EUROCONTROL

Additional ASMA time performance indicator document

Technical documentation on the methodology for the calculation of the additional ASMA time indicator

Overview

The Additional Arrival Sequencing and Metering Area (ASMA) Time addresses the time impact of the management of the arrival flow in the airspace surrounding an airport, and thus flight duration (i.e. efficiency).

This document describes the conceptual, logical and implementation independent model of the additional ASMA time performance indicator.

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Abstract

This document describes the conceptual, logical and implementation independent model of the additional ASMA time performance indicator.

Keywords

Performance indicator
Additional Arrival Sequencing and Metering Area (ASMA)

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1 Introduction

1.1 General

This document describes the conceptual, informational, and implementation independent model of the additional ASMA time performance indicator.

This document focuses on the analysis of additional ASMA time. A separate document is available regarding the analysis of additional taxi-out time [1] and additional taxi-in time [2].

1.2 Purpose of the document

The purpose of this document is twofold:

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

1.3 Scope

This document provides a technical description on the methodology used in the analysis of the additional ASMA time performance indicator. The present methodology is the result of a complete review of the previous methodology for this same indicator. This review was performed by a specific working group created for this purpose and participated by several internal and external members between November 2021 and October 2022.

The calculation of this performance indicator by EUROCONTROL makes use of the data collected through the Airport Operator Data Flow according to the specification EUROCONTROL-SPEC-175 for data collection and processing, under the responsibility of the airports team in the OPS section of the Aviation Intelligence Unit. For the calculation of the indicator, the Airport Operator Data Flow is combined with trajectory data provided by the Network Manager.

The objective of the methodology is to measure and observe additional time spent in the Arrival and Sequencing Metering Area (ASMA) without highlighting specific reasons for the observed behaviour. More detailed case studies are needed to find out reasons for particular observations.

While this document focuses on the methodology itself, results for a number of airports across Europe are available in regular publications at http://www.ansperformance.eu.

1.4 Summary of the performance indicator information

Additional ASMA time: Summary			
Current version status	Monitoring		
Version status and evolution	Conceptual Phase	2008	Phase completed
	Technical Development	2008 2022 (review)	Phase completed
	Prototyping / Validation	2008 2022 (review)	Ongoing
	Monitoring	2009-today	Active
	Target Setting		N/A
	Phase Out		N/A
Context	KPA (SES II Performance Scheme): Environment (RP2 and RP3) / Capacity (RP1) KPA (PRC) : Efficiency Focus Area: Airport impact on flight duration, punctuality, fuel burn and CO_2 emissions. Trade Offs: throughput and ATFM arrival delays. Originator: ATMAP project. Methodology reviewed in the Working Group for Additional Times Trade-off can be observed between additional ASMA time, ATFM delay and runway throughput.		
Description	This indicator provides an approximate measure of the average inbound queuing time on the inbound traffic flow, during times that the airport is congested.		
Formula and Metrics	This indicator is calculated on the basis of data availability for actual ASMA entry time (flight entering the area within 40 NM radius around the airport) and Actual Landing Time (ALDT). The additional ASMA time is the difference between the actual ASMA transit time and a reference ASMA transit time for the group of similar flights. The ASMA additional time for the airport is the average of the average ASMA values for all flights.		
Unit	Minutes per arrival		
Used in	This indicator as calculated with the previous methodology is used in SES (IR691/2010 & IR390/2013 &IR317/2019): Annual Performance Report; SES eDashboard EUROCONTROL: Performance Review Report		

Table 1: Performance Indicator summary

1.5 Acronyms and terminology

Term	Definition
AIU	Aviation Intelligence Unit
ALDT	Actual Landing Time
APDF	Airport Operator Data Flow
ARWY	Arrival Runway
ASMA	Arrival Sequencing and Metering Area
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATMAP	ATM Airport Performance project
CODA	Central Office for Delay Analysis
CPR	Correlated Position Reports
CTFM	Current Tactical Flight Model
DRWY	Departure Runway
ET	Entry Time
IR691	COMMISSION REGULATION (EU) No 691/2010
IR390	COMMISSION REGULATION (EU) No 390/2013
IR317	COMMISSION REGULATION (EU) No 317/2019
KPA	Key Performance Area
KPI	Key Performance Indicator
LT	Local Time
PI	Performance Indicator
PRISME	Pan European Repository of Information Supporting the Management of EATM
PRU	Performance Review Unit
QoS	Quality of Service
RWY	Runway
SEC	ASMA sector
SES	Single European Sky
TMA	Terminal Manoeuvring Area

Table 2: Acronyms and terminology

2 Conceptual model

2.1 What we would like to measure

On the conceptual level, the indicator aims to address the operational penalty associated with airport capacity issues and/or techniques used to maximize runway utilisation for inbound traffic flows at an airport, i.e. the accumulation of additional approach time resulting from speed control, path stretching and circling in the vicinity of the airport (use of holding patterns/stacks).

