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Trial Report

Schiphol TTO Trial

LVNL KLM to70

Trial Report
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Final Report

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Executive Summary

In 2018 the different Schiphol sector stakeholders developed multiple measures to improve the predictability of the traffic flows inbound Schiphol and to reduce the 4th runway to align with the ORS (OmgevingsRaad Schiphol) regulations. KDC was tasked to prepare a concept and trial, which resulted in the Initial TTO concept for Schiphol. The TTO trial was conducted in the summer of 2019.

The objective of the TTO trial were:

1. To demonstrate effects on the distribution of flights in the EHAM FIR using the TTO and CTOT.
2. To demonstrate feasibility of the concept for flights crews.
3. To demonstrate validity of the concept using data analysis.

Scope of the short-term effects during the trial were expected to be:

1. Enhance arrival predictability of flights
2. Improve the effectiveness of the regulations and reduce bunching of traffic.
3. Reduced need of fourth runway use (one of the 4th runway measures)

A steering concept was determined applying level playing field for all airlines aimed to adhere to CTOT and flight plan.

Conclusions
In general the current TTO-trial for all Schiphol inbound flights has no significant effect on the set of objectives (improvement of flight predictability and regulation effectiveness) and no effect on the reduction of the 4th runway use at Schiphol.

The applied steering concept appears to be insufficiently accurate. The large CTOT window of 15 minutes enables significant deviation from the flight plan, contributing strongly to TTO inaccuracy. Airlines have limited options to aim accurately for actual take off on CTOT. Enroute deviations instructed by ATC further contributed to shorter flight execution, adding to more TTO inaccuracy.

In addition the original steering concept using TTO within the cockpit was abandoned for the purpose of creating a level playing field and increase of airline participation. The alternate steering concept aimed on adherence to CTOT and “follow the flight plan” was applied, in line with Eurocontrol Network Manager and EASA instructions.

The summary of the data analyses resulted in a minor or no shift of the TTO adherence. For the KLM and KLC flights there was a limited positive trend visible. As a consequence no significant change in the predictability of the arrival time process on FIR entry waypoints could be detected. Hence the effectiveness of the applied CTOT regulations has not significantly increased, and use of the fourth runway has not decreased because of this trail.

Recommendations
To improve the predictability of the arrival process at Schiphol airport and to reduce the number of regulations, including the effectiveness of those regulations, the following recommendations are developed for further trial phases:

1. For the short term introduce TTO in the cockpit and improve the steering concept. Improve the flight plan accuracy together with Eurocontrol, and enhance stakeholder awareness about purpose and concept of the trial.
2. For the long term create structural changes to the CTOT slot tolerance window, reducing flight plan deviation at take-off, while further enhancing flight plan accuracy.
3. For future Concepts develop stakeholder incentives based on the principle “Best Planned Best Served” where performance in predictability is rewarded. Transform the steering concept from ATFM perspective using TTO towards Arrival Management by LVNL using TTA.

Table of Contents

1 Introduction

This document is the trial report for Target Time Over (TTO) trial for Schiphol inbound traffic, conducted in the summer of 2019.

1.1 Background

Discussions in the fall 2018 between Schiphol sector stakeholders with the Omgevingsraad Schiphol (ORS) resulted in a need for more predictable traffic flows to Schiphol resulting in less required 4th runway usage. One of the measures is to improve the distribution of the traffic in accordance with applied regulations by using Target Time Over (TTO) information. Improving the effectiveness of regulations can help in reducing traffic bunching. Based on the regulations a flight is subject to, the Network Manager (Eurocontrol) systems calculates entry times for the regulations. Based on the most penalising entry time a Calculated Take off time (CTOT) is generated by the Network Manager (Eurocontrol). The entry time of the most penalising regulation is published as a TTO together with the CTOT.

KDC was tasked to prepare a concept and trial, which resulted in the Initial TTO concept for Schiphol in an NLR report published in March 2019 (ref 1). Based on the findings and readiness of LVNL and KLM, a trial should start as soon as possible.

SESAR provides a concept for Target Times of Arrival (TTA) on dedicated waypoints in order to enhance predictability of the arrival demand. Several trials have been conducted in European countries that provide valuable lessons. Based on these lessons a dedicated trial concept for Schiphol was determined. Aim was to execute this trial in the summer of 2019 and deliver a Trial report by the close of 2019.

1.2 Purpose and Scope

The objective of the TTO trial is:

4. To demonstrate effects on the distribution of flights in the EHAM FIR using the TTO provided by NM in slot messages (SAM/SRM).
5. To demonstrate feasibility of the concept for flights crews
6. To demonstrate validity of the concept using data analysis.

Scope of the short-term effects during the trial are expected to be:

4. Enhance arrival predictability of flights
5. Improve the effectiveness of the regulations and reduce bunching of traffic.
6. Reduced need of fourth runway use (one of the 4th runway measures)

Scope of the medium to long term effects, should the trial become standard practice:

1. Reduced window of ATFM regulations including number and duration of the regulations
2. Improved arrival punctuality and ATM performance in NL-FIR.

This trial aims to improve the effectiveness of ATFM regulations although potential positive results may contribute to capacity improvements in the long term. Safety analysis is no subject for analysis in this trial, however workload in the cockpit is evaluated.

2 TTO Trial Concept

Based on the objectives of the trial a concept for steering can be determined for execution. This section describes the purpose and design of the TTO Trial as prepared for Schiphol inbound traffic.

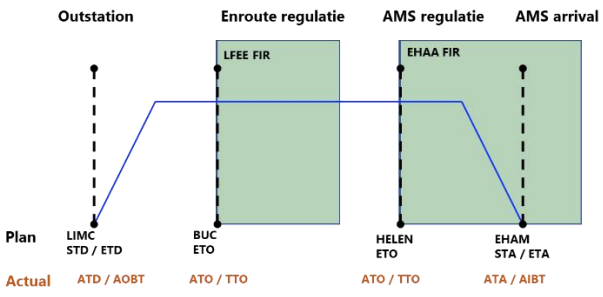
2.1 Purpose

Purpose of the TTO trial is to validate in real operations whether a change of flight behaviour by all aircraft results in a change on traffic distribution inbound to Amsterdam Schiphol, reducing deviation between planned and actual flights entering the Dutch airspace. A change of the inbound traffic distribution would further enable reduced use of the fourth runway (regulatory requirements).

