INTERNATIONAL CIVIL AVIATION ORGANIZATION

ASIA/PACIFIC REGIONAL

AIR TRAFFIC FLOW MANAGEMENT

CONCEPT OF OPERATIONS

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This document was developed by the Asia/Pacific Air Traffic Flow Management Steering Group (ATFM/SG)

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1. Overview

Concept Development

1.1 This Asia/Pacific Regional Air Traffic Flow Management (ATFM) Concept of Operations, hereinafter referred to as the CONOPS, was initially developed under a collaborative effort involving the Civil Aviation Authority of Singapore and research and industry partners, and further developed through expansion of the stakeholder group to include other ANSPs (AEROTHAI, Department of Civil Aviation Malaysia, Hong Kong Civil Aviation Department), IATA and major airlines.

1.2 The Concept was tested in a series of Human-in-the-Loop (HITL) simulation exercises held at the Singapore Aviation Academy. It is based upon operationally proven *ATFM Measures* or Traffic Management Initiatives (TMIs), used to more efficiently manage delays incurred by all aircraft arriving at a constrained resource, such as an airport or a sector of airspace, regardless of their point of departure and including flights controlled by ANSPs outside the control authority of ATC at the constrained resource.

Fundamental Concept of ATFM

1.3 Central to this CONOPS is the fundamental concept of balancing air traffic demand and capacity. While ANSPs and airport operators should strive to increase and optimize airspace and airport capacity to meet demand, traffic growth, surges in traffic and capacity constraining events cause imbalances. TMIs that may be utilized include *inter-alia* strategic landing slot allocation, miles/minutes in trail, level capping, re-routing and tactical airport slot allocation.

1.4 Implementation of effective ATFM improves predictability, reduces fuel burn and operating costs, reduces pilot and ATC workload, and improves and maintains safety.

ATFM and Collaborative Decision-Making

1.5 The Collaborative Decision Making (CDM) process, a key enabler of ATFM, allows all of its subscribing members, called CDM stakeholders, to participate in decisions that affect them after all relevant information has been made available to them. This applies to all types of decisions in the strategic, pre-tactical, and tactical phases.

1.6 **Figure 1** illustrates the integration of CDM into ATFM functions. The flow shows the independent evaluation of capacity and demand for the resource, the monitoring of the demand and capacity, the evaluation of TMIs, the involvement of stakeholders through CDM, and the execution and updating of the TMI. Core functions of shared situational awareness and post-operations analysis are supported across all functions.

1.7 Using the available data, demand and capacity are monitored throughout the day with close communication with other resource managers to identify any imbalances. Flow Managers have tools in order to evaluate various TMIs before implementation. Once a TMI is implemented, Aircraft Operators perform CDM actions, such as substitutions, to optimize their operations while the Flow Manager monitors the effectiveness of the TMI.

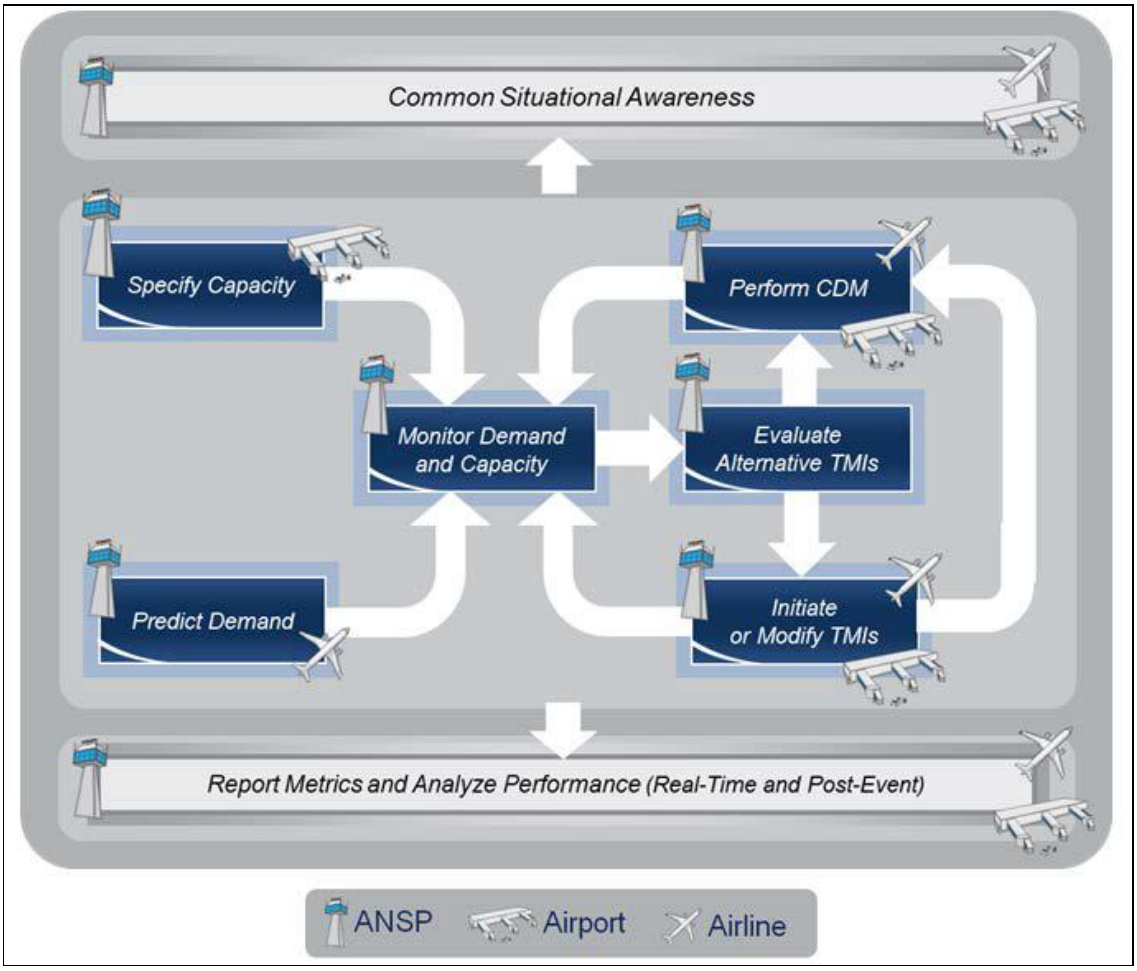


Figure 1: ATFM/CDM Functions

2. Scope

2.1 This document presents the Asia/Pacific Regional ATFM Concept, supporting demand and capacity balancing for airports and airspace within the Asia/Pacific Region. The Concept includes existing ATFM/CDM principles, and a new Traffic Management Initiative (TMI) concept that complements conventional Ground Delay Programs (GDPs). Collaborative Decision-Making

2.2 (CDM) is a key component of the Concept and is covered throughout the document. The Concept may be applied to any airport or airspace within the Asia Pacific region or elsewhere, especially in those airports or airspace servicing significant numbers of international flights.

Document Overview

2.3 The document first discusses current operations, providing the justification for the Regional ATFM Concept. The proposed concept is then provided, followed by an operational scenario illustrating the concept, and finally the expected benefits.

2.4 The concept will affect each stakeholder differently. The specific roles of each stakeholder group are detailed; Flow Management Position (FMP), Aircraft Operators, Airport Operators, the ATC Tower, and the ATC Area Control Center roles are explained in Section 4.

The document has the following Sections:

- **Section 3 - Current Operations**, describes the current state of ATFM operations in Asia Pacific and the associated need for improvement.
- **Section 4 - Proposed Concept – Regional ATFM**, provides a detailed description of the concept, including assumptions, core capabilities, stakeholder responsibilities, and policy considerations. The section first describes the parts of the concept that must be consistent for any implementation of Regional ATFM. Implementation considerations, adaptable according to the needs of individual ANSPs are also described.
- **Section 5 - Operational Scenario**, illustrates an example of the step-by-step procedures for handling a given capacity reducing event, following the Regional ATFM Concept.
- **Section 6 - Expected Benefits of Proposed Concept**, presents a summary of the expected benefits resulting from the implementation of the proposed concept.

3. Current Operations in the Asia/Pacific Region

3.1 ANSPs in the Asia/Pacific region currently have limited ATFM/CDM procedures in place to manage the traffic flows within their areas of responsibility. There are also very few regional agreements to manage traffic flows between ANSPs. Asia/Pacific stakeholders do have some tools and processes to monitor and predict resource utilization, but the predictions are not always accurate, automated, or shared among regional stakeholders.

3.2 Strategic balancing of capacity at airports in the region is currently undertaken through the airport slot allocation process. During the pre-tactical and tactical ATFM phases[1], balancing of arrival demand with the available capacity at airports is mostly reactive in nature. Planning TMIs ahead of time is difficult because the demand data are not generally accurately predicted and there is limited control of departures. As a result, most of the demand balancing is carried out by ANSPs within their own area of responsibility through tactical flow management with the support of arrival management systems (AMAN). This reactive management of demand often results in inefficient means of balancing flows, such as airborne holding and vectoring.