2.2 Concept of runway optimisation

When aircraft cannot fly or taxi unimpeded trajectories to the runway, there are generally three places at which queuing takes place, as illustrated in Figure 1:

- 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.)

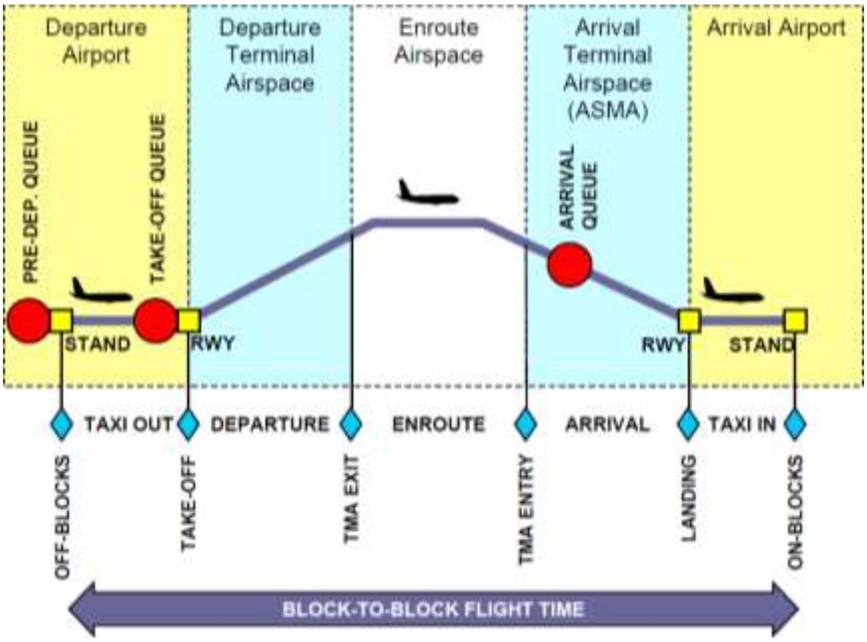

Figure 1: Outbound and Inbound Traffic Queues from a Flight Phase Perspective

Uncertainty of approach conditions (e.g. pilot performance, landing clearance time, approach speed, wind conditions) makes traffic supply to runways a stochastic phenomenon.

In order to ensure continuous traffic demand at runways and maximise runway usage, a minimum level of queuing is required. A certain extent of arrival queuing in airspace is necessary to allow arrival management (sequencing and metering) to optimise runway utilisation when demand is at or near the operational capacity.

However, additional time in holding or queuing is detrimental to operations efficiency, fuel consumption and the environment. Therefore, a trade-off exists between approach efficiency and runway throughput.

Optimisation of the runway utilisation may require:

1. Re-sequencing the take-off/ landing order at the runway (first come is not first served), and
2. Buffering a sufficient number of aircraft in the queue to be able to fine tune the metering and the runway throughput (to optimise the separation of aircraft released from the queue to the runway).

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

To reduce cost and environmental impact, the departure and arrival queuing time should be kept to the minimum needed to achieve the selected runway utilisation objectives. If possible, any departure and arrival delay that is needed for other reasons than sequencing and metering should therefore 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 assessing the “operational cost” associated with sequencing and metering in function of the selected runway utilisation objectives.

2.3 Conceptual approach

The additional ASMA time is a proxy for the management of the arrival flow, understood as the average arrival runway queuing time on the inbound traffic flow, during periods of congestion at airports.

Performance in terms of additional ASMA 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.

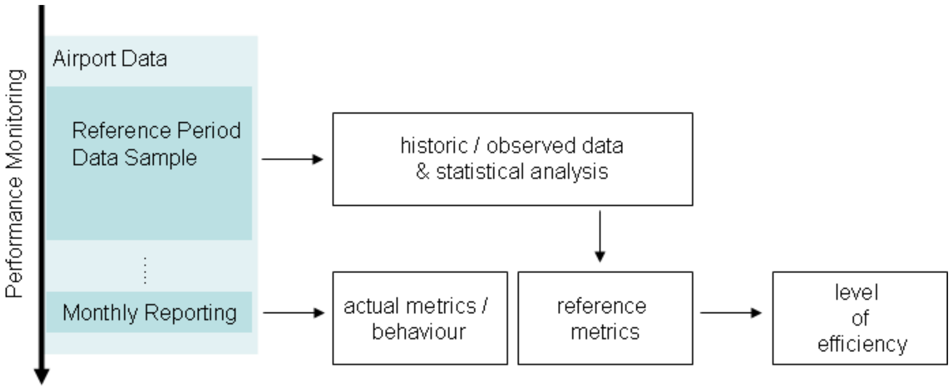

Figure 2: Performance Measurement Approach

The indicator is defined as the difference between the ASMA transit time (actual ASMA time) and the reference ASMA transit time.

$$Actual\ ASMA\ Time = Reference\ ASMA\ Time + Additional\ ASMA\ Time$$

The reference times intend to reflect the required time to perform the approach procedures assuming no inefficiency (i.e. no holding or vectoring) and are determined based on a statistical analysis of historic data observed at the airport (last 12 months), for groupings of similar flights expected to have similar approach times. The additional ASMA time is a measure for the extent of which the actual ASMA time exceeds the reference.