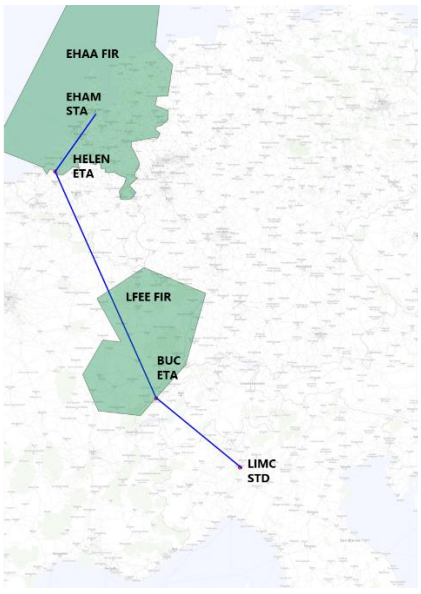
2.2 Process & design

Based on the regulations a flight is subject to the Network Manager (Eurocontrol) systems calculates entry times for the regulations. Based on the most penalising entry time a Calculated Take Off Time (CTOT) is generated. The entry time of the most penalising regulation is published as a TTO together with the CTOT. Flight crew are encouraged to plan their take-off time in adherence with the CTOT and aim for the TTO (if available). In addition, flight crew should do their best to adhere to the flight plan within ATC ICAO rules and the limits of their company policy. Therefore, flight crew should not request short-cuts for delay recovery. Flight crew is informed of this concept by NOTAM and where available internal company communications.

LVNL monitors the effectiveness of the regulations. No special instructions or working methods for supervisors or controllers apply. However, LVNL provides data for analysis purposes, and they monitor the effects of the trial. In case undesired effects are observed evaluation to adjust or terminate the trial may be called by all relevant stakeholders.

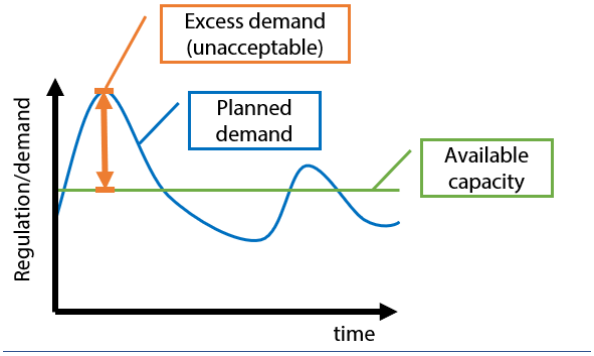


Schiphol TTO Trial Concept

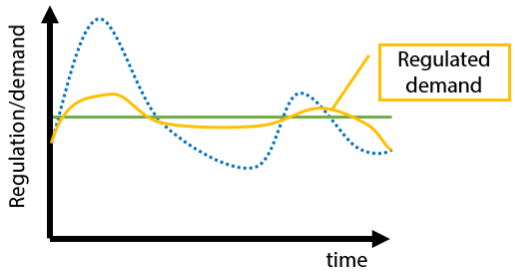


2.3 Improving Regulation Effectiveness

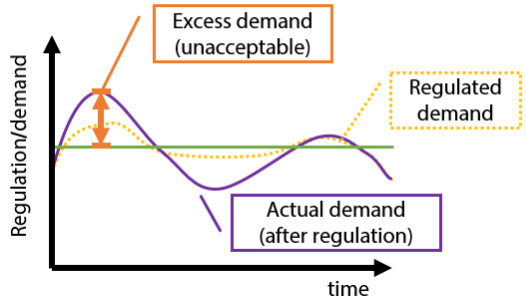
Due to deviation from the TTO, the actual presentation of traffic at the FIR boundary may at moments differ from both the scheduled as well as the regulated demand. In the following figures, this mechanism is explained.



Initially, planned demand is higher than the available capacity.
LVNL requests a regulation, based on the available capacity, to the Network Manager.



The Network Manager calculates when flights may enter the airspace without exceeding the declared capacity.
Based on these TTOs NM issues CTOTs to these flights.
By regulating flights, the expected demand is reduced.



Flights can deviate from the regulated flight plan (for example due to short-cuts, different speeds, other en-route regulations, differences between NMs model and the AUs flight plan).
As flights arrive at a different time than the TTO, the actual demand may still exceed acceptable levels.

By adhering to the TTO, the difference between actual demand and regulated demand is expected to be smaller. This improves the effect of that regulation.

2.4 Stakeholders

The main stakeholders are LVNL and airlines operating at Schiphol. The Eurocontrol Network Manager and other ANSP's are informed about the Schiphol TTO trial. Additional briefing material can be made available on request. With this information airlines can make dedicated flight crew briefings.

In the preparation of the trial a level playing field is created in order to allow all airlines to participate. Purpose of the expansion of participants is to avoid different behavior by different airlines, and adhere in line with the NOTAM.

2.5 Phasing of the Trial

The TTO Trial for Schiphol is held during the summer period. All flights with an allocated CTOT (regulated flights) arriving at Amsterdam Schiphol Airport are automatically viable to participate in the trial. This does not include intercontinental ICA flights.

Only flights which are regulated by the network manager for ATFM restrictions inbound AMS execute flying the TTO concept, which means unregulated flights do not participate in the trial.

2.6 Concept conditions

Regulated flights receive CTOT and TTO for the most penalizing regulation from the Network Manager. For EHAM arrivals this is often an EHAM FIR regulation due to capacity with a TTO time on the FIR or TMA border (IAF regulation). The CTOT is based on the entry time of the most penalising regulation a flight is subject to and is determined by NM systems.

Only the last CTOT applicable to take-off shall relate to the TTO that needs to be complied to. After take-off from outstation, updates to the CTOT and TTO are not sent by NM.

3 Evaluation Methodology

The trial provides data for analysis and evaluation. Rasmussen's Abstraction Hierarchy (ref 8) provides a suitable means to determine the relevant KPI's. The trial requires measurement in three groups:

1. Trial validity - To what degree is it valid to draw conclusions from the trial?.
2. Concept feasibility - Is it possible to adhere to the TTO for a flight with a CTOT?.
3. Concept objectives - Does adherence to TTO measures lead to the expected operational improvements?.

These three groups define the Key Performance Areas and the necessary measurements. Details of the Analysis, KPI's and Evaluation are described in the Evaluation Plan (ref 9), which serves as an appendix to this Trial Plan.

3.1 Key Performance Areas

3.1.1 Trial validity

The trial validity depends on for how many participating flights it was (fully) attempted to meet TTO. Furthermore, sufficient flight data needs to be available to be able to draw conclusions. Therefore, participation and data availability should be maximized. In Figure 1 the different subsets of flights in this trial are illustrated.