3.3 A challenge in terms of implementing more advanced ATFM systems within the region is the high percentage of international traffic. This characteristic poses a challenge to implementation because initiatives such as Ground Delay Programs (GDPs) assign flights Calculated Take Off Times (CTOTs) with which they must comply. In current ATFM implementations, flights departing from airports outside of the ANSP's controlling authority operate as they originally intended, without absorbing all of the delay. Because of the unique characteristics of the Asia Pacific region a new cross-FIR boundary concept is proposed to overcome this challenge and effectively apply ATFM measures to flights operating into constrained airports and airspace, while operating from airports or in the airspace of a different control authority.

3.4 There are, however, several ANSPs in the region with significant domestic traffic, such as in Australia and Japan, where GDPs are effective with only domestic traffic operating in accordance with assigned slots. International collaboration for demand and capacity balancing has been demonstrated by such initiatives as the Bay of Bengal Cooperative Air Traffic Flow Management System (BOBCAT).

Bay of Bengal Cooperative Air Traffic Flow Management System (BOBCAT)

3.5 BOBCAT is a secure web-based computer system used to manage westbound aircraft operating through Afghanistan airspace from South and Southeast Asia to Europe during the busy nighttime period.

3.6 As a result of the lack of Communication Navigation Surveillance (CNS) facilities and military operations aircraft flying through this airspace are subject to restrictive separation requirements. In 2006 ICAO, upon request of IATA, formed a task force to implement a solution to the restrictions placed on aircraft flying through Afghanistan airspace. AEROTHAI consequently developed a web-based solution which was implemented in July 2007.

3.7 BOBCAT assigns take-off times (departure slots) and levels for flights crossing the Kabul FIR based on Aircraft Operator requests. The request period is specified and the slot allocation occurs based on the existing requests. Aircraft Operators can request adjustments to the slot allocations based on their operational need and availability.

3.8 Some of the benefits realized since implementation of BOBCAT are:

- Regularity of departures
- Orderly Afghanistan entry
- Optimal FL achieved (80 – 90% in Afghanistan)
- Reroutes and technical stops eliminated
- Reduction of Air Traffic Control Officer and flight crew workloads

[1] Strategic, Pre-Tactical and Tactical ATFM Phases are defined in ICAO Doc 9971 – *Manual on Collaborative Air Traffic Flow Management*

- Environmental Outcomes (Annual, based on IATA estimates in 2007):
  - Estimated Airline Cost Savings: US$86 million
  - Estimated Fuel Savings: 85,000 metric tonnes
  - Estimated Emissions Savings: 356,000 metric tonnes

<u>ATFM in Australia</u>

3.9 Airservices Australia has an automated ATFM system where projected demand and capacity are balanced through the implementation of TMIs, predominantly GDPs, and the assignment of ATFM slot times to aircraft. Aircraft Operators are advised of flight-specific off-block times at the domestic departure airports. These off-block times are calculated to deliver aircraft to the destination airport at the allocated arrival slot time. The ATFM system is used for pre-tactical and tactical planning and managing the arrival flows associated with the major Australian airports of Sydney, Melbourne, Brisbane, and Perth. The system offers effective pre-tactical and tactical decision support for managing demand-capacity imbalances and reducing air traffic saturation. CDM is supported through flight schedule updates, shared situational awareness, and schedule management (e.g., substitutions and cancellations).

<u>ATFM in Japan</u>

3.10 In 2005 the Japanese Civil Aviation Bureau (JCAB) established the Air Traffic Management Center (ATMC) by recomposing the existing ATFM Center to act as the leading and central function in order to drive forward Japanese Air Traffic Management (ATM). Through this office they are developing and implementing typical ATFM measures such as GDPs with slot swapping capability, re-routing, miles/minutes in trail, and Specifying Calculated Fix Departure Time for Arrival Spacing Program (SCAS). The ATMC has implemented CDM practices through twice yearly stakeholder meetings and making available dynamic capacity changes every hour using web-based information sharing.

4. Concept – Regional ATFM

4.1 The regional concept was developed specifically for ANSPs in the Asia Pacific region, but could also be implemented in other regions. The Asia/Pacific region is comprised of independent ANSPs, each with ATM authority for their respective FIR and no overarching authority for the entire region such as EUROCONTROL in Europe. The ATFM Concept for the Asia/Pacific Region is based on a model of distributed authority throughout the region. Each individual ANSP will be responsible for issuing TMIs to balance demand with capacity for airports and airspace within their FIR. Aircraft Operators will adhere to the ATFM policies, rules, and guidelines as defined by the ANSP. Other stakeholders support each ANSP's ATFM measures as further described in this CONOPS.

4.2 The Concept is described from the perspective of a single ANSP managing the flow of traffic to their arrival airports. These individual ATFM systems will communicate to ATFM systems in other ANSPs, providing the stakeholders with network-wide information.

Concept Overview

4.3 ICAO Doc 9971 – Manual on Collaborative Air Traffic Flow Management is the foundation of the Regional ATFM concept. While this document provides guidance for harmonizing ATFM concepts across the world, different States and Regions still have the flexibility to devise policies and procedures to suit their individual circumstances. The concept for Regional ATFM considers the unique characteristics of the Asia/Pacific Region, such as high international traffic volume from a wide variety of aircraft operators, and the large number of small FIRs.

4.4 Within the region there is a need to balance demand against capacity at airports with a high concentration of international traffic (e.g., Changi in Singapore, Chek Lap Kok in Hong Kong, and Bangkok-Suvarnabhumi) during the pre-tactical and tactical phases. In the majority of ANSPs that have advanced ATFM capabilities implemented, GDPs are used to effectively match the demand with the airport capacity by redistributing the demand by issuing departure times to flights operating within the control authority of the ANSP. This trades airborne holding for ground delay, which is the fundamental benefit of a GDP. The Regional ATFM concept adopts the GDP as the foundation of operations, but with several key differences.

4.5 One of the parameters for a GDP is the scope of non-exempt and exempt flights. Exempt flights are considered in the demand but are not expected to respond to an ATFM control time. Reasons for exempting flights include flights departing outside of a certain distance or international flights1. The longer flights are typically exempted when a GDP is implemented due to a capacity reducing event that has potential to be cancelled early; if many flights are airborne at the time the TMI is cancelled, they will have absorbed delay that cannot be recovered. International flights are normally exempted from GDPs because ANSPs do not have the authority to delay flights departing from airports outside of their control, and due to the fact that international flights generally travel longer distances. However, the Regional ATFM concept, which aims to address cross-border ATFM, includes short- and long-haul international flights to achieve optimised demand/capacity balancing at constrained resources.

4.6 When a GDP is implemented, exempt flights are assigned to slots first, followed by non-exempt flights—meaning exempt flights will receive minimal delay. Even though exempt flights are issued a slot, they are not required to absorb any delay assigned by the GDP. As a result, it is important to have sufficient "participation" (i.e., a high volume of non-exempt flights) in order to implement a fair and effective GDP.

4.7 ANSPs set the rules by which flights are exempted based on agreements with airlines, ANSPs, or airports. One of the main challenges for the Asia Pacific region is achieving agreements with enough stakeholders to issue effective GDPs. ATFM/CDM models in other parts of the world only include domestic traffic in TMIs (GDP and ground stop [GS]). In the case of Singapore, Hong Kong, and other major hubs in Asia Pacific, where all traffic is international, this model cannot be applied.

4.8 Data analysis studies were conducted for Singapore's Changi Airport to estimate the percentage of non-exempt traffic needed to implement effective programs. Based on the analysis and operational experience in the U.S., South Africa, and Australia, a participation level of 75% is desirable for effective and equitable AFTM using existing GDP principles (see Attachment B for a summary of the Singapore participation case study).

4.9 The Regional ATFM concept consequently requires participation from many departure airports, ANSPs, and airlines to achieve a high level of non-exempt flights. For this reason, one of the fundamental principles of the Regional ATFM concept is providing Aircraft Operators (i.e., airlines) the ability to specify their delay absorption intent between ground delay and airborne flying time adjustments to achieve their assigned ATFM arrival slot. This overall flexibility is expected to increase participation by giving long-haul flights the ability to take their delay in the air, where the delay can be recovered if the program is canceled early. Also, flights that are airborne at the time the program is implemented will be able to absorb program delay in this concept, further increasing participation.

Delay Absorption Intent

4.10 One unique aspect of the Regional ATFM concept is that instead of flights being required to take all of the delay on the ground, Aircraft Operators can choose how to distribute the delay assigned by the TMI throughout various phases of flight. The three delay intent fields are described below.

- **Gate Delay Intent:** Delay intended to be taken while parked at the gate. By default, pre-departure flights are assumed to take all program delay at the gate. Before the flight pushes back, the Aircraft Operator has the ability to move all or a portion of the delay to the Airport Surface Delay Intent and/or the Airborne Delay Intent.

- **Airport Surface Delay Intent:** Delay intended to be taken between pushback and takeoff. This allows for flights to plan taking additional ground delay in cases where the airport or ATC requires the parking stand to be vacated prior to the absorption of all intended ground delay.

- **Airborne Delay Intent**: Delay intended to be taken efficiently during the cruise portion of flight. For flights that are airborne or will soon be airborne when the TMI is implemented, all of the program delay is assigned to the Airborne Delay Intent. The ability to absorb program delay in the air is not part of any current operational ATFM system.

4.11 **Figure 2** illustrates the opportunity for absorbing delay in various phases of flight.