3 Methodology

This section describes the underlying logical modelling and drives the implementation of the additional ASMA time algorithm.

3.1 Approach and assumptions

The purpose of the **additional ASMA time** indicator is to provide an approximate measure of the **average inbound queuing time** on the inbound traffic flow, usually observed during times that the airport is congested.

The calculation of this indicator is based on generalised ASMA (Arrival Sequencing Metering Area) defined around an airport. Aircraft are subject to the management of the arrival flow upon entering the ASMA area, that is, in the ASMA transit time, elapsing between entering the ASMA area (actual ASMA entry time, ET) and the actual landing time of an arriving flight (ALDT). The generalised ASMA area is defined by a cylinder of radius 40NM around the airport extending to unlimited in terms of altitude.

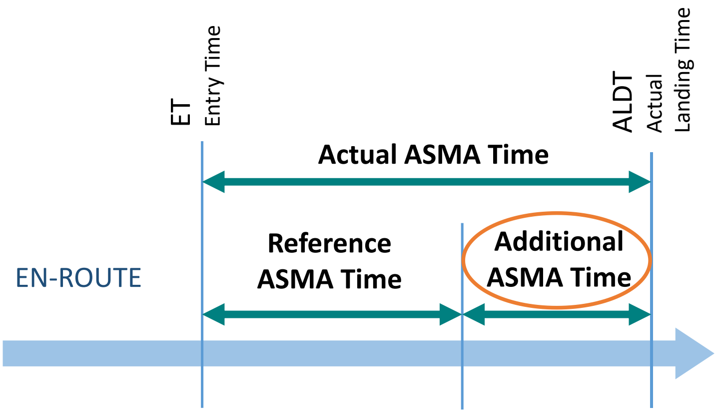

Figure 3: Conceptual approach for Additional ASMA Time

In case the arriving flight crosses several times the boundaries of the ASMA cylinder, the **first entry** will be considered the actual ASMA entry time (ET).

The additional time is measured as the additional time beyond a reference ASMA time, which is a statistically determined time based on actual ASMA times recorded for a certain reference period.

Note: The indicator is currently defined for a radius of 40 NM to allow for comparability across Europe. For monitoring purposes, a supporting metric considering a radius of 100NM is calculated by PRU[1].

This indicator excludes influence of the following factors:

1. Impact of noise management and terrain clearance aspects: the same effects are included in both the transit times of the flights under analysis and the flights used to calculate the reference transit times; therefore this does not show up in the additional time which is the difference between each flight under analysis and the corresponding reference time.
2. Impact of runway in use or approach procedure: a separate reference is calculated for each combination of these factors, so they are included in both the transit times of the flights under analysis and the flights used to calculate the reference transit times; so like in the previous point this does not show up in the additional time.

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[1] The 40/100NM positions and timestamps are calculated from data feeds the Network Manager receives from member states.

3.2 Grouping of flights

The reference ASMA times are, as mentioned in 3.1, statistically determined based on actual ASMA times recorded for the flights arriving at an airport during a certain reference period. Each reference time calculation requires then a sample of flights for analysis. This sample is obtained by establishing groups of flights that are expected to follow similar procedures and therefore have similar optimal transit times. This is done through combinations of entry points (or ASMA entry sector) and landing runway. Each grouping of flights has a reference ASMA time associated.

To reduce the number of combinations of unique entry points and arrival runway, arriving flights entering the ASMA area within certain limits are grouped together. The clustering is based on observed arrival flows (i.e. crossing of flown trajectory with the ASMA cylinder).

The result of this clustering yields the **ASMA sectors** and should not be confused with the actual TMA or approach sectors around the airport. Each ASMA sector covers a major arrival flow, and the extent of the sector is based on visualization of arrival radar tracks (see Figure 4 below) and the entry points.

When possible, this clustering is discussed with the corresponding ANSP to establish the best boundaries for the ASMA sectors.