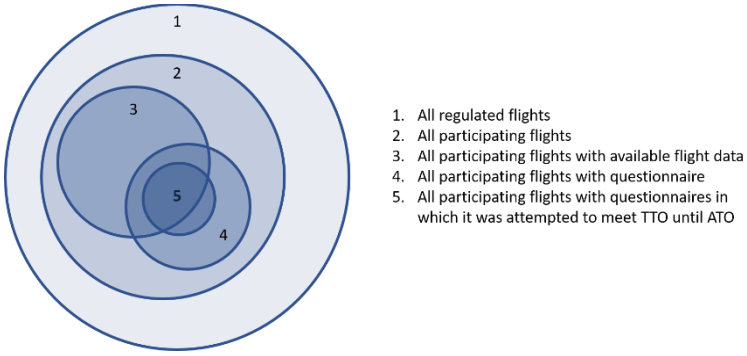


Figure 1: Different subsets of flights in the trial. For validity of the trial, the subsets need to be as large as possible.

As the TTO is only available for regulated flights, the maximum participation of flights would be if all regulated flights would take part in the trial (1 = 2). However, not all operators are participating in the trial and the trial is limited to European flights only. Therefore (2) is a subset of (1).

For evaluation of the trial, sufficient data needs to be available for analysis. For example, to analyse TTO adherence, the required data needs to be available and complete for that flight. It was expected that data becomes available for a vast majority of flights. Likewise, post-flight questionnaires provide insights per flight from a pilot perspective. Flight crews need to fill in the questionnaires to evaluate the TTO concept feasibility. Hence completion of the questionnaire after a participating flight is encouraged to pilots (4). However, meeting TTO might not always be attempted due to other priorities, hence this (5) is a subset of (4).

Overall, all these subsets need to be maximized. This leads to the following validity KPI's:

- Percentage of participating flights
- Percentage of participating flights with available flight data
- Percentage of questionnaires completed
- Percentages of full attempts to meet TTO; this can only be directly measured by means of the questionnaire but indicates the overall participation when it comes to (fully) attempting to meet TTO.

3.1.2 Concept feasibility

The concept is feasible when sufficient flights are able to meet the TTO-concept and related instruction in the NOTAM, including not requiring excessive workload for the flight crews. Feasibility can be separated in two subgroups:

- The feasibility of the TTO itself. This is the degree to which the TTO can be achieved at all.
- The feasibility once the aircraft has departed. This is the degree to which achieving the TTO is disturbed.

The following KPI's are defined:

- The feasibility of the TTO itself
  - TTO adherence vs. days since trial initialization
  - TTO adherence vs. time to meet TTO (TTO – CTOT)
  - TTO adherence vs. initial deviation from regulation (CTOT – ATOT)
  - TTO adherence vs. CTOT publication horizon (CTOT – publication time of CTOT)
- The feasibility once the aircraft has departed
  - Percentage of attempts to meet TTO until ATO, based on the questionnaires.

Furthermore, the change in workload due to meeting TTO is evaluated throughout the trial.

3.1.3 Concept objectives

Figure 2 shows the propagation of the trial concept into short term and long-term effects. These effects are measured using the listed KPI's. As the objective of the concept leads to an expected change in these KPIs, they are compared with a similar period in 2018.

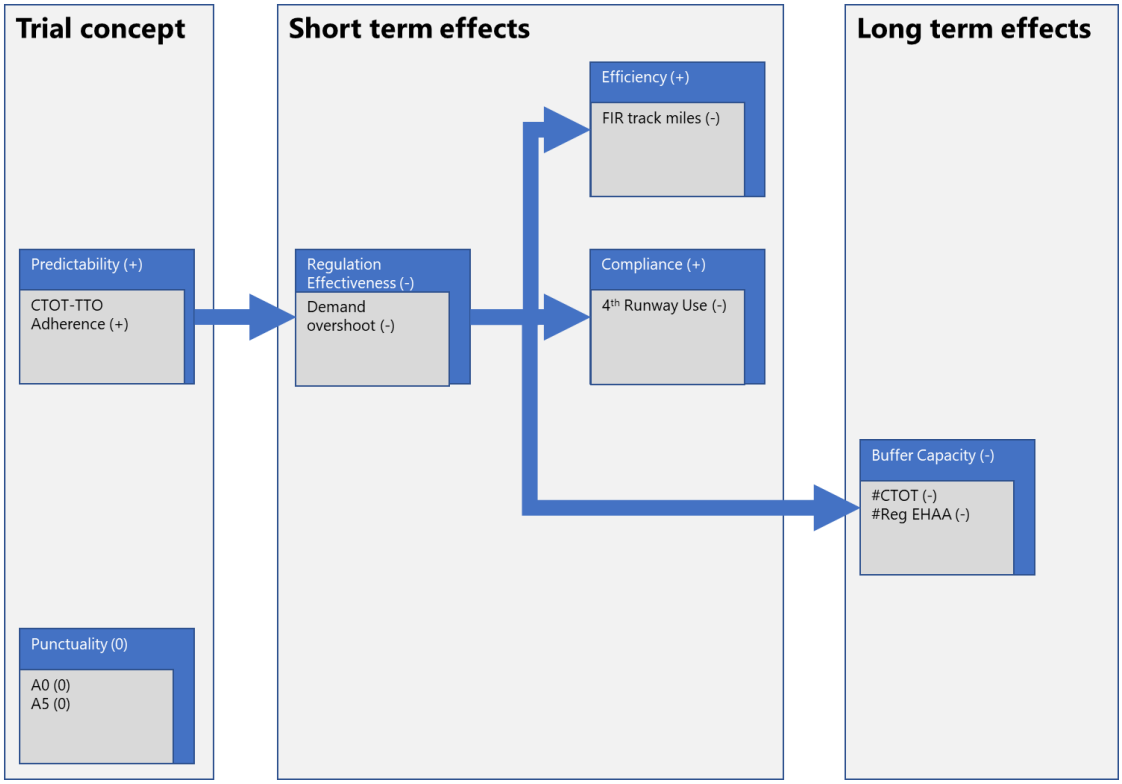


Figure 2: Propagation of the trial concept into short-term and long-term effects. ('+' means increase, '-' means decrease, '0' means no effect).

