ATFM POST-OPERATIONS ANALYSIS RECOMMENDED FRAMEWORK

This document provides recommendations on how ATFM operations analysis can be conducted, with overview of analyses that can be carried out during each phase of ATFM operations from planning demand and capacity to post-operations analysis of an ATFM program with various ATFM measures.

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1. Introduction

Motivation

1.1 ICAO Manual on Collaborative ATFM (Doc 9971) specifies in great detail the planning, implementation, and execution of ATFM services. **Figure 1**, taken from Figure II-4-1 in Doc 9971 (3rd ed.), summarizes the different phases of ATFM operations.

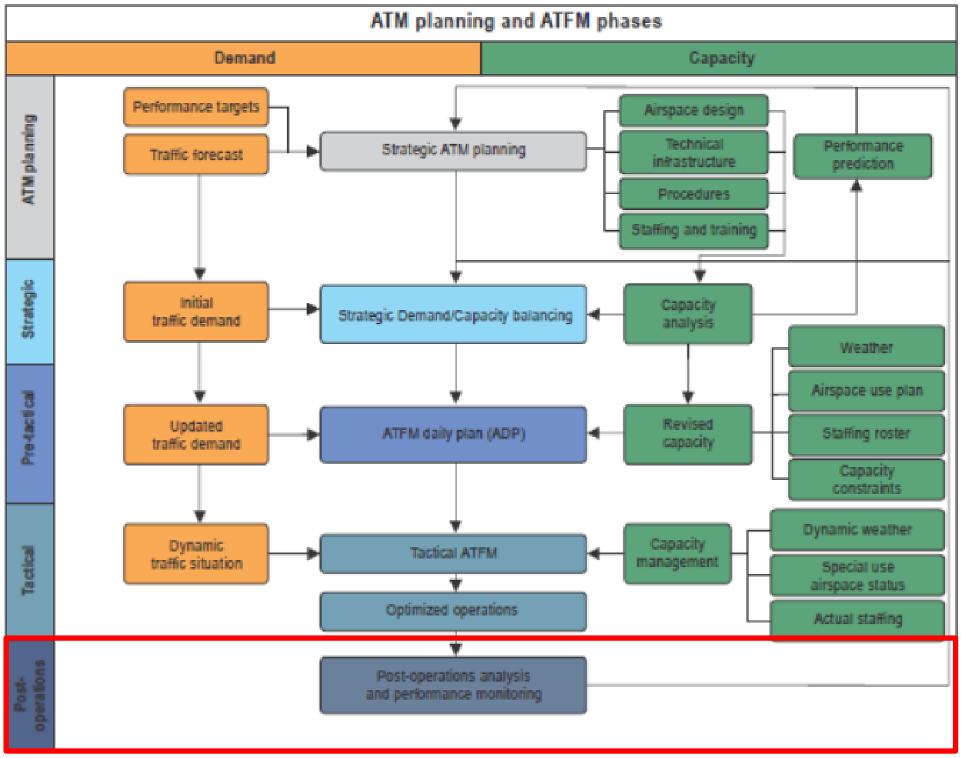

Figure 1 - ATFM Phases

1.2 The final phase in the ATFM operations is post-operations analysis, where an analysis is conducted to measure, investigate, and report on operational processes and activities. This is the cornerstone process to develop lessons learned and best practices for further improvement of the operations.

1.3 As ATFM measures – particularly cross-border ones involving international flights and stakeholders – become more common, it is essential that ANSPs / ATFMUs are able to perform quantitative analyses of operational data effectively and apply the results for program improvements as well as strategic capacity enhancement planning.

1.4 Taking experience from cross-border ATFM operational trial and implementation in Asia-Pacific, this ATFM Post-Operations Analysis Recommended Framework was developed to provide a guideline to States/Administrations looking to implement ATFM and to join the ATFM network in the region. The framework ensures ATFM service providers are able to capture key results from ATFM operations, and collaboratively assess ATFM operations with stakeholders using appropriate metrics.

Objectives

1.5 The framework seeks to provide ANSPs and ATFM stakeholders with the following:

(1) A recommended set of performance indicators to determine the effectiveness of traffic demand prediction capability within their domain, which is a pre-requisite to implementing an effective ATFM solution;

(2) Recommended sets of considerations and performance indicators to support dynamic capacity determination and capacity accuracy assessment;

(3) Recommended sets of performance indicators to determine the impact and effectiveness of various ATFM solutions prescribed in ICAO Doc 9971;

(4) An understanding on the importance of collaboration between stakeholders for ATFM post-operations analysis, and a recommended workflow to facilitate such collaboration; and

(5) Case studies from Asia-Pacific States / Administrations / ANSPs that have done post-operations analysis in their domains.

Document Structure

1.6 The framework is divided into 4 parts, loosely aligning with ICAO Doc 9971 and following the phases of ATFM implementation. The parts are as follows:

(1) ***Traffic Demand Analyses*** - This section provides a recommendation on how an ANSP may determine the accuracy and completeness of traffic demand used for ATFM operations. The analyses in this section largely centers on the comparison between predicted traffic demand and actual operations, as well as how far in advance a most reliable traffic demand profile becomes available.

(2) ***Operational Capacity Determination and Analysis*** – This section provides recommendations on how an ANSP may determine operational (dynamic) capacities at their ATM resources, and how actual operational capacities can also be analyzed post-operations.

(3) ***ATFM Measure Metrics and Analyses*** – This section provides a recommendation on how an ANSP may characterize the ATFM solution, assess the impact, and analyze effectiveness of different ATFM solutions described in ICAO Doc 9971. Indicators of different ATFM solutions vary according to the natures, but all centralize on the comparison between expected outcomes and actual / achieved outcomes.

(4) ***Collaborative Post-Operations Analysis*** – This section highlights the importance of

collaboration between stakeholders in the post-operations analysis process. With a focus on effective collection and sharing of data and information, this section discusses a possible workflow for stakeholders to join hands in ATFM post-operations analysis.

(5) ***Case Studies*** – This section provides case studies from various ANSPs in their ATFM post-operations analysis. Contributions to the case studies include…<to do>

1.7 In each of the metrics covered in various sections, the document also provides rationale behind them. Post-operations analysis should not be conducted for the sake of reporting, but its result should be used to identify areas of challenge and plans for operational improvements.

1.8 *While this framework contains a large set of recommendations, it is by no means complete. ANSPs should take this framework as a starting guideline, but adapt it to their own operational environment, objectives, and maturity of their ATFM systems. The most important note to keep is that post-operations analysis, along with associated data collection and processing workflow, should be integrated into the implementation of ATFM either from the very beginning or in a later phase but with clear roadmap. It should always be a cornerstone process throughout the ATFM operations.*

Flight Event Times Nomenclature

1.9 In this document, several flight event times will be mentioned. To avoid confusion and to ensure alignment with ICAO Doc 9971, the flight event time terminologies are defined in accordance to Table II-6-3 in ICAO Doc 9971 (3rd ed.). The terminologies are shown here in **Table 1**.

Flight Event Times	Scheduled	Flight Plan	ATFM Measure	ATFM System Estimate	Actual
Off-Block Time (OBT)	SOBT	EOBT	COBT		AOBT
Take-Off Time (TOT)			CTOT	ETOT	ATOT
Time Over (TO)			CTO	ETO	ATO
Landing Time (LDT)			CLDT	ELDT	ALDT
In-Block Time (IBT)	SIBT				AIBT

Table 1 - Flight Event Times

2. Post-Operations Analysis in the Guidance Documents

2.1 There are a number of guidance documents available on ATFM and ATFM implementation. At the global level, there is ICAO Manual on Collaborative ATFM (Doc 9971) which provides the basics and recommendations on every aspect of ATFM planning, implementation, and execution. At the regional level, there are the Asia/Pacific Regional ATFM Concept of Operations and the Asia/Pacific Regional Framework for Collaborative ATFM. All of these documents refer to post-operations analysis as one of the key processes enabling improvements in the ATFM operations and provide guidance on how the analysis may be conducted.

2.2 This framework does not aim to duplicate the work in the abovementioned documents, but rather to supplement them with more details and techniques ANSPs can employ for their analytical process. Prior to diving into the details and techniques, however, this section summarizes how post-operations analysis is represented in each of the guidance.

ICAO Manual on Collaborative ATFM (Doc 9971, 3rd Ed)

2.3 **Part II, Chapter 4** of the ICAO Manual on Collaborative ATFM (Doc 9971) discusses at length the ATFM phases and solutions. Within this chapter, subsection 4.1.4.4 provides high-level guidance on post-operations analysis for ATFM. Some of the key excerpts are as follows:

- *(4.1.4.4.2)* During this phase, an analytical process is carried out to measure, investigate and report on operational processes and activities. ***This process is the cornerstone*** in developing best practices and/or lessons learned that will further improve the operational processes and activities. ***It should cover all ATFM domains and all the external units relevant to an ATFM service***.

- *(4.1.4.4.3)* While most of the post-operations analysis process may be carried out within the ATFM unit, ***close coordination and collaboration with ATFM stakeholders will yield better and more reliable results***.

- *(4.1.4.4.4)* The post-operations analysis should be accomplished by evaluating the ADP and its results. Reported issues and operational statistics should be evaluated and analyzed in order to ***learn from experience and to make appropriate adjustments and improvements in the future***.

2.4 The document recommends the following process to ensure communication of analysis results to and discussion with relevant ATFM stakeholders:

(1) Collect and assess data by including a comparison with targets;
(2) Hold a daily briefing for a broad review and further information exchange;
(3) Conduct weekly operations management meetings to assess results and recommend procedural, training and system changes, where necessary, to improve performance; and
(4) Conduct periodic operations review meetings with stakeholders, which could take place, e.g., in conjunction with or after each seasonal scheduling conference

(roughly every 6 months) or more frequently as deemed appropriate.

2.5 The recommended processes, specifically review briefing / conferences, are explored as part of the Distributed Multi-Nodal ATFM Network Common Operating Procedure. It is pertinent, however, that ANSPs also consider adding regular local stakeholder engagements in addition to cross-border ones as well.

Asia/Pacific Regional ATFM Concept of Operations

2.6 The Asia-Pacific Regional ATFM Concept of Operations had been developed through a collaborative effort between Asia-Pacific States and partner organizations, and provides overview of cross-border ATFM operational concept used in the region. **Part 4** (Concept – Regional ATFM) of the document provides a section on post-operations analysis (starting para. **4.36**) with 2 tables listing possible metrics for characterization and impact measurement of the program, as well as assessment of Collaborative Decision Making (CDM) actions taken by stakeholders. The tables are copied here for reference (**Table 2** and **Table 3**):

Metric	Description	Type
Number of Flights	The total number of flights that received calculated times	TMI Parameter
Start / Stop Time	The start and end time of the TMI. The time period when the FMP wanted to control the demand.	TMI Parameter
Lead Time	The number of minutes the TMI was implemented before the Start Time	TMI Parameter
Number of Exempt / Non-Exempt Flights	The number of flights that were exempt from the TMI according to the parameters specified by FMP	TMI Parameter
Number of TMI Events	The number of FMP actions that reassigned flights in the TMI (i.e. number of revisions and compressions)	Operational Activity
Total Assigned Delay	The sum of delay assigned by TMI	Operational Impact
Max / Average Assigned Delay	The maximum and average delay	Operational Impact
Total Gate/Surface/Airborne Delay	The total actual delay taken at the gate, on the airport surface, and in the air	Operational Impact
Number of cancellations	The number of flights cancelled and were part of a given TMI	Operational Impact
Number of Unexpected Flights	The number of flights that appeared after the TMI was already implemented	Operational Impact

Table 2 - General ATFM Program Metrics

Metric	Description
Number of Substitutions	Total number of flights that were substituted
Number of Inter-Operator Slot Exchanges	Total number of ISEs
Number of Bridged Flights	The number of flights that were bridged
Number of Cancellations	Total number of cancelled flights for a given time period
Substitution Savings	The amount of savings in minutes of flights that move forward as a result of a substitution
Bridging Savings	The amount of savings in minutes of flights that move forward as a result of being bridged

Table 3 - CDM Actions Metrics

**Note: The nomenclatures used in the tables are exactly as appeared in the Regional Concept of Operations at the time it was developed, and they may differ from nomenclatures used currently and elsewhere. Key examples include:*

- *TMI = traffic management initiative; now commonly referred to as ATFM Measure*
- *FMP = flow management position; also commonly referred to as ATFMU Staff*
- *Assigned delay = delay* assigned as part of the ATFM measure; also commonly referred to as ATFM delay

2.7 These indicators are good starting points for the characterization and impact assessment of an ATFM program. They will be explored further in Chapter 5 – ATFM Measure Metrics and Analyses.

