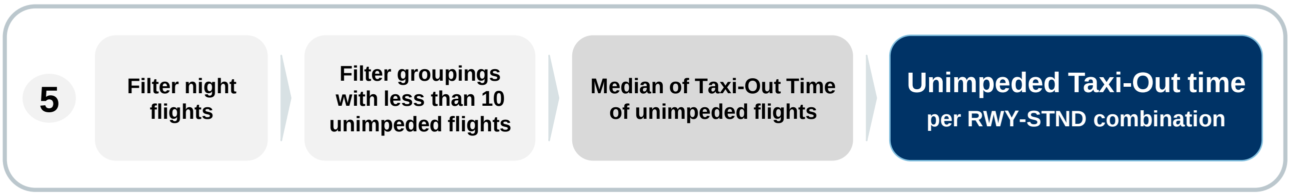
With the aim of designating the unimpeded flights, fu_{c_i} is defined as a binary variable, denoting that a flight f_{c_i} belonging to the grouping c_i is an unimpeded flight. A flight is considered unimpeded if its congestion level

$seq(f_{c_i})$ is less than or equal to the product of congestion limit cl and the flight's grouping saturation level $L(c_i)$.

$$fu_{c_i} = \begin{cases} 1, & \forall f_{c_i} \ni seq\left(f_{c_i}\right) \leq cl * L(c_i) \\ 0, & otherwise \end{cases}$$

4.2.5 Step 5: Computation of Unimpeded Time per Grouping

The unimpeded taxi-out time per grouping is computed as the median of the actual taxi-out time only for the unimpeded flights.



The **Unimpeded Taxi-Out Time** $UTXOT\ (c_i)$ for a grouping c_i is a calculated constant at the airport j.

In order to derive statistically meaningful and representative unimpeded times per group, only those groupings with equal or more than 10 flights are retained in the calculation. For groupings c_i that have less than 10 unimpeded flights fu_{c_i}, the associated unimpeded time $UTXOT\,(c_i)$ is not calculated. These groupings c_i do not have unimpeded times since the reference times are not representative enough (consequently, it is not possible to calculate additional taxi-out time for those groupings).

Night flights are excluded from the calculation at this point, so only the flights taking off during day time are considered for the calculation of the reference UTXOT. On the standard calculation day time is defined between 06:00 and 22:00 of airport local time. Calibration of day time definition may lead to different definition in some of the busiest airports (see section 5).

For the groupings c_i that have 10 or more unimpeded flights, the unimpeded time is defined as the median of the Actual Taxi-out Time $AcTXOT\left(f_{c_i}\right)$, of all unimpeded flights fu_{c_i} belonging to the grouping of flights.

$$UTXOT\ (c_i) = \begin{cases} median\ (AcTXOT\left(f_{c_i}\right)), & \forall c_i \ni count(fu_{c_i}) \geq 10 \\ null, & otherwise \end{cases}$$

These times are aggregated in an unimpeded references table for the calculation of the additional taxi-out time as described in Section 4.1.

An example is given in Table 3 below:

Airport	Stand	Runway	Unimpeded time	Saturation level	Unimpeded flights
EXXX	119	07L	…	…	…
	120	07L	11.50	10	25
	121	07L	…	…	…

Table 3: Example of unimpeded reference table of airport EXXX

Regular checks are made to ensure that unimpeded times remain representative of the operations for the airport under consideration (see section 5.2). In case a change of unimpeded times is detected, the causes of that change are investigated. When required, new unimpeded time constants are calculated.

5. Calibration of model parameters

This section describes the model parameters that need to be customized for every airport and the approach used for obtaining and updating them.

For the additional taxi-out time indicator, the parameters that need manual calibration are the stand groupings and the unimpeded times.

5.1 Stand groups

In the current calculation, grouping of flights according to departure runway and stand groups is used in airports with the greatest number of stands: London Heathrow (EGLL), Amsterdam Schiphol (EHAM), Madrid Barajas (LEMD), and Paris Charles de Gaulle (LFPG).

Grouping of stands is calibrated using airport maps.