A short explanation of the most important KPI's:

- TTO adherence: during the trial the TTO adherence (|ATO – TTO|) is expected to improve.
- CTOT adherence: during the trial the CTOT has been monitored for all flights in relation to the TTO.
- A0 and A5: the trial is not expected to affect overall punctuality. This is evaluated by monitoring the A0 and A5 KPI's during the trial. However, A0 and A5 are sensitive to other (external) factors and therefore it is difficult to correlate any change in A0 and A5 to the trial.
- Trip duration deviation: deviation between scheduled and actual trip duration. This punctuality measure is not expected to be affected by the trial as well. However, it is less sensitive to other factors than A0 and A5, as it takes into account delays at origin. Therefore, it is a valuable addition to the A0 and A5 KPI's.
- Throughput overshoot: the arrival throughput exceedance of the declared arrival capacity. Improved TTO adherence is expected to lead to less bunching and therefore to less overshoot of the declared arrival capacity. When less overshoot occurs, the declared capacity could be raised.
- FIR track miles: because of improved TTO adherence, it is expected that less delta time needs to be absorbed in the FIR (e.g. use of holdings). Therefore, FIR track miles are expected to decrease.
- 4th runway use: because of improved TTO adherence and less throughput overshoot, it was expected that a 4th runway usage decreases.
- Number of EHAA regulations: this KPI is eventually expected to decrease, if the declared capacity would be raised because of better TTO adherence.
- Number of CTOTs: because of a decrease in the number of EHAA regulations, the number of CTOTs could decrease as well, depending on whether non-EHAA regulations are applicable.

3.2 Measurement methods

Measurements are performed using three techniques:

- Objective data from different systems
- Post-flight flight crew questionnaires
- Input from workshops with stakeholders

3.2.1 Data

Necessary data elements are collected via LVNL and Eurocontrol Network Manager for each participating flight. Sources are

- EFD messages
- Radar observation
- IFPS data

3.2.2 Questionnaires

Flight crews (KLM B737 unit only, voluntary feedback) provide feedback through:

- a digital e-form questionnaire post-flight

Purpose of the quick questionnaire is to collect flight relevant data, which enables analysis and correlation of data.

3.2.3 Workshops

Airline Flight Operations and Flight Crew representatives can provide feedback to the concept and performance analysis in workshops. Flow Management Position (FMP) and Area Control Centre (ACC) supervisors attend these workshops on behalf of LVNL. Based on these workshop discussions the concept can be adjusted, the trial expanded or revised, and data analysis and collection adjusted.

3.2.4 Network Manager

A visit to the Eurocontrol Network Manager in Brussel aims to discuss results and benchmark against other European initiatives.

3.3 Data analysis

Data is collected and correlated per flight. Subsequently analysis is performed at different strata of aggregation:

- Per airline/flight (incl. KLM/B737 & KLC (E175/E190)
- Per group over flights in a particular area/time interval
- Over the whole experiment
- Per aircraft type
- Per period of time (hours/peak hours)

3.4 Success Criteria

To assess success, the following criteria apply:

1. A measure of success is when a significant improvement of CTOT-TTO adherence compared to the reference period is observed.
2. A measure of success is when a significant reduction of demand overshoot compared to the reference period is observed.
3. A measure of success is when reduced use of the fourth runway configurations is observed

4 Results

The results were obtained through data analysis. This data was received bi-weekly from Eurocontrol Network Manager. In addition feedback forms were received from KLM EUR, which provided the quality information that provided insight in feasibility of the steering concept.

In this section the results are described.

4.1 Validity

4.1.1 Percentage of participating flights

All airlines flying to Schiphol could have participated as the trial was communicated per NOTAM. 18,381 flights had a TTO/CTOT during the trial period. Some airlines indicated that they would not participate in the trial, despite the NOTAM. Others did not state whether they actually did participate, or not.

Given KLM's active participation, and visible impact in results described in section 4.3, there is sufficient certainty that KLM actively participated to the trial.

4.1.2 Percentage of participating flights with available flight data

For all flights with a TTO, the Network Manager supplied post-ops data. 63% of these participating flights have an ATO registered by the Network Manager, which is required to calculate TTO adherence.

4.1.3 Percentage of questionnaires completed

The questionnaires were only accessible among KLM Europe crew. Crew from other airlines did not participate in the questionnaires. 174 questionnaires were completed which is 3% of the 5894 flights which had an arrival regulation. This is not a high percentage to extrapolate the insights to all KLM flights or all flights. Nonetheless, it may provide relevant insight in the feasibility of the trial.

4.1.4 Percentages of full attempts to meet TTO

Of all the questionnaires that were completed, for only ten of them (5.7%) the response was that they did not participate in the trial from the beginning. In another seven of them (4%), TTO trial participation was aborted. This means 90% of the flights with a completed questionnaire, it was fully attempted to meet TTO.

4.2 Feasibility

From the received feedback forms, it could be observed that nearly all respondents participated and completed the trial participation. This means they did their best to plan their take-off time in adherence with the CTOT and adhere to the flight plan as requested in the NOTAM.

In Figure 3, the workload changes as reported by the pilots is shown. The trial yielded an overall similar or increased workload with respect to the normal situation. Workload mostly resulted from the ground phase in order to aim for an actual take off on or near CTOT. In flight there was not any major workload experienced, as TTO did not require any action.

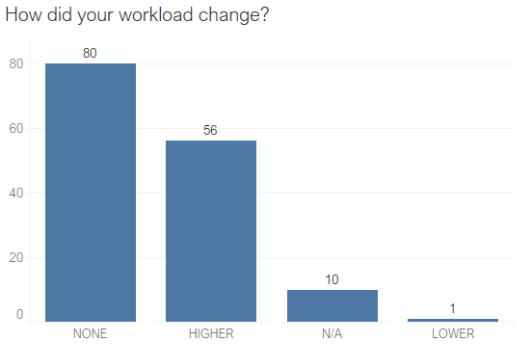


Figure 3: Workload change

In Figure 4, flight plan deviations are shown. Route changes is the most common deviation, often directs instructed by ATC. Speed changes are also common; either instructed by ATC, for delay recovery and due to connecting flights. Flight level changes are less common; usually a heavy aircraft lead to a request for a lower flight level due to climb limitations.

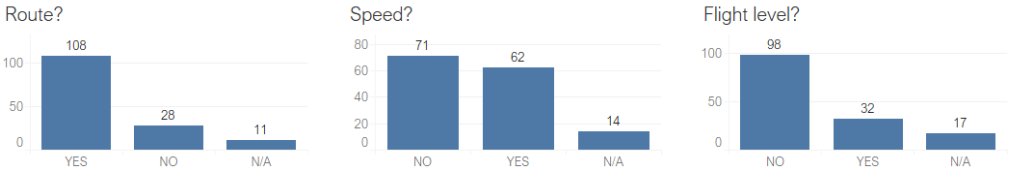


Figure 4: Did you deviate from flight plan (route-wise, speed-wise and/or level-wise)?