Asia/Pacific Regional Framework for Collaborative ATFM

2.8 The Regional Concept of Operations document formed the basis for Asia/Pacific Regional Framework for Collaborative ATFM (*"Regional Framework"*). The Regional Framework provides a common guideline, in terms of ATFM service capabilities and performance, for States in the region in their ATFM implementation plan. In particular, the framework sets out *Performance Improvement Plan* with details on elements of ATFM operations that States should aim to accomplish.

2.9 The Performance Improvement Plan divides ATFM implementation into 2 main phases in alignment with the Asia-Pacific Seamless ATM Plan's phased approach. Phase I has also been further sub-divided into Phase IA and Phase IB. With respect to ATFM post-operations analysis, the following have been recommended (**Table 4**):

	Detail	Target Implementation
Phase IA	***The accuracy and effectiveness of capacity and demand analyses and ADP preparation and distribution****, including supporting information […], should be* ***verified through comparison with operational outcomes observed****, and rectification of discrepancies included in planning for system and process improvements*	12 Nov 2015

	Detail	Target Implementation
Phase IB	***Procedures and agreements should be developed to ensure post-operational analysis of cross-border ATFM programs****, including the canvassing and consideration of feedback from airspace users, airport operators, ATS and other ATFM units.* ***Daily post-operations analysis conferences should be held****, supplemented where necessary by ad-hoc conferences called to assess the outcomes of programs of ATFM measures responding to non-normal situations*	25 May 2017
Phase II	*(No specific mention of post-operations analysis as Phase IB has already covered all that need to be conducted)*	8 Nov 2018

Table 4 - Post-Operations Analysis in Regional ATFM Framework

3. Traffic Demand Accuracy and Reliability

3.1 Traffic demand is one of the two main elements in the planning and execution of ATFM, a service focused on balancing demand against ATM resource capacity. Obtaining accurate and reliable traffic demand profile with sufficient lead time is an important pre-requisite to implementing successful ATFM solutions. This section recommends various indicators an ANSP providing ATFM service can use to determine the reliability of their traffic demand sources.

3.2 The analyses can be used to determine possible and appropriate ATFM solutions. They can also be used as a basis for the establishment of regulatory process and procedure, such as advance flight planning requirements, to ensure reliable traffic demand information furnished by stakeholders.

3.3 *It should be noted that these traffic demand analyses are not limited to ANSPs providing ATFM service but can also be carried out by States / Administrations / ANSPs that are not yet implementing the service but looking to in the future. Analyzing traffic demand information and putting in place necessary regulations and process to ensure completeness and accuracy, are good first steps to planning for ATFM. Pre-implementation analysis results can also be used in comparison with post-implementation results to determine the effectiveness of the implementation program and form the basis for cost-benefit analysis in ATFM.*

Strategic & Pre-Tactical Data Completeness

<u>Schedule and Flight Plan Completeness</u>

3.4 The first level of traffic demand analysis is to assess its reliability. Strategic and pre-tactical demand profiles are made of (1) flight schedules obtained from marketing sources, seasonal airport slot coordination, updated airline schedule, and/or flight permissions, and (2) flight plans submitted prior to departures. Analyzing the completeness of these demand sources allow ANSPs to assess how reliable their traffic demand predictions are, and to establish necessary process to ensure they can capture sufficient information for ATFM program management.

Key Question:

How complete is the strategic and pre-tactical traffic demand information?

Data Needed:

- *Flight Schedule (e.g. strategic airport slot coordination, marketing information)*
- *Updated Airline Schedules*
- *Flight Plans*

Analysis Complexity:

Low complexity

Recommended Metrics:

Metric	Description
Number of Flights with **SCH but no FPL**	Total number of scheduled flights with no flight plan *This represents extraneous strategic demand at the resource.*
Number of Flights with **FPL, No SCH**	Total number of flights with flight plans but no strategic schedule *This represents traffic demand with limited advance information.*
Number of Flights with **SCH + FPL**	Total number of flights with both strategic schedule (e.g. airport slot / marketing information) and flight plan *This represents flights that make up the most reliable demand profile.*

Table 5 - Schedule and Flight Plan Completeness

How this helps:

The analysis can be used to support establishment of appropriate procedure to ensure a large ratio of flights with both strategic schedule and flight plan information. With good portion of the traffic demand captured strategically through schedule, ANSP can form initial demand profile for effective capacity planning and strategic ATFM execution. Flight plan information will then supplement with accurate flight models that can be used for pre-tactical / tactical ATFM execution if needed.

Pre-Departure Changes

3.5 While flight plan information should form the most reliable information about a flight, pre-departure changes such as EET alterations or departure delays do happen. Tracking the number of pre-departure changes for each flight through ATS messages (CHG / DLA / CNL) can provide insight into how reliable initial flight plan information is.

Key Question:

How many pre-departure changes to flight plans occur?
How reliable are the initial flight plan information?

Data Needed:

- *Flight Plans*
- *(Count of) ATS messages (CHA, DLA, CNL)*

Analysis Complexity:

Low / Medium complexity
***ANSPs will need a means to correlate the number of ATS messages with flight plans*

Recommended Metrics:

Metric	Description
Number of FPL with (various) Pre-Departure Changes	Numbers (or ratios) of flight plans with various number of pre-departure changes, counted from associated ATS messages

Table 6 - Pre-Departure Change Count

How this helps:

The analysis can be used to inform ANSP / regulator when establishing flight planning requirement and procedure. The requirement should balance between attempting to capture traffic demand with long lead time and getting accurate flight information from the operators. If, under the existing FPL submission lead time requirement, a large number of pre-departure changes to flight plans are encountered; it may mean the requirement should be shortened to allow operators time to collect accurate operational information before filing more accurate flight plans.

Demand Look-Ahead

3.6 ATFM execution focuses on balancing demand against capacity, using various solutions available. **Figure II-4-3 in Section 4.5.2 of Doc 9971** describes an ATFM measure selection process, based largely on the type of constraints and lead time available at the resource. As capacity constraints are closely related to the traffic demand volume, lead time determination should also include a look at the lead time an ANSP has on the traffic demand coming into the resource. This is what is described in this section as ***demand look-ahead****.*

Flight Plan Submission Lead Time

3.7 The first level of assessing demand look-ahead starts with analyzing flight plans' submission time. Most ANSPs prescribe that flight plans are submitted a certain amount of time prior to their planned departure (Estimated Off-Block Time: EOBT). With appropriate ***flight plan submission lead time***, defined as the amount of time FPLs are submitted before EOBT, ANSPs can ensure they receive the flight information with sufficient time to plan their ATM resources accordingly. In Asia-Pacific, especially with the introduction of cross-border ATFM, a requirement of *3 hours (180 minutes)* in *lead time* is a common and recommended practice.

Key Question:

How far in advance (of EOBT) are flight plans submitted?

Data Needed:

- *Flight Plan submission times*

Analysis Complexity:

Medium complexity
***Practice of collecting FPL submission times may not be common for ANSPs*

Recommended Metrics:

Metric	Description
Tabulation of FPL submission lead time	Times (in minutes or hours) the flight plans are submitted prior to their planned departure times (EOBT) *The tabulation can be displayed as scatter plot on a time axis, distribution of lead times, or whisker plot.*

Table 7 - Flight Plan Submission Lead Time Tabulation

How this helps:

The analysis provides ANSP a sense of how far in advance flight plans are submitted by operators. Different ATFM measures require different lead times in their execution, e.g. a GDP generally requires a long lead time to allow for early CTOT delivery, and thus will require fairly long FPL submission lead time. Understanding the make-up of lead times among FPLs in the system gives ANSP a sense of which ATFM measures can be utilized when congestions happen. The analysis result can also be used by ANSP / regulator to determine if a revision / new FPL submission time requirement is needed for effective ATM planning

Demand Look-Ahead

3.8 Further to the FPL submission lead time analysis, ANSP can also analyze *demand look-ahead*, defined as the amount of time flight information is available at the designated ATM resource prior to its arrival. For example, a ***demand look-ahead*** at the ***arrival airport*** can be calculated as:

Demand Look-Ahead = FPL submission lead time + STT+ total EET*

**STT = standard taxi-out time at departure*

3.9 For a flight whose EET from departure airport (with standard taxi-out time of 15 minutes) to the arrival airport is 1:30 hours (90 minutes) and whose FPL is submitted 3 hours (180 minutes) prior to departure, the *demand look-ahead* is 180 + 15 + 90 which is 285 minutes (4 hours 45 minutes).

3.10 *This demand look-ahead calculation can be carried out for any given ATM resource along the route by substituting total EET with EET required for the flight to reach the resource.* The look-ahead times for the flights can then be tabulated and presented for analysis, which can be helpful in determining appropriate ATFM measures as they require different lead times in execution.

Key Question:

How far in advance (to their arrivals) do flight information become available to the ANSP, based on their FPL submission time and time required to arrival (at designated ATM resource)?

Data Needed:

- *Flight Plan submission times*
- *Estimate elapse times to designated ATM resource*
- *(Standard taxi-out times at departure airports – added for accuracy)*

Analysis Complexity:

Medium complexity for data collection
High complexity for data presentation
***Presenting and explaining distribution of demand look-ahead may be complicated*

Recommended Metrics:

Metric	Description
Tabulation of flights' demand look-ahead times	Times (in minutes or hours) the flight information become available in the ANSP's system prior to their arrivals, generally defined as *Demand Look-Ahead = FPL submission lead time + Time required to arrive at designated resource (STT + EET)* *The tabulation can be displayed as distribution of look-ahead times, to give a sense of percentage of flights captured at various look-ahead points.*
Look-Ahead Point for *XX%* Traffic	Look-ahead time at which *XX%* of traffic demand at designated ATM resource is captured in the system *The percentage point can be defined based on the needs; generally 80% is chosen to represent a useful majority for ATFM measure execution.*

Table 8 - Demand Look-Ahead Analysis

How this helps:

Demand Look-Ahead analysis can be used to determine appropriate ATFM measure for a given ATM resource. Different ATFM measures require different lead time in their execution; a GDP generally requires longer lead time for effective CTOT notification, while a Minutes-in-Trail does not require as much since it can be readily applied through ATC intervention to airborne flights. Thus, the different measures will be suitable for traffic set with different demand look-ahead distribution. While the analysis may be complex, it can be useful as part of the decision-making process

Demand Accuracy

<u>Pre-Tactical Demand Accuracy</u>

3.11 Accurate ATFM measure execution relies on using the most accurate data available to the system at the time of calculation. Generally, flight plan information are used for this purpose, thus the reliability of the information should be always be assessed. At the most basic level, flight plans' flight timings – departure, enroute elapsed, arrival – can be compared against their actual timings and distribution in the time difference analyzed.

Key Question:

How accurate are flight information, particularly flight timings, provided in flight plans?

Data Needed:

- *Flight plan timing information*
- *Flights' actual operation timings*

Analysis Complexity:

Low complexity

Recommended Metrics:

Metric	Description
Push-Back Time Comparison (AOBT – EOBT)	Comparison of a flight's estimated off-block time filed in the flight plan against its actual push-back time from the parking bay at departure airport. *Distribution of the difference in the set of flights can be plotted to get overall picture of flight plan accuracy.* **Note that the actual off-block times (AOBT) for flights may not be readily available to ANSPs without surface movement surveillance system, and may require coordination with the airport operator or airspace users to obtain such information.*
Departure Time Comparison (ATOT – ETOT)	Comparison of a flight's estimated take-off time derived from flight plan and default /standard taxi-out time at departure airport against its actual take-off time. *Distribution of the difference in the set of flights can be plotted to get overall picture of flight plan accuracy.* **Note that tactical variations due to, e.g., operational issues and departure ground congestion, do occur. The time difference should also be attributed in part to those tactical variations.*
Arrival Time Comparison (ALDT – ELDT)	Comparison of a flight's estimated landing time derived from flight plan information against its actual arrival time at destination airport. **Note that, as with departure time comparison, tactical variations in flight times do occu, thus the time difference should also be attributed in part to those variations.*
Elapse Time Comparison (AET – EET)	Comparison of a flight's estimated elapse time to a given ATM resource derived from flight plan information against its actual elapse time over the same area. **Note that, as with departure and arrival times, tactical variations should also be accounted for in the attribution of difference.*

Table 9 - Pre-Tactical Demand Accuracy

How this helps:

Assessment of pre-tactical demand accuracy based on flight plan information provides an initial view of how reliable flight plans are and whether they are suitable as bases for ATFM execution. When flight plan information is not reliable, an ANSP may consider implementing additional procedure to obtain accurate flight intents from airspace users prior to ATFM execution.