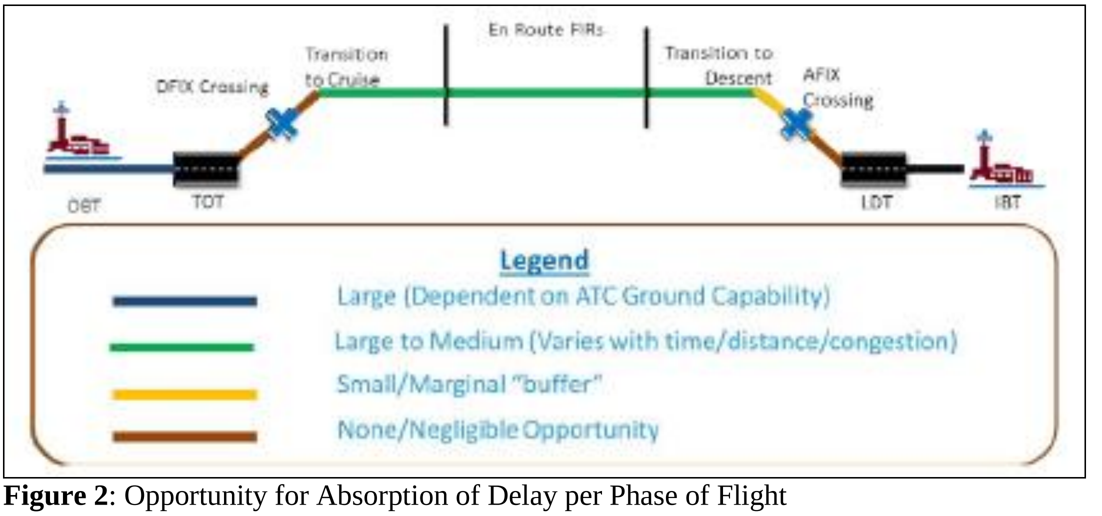


Figure 2: Opportunity for Absorption of Delay per Phase of Flight

4.12 Permitting flights to absorb ATFM program delay in the air can increase the number of flights participating in the program. In current ATFM systems GDPs generally exempt longer distance flights (e.g., flights traveling more than 2000 NM) due to risk of such flights taking unrecoverable delay; these flights could absorb delay on the ground, depart, and then the constraint at the arrival airport does not materialize, meaning that the flight absorbed delay unnecessarily.

4.13 Under the Regional ATFM concept these longer flights can fly at a slower speed without any increase in fuel burn. For example, one study has shown that a flight between Rome and Paris can decrease its cruise speed by about 6% without changing altitude or fuel burn (**Figure 3**). The risks of long haul flights either taking unrecoverable delay or not participating in the ATFM program are decreased.

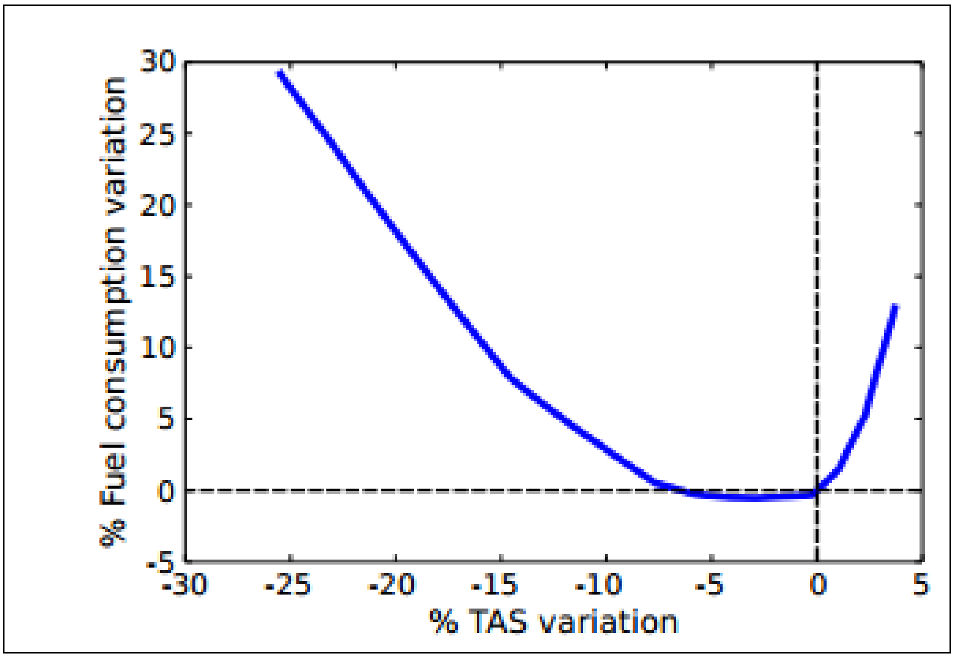


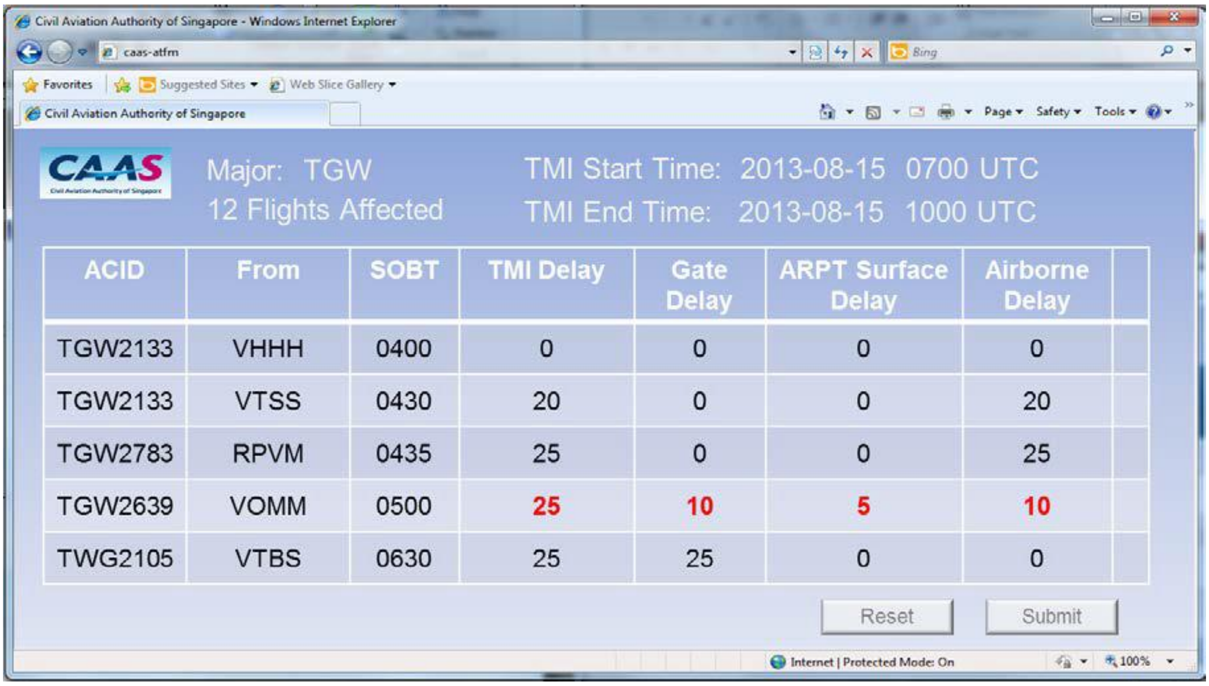
Figure 3: Fuel consumption variation for A320 Rome-Paris, F320, Mach 0.78, Cost Index 25 [Muñoz 2013]

4.14 Aircraft Operators may notify their delay intent by using one of two methods:

- via a web-based interface; or
- via a new flight plan or flight plan amendment.

4.15 When using the web interface, the Aircraft Operator directly enters the delay intent fields demonstrated in **Figure 4**. The aircraft operator may apportion some or all of the total delay to any of the three fields.

4.16 If the flight plan method is used the ATFM system infers the Intended Gate Delay and Intended Airborne Delay based on the filed Estimated Off-Block Time (EOBT) and filed Estimated Elapsed Time (EET) extracted from the new or amended flight plan.



ACID	From	SOBT	TMI Delay	Gate Delay	ARPT Surface Delay	Airborne Delay
TGW2133	VHHH	0400	0	0	0	0
TGW2133	VTSS	0430	20	0	0	20
TGW2783	RPVM	0435	25	0	0	25
TGW2639	VOMM	0500	25	10	5	10
TWG2105	VTBS	0630	25	25	0	0

Figure 4: Example of web-based interface for delay absorption intent.

4.17 If the flight plan method is used to submit delay intent, en-route ATC will be aware of the flight-planned cruise speed and will control the flight appropriately. Flights that specify airborne intent via the web interface are expected to communicate their intended cruise speed to en route ATC as a request per current ATC procedures. ATC will continue to control the flight as done in current operations but may assist the pilot in meeting their intended airborne delay. This approach minimizes the required training and involvement of en-route ATC for deployment of this Regional ATFM concept. Involvement of en-route ATC is a future consideration for the concept.