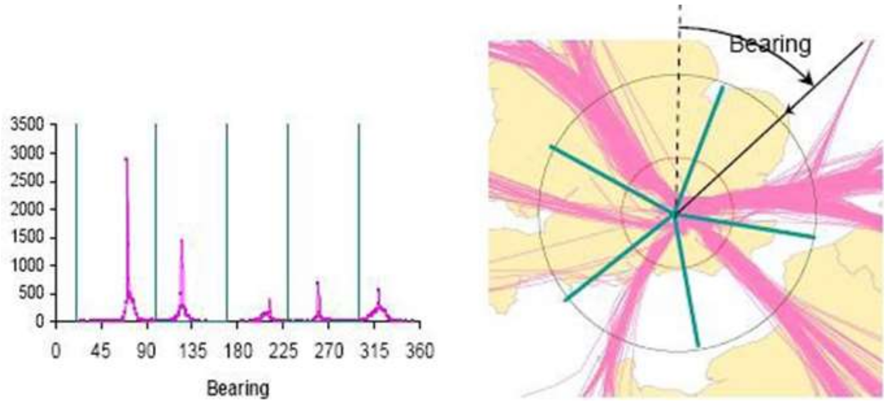

Figure 4: ASMA sectors and bearing

The aircraft class or aircraft type could also have an impact on the speeds and therefore the transit times. Nevertheless this additional factor breaks down the sample into more groups, reducing consequently the sample size for each group, but not having major impact in the results.

Since the sample size is key for the calculation of realistic reference times, the aircraft class is not used as a factor in the grouping of the flights.

For each airport, flights are then grouped by combos with the same ASMA sector and landing runway and each grouping of flights with the same combo will have a reference transit time associated.

3.3 Overview of the logical model of the Additional and Reference ASMA Times

This section focuses on the algorithm for the calculation of the additional ASMA time indicator from a logical point of view. The additional ASMA time calculation for a given airport in a given "month i" is depicted below and explained in the next section 3.4.

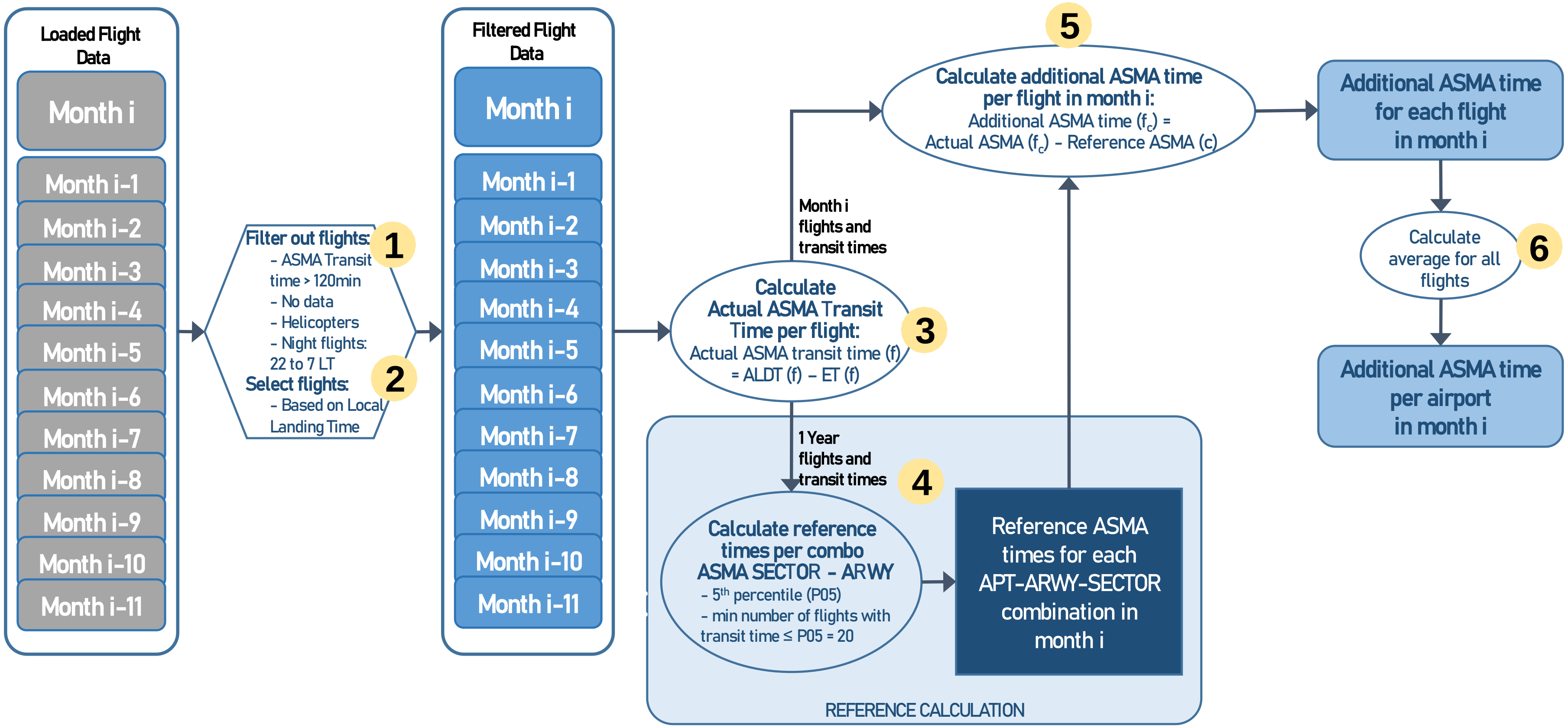

Figure 5: Logical steps for the monthly Additional ASMA Time calculation

3.4 Calculation of the Additional ASMA Time

The computation of the indicator for a given airport is based on six consecutive steps as shown in Figure 5:

1. Starting with all the loaded flight data in the system, filter out the flights with some missing data (e.g. no runway information, no entry time in the ASMA area), flights with ASMA transit time longer than 120min, night flights with landing time ≥ 22:00 or <07:00 LT and helicopters.
2. For the analysis of month i, select the arrivals of the last year based on the runway time in local time, that is [month i-11:month i] (e.g. for month Nov-22, take all arrivals landing between 01-Dec-21-00:00:00 until 30-Nov-22-23:59:59 inclusive, in local time).