Note though that tactical variations in flight do occur, and minor time difference between actual operations and the flight plans is common. When performing the analysis, these minor tactical variations should be accounted for.

Strategic Demand Accuracy

3.12 Flight plan information is normally available between 3 – 5 hours before flight. While they represent most accurate flight information prior to operations and are useful for tactical ATFM measure calculation; they are not available early enough to facilitate strategic and pre-tactical ATFM operations (e.g. demand-capacity outlook and ATFM daily plan preparation). In the strategic and pre-tactical phases; operations are normally based on flight schedule information, obtained from airlines' marketing schedules and/or airport slots, as they are available on a seasonal basis. This strategic demand information should also be assessed for its reliability through comparison with the associated flight plan information in a similar manner as Pre-Tactical Demand Accuracy assessment.

Key Question:

How accurate are flight information available strategically?

Data Needed:

- *Strategic schedule timing information*
- *Strategic airport slots information*
- *Flight plan timing information*

Analysis Complexity:

Low complexity

Recommended Metrics:

Metric	Description
Push-Back Time Comparison (EOBT – SOBT) (AOBT – SOBT)	Comparison of a flight's estimated off-block time from flight plan against its scheduled off-block time, and similarly comparison of a flight's actual off-block time against its scheduled off-block time. **Note that the scheduled information can come from airlines' schedule or from airport slots. Comparison between airport slot times and airlines' schedule can also be assessed if they differ often*.
Arrival Time Comparison (AIBT – SIBT)	Comparison of a flight's actual arrival time at the parking bay (actual in-block time) against its scheduled in-block time at destination airport. **Note that the scheduled information can come from airlines' schedule or from airport slots. Comparison between airport slot times and airlines' schedule can also be assessed if they differ often*.

Metric	Description
Schedule Buffer Analysis (AIBT – AOBT) – (SIBT – SOBT)	Comparison of a flight's actual block time from push-back at departure airport to destination gate arrival against its scheduled block time. This can provide insight into "schedule buffer" worked into strategic planning process by airspace users. With large schedule buffer, the accuracy of strategic schedule becomes less and its reliability reduced. **With good taxi-out and taxi-in estimates available, ANSPs can also isolate scheduled airborne times to compare against actual airborne times and gain insight into the airborne portion of the schedule buffer.*

Table 10 - Strategic Demand Accuracy

How this helps:

Assessment of strategic demand accuracy based on schedule provides a view of reliability in the strategic schedule and whether they can be used as bases for strategic / pre-tactical ATFM execution. With unreliable strategic schedule, the ANSP would have less time to enact appropriate ATFM measures in response to congestions and may have to rely solely on tactical ATFM measures.

Tactical Demand Information

3.13 In effectively implementing ATFM programs, not only does an ANSP need to look at traffic demand completeness, reliability, and lead time, but also needs an effective monitoring of tactical traffic situation. Accurate and complete tactical demand information should be made available to the ATFM unit for further usage, and the analysis should be carried out to determine whether a lapse in the information is present and should be addressed.

3.14 At the most basic level, tactical demand information comes from flight movement messages such as DEP and ARR. A simple analysis into the completeness of these messages can be conducted, and measures taken to address the lack of deliveries appropriately.

Key Question:

How complete are tactical demand information supplied through movement messages (e.g. DEP, ARR)

Data Needed:

- *Movement messages (DEP, ARR)*

Analysis Complexity:

Low complexity

Recommended Metrics:

Metric	Description
% of DEP message received	These represent completeness of tactical flight update information, based on the simple count of relevant ATS messages.

Metric	Description
% of ARR message received	*For ANSPs with more sophisticated flight trajectory update capability, other means of tactical update completeness analysis can be conducted.*
% of DLA message received for delayed flights	
% of CNL message received for cancelled flights	

Table 11 - Tactical Demand Information

How this helps:

Accurate tactical updates to traffic demand rely heavily on completeness of flight movement messages. Assessment of completeness of DEP, ARR, DLA, CNL can inform an ANSP if there is an issue in this domain and whether measures need to be taken against non-deliveries. By ensuring that movement messages are delivered appropriately, an ANSP will have accurately updated traffic demand profile and can execute ATFM measures effectively. Alternatively, if movement message delivery is proven to be a problem and cannot be resolved, an ANSP may also consider other sources of updated traffic demand information.

3.15 (placeholder)

4. Operational Capacity Determination and Analysis

4.1 ICAO Manual on Collaborative ATFM (Doc 9971) describes the various factors contributing to ATM resource capacities (Part II, Chapter 3). The chapter also describes the two common schools of thoughts on determining baseline capacity numbers at various ATM resources. The baseline capacity numbers, however, often need to be adjusted by dynamic factors such as weather and staffing level to create *operational capacities.* These operational capacities, in turn, determine the needs for ATFM measure(s) when compared against operational traffic demand.

4.2 On the one hand, accurate determination of traffic demand generally relies on simply ensuring the completeness and reliability of demand data sources. Accurate determination of dynamic *operational capacities* with the required lead time, on the other hand, can be a relatively more complex exercise relying on many factors with varying effects.

4.3 This section describes key considerations in working with dynamic operational capacities.

General Considerations in Operational Capacity Determination

<u>Lead Time and ATFM Program Participation</u>

4.4 Different ATFM measures require different lead time to be effective. For example, a Ground Delay Program (GDP) requires that Calculated Take-Off Times (CTOTs) be delivered to flights long before EOBT. That required lead time, in turn, determines the lead time an ATFM unit needs to know about the operational capacity. When an ATFM unit is able to determine the operational capacity far ahead of time, there is a higher chance that an appropriate ATFM measure can be activated and managed effectively. The longer lead time also enables stakeholders, especially airspace users, to participate in the ATFM program and operate flights in compliance to the measure. Well-planned events with long lead times thus permit greater certainty and larger number of flights participating in the ATFM program. On the other hand, dynamic constraints with shorter lead times may not allow the ATFM program to be activated in time to capture the level of participating flights required for efficient and equitable distribution of ATFM measures.

4.5 *Ideally, an ATFM unit (ANSP) should have in place a dynamic capacity determination mechanism that allows for their ATFM programs to be activated with enough lead time to capture at least the optimum 70% flight participation level where possible.*

<u>Coordination between ATFM Unit and ATS Units</u>

4.6 ATFM Unit should ensure to collaborate closely with associated ATS Units to understand and quantify the impacts that various dynamic constraints will have on particular airports or airspace volumes. These may be unique to a particular airport layout or airspace location depending on local procedures. While general guidelines exist, a relationship between, for example, specific weather phenomena in one area may affect another area differently. *Only through close coordination and exchanges between the ATFM unit and their associated ATS units would effective operational capacity determination be achieved.*

Target Level of Service and Sensitivity to Capacity Reductions

4.7 Once operational capacities have been determined, sensitivity to their reductions should also be established. Sensitivity level determines how severe a capacity reduction should be before an ATFM measure has to be activated. The sensitivity should be determined based on analysis of impacts and implications from various capacity reduction scenarios.

4.8 *One helpful approach to establish the sensitivity level is to determine first a target level of service. The target level of service, e.g. acceptable airborne delay threshold, should be agreed upon with stakeholders to determine what level of capacity reduction warrants ATFM measures to be implemented.*

Key Factors Impacting Operational Capacity

4.9 The following lists, while not exhaustive, are some of the factors that should be considered when determining operational capacity at airports and airspace sectors.

Airport Capacity

- Average Runway Occupancy Time (ROT)
  - This can be determined for different aircraft / approach categories and for different entry / exit taxiways.
  - Under some circumstances, ROT may be an overriding factor to the separation minima on final approach/departure.
- Target Final approach spacing under different runway operating Modes e.g. independent, dependent, mixed, LVO Cat II/Cat III
- Traffic Mix
  - Weight or wake turbulence categories
  - Final approach speed
  - Arrival-to-Departure ratio
- Airport operational constraints
  - Taxiway and Rapid Exit Taxiway (RET) closure
  - CNS serviceability and instrument approach availability
  - Runway dependencies
- Critical meteorological conditions
  - Headwind / Crosswind components
  - Visibility
  - Ceiling
  - Wind shear

- Thunderstorm or thunderstorm cloud affecting initial approach areas or sequencing / holding areas

Airspace Capacity

- Average flight times in sector
- Traffic Mix
  - Arrivals / Departures / Enroute flights
- Traffic Complexity
  - Climbing / Descending
  - Uni-directional / Bi-directional routings
  - Confliction points
- Flight Level Allocation Scheme (FLAS) disruptions
- CNS serviceability
- ATS staffing level

Analysis of Operational Capacity Determination

4.10 An ANSP (or ATFM unit), having determined operational capacities at their resources, should regularly perform post-operational analysis to determine the actual capacities achieved and how the various environmental factors affect them. The following lists are examples of ways to analyze actual operational capacities at an airport and an airspace volume.

	Possible Analysis for Operational Capacity
Analyzing Airport Operational Capacity	▪ Seasonal ROT study ▪ Seasonal traffic mix study ▪ Regular analysis on the comparison between target final approach spacing vs. actual spacing achieved ▪ Sampling and comparison of predicted Airport Arrival Rate (AAR) vs. actual rates achieved, particular on days with inclement meteorological conditions affecting the airport capacity ○ *Note: Deviations of >10% between predicted AAR and actual AAR typically warrant further detailed analysis.*
Analyzing Airspace Operational Capacity	▪ Sector entry and occupancy counts – peak, instantaneous, average ▪ Hourly waypoint-crossing counts – peak, average ▪ Analysis on instances of non-optimal assigned FL due to route overload

Table 12 - Operational Capacity Analysis

4.11 (placeholder)

5. ATFM Measure Metrics and Analyses

5.1 ICAO Manual on Collaborative ATFM (Doc 9971) specifies a number of ATFM measures that can be used for different demand-capacity imbalance situations, as shown in **Figure 2** (Figure II-4-3 in Doc 9971, 3rd Ed.). As these measures are suitable for different situations, they have different metrics to measure their performance. This section describes the different ATFM measures and recommends a set of metrics that can be used to assess their operational performance. As with other sections in this document, the metrics provided should be used as a starting guideline supplemented by any additional information/analysis relevant for local environment.

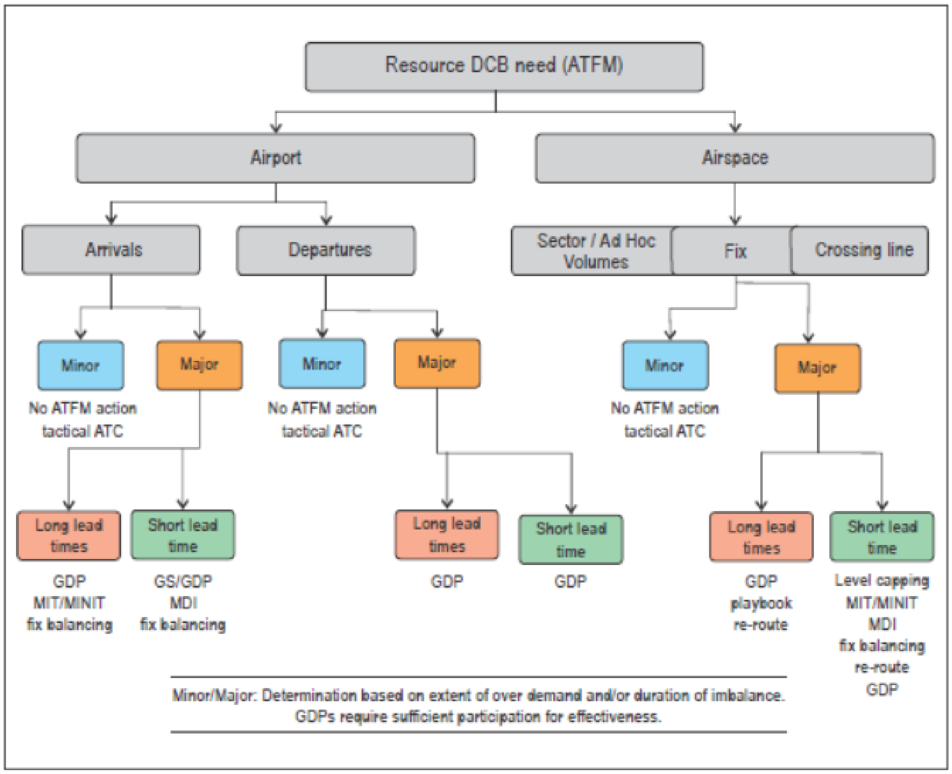

Figure 2 - ATFM Measure Selection Process

Analyzing an ATFM Program: 3-Part Story

5.2 Performing post-operations analysis for an ATFM program can seem daunting, with the amount of data available and the many facets of the program that can be reported. To simplify the process and the reporting, this framework adopts a ***3-Part Story*** approach to characterizing and reporting on an ATFM program. The 3-Part Story approach organizes ATFM data into 3 main parts, which together create a smooth flow of story about a given ATFM program; from characterizing the impact to assessing compliance to evaluating its effectiveness.