4.18 Since many of the major airports in the APAC region are IATA level 3 Slot Controlled Airports, much of the work to balance demand and capacity in the strategic ATFM phase is already taking place. This process requires a rigorous analysis of the airport operations in order to determine the capacity of the airport. The scheduled demand is usually coordinated during bi-annual IATA Slot Conferences.

4.19 Airport Strategic Slot information is used by the ATFM process to transition from the strategic plan to the pre-tactical plan, then to the tactical plan on the day of operations. The flight data from the Strategic Slots is loaded in the ATFM System by the Aircraft Operators or ANSP at least one day prior to the day of operations. Figure 5 shows a sample of the type of demand graph that should be available to the relevant stakeholders to easily identify periods of demand-capacity imbalances and decide whether or not an initiative must be implemented.

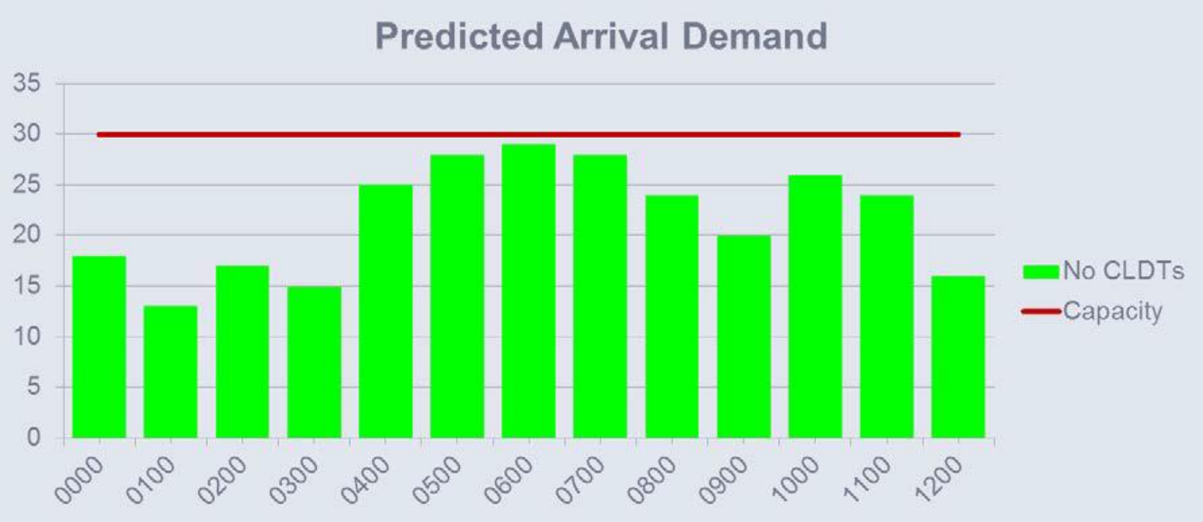


Figure 5: Example of capacity and demand

4.20 The stated capacity may change throughout the day due to operational factors or forecast weather. Capacity rates can be loaded into the ATFM system to reflect the capacity during a certain time period. For example, runway configuration changes could vary the rates in a predictable manner.

Initiating a TMI

4.21 The Flow Management Position (FMP) continuously monitors the demand and capacity. When the current or predicted demand exceeds the capacity, the FMP will determine whether or not an ATFM program is needed based on the severity of the demand-capacity imbalance as well as feedback from CDM stakeholders. Prior to implementing TMIs under an ATFM program, the FMP and CDM stakeholders will have the ability to model with different parameters, including:

- TMI start and end time
  - Flights with estimated landing times within the start and end time of the program will receive ATFM slots
  - Non-exempt and exempt flight criteria
- Exemption criteria by: airline, airport, distance from arrival airport, or flight
  - Airborne Exemption Horizon: Flights that are airborne when the program is initiated and expected to land within the Airborne Exemption Horizon are exempt from the program
- Airport Acceptance Rate (AAR)
  - Number of aircraft that can land at the airport in a given time bin based on the predicted conditions

- Required Notification Time
  - When a TMI is run, pre departure flights that are expected to depart sooner than the Required Notification Time will have a default delay intent to absorb all of their delay in the air

4.22 The FMP will evaluate if the demand is sufficiently smoothed and also consider the average delay, maximum delay, and number of affected flights to determine the impact of the ATFM program. Once the optimal parameters are set, the FMP runs the program and slot times are sent to Aircraft Operators, air traffic control towers, and other stakeholders.

Maximum Delay

4.23 Included in the concept it is the acknowledgement that certain flights will have a limited amount of delay that can be absorbed. For example, an active flight cannot absorb any delay on the ground and will only be able to efficiently absorb a limited amount of delay in the air based on remaining flying time. Also, flights may have a limited amount of delay they can absorb on the ground due to constraints of the departure airport. For example, if some airports have very high gate utilization and very few holding areas, the amount of ground delay for a flight will be limited.

4.24 To address this, the concept includes a component termed Maximum Delay. Maximum Delay is made up of three parameters: *Maximum Gate Hold*, *Maximum Surface Hold*, and *Maximum Airborne Adjustment*. The Maximum Gate Hold can be provided by the associated departure Airport Operator and the Maximum Surface Hold can be provided by the departure tower. Both of these parameters can be set by time frame and by departure terminal. The Maximum Airborne Adjustment is estimated by the ATFM system considering the distance between the departure and arrival airports or remaining flying time for airborne flights.

4.25 The use of the Maximum Delay concept can be tailored for implementation based on the needs of individual ANSPs. The considerations for the use of Maximum Delay are presented in paragraphs 4.76 and 4.77.

Collaborative Decision-Making

4.26 A key benefit of the Regional ATFM concept is an increase in collaboration that must take place in order to have an efficient and effective Regional ATFM concept. Through the ATFM System, stakeholders will be given a broader view of system constraints that might affect their operation with enough lead time to create a plan of action. This increased situational awareness will facilitate stakeholder collaboration in deciding a course of action.

4.27 Aircraft Operators are given the flexibility to manage their allocated ATFM delays in order to best meet their business objectives. Aircraft Operators will have the capability to substitute slots between any two flights that they operate. This can be done to reduce the delay of a high priority flight or move a delayed flight (e.g., mechanical delay, crew delay, or delay from a prior flight segment) into a slot that it can meet.

4.28 Aircraft Operators also have the ability to substitute flights into a later slot even if they don't have another flight that they operate to swap into the earlier slot. This is called an Inter-operator Slot Exchange. The flight requesting a later slot submits the earliest time that it can operate and the system automatically selects one or more flights to move forward. Notifications are then sent to the Aircraft Operators that have flights which had their delay reduced, known as *bridged flights*.

Compliance

4.29 Non-exempt flights will be measured for compliance based on their allocated slot times versus actual time of operation. Medium and long range flights which have the ability to absorb some delay in the air are measured for compliance with reference to the calculated time over (CTO) an arrival fix (AFIX). Short haul flights that do not have the ability to efficiently absorb a significant amount of delay in the air may instead be measured for compliance with either their actual off-block time (AOBT) or actual take-off time (ATOT).

4.30 For ATFM measures relating to airspace demand and capacity balancing, compliance may be measured against the CTO at an en-route fix (RFIX).

4.31 Compliance is measured at a fix rather than at landing as flights have more control over meeting a fix crossing time prior to initiated tactical ATC sequencing into the arrival airport. ANSPs specify the fixes that are to be used both for TMIs and measuring compliance. Flights will attempt to arrive at this fix within a compliance window.

4.32 Exempt flights are not considered for compliance measurement. These exempt flights are determined by the FMP for a given program and could include flights outside a given radius, flights departing from certain airports, and special case flights, for example very-very important person (VVIP) flights. These flights will be assigned a slot time, which may involve some delay, but the flights will not be expected to comply with their assigned delay.

4.33 Additionally, flights will be filtered from compliance consideration in cases where the Aircraft Operator is not at fault. For example, if the pilot does everything in their control to meet assigned slot times yet the flight arrives early or late due to an ATC constraint, then the flight will not be considered non-compliant.

4.34 ANSPs have flexibility to develop their own policy and procedures for the handling of non-compliant flights. The considerations for the alternatives are explained in paragraphs 4.71 to 4.75.

4.35 Measuring and sharing of compliance statistics must be part of every implementation of the Regional ATFM concept.

Post-Operations Analysis

4.36 A key component of the ATFM system as a data-sharing platform is the analysis capability enabled to study the effectiveness of ATFM programs and TMIs, and to establish trends over time. Post-operational analysis is indispensable for the FMPs to improve the parameters in the TMIs to achieve the desired outcome. The results of these analyses can be shared among FMPs in the region and “best practices” can be established.

4.37 The metrics used for post operations analysis are listed in the tables below. **Table 1** lists the general scenario metrics, which are used to measure the severity of events that occurred, the TMI parameters selected to resolve the issues, and the impact of the TMI on stakeholders during a given time period. **Table 2** lists the CDM action metrics, which are used to determine how active the Aircraft Operators were in managing their flights.