5.2 Unimpeded Times

The base period for the calculation of unimpeded times (which are constants for each one of the groupings) is the year 2011, if available. Otherwise, the first full year with available data is taken as the reference year.

However, the unimpeded times are recalculated every month to investigate whether there are any changes in unimpeded times. Changes at the airport can have an impact on the unimpeded times. In cases where substantial changes are reported for an airport, the differences will be investigated with the particular airport, and new unimpeded times will be calculated if applicable.

Because the unimpeded time constants calculation method is based on statistical analysis of the actual taxi-out time, a period of three months after the change is required before new robust unimpeded times references can be established.

The following represents an example considering an airport XXXX with its reference unimpeded times based on the full year of 2011:

As part of the monthly values calculation, the unimpeded times will be recalculated each month (e.g. for June 2014) and compared with the “reference” ones (based on 2011).

- If the values are considered similar enough, the static values will be kept: the airport reference period will still be 2011. The validity of the reference unimpeded times based on 2011 will be extended to June 2014)
- If a change is detected in the June 2014 results (the unimpeded times recalculated based on June 2014 are significantly different from the 2011 ones), the issue will be investigated and discussed with the airport, in order to decide which new reference to take. If, for example, the change was due to a new runway opened in June 2014, the new reference will be the following year: June 2014-June 2015. However, if the difference corresponds to a runway closure of 3 months, the reference would be modified only for the affected 3 months.

Two parameters can trigger the renewal of the unimpeded time reference for one airport, each month:

- The number of flights that do not have unimpeded reference (are not in a grouping with more than 10 unimpeded flights) are more than 10% of the total traffic of the concerned month.
- The standard deviation of the unimpeded times of all the flights of the month is higher than 2 minutes.

5.3 Day time

Due to extended opening hours in certain airports, day time may be extended for the filtering of the flights in the unimpeded taxi-out time calculation.

6. Source data

The additional taxi-out time indicator is calculated using data provided by the airport operators:

Departure airport	ADEP	Airports	ANSPs, Airlines
Actual Off-block time	AOBT	Airports	ANSPs, Airlines
Actual Take-off time	ATOT	Airports	ANSPs, Airlines
Actual landing time	ALDT	Airports	ANSPs, Airports
Departure Stand	D-Stand	Airports	
Departure Runway	D-RWY	Airports	

Table 4: Data Sources

The airport operators provide the actual off-block and take-off times, the aircraft type, the departure stand and the runway used for departure.

7. Quality management

7.1 The Airport Data Flow process

The Airport Data Flow process (APDF) starts with Airport Operators sending the Data to EUROCONTROL, as required by IR691 and IR390 Regulations, on a monthly basis. Several activities are performed in the data flow process, involving different actors, until Performance reports are published.

As a summary, a high level overview of the activities can be found below:

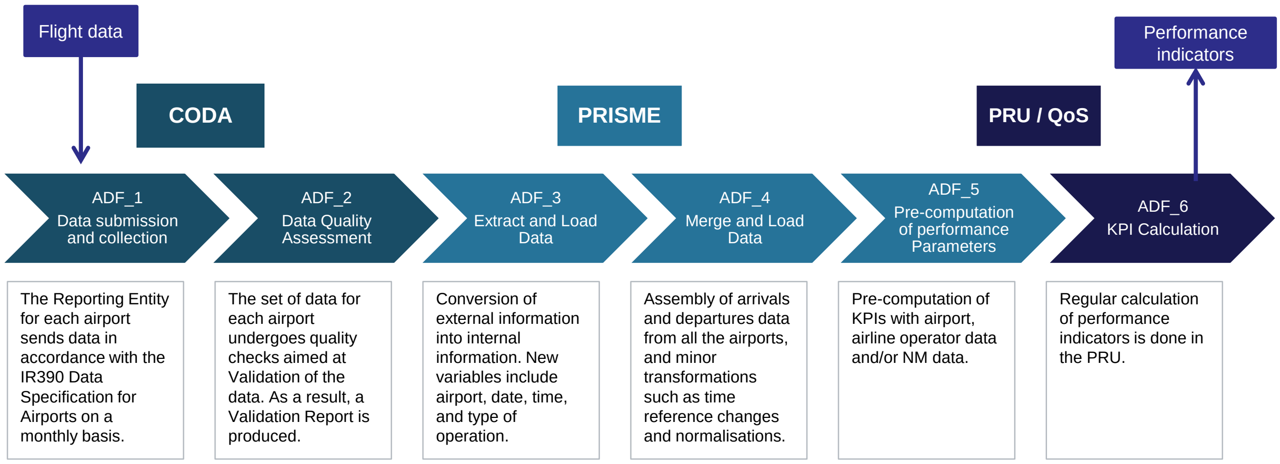


Figure 6: Airport Data Flow process scheme including activities and actors involved.

For each of the activities found in the data flow process, an owner can be defined:

- APDF_1 – Data Collection
- APDF_2 – Data Validation
- APDF_3 – Data Extract, Transform and Load
- APDF_4 – Data Merging
- APDF_5 – Pre-Computation of performance parameters
- APDF_6 – Calculation of Performance Indicators

Main sub-processes are performed by the PRISME Support team on the flight data provided by Airport Operators and validated by CODA. In the final stage, PRU computes the Key Performance Indicators using the input provided by the PRISME Support team.

The latest up-to-date ADF Process description is available at QMS Sharepoint.

7.2 Quality Assurance Framework

Quality assessment in the Airport Data Flow process is focused on implementing a Quality Assurance Framework based on the ISO 9001 Standard. The Airport Data Flow process includes several data processing activities, starting from the moment flight information is provided by the Airport Operator until Performance reports are released.

The Standard Operating Procedures for all parts of data gathering and processing have been established.

All the required quality documentation is available at QMS Sharepoint.

7.3 Data Quality checks

For each of the Areas, a list of the indicators is shown in the figure below and details are provided in the following sub-sections.

Mapping	Mapping consists of checking the format of submitted data and ensuring that the data to be stored in PRISME follow the same coding convention
Completeness	This process checks the number of operated flights, and the amount of not null values for the main fields in the airport data (e.g., OOOI, STA, STD)
Matching	A set of filters is applied to search among flights submitted by the airport operators/air carriers and find the exact flight matches in the NM database
Data Accuracy Validation	This quality check mainly assesses the quality of OOOI data (Off Block, Take Off, Landing, In Block) through a set of acceptability criteria.

Figure 7: Quality Performance Areas and corresponding Quality Indicators

More detail on these Quality checks can be found in the Airport Data Flow Data Specifications (see [3]).

7.4 PI quality checks

In the final results, the main indicator provided is the average additional taxi-out time per flight grouped by airport and month. In addition, some parameters are given that are used for data validation and statistical analysis:

- Average unimpeded time
- Standard Deviation
- Values for 25%,50% and 75% percentiles
- Number of flights, number of unimpeded flights and number of flights with valid data
- Total additional time, unimpeded time and 25%, 50% and 75% percentile
- Completeness and coverage of the traffic sample

8. References

[1] COMMISSION IMPLEMENTING REGULATION (EU) No 390/2013, Laying down a performance scheme for air navigation services and network functions, 3 May 2013. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:128:0001:0030:EN:PDF

[2] COMMISSION REGULATION (EU) No 691/2010, Laying down a performance scheme for air navigation services and network functions and amending Regulation (EC) No 2096/2005 laying down common requirements for the provision of air navigation services, 29 July 2010. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:201:0001:0022:EN:PDF

[3] Airport Data Flow Data Specifications

[4] Performance Review Commission, ATM Airport Performance (ATMAP) Framework, Measuring Airport Airside and Nearby Airspace Performance, December 2009

Revision History

Edition	Description	Comment
00-01	new draft – all pages	new document
00-02	Refinement of the logical and mathematical models	
00-03	Refinement of the logical and mathematical models and the description of the new unimpeded reference versions method.	
00-04	Increased detail in algorithm description and minor corrections.	
00-05	Improvement in the KPA definition	