5.3 The 3-Part Story approach to crafting post-operations analysis focuses on the following (**Table 13** and **Figure 3**):

Figure 3 - 3-Part Story Approach to Post-Ops Analysis

Key Performance Areas	Description
Impact Analysis	***Key Question: Who are impacted by the ATFM program, and how?*** This section should analyze the impact of the ATFM measure activated. The analysis should include breaking down the various Airspace Users and Airport Operators involved along with the impact – such as ATFM delays – they face. Impact analysis should be able to provide insights such as ATFM delay trend, fairness in ATFM delay distribution, and particular areas where further collaborations are needed.
Compliance Assessment	***Key Question: How well do stakeholders comply with the ATFM measure?*** This section should assess the level of ATFM compliance exhibited by impacted stakeholders. ATFM measure generally works best when majority of flights included in the program comply with the requirements assigned. Analyzing the compliance level from different stakeholders can provide insight into areas where more collaboration or even a change in governing procedure can improve the performance.
ATFM Program Effectiveness	***Key Question: How effective is the ATFM measure implemented in delivering the intended level of traffic?*** This section should evaluate the outcome at the ATM resource for which the ATFM measure has been activated, against planned objective(s). For example, if a Ground Delay Program (GDP) is required to manage traffic into an airport during the 2-hour period with thunderstorms, the actual number of arriving traffic should be counted in comparison to the plan. *The most important note to keep in mind is to ascertain that the ATFM measure objective(s) are set appropriately and clearly prior to the activation of the program. Once set, the objectives should be the main driving force behind operational decisions taken.*

Table 13 - 3-Part Story Approach to Post-Ops Analysis

5.4 The following sections describe different metrics for characterizing and analyzing various ATFM measures post-operations, following the 3-part framework mentioned above.

Ground Delay Program (GDP)

Definition and Implementation

5.5 GDP is a pre-tactical or tactical ATFM measure where aircraft are held on the ground in order to manage capacity and demand in a specific volume of airspace or at a specific aerodrome. In the process, departure times are assigned to corresponding available entry slots into the constrained airspace or arrival / departure slots into / from the constrained aerodrome. A GDP aims to, among other things, minimize airborne delays. It is a flexible program, and its form may therefore vary depending on the needs of the ATM system. GDPs are best developed in a collaborative manner even though they are typically administered and managed by an ATFMU or a national / international ATFM center. When a GDP is scheduled to last for several hours, the likelihood of slots having to be revised increases, as conditions could change. There should therefore be a system in place to advise stakeholders of departure slots as well as of any changes to the GDP.

5.6 Generally GDP is used to provide greater predictability to stakeholders and to shift unavoidable airborne delays to less-taxing pre-departure ground delays. The ability of GDP to deliver the predictability and the reduction in airborne delays should thus form the basis for the program's effectiveness assessment.

Characterizing a GDP

5.7 Characterizing a GDP involves recording basic parameters used when the program is activated. These parameters can be used as a baseline in comparing between different GDPs over time. **Table 14** provides a sample list of basic parameters that can be recorded and used to characterize each GDP.

Parameters	Description
Start Time / End Time	The start and end times of the GDP, which signifies the time period an ATFMU wants to control the traffic demand.
Purge (Stop) Time	The times that the GDP is cancelled, if it is cancelled before the intended time; while this signifies improvement in the constraint situation, it can be disruptive for stakeholders who have already planned for ground delays.
Lead Time to Activation	The amount of time GDP is announced prior to its activation, e.g. ADP delivery time compared to GDP start time; this indicates how much time is given to stakeholders to acknowledge and prepare for the ATFM measure.
CTOT Delivery Lead Time	The amount of time CTOTs are delivered ahead of the associated flight's Estimated Off-Block Time (EOBT); this indicates how much time is given to flight crews and related personnel to adjust their operations in an attempt to comply with CTOTs.
Number of ATFM Events	Number of events resulting in the change in GDP, e.g. revision in the End Time, changing of flow rates and consequently CTOTs, changing of the ATFM measure as situation improves or deteriorates.

Table 14 - Characterizing GDP

GDP Impact Analysis

5.8 Following the characterization of GDP, the program's impact can be analyzed. This should include analyses into the flights involved in the program and the ATFM delays assigned. In GDP, ATFM delay should be defined as:

$$ATFM\ Delay = CTOT - ETOT$$

where ETOT is the Estimated Take-Off Time based on the flight's originally-intended operations.

5.9 **Table 15** provides a sample list of impact parameters that should be included.

Parameters	Description
Flight Count Impact	
Total Number of Flights	Number of flights included in the GDP.
Flight Breakdown	Breakdown of the flights included in the GDP, e.g. by Airspace Users / Airspace User Groups, departure aerodromes, departure FIRs.
Number of Exempted Flights	Number of flights included in the GDP but exempted from CTOT, i.e. flights that form part of the demand but are given zero-minute ATFM delay. Flights in this group could include flights outside of the GDP agreement or flights that are already airborne at the time the GDP is activated.
Number of Included Flights	Number of flights included in the GDP and given CTOT; this can be compared to the number of exempted flights and used to analyze if GDP is actually an appropriate measure. If the rate of exemption is high, other ATFM measure may need to be considered.
Number of Slot Cancellations	Number of flights whose CTOTs were cancelled, either due to flight cancellation or re-timing such that they fall outside the regulated period.
ATFM Delay Impact	
Total ATFM Delay (Assigned vs Final)	Total ATFM delays assigned to flights as part of the GDP. Note that there may be difference between originally-assigned ATFM delay, which should be a function of capacity constraint or rate of congestion, and the final ATFM delay, which could include CTOT revisions and thus may not reflect true capacity-induced delays.
ATFM Delay Descriptive Statistics	Descriptive statistics of ATFM delays; e.g. average, maximum, minimum, variance.
ATFM Delay Breakdown	Breakdown of ATFM delays assigned to different stakeholders, e.g. Airspace Users / Airspace User Groups, departure aerodromes. This information can help determine if there is a skewed distribution of ATFM delays between stakeholders. Note that the amount of ATFM delay assigned to each stakeholder should be viewed in conjunction with the associated traffic contribution, e.g. Airspace User with large number of flights operating during the GDP period should expect larger total ATFM delays.

Table 15 - GDP Impact Analysis

5.10 Another characteristic of a GDP, per ICAO Doc 9971's definition, is the possibility of slot management (revisions, additions, cancellations) that should be facilitated by the ATFMU initiating the program. A recording and tabulation of these slot management actions, sometimes referred to as CDM actions, can also be an indicator of stakeholders' awareness and active participation in the program as well as the impact they face. **Table 16** provides a sample list of CDM action elements that can be recorded.

Parameters	Description
CDM Actions / Slot Management	
Number of Slot Changes	Number of times a slot change (into open slot) occur.
Number of Slot Substitutions	Number of times a slot substitution between 2 flights occur.
Number of Slot Cancellations	Number of times assigned CTOTs are cancelled, either due to flight cancellation or re-timing such that they fall outside the regulated period.
Number of Added Slots	Number of times additional slots / CTOTs have to be allocated to flights after the initial distribution. This can be related to the number of "pop-up" flights which had not been accounted for during the demand prediction process.

Table 16 - GDP CDM Actions

5.11 Further analysis of CDM actions can help ANSPs better understand the behaviors of stakeholders when a GDP is activated.

GDP Compliance Assessment

5.12 The next step after impact analysis is assessing compliance to GDP. An effective GDP relies heavily on compliant departures from the points of origin, and low departure compliance can result in unintended or undesirable effects at the constrained resource. There have been examples where a large number of non-compliant departures adversely affect the smooth flow of traffic, often forcing compliant flights to take undue additional airborne delays and reducing the overall effectiveness of the GDP. Analyzing departure compliance against CTOT should be the first-level analysis done on flights included in each GDP, and statistics surrounding compliance rate can provide insight into areas where improvements are needed. For a GDP, CTOT compliance should be based on the comparison between flight's assigned CTOT and its actual take-off time (ATOT):

$$\boldsymbol{Departure\ Difference = ATOT - CTOT}$$

The departure difference should be evaluated against established ***compliance window***. The compliance window is a factor built into GDP to allow for variations in tactical operations at the departure side; it is normally defined as **(-5/+10) minutes** in Asia-Pacific. Departure differences that fall outside of the established window should be considered non-compliant. **Table 17** provides a sample list of statistical analysis that can be done on the departure difference and CTOT compliance.

Parameters	Description
CTOT Compliance Ratio	Counts and ratios of CTOT compliance statuses; this can include the counting of compliant, early, and late departures, or can include finer grouping e.g. 5-10 minutes early, >10 minutes early, 5-10 minutes late, >10 minutes late. The degree of granularity in groupings depends on the use of the information.
Departure Difference Distribution	Grouping compliance into statuses (compliant, non-compliant) may not be sufficient to provide a picture of departure situation; a (histogram) distribution of departure differences may provide a better picture and insight.
CTOT Compliance Breakdown	Breakdown of CTOT compliance statuses among different stakeholders, e.g. Airspace Users / Airspace User Groups, departure aerodromes, Airport Operators, countries of origin. The breakdown can help ANSP identify particular area that needs improvement or particular stakeholder that needs to be investigated and collaborated.

Table 17 - GDP Compliance Assessment

5.13 While a GDP generally focuses on the departure end, a similar compliance analysis can be carried out at the arrival / constrained resource end as well. This can be done by comparing actual times of arrival at the constrained / congested resource, e.g. actual landing time (ALDT) or actual time over a significant point (ATO), against the associated calculated times (calculated landing time – CLDT, or calculated time over a significant point – CTO). Similar to departure difference, the arrival difference should be compared against established compliance window.

$$\boldsymbol{Arrival\ Difference = ALDT - CLDT}$$

$$\boldsymbol{Time\ Over\ Difference = ATO - CTO}$$

5.14 It is worth noting, however, that compliance at the arrival end may not fully fall under the responsibility of Airspace Users unless otherwise agreed and appropriately announced during the ATFM implementation process. Due regards should thus be given to tactical airborne variations that can result from various uncontrollable factors such as weather deviations and tactical pilot and ATC interventions. Analysis result from arrival compliance should be used cautiously and not without proper accounting for the tactical variations.

GDP Effectiveness Measurement

5.15 Compliance analysis should lead naturally to the measure of GDP's effectiveness in regulating traffic against desired objectives. As mentioned in **Table 13**, ***clear objective statements*** should be set by the ATFMU initiating the GDP prior to its activation and the post-operations analysis. The objective statements should then be used as bases for effectiveness measurement.

5.16 GDP, as with other ATFM measures, should have the main objective of balancing demand against available operational capacity; applied at an aerodrome, airspace volume, a particular waypoint, or a segment of route. Another objective often quoted along with demand-capacity balancing is GDP's ability to transfer unavoidable airborne delays into less-disruptive ground delays pre-departure, adding predictability and reducing fuel consumption for Airspace Users while minimizing airborne air traffic complexity for ATC.

5.17 **Table 18** provides *samples* of 2 GDP performance objectives and possible associated indicators as guideline for GDP effectiveness measurement in the post-operations analysis process.