4.3 Concept Objectives

4.3.1 Delta target times over (Delta TTO)

The independent variable of the trial is the difference between ATO and TTO, which will be referred to as "Delta TTO". In Figure 5, the Delta TTO distribution is displayed for both the benchmark and the trial period for all regulated inbound flights.

To increase predictability, a higher TTO adherence is desired. TTO adherence is defined as flights that have an (absolute) Delta TTO of 2 minutes or less. High TTO adherence means the Delta TTO distribution concentrates around Delta TTO=0. Hence, TTO adherence improves with respect to the benchmark when the ATO-TTO distribution shifts to the right and the dispersion declines.

Overall, neither a shift to the right nor a declination of dispersion is observed during the trial.

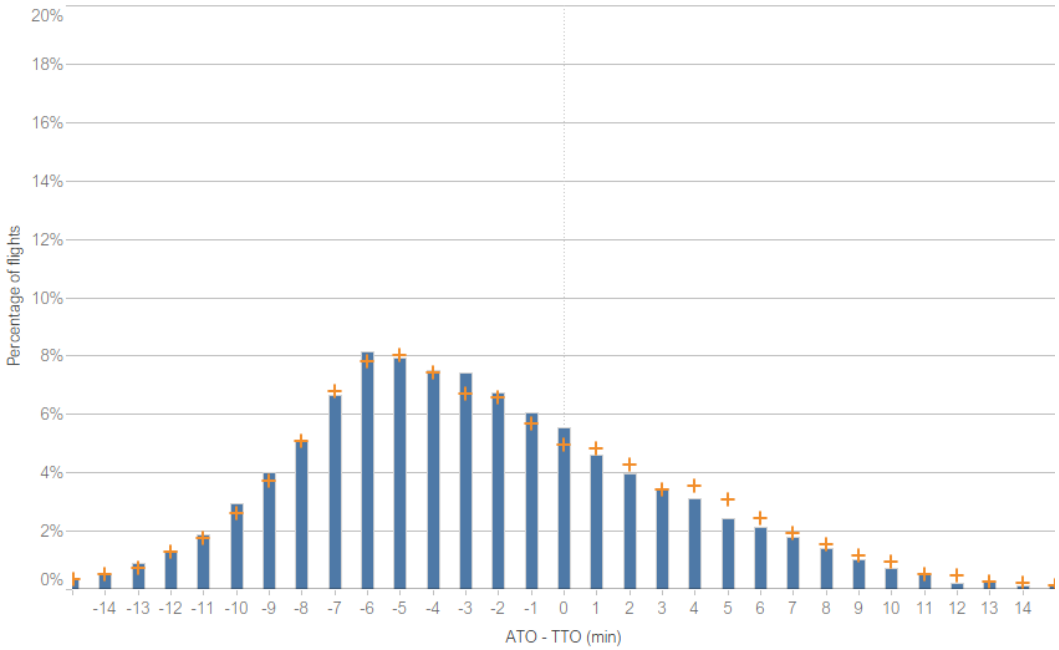


Figure 5: Delta target times over (Delta TTO) – All operators. Trial period in blue, benchmark in orange.

Figure 6 presents the same statistics, but only for KLM Cityhopper flights. For those flights, a shift is observed towards Delta TTO=0 when comparing the trial and the benchmark. However, no change in the dispersion is observed.

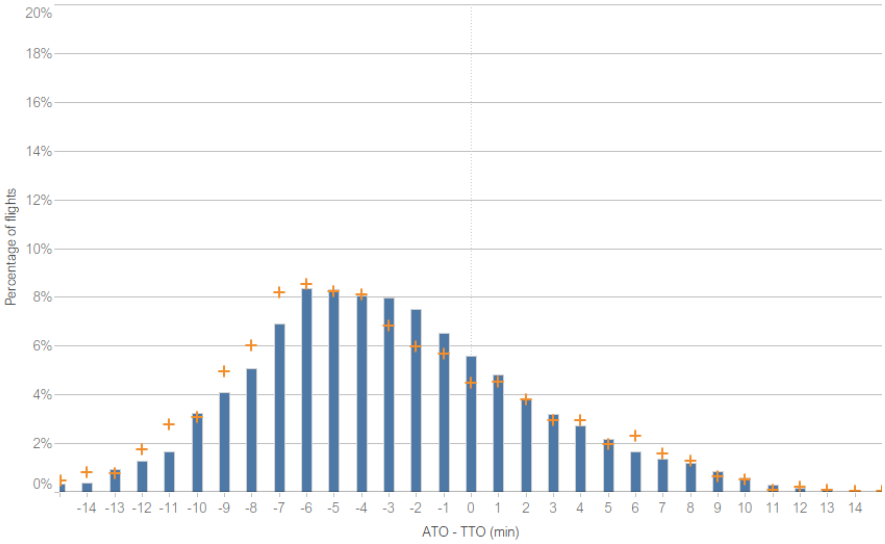


Figure 6: Delta target times over (Delta TTO) for KLM Cityhopper. Trial period in blue, benchmark in orange.

Figure 7 focuses on KLM Europe flights (B737). For those flights, neither a shift towards Delta TTO=0 nor a decline in dispersion is observed.

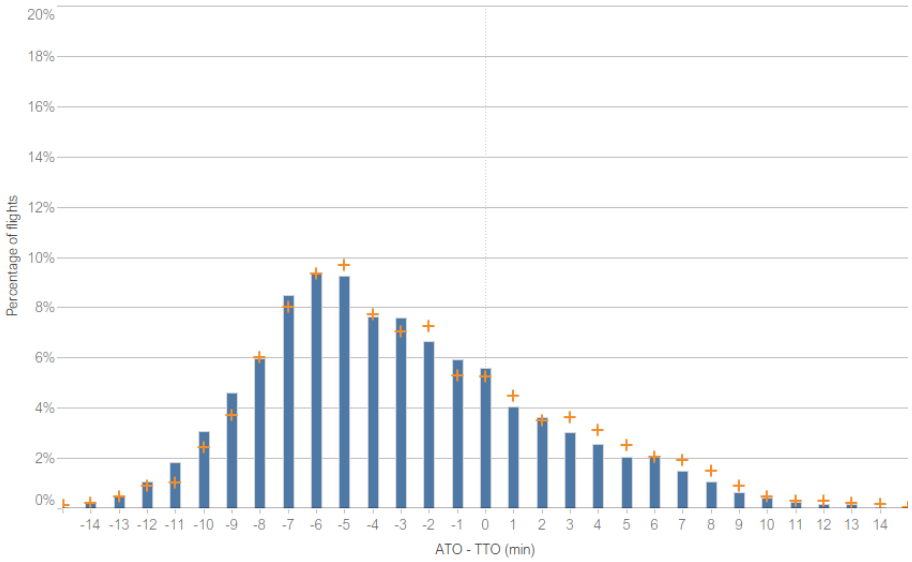


Figure 7: Delta target times over (Delta TTO) for KLM Europe. Trial period in blue, benchmark in orange.