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 the delay assigned by the 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 canceled 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 1: General Scenario 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 canceled flights for a given time period
Substitution Savings	The amount of the savings in minutes of flights that move forward as a result of a substitution
Bridging Savings	The amount of the savings in minutes of flights that move forward as a result of being bridged

Metric	Description
Number of Delay Modifications	Number of modifications made by the Aircraft Operator to their flight event times to show flight would be delayed
Number of Delay Intent Modifications	Number of modifications made by the Aircraft Operator to their delay intent values

Table 2: CDM Action Metrics

4.38 Compliance metrics are useful for reviewing the effectiveness of a TMI and finding systemic hindrances on the effectiveness of TMIs. There are many ways that users can view compliance metrics. For example, in **Figure 6** compliance is compared at various points in flight progress. The different colors in the pie chart show different levels of compliance, where orange and red are different degrees of late and blue and dark blue are different degrees of early.

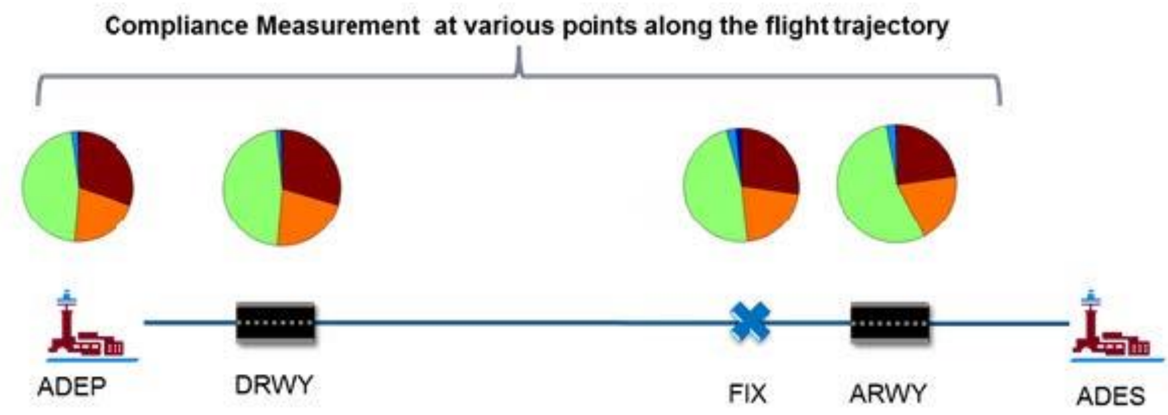


Figure 6: Compliance Metrics

Stakeholder Roles and Responsibilities

4.39 With the exception of the FMP, Regional ATFM stakeholders are the same as in the flight and ATM operations, but with added roles. First of all, stakeholders will collaborate on a daily basis in order to ensure the smoothest operations. This communication is done by sharing data with the ATFM System as well as during teleconferences chaired by the FMP. This communication will lead to a common view of the most accurate demand and resource capacities. When multiple ANSPs have implemented this concept, the teleconferences may exist at one or more levels of stakeholder participation to provide the necessary information to all stakeholders in the region.

4.40 In addition to increased communication among the stakeholders, each stakeholder group has specific changes that result from the concept, described as follows:

Flow Management Position

4.41 Upon implementation of Regional ATFM, an FMP position will need to be established within each ANSP. FMPs will be part of a new flow management unit that is responsible for managing the operation of the ATFM system and the associated CDM processes within the ANSP.

4.42 The main responsibility of the FMP is to monitor the demand by viewing flight data from the ATFM System and comparing that to the arrival capacity of the airport(s) in their jurisdiction. The FMP collaborates with relevant stakeholders to update the capacity (i.e., AAR) when there is a constraint such as predicted weather or resource maintenance/outage. Whenever the predicted demand exceeds the capacity, the FMP must determine the best solution for the problem, which will likely involve implementing a TMI. The FMP will have the ability to model various initiatives to smooth the imbalance and, in coordination with local stakeholders, select the solution that causes the least operational impact. Additionally, if multiple ANSPs in the region have an ATFM system, the FMP may coordinate with FMPs of other ANSPs to establish the best regional solution taking all the regional requirements into consideration. While ANSPs may have different ATFM systems, they will transmit and receive data in a common way, thereby enabling all regional FMPs to share the same operational information.

4.43 Once the ATFM program is run, the FMP will monitor the performance of the program. The FMP has the ability to revise a program if any of the parameters need to be changed. The FMP also has the ability to perform a compression (optimizing slot allocation) on a program to reassign flights to slots and to fill in any empty slots. Both of these actions involve having new slot times assigned and sent to the Aircraft Operators; therefore, these FMP actions are limited to operational need based on updated flight data or capacity information.

4.44 The FMP will also be responsible for chairing scheduled and ad hoc teleconferences. Scheduled teleconferences will likely be held daily in the morning and afternoon. The daily airspace plan will be discussed and could include: demand anticipated during the day, weather forecasts and constraints, resource availability/non-availability, special use of airspace, Aircraft Operator operations, proposed TMI modeling and implementation, and post-event analysis. Ad hoc teleconferences can also be held should circumstances dictate a need.

<u>Aircraft Operators</u>

4.45 Aircraft Operators will see changes in the way they manage their flights due to the redistribution of inevitable delay. When a demand and capacity imbalance is predicted, an ATFM program will shift the delay from the more costly airborne holding delay to the more efficient ground delay or airborne adjustment. Both the Flight Operations Center (FOC) and pilot need to be aware of the assigned TMI and work to comply with it in order for the concept to be effective and equitable.

4.46 An additional role of the Aircraft Operator is to provide the demand inputs into the ATFM System in the pre-tactical and tactical time frame. These data could include flight schedule uploads and flight plans. As the time to operate the flight approaches, the Aircraft Operator can update flights' EOBT (e.g., flights delayed due to mechanical issue) through the ATFM System, making the changes visible to all stakeholders.

> *Note: Delay information input to the ATFM system does not replace the aircraft operator or pilot-in-command obligation to file delay, amendment, or cancellation and new FPL information, as specified in ICAO Doc 4444 PANS-ATM and State AIP.*

4.47 When an ATFM program is implemented, Aircraft Operators have the flexibility to prioritize flights within the pool of slots they have been assigned and to specify the intended delay distribution for their flights. The FOC will communicate this delay intent to pilots and the flights will be measured for compliance with the slot times, as described in paragraphs 4.71 to 4.75.

Airport Operators – Departure Airports

4.48 Airport Operators will be impacted by implementation of a TMI as a departure flight may elect to take ground delay at the gate or between pushback and departure, which affects gate allocations and movement area and apron and taxiway usage. The Airport Operators' main involvement in the regional concept is to coordinate with Aircraft Operators for absorbing delay on the ground whenever necessary.

4.49 Where airport terminal (gate) capacity is constrained Airport Operators may submit Maximum Gate Delay values to the ATFM system, as described in paragraphs 4.24 to 4.26.

Airport Operators – Arrival Airports

4.50 Airport Operators will be responsible for advising the FMP on capacity constraints predicted at the airport. They will be expected to participate in scheduled and ad hoc teleconferences. The Airport Operator will advise the FMP should the TMI have an adverse effect on operations at the monitored airport.

Airport Collaborative Decision Making (A-CDM) Interface

4.51 A-CDM systems should interface with the ATFM system, using the Regionally agreed terminologies relevant to both ATFM and A-CDM; CTOT and calculated landing time (CLDT).

ATC – Departure Tower

4.52 The Tower ATC can facilitate compliance with ground delay intent as far as operational constraints allow. With access to the flight-specific intended takeoff time, Tower ATC staff can assist flights to have a compliant departure.

4.53 In addition, the Departure ATC Tower can coordinate where to best place the flights if the aircraft are to be held on the movement area in order to absorb the ground portion of the delay.

4.54 Lastly, the Tower can submit Maximum Surface Delay values to the ATFM system, as described in paragraphs 4.24 to 4.26. The ATFM system should flag Maximum Surface Delay values input by ATC to identify where ATC or airport surface capacity constraint results in non-compliance with a TMI.

ATC – Arrival Tower

4.55 The ATC Tower supervisor will be required to keep the FMP advised of constraining events at the airport. The Tower supervisor will be required to participate in teleconferences so as to add to the pre-tactical and tactical CDM processes. In addition the tower supervisor will be required to tactically determine the AAR and advise the FMP if any change in the AAR is required.

ATC – Area Control Centre (ACC)

4.56 En-route ATC units and centres will have no requirement to change their operational procedures to accommodate flights subject to a TMI. Pilots may request an altitude or speed change in order to comply with their delay intent distribution. The ATC will follow normal ATC operating procedures before approving these changes. Education on the fundamental principles of the Regional ATFM concept will serve to increase controllers' awareness.

4.57 Terminal Area (TMA) ATC unites in certain implementations of ATFM may have the authority to de-prioritize non-compliant flights. This model can be adopted but requires compliance status of flights being available to ATC. Adding this function to the terminal ATC depends on the ANSP's decision made in terms of compliance handling described in paragraphs 4.71 to 4.75.

Proposed Changes Resulting from Implementation

4.58 The following Technology and Policy changes supporting the implementation of the Regional ATFM Concept are proposed.

Technology Changes

4.59 Stakeholders will able to perform demand and capacity balancing during the pre-tactical and tactical phases with the ATFM system. Through this system the FMP can model ATFM programs with various parameter values to optimize the solution. When the TMI is acceptable to the FMP, the TMI is run and the slot times are automatically calculated and sent to the appropriate Aircraft Operators.