Parameters	Description
Performance Objective: **Balancing demand against available operational capacity at constrained / congested ATM resource**	
Comparison of Traffic Demand	Comparison of traffic demand achieved at the ATM resource for which GDP is activated *against scheduled / intended / planned demands figures.* The comparison should be made between: *1. Scheduled / flight planned demand vs. GDP planned demand* *2. GDP planned demand vs. Actual demand* *3. Scheduled / flight planned demand vs. Actual demand* Analysis (1) can show whether the parameters used in planning and executing the GDP is effective in regulating the original demand. If the GDP planned demand is very similar to the scheduled / flight planned demand, and is still over capacity, a revision in the GDP parameters – time period, flow rate, exemption/inclusion rules – may need to be revised. Analysis (2) can show whether the actual traffic demand fits the demand that had been planned with GDP. A large difference here may be resultant from low departure compliance or high tactical variations during flights. This can be ground for further investigation into the causes of low compliance or high airborne variations. Analysis (3) is closely related to ATFM delay analysis in the impact assessment section, as it shows the degree to which traffic demand is adjusted from its original schedule/intention. It may also be used in conjunction with compliance analysis to assess stakeholders' behaviors against GDP as well, e.g. whether Airspace Users or Airport Operators elect to adhere to original schedule/intention rather than the assigned ATFM delays. The insight can be ground for further coordination and awareness effort to improve the trend.

Parameters	Description
Capacity Utilization Ratio	Comparison of traffic demand achieved at the ATM resource for which GDP is activated *against operational capacity available*. The comparison should be made between: *1. Scheduled / flight planned demand vs. operational capacity* *2. GDP planned demand vs. operational capacity* *3. Actual demand vs. operational capacity* Analysis (1) can be used to justify the activation of a GDP as, ideally, GDP should only be activated when the intended demand (scheduled / flight planned) exceeds available operational capacity. Analysis (2) can be used to gauge the appropriateness of GDP activation parameters (time period, flow rate, exemption/inclusion rules). Ideally, the GDP planned demand should closely match available operational capacity. ▪ If the planned demand *exceeds* capacity, the program is said to have *over-utilized* the resource and may not solve the problem. ▪ If the planned demand *falls below* capacity, the program is said to have *under-utilized* the resource and may be too stringent on the stakeholders, with possibly too much ATFM delays assigned. Analysis (3) can be used to gauge whether the GDP has helped to regulate the traffic demand against available operational capacity. The degree of difference between actual demand and operational capacity can be a function of CTOT compliance rate and/or degree of airborne variations in-flight.
Performance Objective: **Reducing or shifting airborne delays into less-taxing pre-departure ground delays**	

Parameters	Description
Airborne Delay Analysis	Calculation, tabulation, and descriptive statistics of airborne delays for flights included in the GDP. There are a number of ways to calculate airborne delays for flights, each with varying complexities. 2 example ways at the opposite ends of complexity spectrum are: ▪ *"Time-based" calculation* – Calculating actual airborne time based on (ALDT – ATOT), and compare against "expected flight time" which can be defined as ATFM system estimate or based on flight plan's total EET. This is the simplest calculation with data readily available from flight plan and ATS message processing systems. ▪ *"Track-based" calculation* – Calculating actual airborne time, or even actual flown track, from surveillance data and compare against "expected flight time" or "expected track". The excess in flight time or extension in flight track can be considered airborne delays. This is a more complex way of deriving airborne delays, relying on high data-processing power and good surveillance data management.
Airborne vs. Ground Delay Comparison	Comparison between a flight's airborne delay and ground delay. The comparisons, especially when grouped based on CTOT compliance statuses, can show the effect of complying to CTOTs as well as the GDP effectiveness in reducing airborne delays for compliant flights. The analysis can also highlight any troubling trends such as adverse effects from uncontrollable factors, e.g. compliant flights seeing relatively higher airborne delays. The troubling trends are important areas that ANSPs should focus on when improving GDP further.

Table 18 - GDP Effectiveness Measurement

5.18 GDP effectiveness measurement is, in a way, one of the most important aspects of post-operations analysis. Its result is very closely related to, or can form a basis for, ATFM benefit analysis. Successful GDPs should be able to demonstrate that they can achieve the performance objectives set out from the beginning, and that they provide benefits to all stakeholders when they participate and comply to the requirements.

Anecdotal Feedback from Stakeholders

5.19 GDP post-operations analysis should not rely on numerical analyses alone. Equal importance should also be placed on obtaining and analyzing anecdotal feedback from stakeholders, especially those supporting the compliance facilitation at the departure end. Anecdotal information such as departure ground congestion due to weather or unforeseen aircraft problem are often obscured from numerical analyses, and stakeholders can be misrepresented when the numerical analyses are taken out of operational context. While consistently low compliance on the part of an Airspace User or a departure aerodrome may be indicative of the lack of awareness or supporting procedure to support GDP, abnormally low compliance in a few instances may be a result of unusual departure circumstances. These "unusual circumstances" can only be accounted for when numerical analyses are supplemented by anecdotal information obtained through collaboration with stakeholders.

5.20 Coordination and collaboration with stakeholders should thus always be a part of GDP post-operations analysis workflow. Section 6 in this Framework will provide an example of how such collaborative workflow may be established.

Miles-in-Trail / Minutes-in-Trail (MIT / MINIT)

Definition and Implementation

5.21 Miles-in-Trail (MIT) and Minutes-in-Trail (MINIT) are tactical ATFM measures expressed in terms of required *spacing* between successive aircraft overflying a given waypoint or crossing a sector or FIR boundary. The measures are normally applied at FIR boundary waypoints. The main objective of MIT/MINIT is to reduce the workload of ATC responsible for the receiving (downstream) FIR by keeping entering aircraft further apart than usual. The measure, however, can create additional workload for the ATC responsible for upstream FIR in managing the traffic to achieve required spacing. Additionally, this ATFM measure can be expanded as the requirements get passed to further FIRs. As such, regular usage of MIT/MINIT may indicate that more appropriate ATFM measures should be used in their places.

Characterizing a MIT/MINIT

5.22 Characterizing MIT/MINIT involves recording basic parameters used when the program is announced, along with parameters describing the program's predictability. **Table 19** provides a sample list of parameters that can be used to characterizing such ATFM program.

Parameters	Description
Program Predictability	
ADP Accuracy (Planned ATFM measure vs. actual ATFM measure)	Comparison between planned MIT/MINIT announced in the ATFM Daily Plan (ADP) and actual MIT/MINIT activated.
Lead Time to Activation (Notification Lead Time)	The amount of time MIT/MINIT is announced prior to its activation. This can be calculated from MIT/MINIT activation time – Coordination time where coordination time can be defined as time at which MIT/MINIT requirements are coordinated with upstream units, e.g. NOTAM publication time if the requirements are notified by NOTAM.

Parameters	Description
Lead Time when Changing Restrictions or Changing End Time (Revision Notification Lead Time)	The amount of time MIT/MINIT revision is announced prior to its activation. This can be calculated from MIT/MINIT change/end time – Coordination time where coordination time can be defined as time at which MIT/MINIT requirements are coordinated with upstream units, e.g. NOTAM publication time if the requirements are notified by NOTAM.
Restriction Change Records	Records of the changes to MIT/MINIT restrictions. These records can provide insight into how "stable" the restrictions are. The more volatile the restrictions, the less predictable the program becomes for stakeholders.
Restriction Severity	
Original Restriction Imposed Final Restriction Imposed	The records of the original MIT/MINIT restrictions imposed by the first unit, and the final MIT/MINIT restrictions imposed on the same traffic flow by upstream FIRs. As an example, a 10-MINIT restriction may be initially assigned by ACC "D" to ACC "C"; the ACC "C" may expand the restriction and impose 20-MINIT restriction to ACC "B" to cater for their departure within ACC "C". Similarly, the ACC "B" may further expand the restriction and impose 40-MINIT restriction to ACC "A". In this scenario, the original restriction is 10 minutes while final restriction is 40 minutes. By recording and comparing between final and original restrictions, the degree of MIT/MINIT expansion can be seen, highlighting the potential problems such restrictions can cause to upstream units.

Table 19 - Characterizing MIT/MINIT

MIT/MINIT Impact Analysis

5.23 Similar to GDP, impact of MIT/MINIT can be analyzed following the characterization of the program. The impact analysis can be in terms of overall "size" of the restriction and/or the ATFM delays imposed on the flights.

5.24 Unlike GDP, where each flight is given a specific departure slot and ATFM delay, MIT/MINIT does not directly assign departure slots to flights. Thus, ATFM delays may not be readily apparent. In some instances in Asia-Pacific, the MIT/MINIT restrictions are translated into GDP and CTOTs are assigned to flights in lieu of the restrictions; in these cases the ATFM delay can be defined in the same way as for a GDP:

$$\boldsymbol{ATFM\ Delay = CTOT - ETOT}$$

5.25 When MIT/MINIT restrictions are not translated into GDP, on the other hand, ATFM delay may be defined in terms of the difference between the flight's actual take-off time (ATOT) and estimated take-off time (ETOT):

$$ATFM\ Delay = ATOT - ETOT$$

Note: A flight's ATOT may not necessarily be due to only to the restriction but also to other operational factors, e.g. delays due to boarding or aircraft turnaround process. Where possible, delays due to other factors should be isolated possibly by obtaining operational log or collaboration with airspace user / ground staffs.

5.26 With the ATFM delays computed and tabulated, **Table 20** recommends various indicators to analyze the impact of MIT/MINIT restrictions.

Parameters	Description
Flight Count Impact	
Total Number of Flights	Number of flights captured in the MIT/MINIT restriction. Generally, MIT/MINIT restrictions would capture all flights in the specified traffic flow without exemption.
Flight Breakdown	Breakdown of the flights captured in the MIT/MINIT restriction, e.g. by Airspace Users / Airspace User Groups, departure aerodromes, departure FIRs. The breakdown will provide insight into stakeholders impacted by the restriction.
Restriction Severity	
Original, Intermediate, and Final Restrictions Imposed	The records of - original MIT/MINIT restrictions imposed by the first unit; - intermediate MIT/MINIT restrictions imposed by intermediate units enroute; and - final MIT/MINIT restrictions imposed on the same traffic flow by upstream FIRs. See **Table 19** for detail.
ATFM Delay Impact	
Total ATFM Delay	Total ATFM delays assigned to flights due to MIT/MINIT restrictions. If MIT/MINIT restrictions are translated into GDP, the total ATFM delays should reflect both the original number induced by the restrictions and also the final number with revisions included.
ATFM Delay Descriptive Statistics	Descriptive statistics of ATFM delays; e.g. average, maximum, minimum, variance.

Parameters	Description
ATFM Delay Breakdown	Breakdown of ATFM delays assigned to different stakeholders, e.g. Airspace Users / Airspace User Groups, departure aerodromes. This information can help determine if there is a skewed distribution of ATFM delays between stakeholders. Note that the amount of ATFM delay assigned to each stakeholder should be viewed in conjunction with the associated traffic contribution, e.g. Airspace User with large number of flights operating during the restriction period on the affected flow should expect larger total ATFM delays.

Table 20 - MIT/MINIT Impact Analysis

MIT/MINIT Compliance Assessment

5.27 MIT/MINIT are tactical ATFM measures that work by prescribing required *spacing* between successive aircraft overflying a waypoint. Measuring MIT / MINIT compliance thus focuses on assessing the actual spacing between aircraft against the restriction, as described in **Table 21**

Parameters	Description
MIT / MINIT Compliance	Comparison between actual spacing between successive aircraft and the MIT / MINIT requirement. Note that this analysis will require ability to process a large amount of surveillance data. Note also that tactical airborne variations and originally-planned timing parameters of the aircraft can result in aircraft achieving different spacings than the imposed restriction. These factors should be considered when analyzing MIT/MINIT compliance levels.

Table 21 - MIT/MINIT Compliance Assessment

MIT/MINIT Effectiveness Measurement

5.28 Similar to GDP, ***clear objective statements*** should be set by the ATFMU initiating the MIT/MINIT prior to its activation and the post-operations analysis. The objective statements should then be used as bases for effectiveness measurement. One of the main objectives for MIT/MINIT is to reduce ATC's workload by preventing a large number of aircraft from arriving into the area at the same time through the regulation of their successive spacings. Under this performance objective, TABLE recommends an indicator to assess MIT/MINIT effectiveness.

Parameters	Description
Performance Objective: **Reducing ATC workload by regulating the number of arriving traffic at an airport**	

Parameters	Description
Comparison of Traffic Demand	Comparison of traffic demand achieved at the ATM resource for which MIT/MINIT is activated *against scheduled / intended / planned demands figures*. This analysis would require planned demand (e.g. AAR), aircraft estimated landing times (ELDT), and aircraft actual landing times (ALDT). See Table 18 for recommended indicators on traffic demand comparisons for GDP. Similar comparisons can be utilized to determine the effectiveness of MIT/MINIT.