4.3.2 Delta take-off times (Delta TOT)

Although take-off times are in itself not an independent variable to this trial, they strongly correlate with the Delta TTO, which is the independent variable. Delta TOT is the difference between ATOT and CTOT.

The strong correlation between Delta TTO and Delta TOT is logical: the TTO trial only affects European flights, which are short-haul flights. Nevertheless, re-routes and speed changes by ATC are influencing the TTO accuracy. Therefore, it is worth looking into the Delta TOTs as well. Similar to as previously discussed for Delta TTO, the trial aims to shift towards Delta TOT=0 as well as a smaller dispersion.

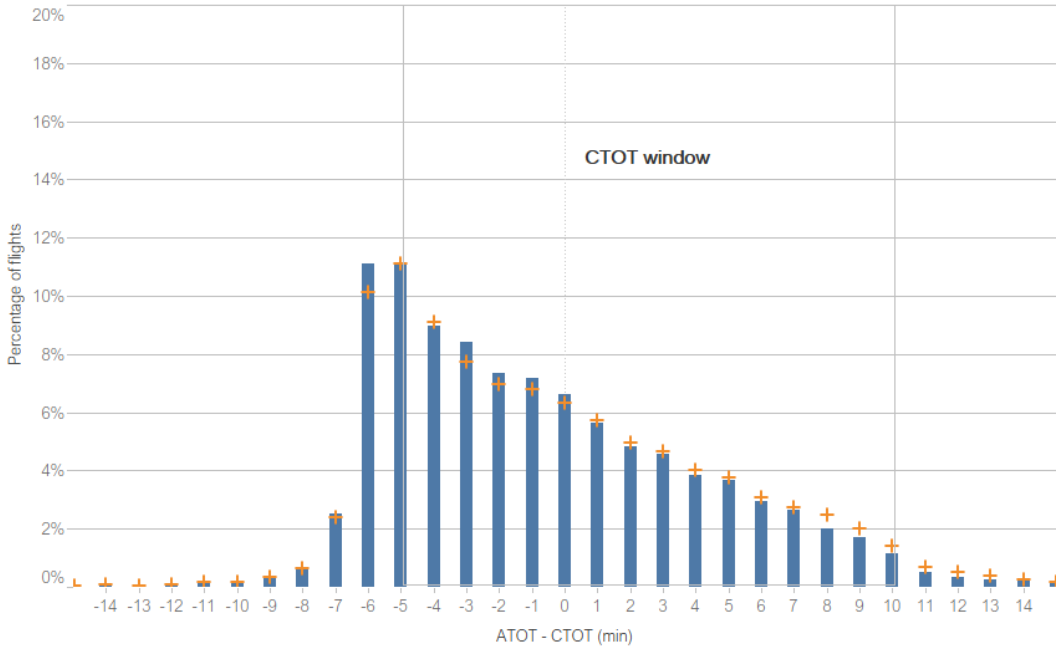


Figure 8: Delta take-off times (Delta TOT) for all operators. Trial period in blue, benchmark in orange.

In Figure 8, no shift towards 0 or a decline in dispersion is observed for all operators. However, when looking at only KLM Cityhopper a shift towards Delta TOT=0 is observed, as shown inFigure 9.

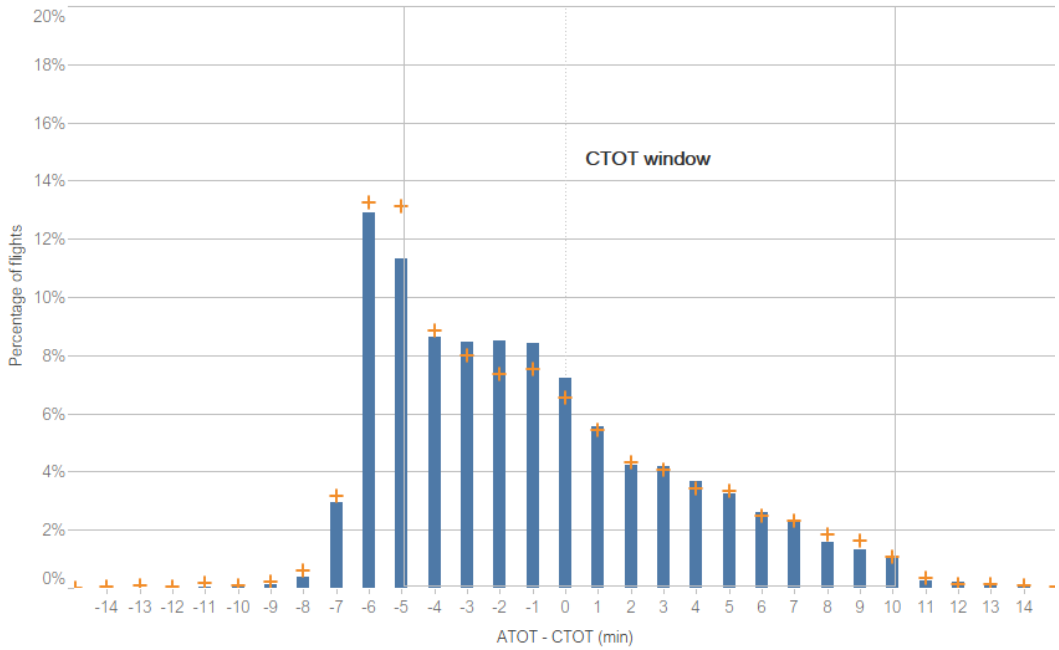


Figure 9: Delta take-off times (Delta TOT) for KLM Cityhopper only. Trial period in blue, benchmark in orange.

For all European regulated inbound flights, no change in TOT adherence is observed. Hence any trial effects that could be observed, cannot be attributed to the TTO trial.