4.60 Common situational awareness for all the stakeholders is essential for implementing effective TMIs; the ATFM system will bring this situational awareness to ANSPs, Aircraft Operators, Airport Operators, and other stakeholders. The ATFM system will integrate various data sources with the most accurate and up-to-date operational information. Users can connect to the ATFM system to view pertinent information as well as update any changes to their operations. Efficient sharing of more accurate data leads to better decision making in a timely manner. A CDM platform is required where Aircraft Operators are able to carry out advanced CDM processes to optimize schedules.

4.61 Users will be able to access stored data for post-operations analysis. Stakeholders will be able to view metrics for any previous day of operations (for a list of metrics, refer to paragraph 4.37 Tables 1 and 2). Statistical analysis of post operations data will help identify shortfalls in operations and methods to improve operations.

Policy Changes

4.62 Policy changes associated with Regional ATFM include involvement in teleconferences, which will increase information sharing compared with current day operations. CDM stakeholders may participate in scheduled teleconferences to discuss the plan for the day as well as to review operations on the previous day. The stakeholders calling into the scheduled teleconferences include the FMP, Aircraft Operators, neighboring ANSP facilities, the ATC tower(s), and the local Airport Operator. If necessary, the FMP will coordinate with the FMPs of other regional ANSPs in a separate teleconference. The FMP may also convene and chair ad hoc teleconferences to handle unforeseen demand and capacity imbalances.

4.63 Policy in terms of data sharing will have to change with the implementation of ATFM, since sharing of data is the foundation of CDM. Aircraft Operators will have the ability to view delay metrics associated with their flights as well as aggregate metrics for all flights. ATC stakeholders will have unlimited situational awareness with regard to slot assignments. Access, security, and data integrity must all be addressed in single ATFM System instances and in the connectivity and data sharing between multiple ATFM System instances.

4.64 Aircraft Operators and third-party agencies generally measure on-time performance (OTP) by comparing flights' actual off-block times (AOBT) with their scheduled off-block times (SOBT). With the implementation of ATFM, the policy for measuring OTP should consider flights impacted by a TMI. For these flights, on-time performance should be determined by comparing flights' actual off-block times and actual landing times with their intended off-block times. This is a challenge for ATFM systems, since Aircraft Operator on-time performance is often defined by legislative action. To date, the impact of an ATFM initiative on a departure OTP metric has not been formalized.

Justification for Changes

4.65 Table 3 summarizes the major changes resulting from the Concept, and their justifications.

Change	Justification
Introduce a Flow Management Position	• A smoother transition of strategic demand and capacity balancing to pre-tactical and tactical demand and capacity balancing • A means of evaluating proposed TMIs in collaboration with the stakeholders prior to implementation • A communication position within the ANSP to keep stakeholders apprised of the operational conditions
Assign slot times to flights to manage demand-capacity imbalances	• Reduced fuel burn • Reduced controller workload • Increased predictability of operations • Enhanced safety due to reduced congestion
Aircraft Operators share flight data with ATFM system	• Accurate and common picture of demand
FMP specifies capacity	• Accurate and common picture of capacity
Aircraft Operators specify delay absorption intent	• Increased participation improves TMI effectiveness and results in a more equitable delay assignment • Increased flexibility for Aircraft Operators to manage flights • Reduced risk of absorbing unrecoverable delay
International and airborne flights participate in TMIs	• Increased participation improves TMI effectiveness and results in a more equitable delay assignment
Aircraft Operators have the ability to substitute flight slots	• Flexibility for Aircraft Operators to manage flights based on their business models
Airport Operators and ATC Tower specify Maximum Ground	• Increased situational awareness − Aircraft Operators: aware of flights which may have received more delay than they can absorb

Change	Justification
Hold	– FMP: more accurate picture of when flights will actually arrive at the terminal area
Measure compliance at a fix prior to landing	• Ensure a smooth flow of traffic to the constrained airport • Move Aircraft Operator compliance point beyond tactical terminal control area.
Post-Operations Reporting	• Provide a means to discover ways to improve operations
Teleconferences	• Increased situational awareness

Table 3: Changes and their Justifications Arising from the Concept

Impacts During Deployment

4.66 The participation of stakeholders has contributed to the development of the concept of operations; this participation will need to continue for successful operational deployments. This participation would include:

- Participation in stakeholder meetings establishing business rules specific to an ANSP's implementation;
- Development of operational procedures;
- Training of staff;
- Participating in operational daily and ad hoc teleconferences; and
- Active participation in data sharing and TMI execution.

Multi-Nodal Concept

4.67 The Regional ATFM concept has been described in the above from the perspective of a single ANSP. The concept readily applies to multiple ANSPs in the same region all implementing this form of ATFM/CDM. A key to the concept is that each ANSP would be responsible for implementing ATFM programs to airports and airspace within their own FIR according to the concept illustrated in this document. Information sharing between the ATFM systems would allow the users of any of the systems to have access to network-wide information. This includes Aircraft Operator access to controlled flights arriving to airports within the areas of responsibility of multiple ANSPs, and air traffic control tower access to ATFM information on departure flights destined for airspace and airports within the areas of responsibility of multiple ANSPs with CTOT and CTO reflecting delay intent from their respective TMIs. Details of the concept and procedures could be customized in each ANSP based on their individual operational requirements, but it is strongly recommended to keep the concept as consistent as possible across the region. Refer to paragraphs 4.70 to 4.78 for the details that can be adapted. **Figure 7** provides an example of three networked ATFM nodes under the Regional ATFM concept.

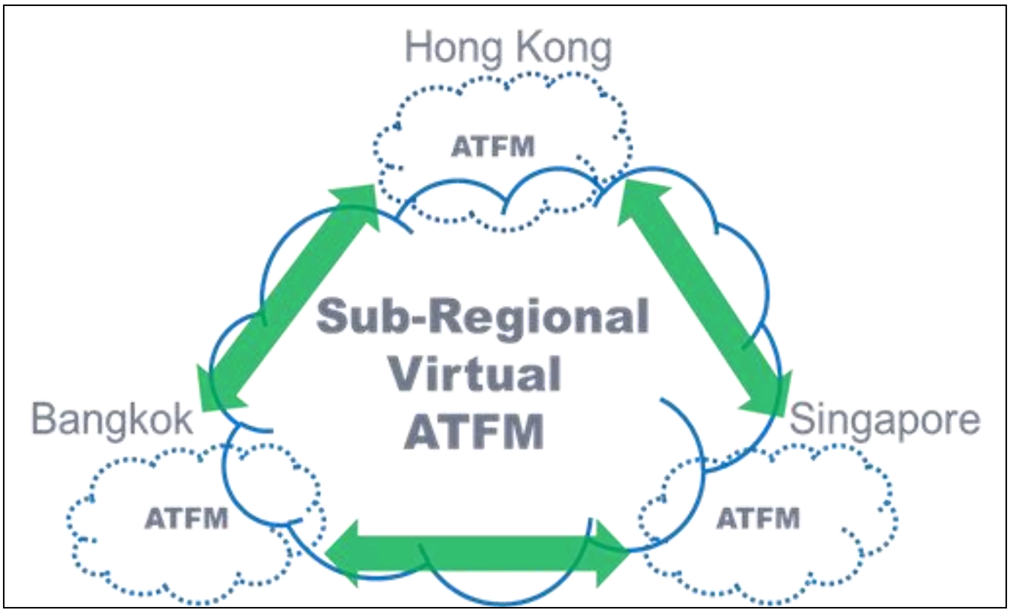


Figure 7: Distributed Multi-nodal ATFM Network

Implementation Considerations

4.68 The following concept elements can be addressed to meet the needs of a specific ANSP. The variations on the elements are described below to provide the full breadth of the concept without indicating a preference for a specific implementation.

Compliance Handling

4.69 High levels of compliance are critical for TMIs to have a predictable and efficient flow of traffic. Non-compliant flights could cause bunching in the arrival flow, requiring ATC to impose airborne holding or other tactical interventions on compliant flights. Non-compliance could consequently result in loss of trust among Aircraft Operators in the efficiency and equity of the Concept.

4.70 In current ATFM implementations ANSPs have developed a range of procedures for preventing non-compliance. The options, together with their advantages and disadvantages, ar: are presented below along with their advantages and disadvantages. Note that the options are not mutually exclusive.

- Sharing of compliance statistics with stakeholders
  - Advantages
    - Promotes CDM principles through the transparency of data;
    - Aircraft Operators will strive for high compliance to maintain/improve the airline's reputation;
    - Flights that are unable to absorb delay (e.g. VVIP flights and medical emergencies) will not be penalized for non-compliance.