   For the month i+1 we will recalculate again the reference ASMA times based on the last year- through a new selection of the flights.
3. Calculate, for each arrival flight f, the ASMA transit time, as the time between the entry time of the flight in the ASMA area (*ET(f)*) and the landing time (*ALDT(f)*).

$$ASMA\ transit\ time(f) = ALDT\ (f) - ET\ (f)$$

4. The reference times are calculated based on the entire year of data as obtained in step 1, 2 and 3. One reference value is calculated for each group of similar flights (same combo ASMA entry sector - arrival runway) in a separate process that is explained in the next section.
5. Calculation of the additional time for each flight based on the reference time of similar flights (that is, the reference calculated for the combo ASMA entry sector - ARWY to which this flight belongs). Therefore, for a flight f_c using a combo *c* with a certain ASMA entry sector - ARWY through subtraction of the combo's reference time from the actual time each flight spent in ASMA space (ASMA transit time).

$$Additional\ ASMA\ time\ (f_c) = ASMA\ transit\ time\ (f_c) -\ ASMA\ reference\ time\ (c)$$

   As explained in the next section, the sample size might not allow to calculate a reference time for certain combos. In that case, it will not be possible to calculate the additional ASMA time for the flights using those combos ASMA sector – ARWY and these flights will not be taken into account in the final computation.
6. Calculation of the average additional ASMA time for the airport in month i as the average of the additional ASMA times of all n flights f (regardless of their combo) from month i with a valid calculated additional time. [min/arrival].

$$Average\ additional\ ASMA\ time\ (month\ i) = \frac{\sum_{f=1}^{n} Additional\ ASMA\ time\ (f)}{n}$$

3.5 Calculation of the Reference ASMA Times

The objective of the reference times is to identify what would be the *optimal while possible* time to perform the approach procedure without holding or vectoring.

The calculation of these reference times is done as an approximation via a statistical analysis of a reference sample. This reference sample is specific for each airport and each month. As shown in Figure 5, the period considered as the sample for the reference calculation is the last year of traffic arriving at that airport up to and including the month of operations under analysis. The reference sample is therefore dynamic: a rolling year of traffic data, filtered and selected according to local time.

The computation of the reference times for a given airport in a given month is based on step 4 as shown in Figure 5 which includes steps 4a and 4b as depicted in Figure 6:

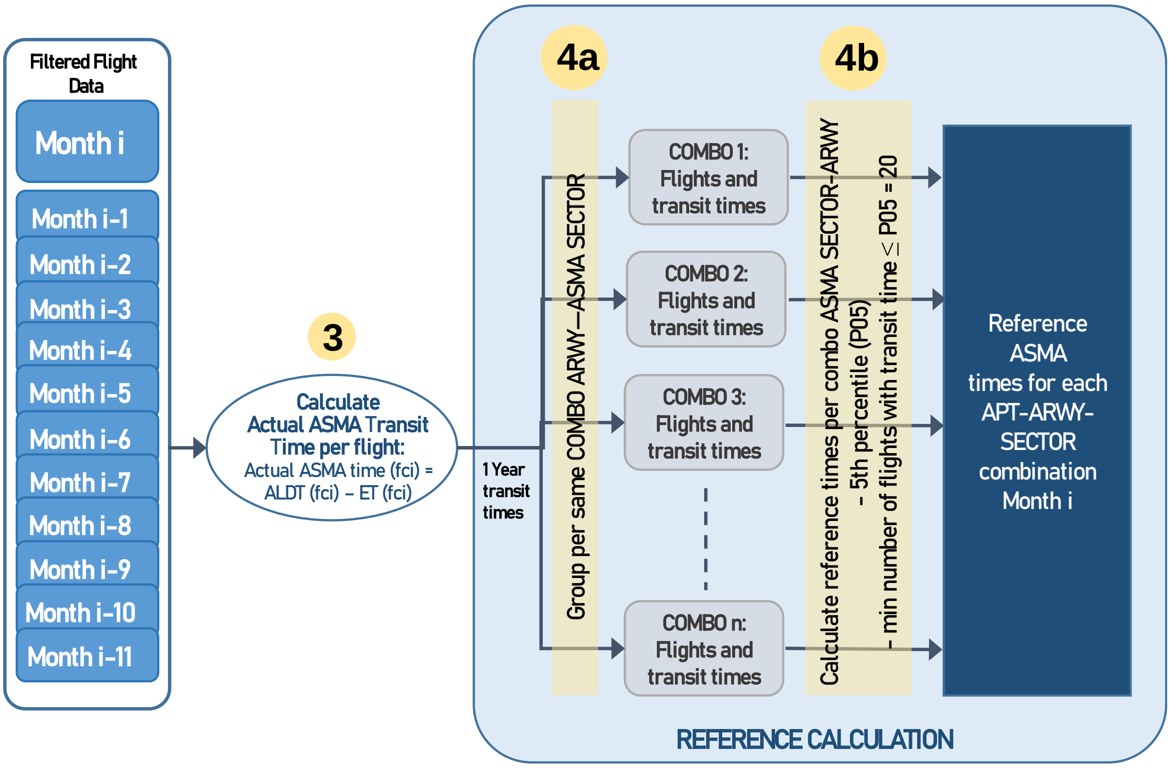

Figure 6: Steps of the reference ASMA times calculation

Starting with the full set of data for the year, and after steps 1 to 3 in Figure 5, we obtain the sample of 1 year of arriving flights with their ASMA transit times and their ASMA sector and arrival runway.

4.a This sample is then broken-down into the different samples with flights and transit times for each possible combo at the airport given its runways and ASMA sectors (step 4a in Figure 6).

4.b For each one of these samples of flights, the reference time for that combo ASMA sector—ARWY is calculated as the **5th percentile** of those transit times:

$$ASMA\ Reference\ time_{combo\ j} = 5th\ percentile\ (ASMA\ transit\ times)_{combo\ j}$$

The 5th percentile is estimated to provide the best approach to the optimal (while possible) transit times in the distribution of all ASMA transit times for a given combo (Figure 7).

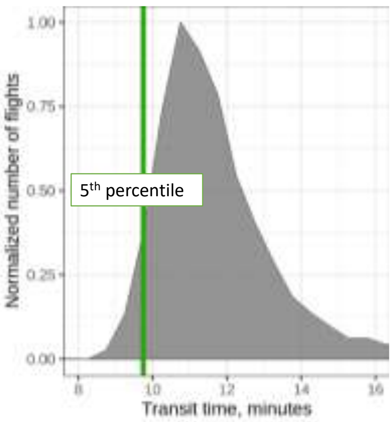

Figure 7: Reference as the 5th percentile of the transit times

For a calculated reference time to be considered valid and representative of the *optimal while possible* transit times for a certain combo ASMA sector—ARWY, there must be at least 20 flights in the sample with a transit time equal or shorter than the calculated reference time.

$$(\text{Minimum number of flights with ASMA transit time } \leq 5\text{th percentile})_{combo\ j} = 20$$

Combos where the sample size is too small and this condition is not met will not have any ASMA reference time assigned.

4 Error description

The error in the results depends on the accuracy and precision of the available data. The time stamps used for the calculation use the format HH:MM:SS, so the highest precision is seconds. Nevertheless, in some cases the data provided might be limited to a HH:MM format, so in those cases the precision is lower.

The time of the (first) entry time in the ASMA cylinder can be calculated using CPR (correlated position reports), radar data or ADSB, so it will be as accurate as the data source and in some cases will be the interpolation of two reported positions, so depending as well on the reporting time interval.

5 Factors not considered

There are other factors in addition to the specific approach procedure that can have an impact on the ASMA transit times. These factors are inherently included in both the reference sample and the flights under analysis in month i, but they are not considered in the grouping of the flights, so there is no specific reference time calculated for the different conditions resulting from these factors.

- Weather: temperature and wind impacting the aircraft speed.
- Aircraft class/type, related as well to the aircraft speed.
- Special events affecting the approach procedures. If deemed necessary, specific analysis might use a specific reference sample (see 6.5).

The main reason for not considering these factors is to keep a reasonable sample size that would allow for a more reliable result from the statistical analysis based on a percentile approach.

Considering more factors would increase the possible combinations and therefore reduce the number of flights in each combination, which would have a detrimental effect in the reliability of the statistical result.

6 Implementation and regular monitoring

In the implementation of the regular calculation of the additional ASMA times it is required to establish in parallel a monitoring routine of certain elements to ensure the quality of the result.

6.1 Implementation of the monitoring of additional times

This methodology requires as described in Figure 5 a complete year of data, i.e. rolling 12 months up to and including the month of operations under analysis. Nevertheless, during the first year of data provision the reference sample cannot reach the required 12 months. In that case the reference sample to be used is the traffic sample available to date. Figure 8 illustrates an example where the data provision starts in May, and the reference sample would increase from 1 to 12 months in the first year, and then continue the rolling year.