Table 22 - MIT/MINIT Effectiveness Measurement

(Placeholder for Other ATFM Measures)

5.29 (Placeholder)

6. Collaborative ATFM Post-Operations Analysis

Roles of Stakeholders in ATFM Post-Operations Analysis

6.1 Post-Operations Analysis is the final phase in an ATFM execution process. In this phase; analytical process is carried out, utilizing data analysis techniques based on recommendation in the previous sections, to measure the impact and successfulness of an ATFM program. Lessons learned from this process will be used to further improve the operational processes and activities for future operations.

6.2 While many of the analyses can be carried out within a single ATFMU or ANSP, close collaboration and coordination with other ATFM stakeholders will yield better and more reliable results. An ANSP/ATFMU initiating the ATFM measure may also be limited in their data available without the support from stakeholders, such as the case of actual ground operation information, which is normally only available to ANSP on the departure side or the Airspace User.

6.3 Recognizing the importance of all stakeholders in the post-operations analysis effort, **Table 23** summarizes roles each stakeholder can play in the process.

ATFM Stakeholder	Roles in Post-Operations Analysis Effort
ATFMU / ANSP <u>initiating</u> the ATFM measure	- Lead Post-Ops Analysis effort, from data collection to data analysis - Develop procedure to obtain feedback and share lessons learned with stakeholders - Develop procedure to ensure analyses, feedback, and lessons learned are used to improve subsequent operations
ATFMU / ANSP <u>facilitating compliance</u> to the ATFM measure	- Perform Post-Ops Analysis to the extent possible within their domain, e.g. departure compliance analysis and time estimation accuracy assessment - Ensure complete submission of required data, e.g. DEP messages, to the initiating ATFMU / ANSP - Record challenges and anecdotal feedback on the operations, and provide them to the initiating ATFMU / ANSP for Post-Ops Analysis effort
Airspace Users	- Record flight operations data such as OOOI for use in the Post-Ops Analysis effort - Provide additional data to the initiating ATFMU / ANSP for better Post-Ops Analysis, e.g. OOOI information to aid in Standard Taxi-Out Time accuracy assessment - Record challenges and anecdotal feedback on the operations, and provide them to the initiating ATFMU / ANSP for Post-Ops Analysis effort
Airport Operators	- Conduct study of airport operations data such as gate occupancy time variation and ground movement time to aid the initiating ATFMU / ANSP in improving the accuracy of ATFM operations - Provide additional data to the initiating ATFMU / ANSP for better Post-Ops Analysis - Record challenges and anecdotal feedback on the operations, and provide them to the initiating ATFMU / ANSP for Post-Ops Analysis effort

Table 23 - Roles of Stakeholders in POA

Workflow for Collaborative Post-Operations Analysis

6.4 To help stakeholders in supporting Post-Operations Analysis effort with the roles mentioned in **Table 23**, ATFMU / ANSP initiating the ATFM measure should establish an effective workflow to ensure flight and related operational information get collected in a timely manner. This enables the Originating ATFMU to process information and share result with stakeholders following the ATFM program, possibly through a debriefing web-/teleconference. In the case of long-term ATFM program spanning several days, a debriefing session can also serve as planning session for the upcoming day(s) as well. **Figure 4** provides an example of a workflow that can be established.

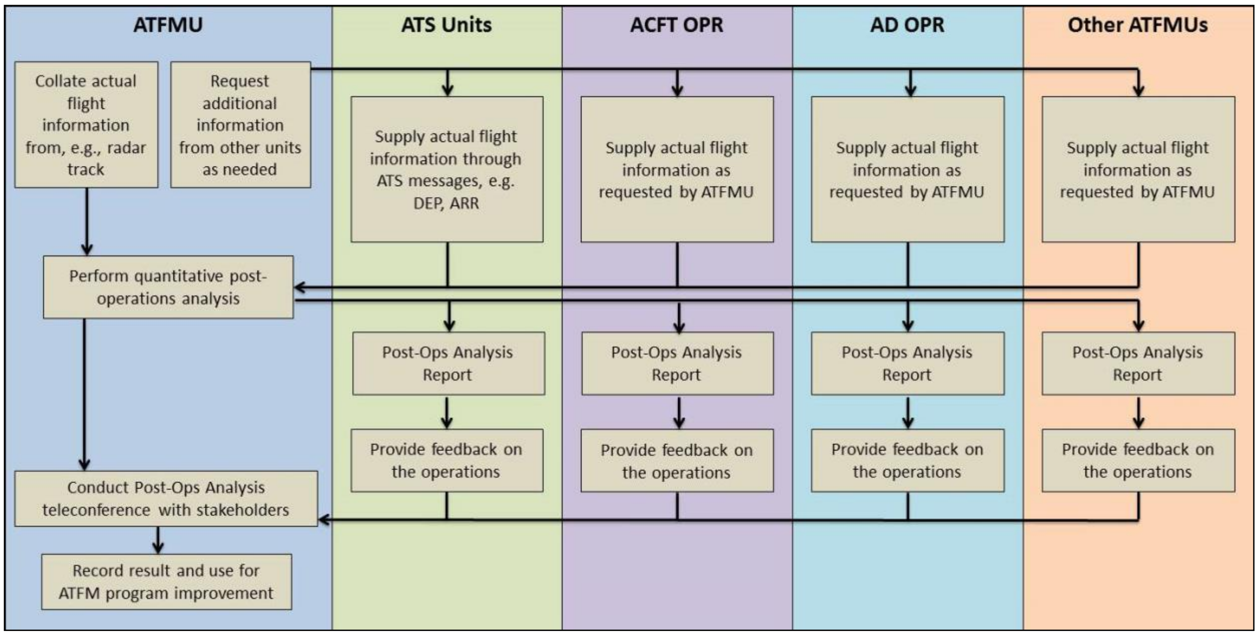

Figure 4 - Workflow for Collaborative POA

6.5 In the figure, the emphasis is placed on **sharing of operational information between stakeholders, and timely debriefing session hosted by the initiating ATFMU** along with the importance of using analysis result for improvement of subsequent ATFM programs.

6.6 In a distributed ATFM environment, such as explored in the Distributed Multi-Nodal ATFM Network, each different initiating ATFMU may establish slightly different workflow with stakeholders. It is important to communicate these workflow and expectations to all involved clearly.

6.7 The importance should also be placed on internal work process for each stakeholder. Internal procedure may need to be established to ensure appropriate operational data are collected by operational personnel or local support system. This may introduce additional workload in some cases, but the information provided can greatly enhance the programs in future rounds.

6.8 ATFM is a collaborative operation, involving and impacting several stakeholders throughout all phases. Post-Operations Analysis should also be collaborative in nature, with ATFMU / ANSP leading the effort to objectively analyze the data collected and information gathered; and with all stakeholders working together to continually assess and improve ATFM operations.

7. Case Studies

Case Study 1: India – Strategic Airport Slot Allocation Analyses

Case Study supplied by Airport Authority of India (AAI)

Introduction

7.1 In India today, the primary method for strategic (long-term) demand-capacity balancing is the Airport Slot Coordination process, with fixed numbers of arrival and departure slots assigned to scheduled aircraft operating into and out of India's most congested airports. Slot allocations are made on a bi-annual basis, with the capacity numbers adjusted for seasonal weather and traffic conditions. The slots equitably distribute restricted airport capacities to aircraft operators, ensuring appropriate distribution of traffic while catering also to non-scheduled aircraft at these major airports. The program includes aircraft operating into and out of Delhi (VIDP), Mumbai (VABB), and Bengaluru (VOBL) airports, which accounts for roughly 60% of the Indian air traffic volume.

7.2 AAI has observed high traffic volumes with significant airborne holdings and delays during peak traffic periods, with non-adherence to strategic slots – in particular early arrivals – being a major contributing factor. The ATM directorate of AAI has decided to combat the issue through in-depth analysis trials of strategic slot adherence between October – November 2018. As part of the trial, data from 22,606 flights in October 2018 and 23,772 flights in November 2018 were analyzed. Key results and lessons learned from the trials are provided in this Case Study.

Analysis Results

Analysis 1 – Comparison between planned and scheduled departures

7.3 In this analysis, a flight's planned departure (**EOBT**, per filed flight plan) is compared against its scheduled departure (**SOBT**, per allocated departure slot). "Early filing" denotes a flight whose flight plan shows EOBT is >5 minutes earlier than SOBT. **Figure 5** shows result from the trial.

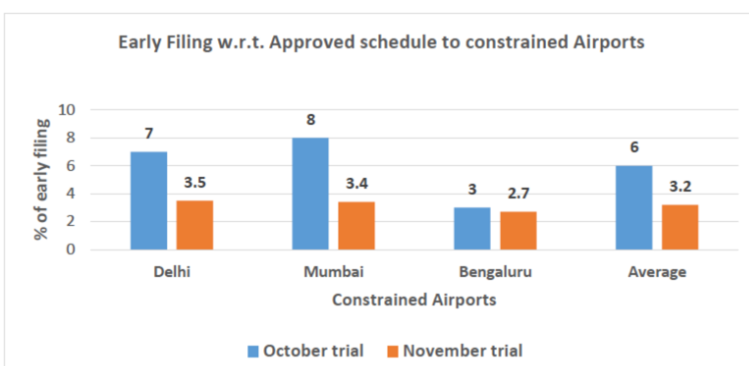

Figure 5 - Case Study 1 - SOBT/EOBT Comparison

7.4 From the figure, India's major airports saw an average of 6% of scheduled flights *filing* early departures in October 2018. In November 2018, the average was reduced to 3.2%.

Analysis 2 – Comparison between actual pushback and scheduled departures

7.5 In this analysis, a flight's actual pushback/start up (**AOBT**, per data from the airport) is compared against its scheduled departure (**SOBT**, per allocated departure slot). "Early pushback" denotes a flight whose actual pushback/start-up is **>5 minutes** earlier than SOBT. **Figure 6** shows result from the trial.

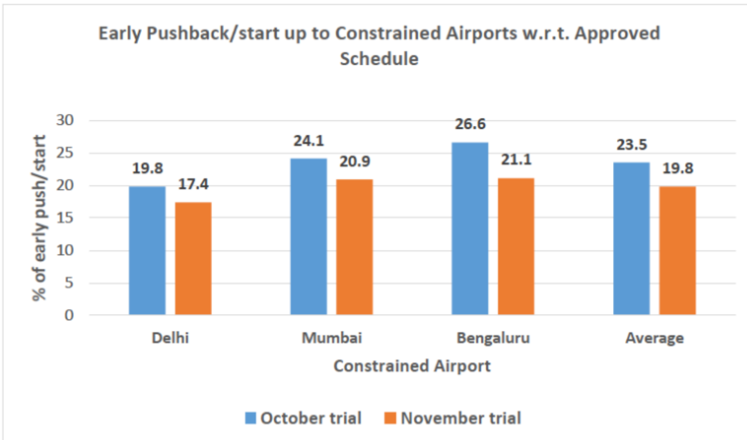

Figure 6 - Case Study 1 - AOBT/SOBT Comparison

7.6 From the figure, India's major airports saw an average of 23.5% of scheduled flights *pushing back* early in October 2018. In November 2018, the average was reduced to 19.8%.

Analysis 3 – Comparison between actual take-off times and scheduled departures

7.7 In this analysis, a flight's actual take-off times (**ATOT**, per data from the airport) is compared against its scheduled departure (**SOBT**, per allocated departure slot). "Early departure" denotes a flight whose actual take-off time is earlier than SOBT which would mean the flight had pushed back far earlier than its allocated slot. **Figure 7** shows result from the trial.