For regulated inbound KLM Cityhopper flights, a change in the Delta TOT (ATOT – CTOT) distribution is observed, which is deemed to have been positively influenced by the TTO trial.

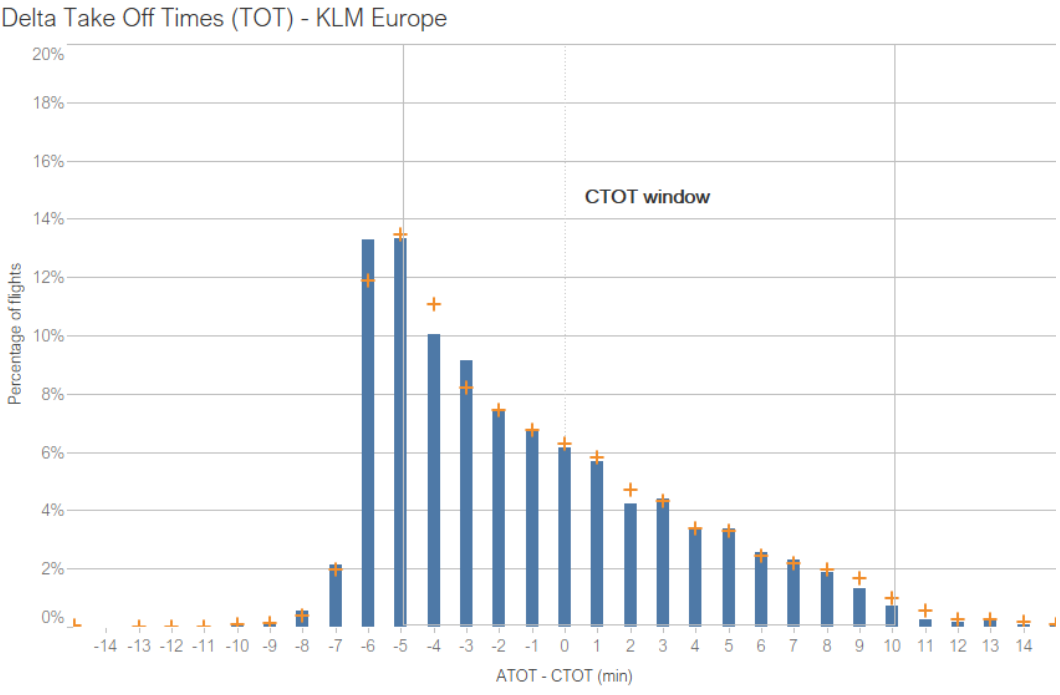


Figure 10: Delta take-off times (Delta TOT) for KLM Europe. Trial period in blue, benchmark in orange.

For regulated inbound KLM Europe flights in Figure 10, no significant change in the Delta TOT (ATOT – CTOT) distribution is observed.

4.3.3 Regulation effectiveness

The trial aims to improve the effectiveness of regulations. This is measured by the difference between the number of FIR entries per 20 minutes and the declared inbound capacity rate for those 20 minutes.

Four categories of regulation effectiveness are distinguished:

- The regulation was effective: no overshoot of flights entering the FIR occurred with respect to the inbound capacity rate.
- The regulation was somewhat effective: a small overshoot occurred of no more than 1 flight per 20 minutes.
- The regulation was ineffective: a larger overshoot occurred.
- There was no regulation during this peak; no effectiveness of a regulation can be assessed.

In Figure 11, the effectiveness of regulations for all days within the trial and benchmark period are shown. Only the first and fifth inbound peaks are displayed as they are the most commonly regulated inbound peaks.

No distinct change is observed between 2018 and 2019 when it comes to regulation effectiveness.

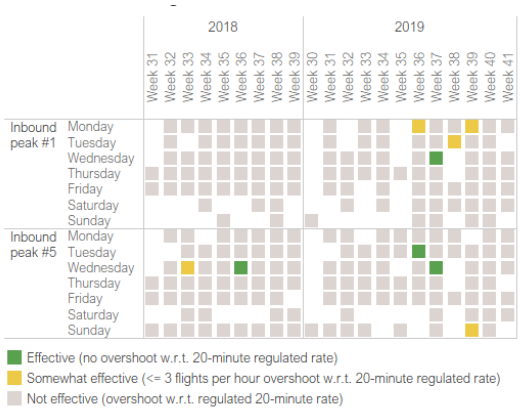


Figure 11: Effectiveness of regulations; a comparison between summer 2018 and summer 2019

4.3.4 Pre-FIR Track miles

Another expected trial effect is that pre-FIR track miles would be a closer match to the track miles in the flight plan. The trial aims that less shortcuts are taken before reaching the FIR than in the current situation. In Figure 12, this effect is not observed.

Another result would be that less excess track miles in the FIR would be necessary, to deal with the inbound bunches inside the FIR. This effect is also not observed.

Note: the NM flight plan does not contain STARs, hence the Delta FIR track miles KPI does not represent the actual extra track miles but is solely an indicative measure in this graph.

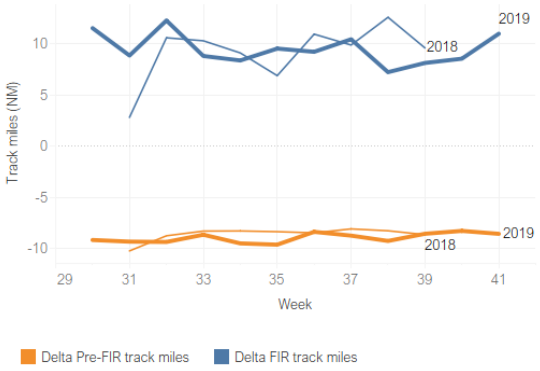


Figure 12: Delta track miles: track miles according to flight plan versus track miles actually flown. Negative means shorter flight path than (regulated) flight plan.

4.3.5 Fourth runway usage

The fourth runway usage is displayed in Figure 13. The latest fourth runway reporting period started on April 1st, 2019. The full-year average should not exceed 40 flights per day. The daily realisation should not exceed 80 flights per day. Note that the graph has not been corrected for exemptions and therefore the KPI is conservative.

During late spring and early summer of 2019, the Electronic Flight Strips were introduced and maintenance works on A8 were performed, resulting in 2+1 runway usage. Note that this is the period before the TTO trial. Since 1st of April, four exceedances of the 80 flights per day are observed in the graph.