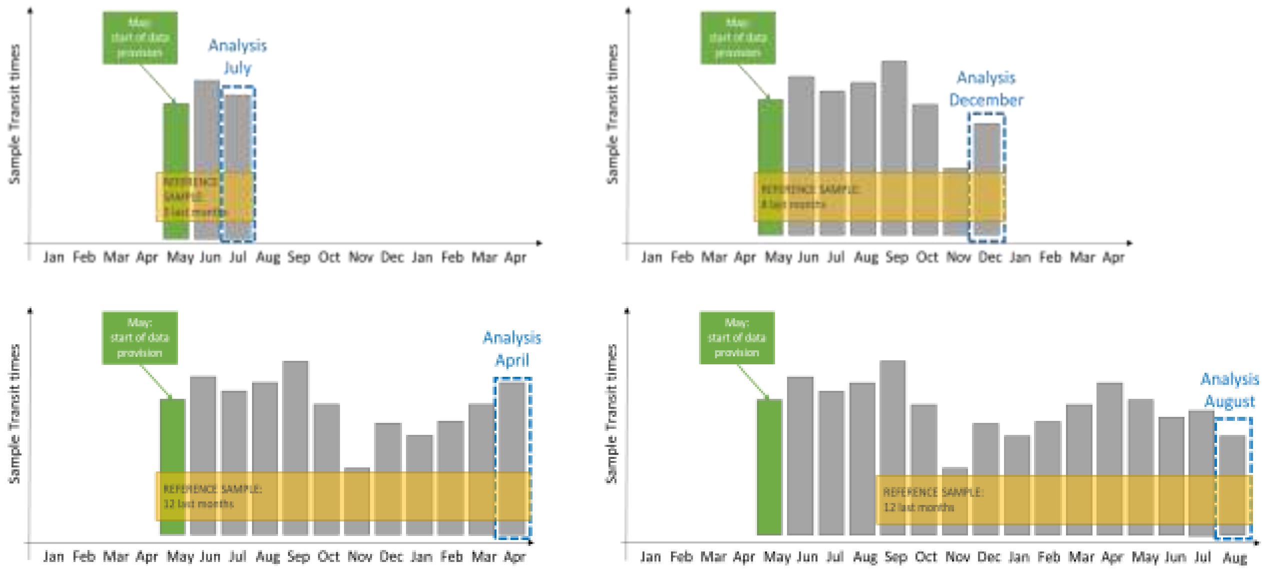

Figure 8: Incremental increase of the size of the reference sample until reaching 1 year

6.2 Evolution of the ASMA reference times

The ASMA reference times, as described in 3.4., are calculated every month based on the past rolling year traffic sample. The reason to implement a rolling reference sample is to automatically adapt to changing situations and keep in this way an up-to-date reference. Nevertheless it is necessary to monitor the evolution of the reference times to identify possible issues in the data provision and calculations.

6.3 Validity of the ASMA Sectors

The clustering of the arrival flows done through the definition of the ASMA sectors is subject to modification when these flows change for some reason, whether new procedures, changes in the TMA, new runway, etc. Therefore this clustering should be periodically reviewed and modified when necessary.

6.4 Share of flights without a valid reference transit time

As observed in section 3.5, the calculated ASMA reference time for a given combo ASMA sector—ARWY is not considered valid when the size of the traffic sample using that combo in the reference year is not big enough to show at least 20 flights with a transit time equal or shorter than the 5th percentile.

Flights belonging to combos for which there is no valid reference will consequently have neither reference nor additional time and will not be considered in the analysis. The share of these flights in comparison with the total number of flights under analysis (that is, the second data set of Month i after the filtering and selection done in steps 1 and 2) should be monitored to identify possible needs for specific action like for example an update of the ASMA sectors.

6.5 Special cases

In some cases the analysis for a given airport must be adapted to its specific conditions or events. The following are only examples of possible special cases:

- Runway denomination change: when a runway denomination changes, the data using the previous runway denomination can be combined with the new data to extend the reference sample. This way, both runway denominations can be considered in the same combos and increase the sample size.
- Special events: in case of special events affecting the normal operation at the airport (trials, implementation periods, new runway, closure of runways, etc) a focused analysis may use a specific reference sample or filter of the flights/dates to be considered. This is more intended for deep-dive analysis than for regular monitoring.

Any deviation from the standard filtering or choice of reference sample (as described in Figure 5) should be published together with the results of the analysis to ensure transparency and reproducibility.

7 Source data

7.1 Main and secondary data sources

The additional ASMA time indicator is calculated by AIU/OPS in EUROCONTROL using data provided by the airport operators and the Network Manager:

- The airport operators provide, through the APDF (Airport Operator Data Flow: EUROCONTROL-SPEC-175) the actual landing times and the runways used for the arrivals.
- The Network Manager provides the entry points to the ASMA cylinder (position and time of entry) coming from the Correlated Position Reports (CPR). CPR trajectories are built from ANSP radar track data and are used for the determination of the entry points to the ASMA cylinder at both 40NM and 100NM. When CPR data for ASMA entry point data is not available, the data from Network Manager's Current Tactical Flight Model (CTFM) is used as a substitute.