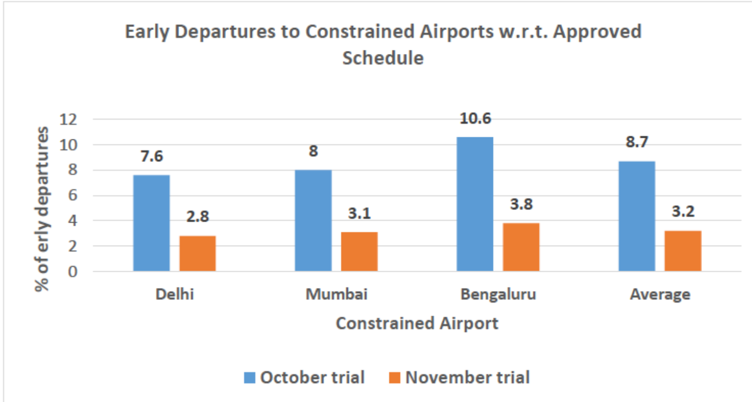

Figure 7 - Case Study 1 - ATOT/SOBT Comparison

7.8 From the figure, India's major airports saw an average of 8.7% of scheduled flights *take-off* early (*pushing back* really early) in October 2018. In November 2018, the average was significantly reduced to 3.2%.

Analysis 4 – Comparison between actual in-block times and scheduled arrivals

7.9 In this analysis, a flight's actual in-block time (**AOBT**, per data from the airport) is compared against its scheduled arrival (**SIBT**, per allocated arrival slot). "Early arrival" denotes a flight whose actual in-block (gate arrival) time is **>15 minutes** earlier than SIBT. **Figure 8** shows result from the trial.

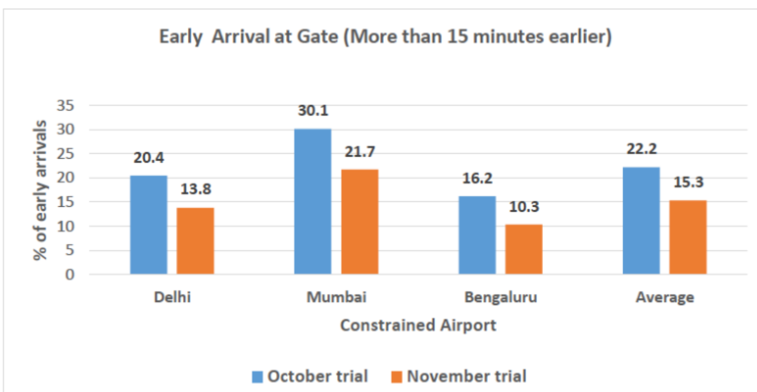

Figure 8 - Case Study 1 - AIBT/SIBT Comparison

7.10 From the figure, India's major airports saw an average of 22.2% of scheduled flights *arriving at their gates* early in October 2018. In November 2018, the average was reduced but remained significant at 15.3%.

Analysis 5 – Block time comparison

7.11 In this analysis, a flight's actual gate-to-gate block time (AOBT – AIBT) is compared against its scheduled block time (SOBT – SIBT) per allocated slots. The analysis was conducted for flights departing from Delhi (VIDP) to other major airports in India (Mumbai, Hyderabad, Chennai, Kolkata, Bengaluru). **Figure 9** shows tabulated result.

Block Time (in minutes)	Mumbai		Hyderabad		Chennai		Kolkata		Bengaluru	
Time Zone (in UTC)	Actual	DGCA	Actual	DGCA	Actual	DGCA	Actual	DGCA	Actual	DGCA
00-03	124	135	128	130	164	175	145	135	162	165
03-06	130	135	140	130	171	175	147	135	171	165
06-09	130	135	141	130	171	175	152	135	173	165
09-12	126	135	136	130	164	175	148	135	180	165
12-15	133	135	138	130	174	175	146	135	170	165
15-18	131	135	138	130	171	175	149	135	171	165
18-21	132	135	139	130	177	175	150	135	172	165
21-24	122	135	131	130	165	175	144	135	165	165

Figure 9 - Case Study 1 - Block Time Comparison

7.12 From the figure, flights from Delhi to Mumbai consistently achieved shorter block times than their approved slots during all hours of the days. Flights from Delhi to Chennai saw similar result with the exception of flights between 1800 – 2100 UTC. On the contrary, flights from Delhi to Hyderabad, Kolkata, and Bengaluru consistently saw longer block times than their slots.

Key Findings and Forward Plan

7.13 Non-adherence to strategic airport slots can be one of the major contributing factors to overloading traffic at the busiest airports in India. The issue is particularly problematic when flights arrive *significantly earlier* than their assigned times, as they could create airport ground congestion. The airport ground congestion could, consequently, create knock-on effect on air traffic operations in the terminal area.

7.14 Through the analyses of airport slot adherence, AAI was able to identify major causes for *early arrivals* as follows:

- Airspace users filing flight plans with earlier EOBTs than their approved slots;
- Flights departing – both pushing back and taking off – earlier than their SOBTs; and
- Airspace users requested and were approved *inflated* block times (SIBT – SOBT), i.e. receiving slots that would result in significantly larger block times that necessary.
  - This was particularly pronounced in the case of Delhi – Mumbai sector.

7.15 AAI plans to further the work by conducting a detailed year-long analysis and looking toward separation between taxi and flight times in the slot allocation process. AAI also plans to raise awareness on airport slot adherence focusing on SIBT at destination airports and EOBT/CTOT at departure airports.

Lessons Learned

Lesson 1 – Data-driven analytical process can identify true underlying demand-capacity problem.

7.16 Through the analysis trial, AAI has uncovered a key problem causing over-demand issues at major airports in India; that strategic airport slot adherence was a major issue. By looking through the right data, AAI was able to identify the specific issues – e.g. early departures and inflated block schedules – and developed plan to strategically address them accordingly.

7.17 Without careful analysis of the data, AAI could have attempted to address the issue with pre-tactical / tactical ATFM measures only to find that they would not solve the issue at the root cause. AAI could also have mistakenly attributed ATFM delays to ATM resource capacity problem, when in reality part of the issue could be inappropriate scheduling practice. Only through data-driven analytical process did the issue become visible.

Lesson 2 – Awareness campaign with stakeholders can improve situations even without undue punitive measures.

7.18 One finding of note from AAI's analysis trial is the marked improvements in slot adherence in November 2018 relative to October 2018. The reason for this due, in large part, to an awareness campaign which was a by-product of the analysis trial. By conducting the trial, AAI demonstrated to stakeholders – particularly airspace users – that strategic airport slot adherence was an important issue and non-adherence could cause over-demand problem. Through a simple data-gathering exercise without unnecessary punitive actions, AAI found that airspace users actually started to focus on their slot adherence and thereby reducing the level of problems seen previously.

Case Study 2: Thailand – Airport Ground Delay Program Analyses

Case Study supplied by AEROTHAI

Introduction

7.19 Thailand saw the establishment of Bangkok ATFM Unit (Bangkok ATFMU) since 2007, with the advent of the Bay of Bengal Cooperative ATFM System (BOBCAT) for westbound flights from Southeast Asia and South Asia into the European continent over Afghanistan airspace. After nearly 10 years of experience providing ATFM service in another region, AEROTHAI and several partner ANSPs in Asia-Pacific came together to build a distributed ATFM network for the region. It was during this time – 2014 – that Bangkok ATFMU began to expand its ATFM service to include the management of traffic demand within Bangkok FIR using mainly Ground Delay Programs (GDPs). The focus of the service is on regulating traffic demand into and over the most constrained and congested airports and airspace sectors over the country.

7.20 As is recommended by ICAO Doc 9971, post-operations analysis is slowly becoming a cornerstone process in Thailand's ATFM operations as AEROTHAI ATFM team and Bangkok ATFMU gain more experience. Using the aforementioned **3-Part Story** approach to post-operations analysis, this case study provides an example of how AEROTHAI ATFM team conducts an analysis of GDPs activated for constrained airports throughout 2018.

2018 Airport Ground Delay Programs: Example Analyses

7.21 In characterizing and assessing Ground Delay Programs, AEROTHAI adopts the **3-Part Story** approach as recommended in **Section 5** of the framework. The approach ensures that ATFM operational data are analyzed in terms of GDP impact, CTOT compliance, and the program's effectiveness in delivering the right level of traffic demand while minimizing airborne delays. The results are tabulated and visualized using various plots and charts as shown below.

Year-in-Review: Overview Dashboard

7.22 Error! Reference source not found. shows an overview dashboard summarizing results f rom *all* GDPs conducted for constrained / congested arrival airports in Thailand throughout 2018. The left side of the dashboard (*Overview Table, Causes of GDP,* and *Constrained Location*) provides **Impact Analysis** of the programs, giving an quick look on the number of GDPs conducted and ATFM delays distributed along with their reasons in the form of delay codes. In the top-right corner (*CTOT Compliance Overview*), overview of **CTOT compliance** is shown, categorized by the *participation levels*[1] of the impacted departure airports. In the bottom-right corner (*Average Delay Comparison*), a comparative

[1] In the Distributed Multi-Nodal ATFM Network Project, participating airports are grouped by their abilities to comply with CTOTs distributed by ATFMUs in the network. *MN-3* and *MN-2* are departure airports which are expected to have established local procedure to facilitate departing flights in compliant to CTOTs. *MN-1* are member airports that are still without such procedure, while *Out-of-Area* are airports not involved in the project.

view of airborne and ground delays is shown, categorized by the flights' CTOT compliance status. This is one view of GDP **Program Effectiveness**, under an assumption that flights operating in *compliant* to CTOTs will have less airborne delays than their *non-compliant* counterparts.

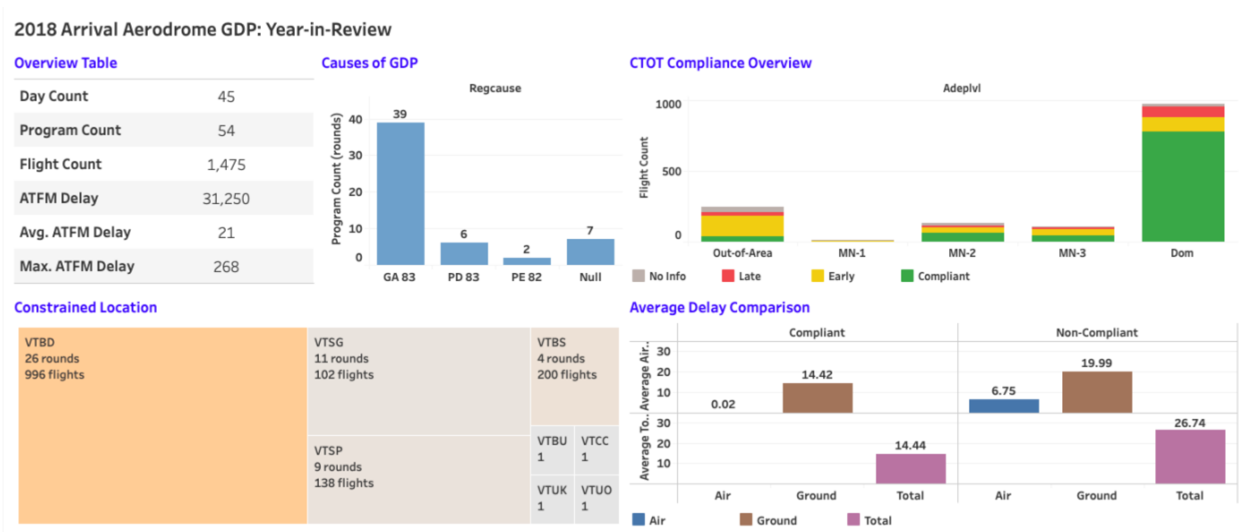

Figure 10 - Case Study 2 - Overview Dashboard

7.23 Few things can be readily observed from the overview figure, namely:

- The leading cause for airport GDPs in Thailand in 2018 was aerodrome capacity issue, represented by the delay code *GA 83*. This issue accounted for 39 rounds of GDP during the year;
- Don Mueang International Airport (VTBD) was the leading arrival airport for which GDPs were activated, accounting for 26 rounds of GDP and impacting 966 arriving flights;
- Departure airports within Thailand did fairly well in facilitating CTOT compliance, with nearly 80% of departures complying to CTOTs. In contrast, level-3 and level-2 airports in the region (see footnote # **1**) still had rooms for improvement. Flights from outside the regional agreement, as expected, departed earlier than their CTOTs presumably with no knowledge of the active restrictions; and
- Flights departing in compliant to CTOTs saw, on average, lower airborne delays than their non-compliant counterparts[2].