As in the previous sections described, the effect of the TTO trial on TTO adherence was very limited to none. Furthermore, no significant change in regulation effectiveness was observed. Therefore, there is no indication that the TTO trial had an effect on the fourth runway usage

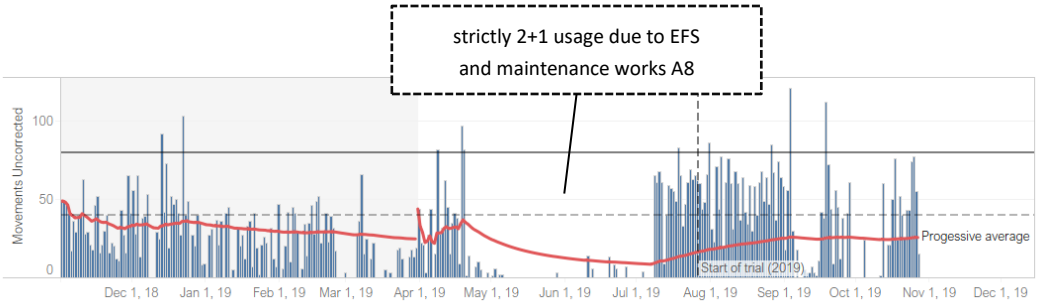


Figure 13: Fourth runway usage, per day. Red line shows the progressive average for the reporting period. Note that exemptions to the fourth runway usage have not been excluded from this graph and hence it is a conservative representation of fourth runway usage.

5 Conclusions & Recommendations

In 2018 the different Schiphol sector stakeholders developed multiple measures to improve the predictability of the traffic flows inbound Schiphol and to reduce the 4th runway to align with the ORS (OmgevingsRaad Schiphol) regulations.

Based on the results described in chapter 4 and the workshops to deliberate the results, this section provides conclusions for validity, feasibility and concept objectives, as well as recommendations for further projects.

On 29 October and 26 November 2019 two operational expert workshops were organized to discuss the results, conclusions and recommendations. In addition, a delegation of the project team visited the Network Manager on 7 November 2019, to discuss results and benchmark to other experiences in similar trials in Europe.

In general, the conclusion is that the success criteria are not met.

5.1 Validity

There is sufficient data obtained from all airlines flying to Amsterdam Airport to come to conclusions in the sections below as data of almost all operated flights was received from Eurocontrol. Sufficient flights received regulation, which makes the resulting images valid to draw conclusions:

- TTO trial is executed for all regulated inbound flights to Schiphol where TTO concept is applied for all airlines and European outstations, and effectively monitored using Eurocontrol data.
- All airlines received a Notam published by the LVNL requesting to plan their take-off time in adherence to the CTOT and do their best to follow their flight plan. For KLM EUR and KLC flights additional communication and company NOTAMS were published which supported and improved trial participation. For the KLM EUR flight additional questionnaires were sent to the flight crew to gather flight information.

5.2 Feasibility

The following conclusions are drawn with regard to the feasibility of the trial:

- The original steering concept using TTO information within the cockpit flight management system was abandoned for the purpose of creating a level playing field and to increase airline participation. A level playing field was created by the NOTAM published by LVNL and providing additional information for airline operators.
- A steering mechanism based on compliance to the CTOT-window and ‘follow the flightplan’ was an alternative solution and in alignment with communication of Eurocontrol Network Manager and EASA to increase the flight predictability within the European Airspace.

5.3 Concept Objectives

The following conclusions are drawn with regard to the Trial and Concept Objectives:

- The steering mechanism from the applied TTO concept and related (calculated) CTOT times in this trial phase, appears to be insufficient accurate:
    - Limited options for airlines to aim actual take-off accurately for the CTOT.

- The designed CTOT-window is large (-5 till +10min). On average the ATOT data resulted in an average offset of -5 minutes compared to the CTOT times for all airlines.
- ATC instruction en-route (e.g. speed, flight level, DCT) resulted in an additional average offset of -2 minutes compared to the TTO.

- There is no significant change in the predictability of the arrival time process on FIR entry waypoints
  - There is a light shift observed where it is considered likely that the trial has had impact although limited. Especially the case for KLM and in particular KLC.
- The effectiveness of the regulations has not significantly increased, and no direct credits can be assigned to this TTO trial.
- Use of the fourth runway has not decreased because of this trail.

5.4 Recommendations

To improve the predictability of the arrival process at Schiphol airport and to reduce the number of regulations, including the effectiveness of those regulations, the following recommendations are developed:

A) Short-term recommendations:
1. Investigate short term improvement of the TTO times, inaccuracies and offset reductions for the purpose of developing a new TTO trial concept.
   a. Introduce TTO in the cockpit.
   b. Investigate the possibility to trial during periods of the day with limited operational impact for airlines.
   c. Investigate the Derived ETA (DETA) concept as new steering mechanism
   d. Investigate other solutions like Extended AMAN and arrival manager solutions developed by the ANSP itself maybe in combination with TTO/TTA.
2. Investigate to mitigation of the detected offsets by:
   a. for CTOT by assignment of TTO 5 minutes
   b. for flight plan by assignment of TTO 2 minutes
3. Urge Eurocontrol Network Manager to start using statistical flight data that accounts for near structural 'short-cuts' (through often military airspace).
4. Improve communication and raise awareness about arrival predictability concept and trial preparations through workshops, applications and newsletters.

B) Long-term recommendations:
1. Investigate with Eurocontrol Network Manager to make structural changes to CTOT window for regulations, by reducing the window to CTOT 0 – 10 minutes, reducing the window period.
2. Investigate with Eurocontrol Network Manager improvements to flight plan accuracy, including new future concepts such as Flight & Flow Information for a Collaborative Environment (FF-ICE).

C) Future concepts:
1. For a future trial concept consider placing incentives to change behavior of aircraft operators.
   a. Define and exploit a new concept for "Best Planned Best Served", where performance in predictability is rewarded.
   b. Determine and agree incentives for good performing aircraft operators with Air Traffic Control and the Network Manager.
   c. Investigate need for knowledge and training amongst stakeholders in order to change behavior.
2. Investigate improvement of the steering mechanism:

a. Target Time for Arrival (TTA), as future replacement for the current TTO. As TTA is provided by Air Traffic Control Arrival Management rather than TTO being provided by the Network Manager, TTA contains more knowledge on the flight track within the FIR, and can therefore be considered more accurate; whereas TTO does not have information on track within the FIR as it does not consider accurate arrival runway information.
b. Technology that ATC requires to determine TTA dynamically based on actual radar positioning information, aircraft information, and trajectory prediction, as well as communication methods such as Controller Pilot DataLink communication (CPDLC).

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