- Disadvantages
    - No direct consequences for non-compliance

- Departure ATC prevents pushbacks or departures if flights will be non-compliant with their assigned CTOTs
    - Advantages
        - Little if any non-compliance with CTOTs
    - Disadvantages
        - Increased workload for ground movement controllers
        - Operational challenges associated with pilots absorbing delay at a holding pad
        - No penalty for non-compliance with intended airborne delay

- Deprioritize non-compliant flights in the arrival airspace
    - Advantages
        - Equitable amounts of delay taken for compliant and non-compliant flights
        - Compliant flights are not penalized when other flights are non-compliant
    - Disadvantages
        - Technical and procedural challenges associated with integrating ATFM system and AMAN
        - Increased workload for approach controllers

4.71 Tactically deprioritizing flights in the approach airspace would require the ANSP to define fixes outside of the approach area that would be used to measure the compliance. If the ANSP has an AMAN, it would be best to measure compliance prior to the AMAN handoff point. This would ensure smooth delivery of the flow into the AMAN, which would then be used to sequence flights to the runway. It would also provide sufficient time for a Flow Manager or supervisor to decide which flights to deprioritize if the ANSP decides to deprioritize non-compliant flights. Due to the unique geometry of the airspaces, the distance from the airport at which compliance is measured will be adapted to each ANSP.

4.72 The size of the window at which flights are considered compliant is dependent on implementation and stakeholder involvement. An asymmetric (e.g. -5, +10 minutes) window could be used because Aircraft Operators have more control over not arriving early than not arriving late. In other words, Aircraft Operators could be late due to a variety of reasons such as weather deviations or an ATC constraint. Pilots generally have enough control over the flight to prevent an early arrival.

4.73 Individual ANSPs in the region will set compliance standards within their areas of responsibility; however, a standard procedure for handling non-compliance is recommended in the region for operating consistency.

Performance Metrics and Post-Operational Analysis

4.74 The metrics for post-operations analysis described in paragraps 4.37 to 4.39 should be applied to all the ANSPs in the region because they are metrics related to the broader Regional ATFM concept and not the specific implementations. The common set of metrics will help the international ATFM community develop a method for comparison with operations around the world. In addition to those metrics, the concept allows for ANSPs to develop their own metrics and statistics particular to their operations. Some possible metrics/statistics to consider are:

- Program Delivery – Shows how effective the TMI was at balancing the capacity and demand. It compares the expected demand after the TMI was implemented with the actual demand. This is useful in identifying periods of non-compliance.
- On-Time Performance Metrics – Typically ATFM only considers whether TMIs were successful in balancing demand with resource capacity. On-Time performance represents another aspect of national airspace operations that is a good indicator of efficiency and is directly tied with impacts to the passengers. It is important to track the impacts to passengers because it gives an insight whether TMIs were able to give benefits to more passengers rather than more aircraft.
- Environmental Metrics – Shifting air delay to ground delay has a positive impact on the environment through emissions reduction. Fuel burn metrics could be developed to study and track positive impacts of implementing a TMI. The metrics could also support achieving the environmental goals any government may have.

Additional metrics could delve deeper into airport and airspace operations. They would be useful in identifying root causes of inefficiencies that have been exposed by higher-level aggregate metrics.

Maximum Delay

4.75 The implementation of the Maximum Delay to flights will be determined by each ANSP. Three options are:

1. Added as a parameter for the Aircraft Operators to compare to assigned delay
2. Incorporated into FMP demand predictions
3. Maximum Delay is incorporated in slot assignment

4.76 The first use will help Aircraft Operators manage their flights by ensuring the assigned delay is not greater than the Maximum Delay via delay intent adjustments and substitutions. The second use will help the FMP determine the effectiveness of a modeled TMI. For example, if many flights are receiving more delay than their Maximum Delays, the FMP could increase the participation to reduce the average delay of participating flights. Maximum Delay during slot assignment could limit the delay assigned to flights such that their assigned delay is less than or equal to their Maximum Delay. This approach is not recommended for an initial implementation, because it requires very accurate calculations of Maximum Delay.

Future Considerations – Role of En-route ATC

4.77 **Role of En-Route ATC**: The Concept of Operations states that the FOC will communicate delays associated with TMIs to their pilots. If the pilot needs to absorb some delay in the air in order to be compliant, the pilot will request speed and altitude changes to ATC, and the controller will approve the request if possible. With this approach, en-route ATC will operate under the same procedures used currently.

4.78 Increasing the involvement of en-route ATC is possible based on ANSP involvement, controller training, and the desire to be actively involved in supporting airborne adjustments. For example, the en-route ATC could be aware of controlled flights' calculated times and actively direct flights to ensure compliance. This involvement increases the workload of en-route controllers, but increases the likelihood that flights are compliant with the ATFM assigned delays. Due to the required time to add this role and the large number of stakeholders impacted, this role is not considered for the current concept, but may be considered in the future.

4.79 **Additional TMIs**: Current implementations of ATFM in the U.S. and in Europe have additional TMIs such as Ground Stops, Airspace Flow Programs, and Departure GDPs. Ground Stops were discussed during stakeholder sessions as a means to balance demand and capacity for capacity reducing events that are predicted with little to no lead time. During Ground Stops, certain flights are held at their departure airports for a specified amount of time. Ground Stops were not included in the initial concept of operations because they would be used less frequently than the TMI described in this document, but may be considered in the future.

5. Operational Scenario

5.1 The initial conditions for this scenario are illustrated in **Figure 8**. The FMP views the demand and capacity predictions at the arrival airport. The FMP sets the runway configuration and AAR after coordinating with the tower and terminal supervisors. The pre-tactical demand is lower than the nominal capacity, so there is no need for any arrival airport TMIs.

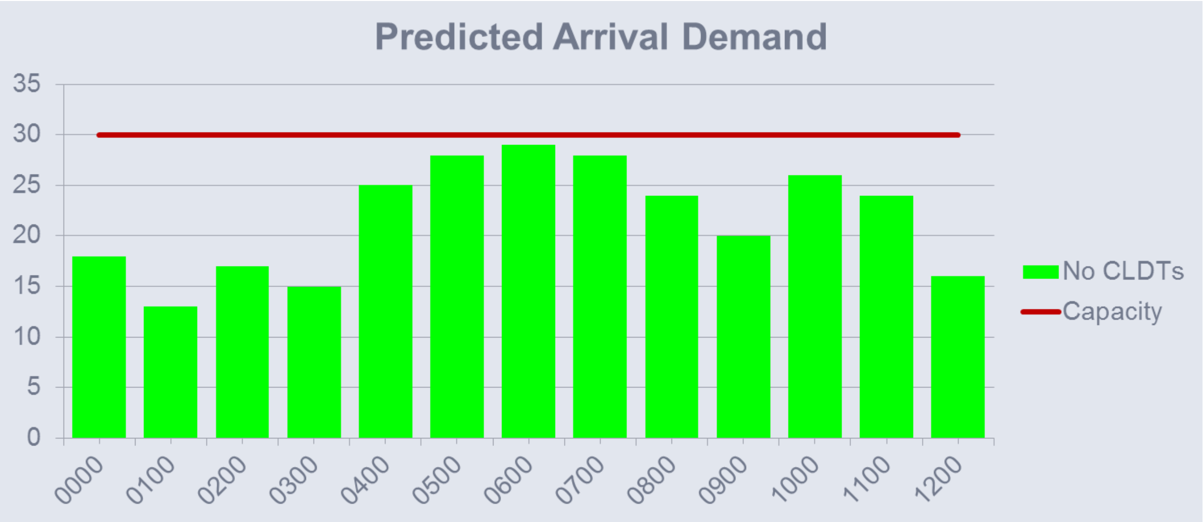


Figure 8: Demand and Capacity Prediction

5.2 At 0000 UTC, the military informs the FMP of a military exercise that will impact the operations at the airport. The reduced capacity will likely cause a demand and capacity imbalance, which can be managed by running a TMI. The parameters for the TMI are selected such that the capacity reducing event will have the least possible impact on all of the stakeholders. The result of the modeled TMI is shown in Figure 9, with the parameters listed below:

- AAR based on the capacity reducing event: 25 between 0500 and 1100 UTC

- TMI start time: 0500
- TMI end time: 1100
  - Flights with estimated landing times between the start and time of the program will receive a slot, or Calculated Landing Time (CLDT), at the arrival airport.
- Non-exempt flights: 15 major airlines from the region
  - The major airlines in the Asia Pacific region will attempt to comply with their assigned slot times, regardless of their departure airport.
  - The few remaining flights from other airlines are exempt and will receive priority in slot assignments.
  - Exempt/Non-exempt status can also be set for specific airports and flights and based on distance.
- Active Flight Exemption Horizon: 1 hour
  - Airborne flights estimated to land within the next hour will be exempt from the program and receive priority in slot assignments because they will not be able to efficiently absorb any delay.
- Required Notification Time: 1 hour
  - The default intent for pre-departures that are estimated to depart within the next hour is to absorb all of their delay in the air because the FOCs require approximately one hour to notify pilots of the TMI.