Name	Source	Alternative Source
Arrival airport	Airports (APDF)	ANSPs
Actual landing time	Airports (APDF)	ANSPs or Network Manager
Arrival Runway	Airports (APDF)	
Actual ASMA entry time and point	Network Manager (based on ANSP)	Network Manager (CTFM)

Table 3: Data Sources

Note: The Network Manager data flow also provides the calculated landing times (from both CPR and CTFM). Given the quality assurance measures defined for the airport operator data flow, Network Manager data flow based timestamps will only be used for complementing the airport operator data flow.

8 Quality management

8.1 The Airport Operator Data Flow process

The airport operator data flow (APDF) comprises all data collection, processing, and performance indicator calculation sub-processes. Reporting entities (i.e. airport operators) submit their data to EUROCONTROL on a monthly basis and in compliance with the APDF data specification.

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 9):

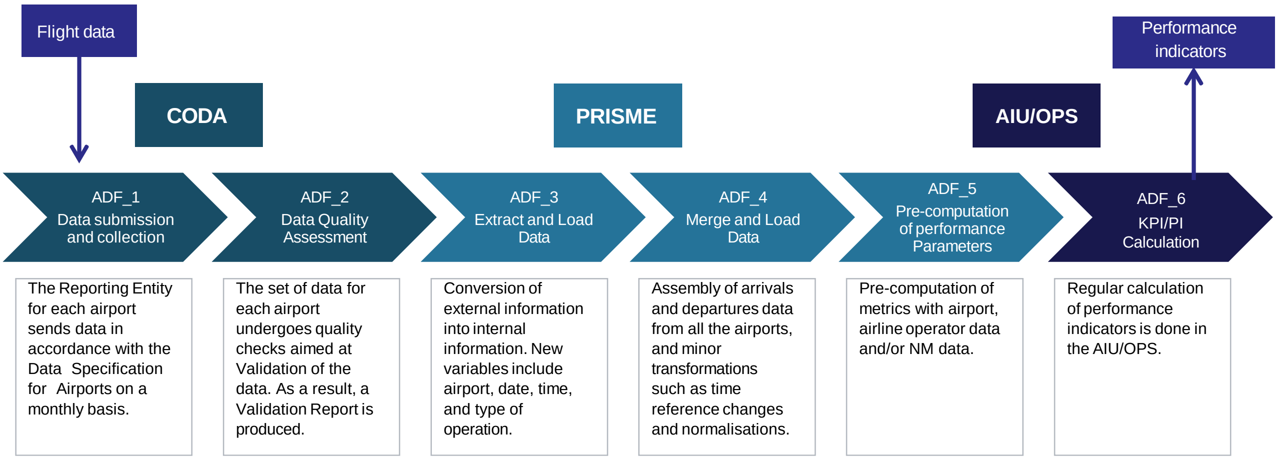

Figure 9: Airport Data Flow process scheme including activities and actors involved.

The airport operator data flow can be conceptualised as stages or sub-processes:

- APDF_1 – Data Collection
- APDF_2 – Data Validation
- APDF_3 – Data Extraction, Transformation and Loading
- APDF_4 – Data Merging
- APDF_5 – Pre-Computation of performance parameters
- APDF_6 – Calculation of Performance Indicators

Each of the sub-processes are governed by quality assurance measures. The AIU/OPS assumes responsibility for the whole flow in terms of quality assurance. Data collection and initial validation is also performed by AIU/OPS. Once the data is loaded, the data processes within the EUROCONTROL data warehouse are managed by PRISME. In the final stage, AIU/OPS extracts the relevant data and computes the performance metrics and indicators.

APDF related documentation is available in EUROCONTROL-SPEC-175.

8.2 Quality Assurance Framework

Quality assessment on airport data flow process is focused towards implementing a Quality Assurance Framework based on the ISO 9001 standard. The airport operator data flow process includes several data processing activities, starting from the moment flight information is provided by the reporting entity until performance reports are released.

Standard Operating Procedures for all these sub-processes have been established and is quality controlled.

8.3 Data Quality Checks

For the APDF the following quality areas have been identified. Quality controls in support of these quality areas are implemented and regularly monitored as part of the aforementioned APDF sub-processes (Figure 10).

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 10: Quality Performance Areas and corresponding Quality Indicators.

More detail on these quality checks can be found in the Airport Data Flow Data Specifications (EUROCONTROL-SPEC-175).

9 References

[1] EUROCONTROL, "Additional taxi-out time performance indicator document," 2023.

[2] EUROCONTROL, "Additional taxi-in time performance indicator document," 2023.

10 Revision History

Edition	Description	Comment
00-01	New draft – all pages	New document
00-02	Amended with WG feedback after internal consultation	Small changes in text, no change in the methodology.
01-00	Final draft after consultation	Minor editorial changes