Program-Specific Review: Program Dashboard

7.24 **Figure 11** shows a dashboard summarizing result from a specific GDP on a given day. The dashboard follows the same structure as the Overview Dashboard. The right side of the dashboard

[2] Note that, in this context, *airborne delay* is inferred from the comparison between flight's actual flying time (ALDT – ATOT) and its planned flight time (total EET field in the flight plan). AEROTHAI ATS units have no policy on giving airborne punitive action against non-compliant flights.

shows the **Impact Analysis** in terms of ATFM delays statistics and impacted departure airports. The top-right corner shows **Compliance Assessment**, categorized by the participation levels of departure airports. The bottom-right corner shows a *different view* of GDP **Program Effectiveness**, displaying the comparison between *regulated* traffic count (based on CLDTs) and *actual* traffic count (based on ALDTs). The assumption is that, with GDP properly activated and CTOTs complied to, the actual traffic level should closely match the regulated one.

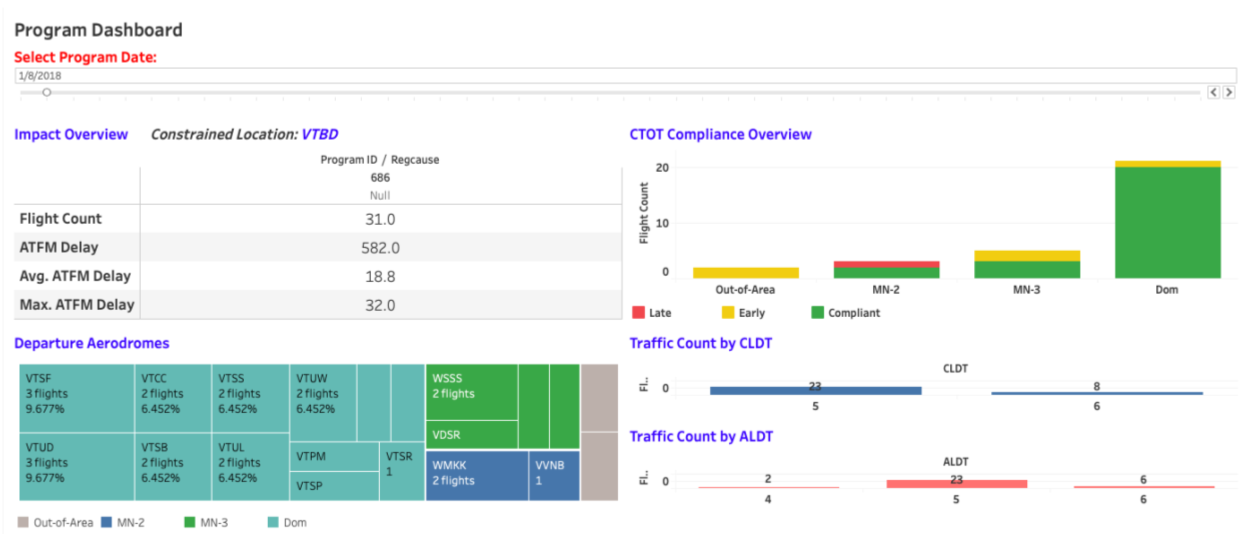

Figure 11 - Case Study 2 - Program Dashboard

7.25 Few things can be readily observed from the figure for this particular GDP, activated on 8 January 2018 for arrivals into VTBD, namely:

- 31 flights were affected by the program. Most of them came from domestic airports with a few flights from international airports in the network and a small number of flights from airports outside the area;
- Domestic departure airports, as expected, contributed satisfactorily with 95% CTOT compliance rate; and
- The actual traffic arriving at VTBD almost perfectly matched the expected traffic level based on the activated GDP, with the exception of 2 flights arriving earlier than expected. This could presumably be due to the 2 early departures from airport outside the ATFM network area, though investigation was needed to verify the assumption.

7.26 Overall; the effectiveness of this particular GDP, in terms of its ability to regulate traffic level during the constrained period, is satisfactory; possibly thanks to high CTOT compliance rate particularly from domestic traffic.

Airline Dashboard and Departure Airport Dashboard

7.27 In addition to the big picture views through *Overview* and *Program* dashboards, airline-specific and departure airport-specific dashboards are also provided; shown in Figure 12 and Figure 13.

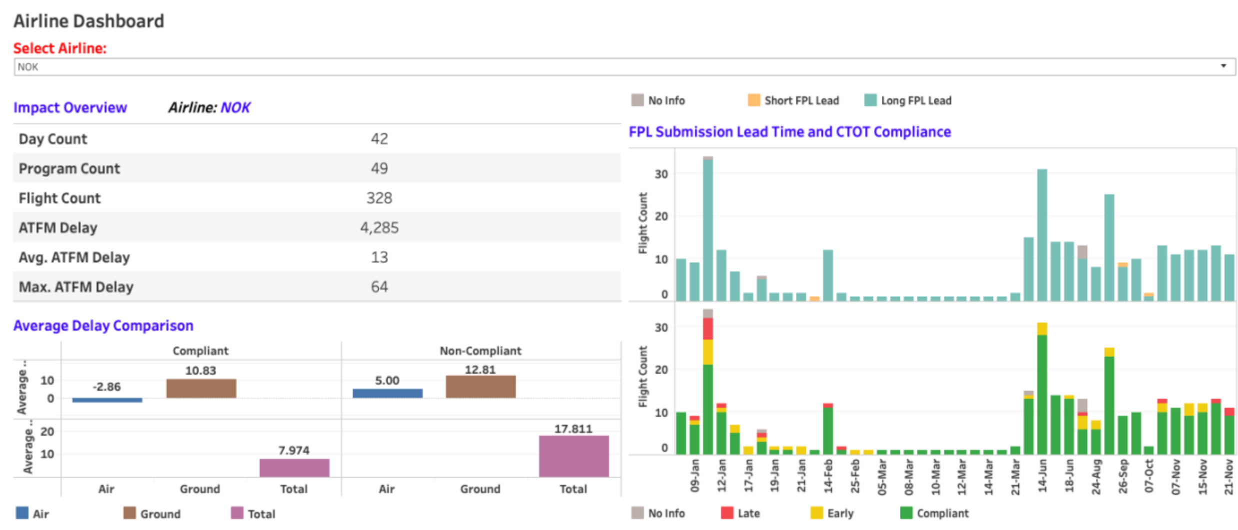

Figure 12 - Case Study 2 - Airline Dashboard

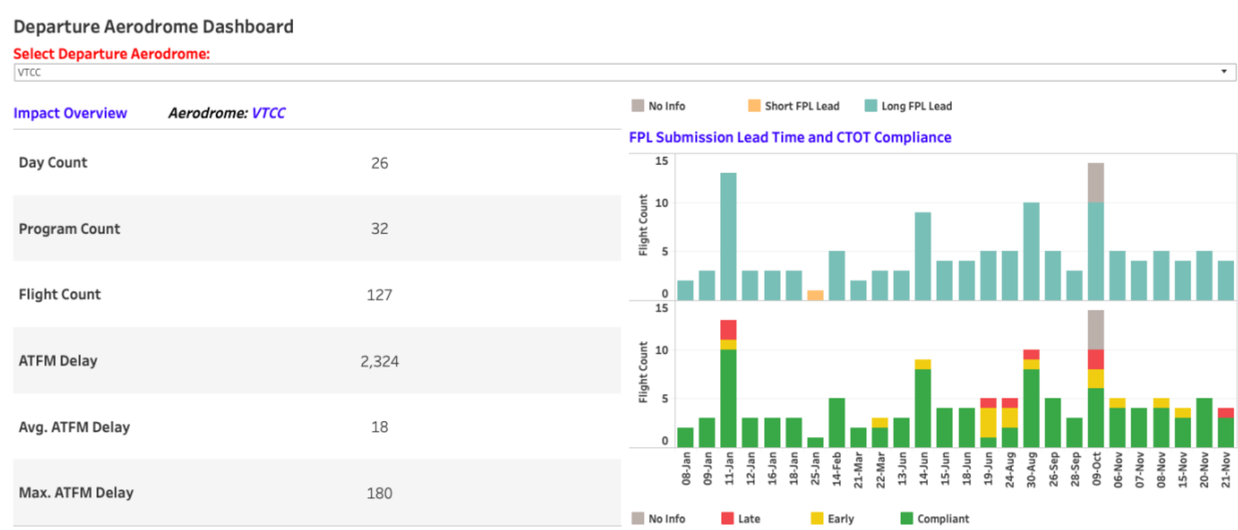

Figure 13 - Case Study 2 - Departure Aerodrome Dashboard

7.28 In these dashboards, emphasis is placed on the impact to the specific airline and departure airport and the responsibility borne by the stakeholder in supporting the programs. **Impact Analysis**, in terms of ATFM delay statistics, are shown on the right side. **Compliance Assessment**, in terms of CTOT compliance over the different days GDPs were activated, is shown on the bottom-right corner.

7.29 Another indicator under the Compliance Assessment category is also introduced here: the compliance to advance flight plan submission requirement. Per AIP Thailand section ENR 1.9, flights subjected to ATFM measures are required to have their flight plans submitted no less than 3 hours before their EOBT. This is seen as primarily a responsibility of the airline, but the responsibility may also be shared by the ATS unit operating the departure airport. As such, the compliance rates for advanced flight planning requirement are also shown in the Airline and Departure Aerodrome dashboards on the top-right corner. In general, over the years, most airlines have been able to comply with the 3-hour requirement without much trouble.

Accessing and Using the Dashboards

7.30 Insofar as possible, the post-operations analysis dashboards such as shown above are made accessible by stakeholders online. For the above examples, they can be accessed – and interacted with – at http://bit.ly/2018gdpairport.

7.31 These dashboards are normally presented during performance review discussions and seminars with stakeholders and other member ANSPs in the ATFM network. Having easily accessible visualizations has proven useful for AEROTHAI ATFM team in identifying areas of concerns and in engaging with stakeholders to continually improve the operations.

Stakeholder Engagement

7.32 In addition to processing data and producing post-operations analysis dashboards, stakeholder engagement is also an important process built into Thailand's ATFM operations. AEROTHAI ATFM team has been, since the expansion of ATFM service in the country, attempting to conduct regular performance reviews through periodic seminars with local stakeholders. The aim has been to conduct such seminars on a quarterly basis, adjusted for availabilities and necessity as appropriate. During these seminars, *all* stakeholders – flight crews, dispatchers, ground service agents, airport operators, as well as internal staffs from the ATS units and the ATFMU – are included in the conversation. The outcome is a forum where experiences are shared, and ideas are exchanged openly between partners in the entire ATFM process.

7.33 Additional to the regular (approx. quarterly) seminars, the team also makes regular visits to flight operations centers of major local air carriers. The purpose of the visits is to enable open, honest, and in-depth conversation about ATFM in a more relaxed environment compared to large seminars. These visits have allowed smaller air carriers to voice their feedback and challenges directly to the team. On many occasions, these visits have brought out issues that may have been overlooked during the seminars.

Lessons Learned

Lesson 1 – Designing data collection and post-operations analysis capabilities as part of the ATFM software specification will be very helpful.

7.34 The sample GDP analysis dashboard shown in this case study was made possible through extensive post-event data extraction from ATFM system database, a static process carried out periodically. The extraction and processing of data into dashboard is not yet, at the time of this writing, automated and integrated into the ATFM system. Consequently, data-driven post-operations analysis do not always get carried out immediately following an operation. Instead, comprehensive analysis – such as a year-long dashboard shown above – is used during quarterly reviews with stakeholders. The lack of automated and integrated post-operation analysis capability is one area of improvement facing AEROTHAI at the moment.

7.35 A key lesson from this predicament is the usefulness of having extensive analytical capability automated and integrated into the ATFM system. To do so, the capability should be included during the initial software specification and design phase. While the system may become more complex and the design more difficult, having the integrated post-operations analysis feature would really help ANSPs learn from and improve their ATFM operations in a timely manner.

Lesson 2 – Periodic performance reviews with stakeholders should be an integral part of ATFM operations.

7.36 Through the regular seminars, the team has been able to obtain valuable feedback from front-end users and to attempt to improve the system and procedure regularly. The team has also been able to clarify, and sometimes dispel, any misunderstanding in the procedure and misconceptions in the ATFM philosophy with key stakeholders.

7.37 Through the operation center visits, the team has not only been able to obtain feedback and discuss overlooked issues but also to understand – first-hand – the challenges and limitations faced by many air carriers. The visits were opportunities for the team to empathize with the counterparts and to learn to be mindful of stakeholders when designing operational procedures.

7.38 Both the regular seminars and operation center visits epitomizes stakeholder engagement in Thailand, a process believed to be integral to the success of ATFM operations in the country.

Case Study 3: (country) – (project name)

Case Study supplied by (organization name)

7.39 Placeholder

7.40 Placeholder

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