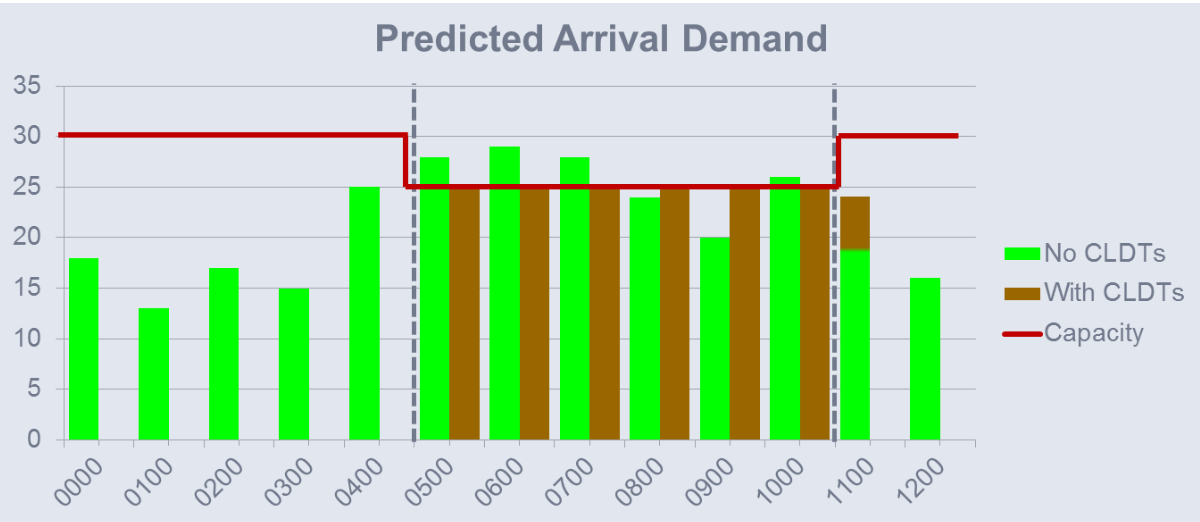


Figure 9: Modeled ATFM program

5.3 The FMP coordinates with CDM stakeholders via teleconference to coordinate the potential impact of implementing the TMI. While all stakeholders can provide input on the program parameters and suggest alternative solutions, the FMP is the ultimate decision maker.

5.4 The FMP runs the proposed TMI and slot assignments are sent to Aircraft Operators. The slot assignment event times are prefixed with the letter C for Calculated and include:

- Calculated Off-Block Time (COBT)
- Calculated Take Off Time (CTOT)
- Calculated Over Fix Time (COFT) (used for compliance measurement)
- Calculated Landing Time (CLDT) (arrival slot time)
- Calculated In Block Time (CIBT)

5.5 Aircraft Operators have the flexibility to distribute the delay intent of pre-departure flights into three attributes: Intended Gate Delay, Intended Surface Delay, and Intended Airborne Delay. In certain cases, Aircraft Operators will coordinate gate and surface delay intents with the Airport Operator to manage gate turnaround times and gate conflicts.

5.6 The Thai Airways FOC decides to absorb a portion of the assigned delay of flight THA641 in the air (**Figure 10**). Of the 20 minutes of assigned delay, THA641 intends to absorb 10 minutes at the gate and 10 minutes in the air. The FOC submits the delay intent to the ATFM system via the web interface. The FOC then informs the pilot of the intended delay.

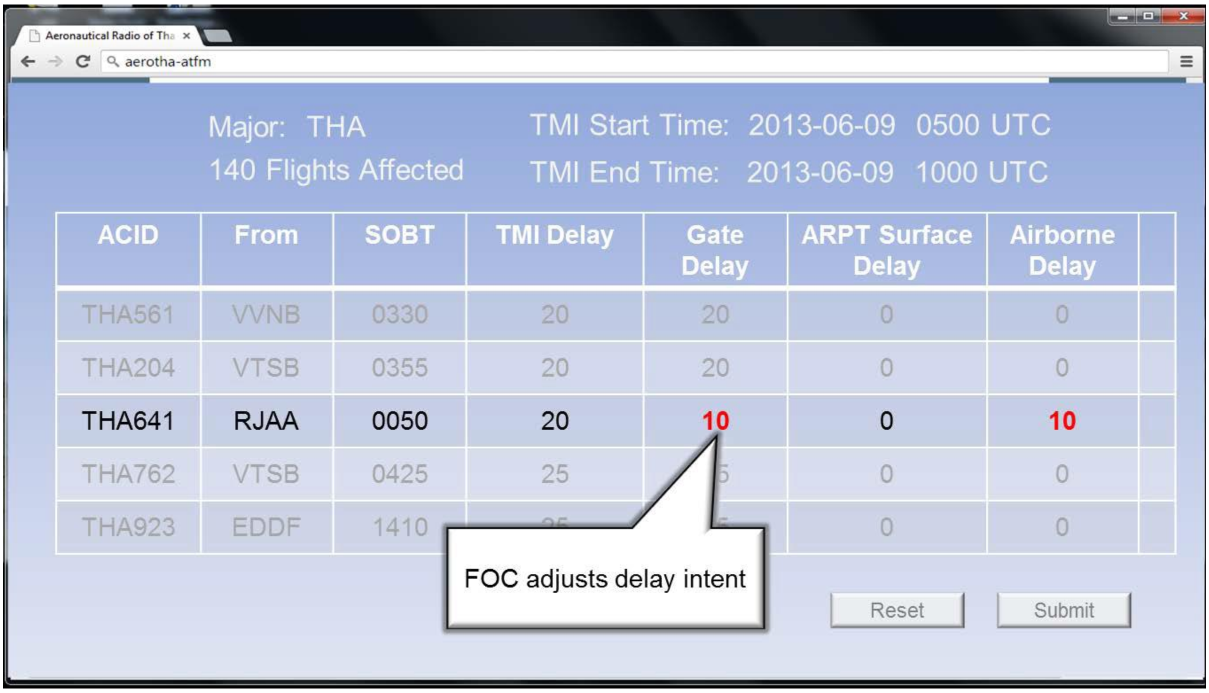


Figure 10: Delay Absorption Intent

5.7 The event times associated with the intended delay are prefixed with the letters "DL". For flights that intend to absorb some delay on the airport surface or the air, their DL Off-Block Time (DLOBT) and DL Take Off Time (DLTOT) will be different from the Calculated "C" times associated with the slot. **Table 3** shows the updated DL-times for THA641 based on ten minutes of gate delay and ten minutes of airborne delay. Notice the DLOBT and DLTOT are both ten minutes earlier than the COBT and CTOT because the flight intends to make up that additional ten minutes delay in the air.

ACID	DLOBT	COBT	DLTOT	CTOT	DLLDT	CLDT

THA641	0100	0110	0110	0120	0600	0600

5.8 Aircraft Operators also have the ability to substitute flight slots in order to meet their business objectives. For example, CPA713 is a high-priority flight, so the Cathay Pacific FOC substitutes it with CPA739. The CLDTs of the two flights are swapped and the CTOTs are recalculated based on the new slot times. The result of the substitution is shown in **Figure 11**.

Pre-Substitution

ACID	ADEP	CTOT	ATOT	SLDT	CLDT	TMI Delay
CPA739	VHHH	0345	----	0705	0710	5
CPA713	VTBS	0455	----	0710	0720	10

Post-Substitution

ACID	ADEP	CTOT	ATOT	SLDT	CLDT	TMI Delay
CPA739	VHHH	0355	----	0705	0720	15 (+10)
CPA713	VTBS	0445	----	0710	0710	0 (-10)

Figure 11: Pre- and Post- Flight Substitution

5.9 Pilots request pushback clearance at the departure airport at the Delayed Off-Block Time (DLOBT). Following the departure airport's procedures, flights receive clearance for pushback. At certain departure airports, procedures may be altered such that flights can only receive pushback approval if the request is within a compliance window.

5.10 Approach and en-route controllers will operate as they do in current operations and may have a basic understanding of the Regional ATFM concept. Flights that intend to absorb some delay in the air may request speed and or altitude changes en-route in order to meet the intent. The en-route controller may accept or reject the speed or altitude request based on ATC operational requirements.

5.11 Arriving flights will be measured for compliance at an AFIX prior to landing. If a flight's actual time over (ATO) the fix is within the compliance window of the flight's CTO for the fix, the flight will be considered compliant. In addition, flights that are late to the fix due to an ATC constraint will not be considered non-compliant.

6. Expected Benefits of the Concept

6.1 There are many expected benefits with the implementation of the Regional ATFM concept. The major areas of improvements upon the current procedures include:

- A smoother transition of demand and capacity balancing from strategic to pre-tactical and tactical phases of ATFM.
- Reduced fuel burn and emissions.
- Accurate and common view of demand and capacity predictions.
- A means of modeling and evaluating proposed TMIs in collaboration with the stakeholders prior to implementation.
- Flexibility for Aircraft Operators to optimize their schedules through a web-based CDM platform.

- Flexibility for flights to absorb inevitable delay on the ground or efficiently through the en route portion of the flight rather than by holding in the terminal area.
- A more reliable data source of stakeholder intent—this applies to Aircraft Operators sharing how they intend to operate the flights, as well as ANSPs and airports sharing any resource constraints.
- Enhanced safety by ensuring safe traffic densities.
- A data platform that integrates various flight data sources and provides common situational awareness to the stakeholders.
- An environment in which TMIs and other operational procedures can be improved through post-operational trend analysis.

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Attachment A: ATFM Background

ATFM Initiatives

There are a wide variety of ATFM measures that resolve demand-capacity imbalances by shifting demand either spatially or temporally. These measures can be classified into the following four groups [ICAO 2012].

- Spacing Restrictions—Require consecutive flights in a common flow to be separated by a specified time or distance.
  - Miles-in-Trail (MIT)
  - Minutes-in-Trail (MINIT)
  - Minimum Departure Intervals
  - En route Sequencing Program
- Rerouting—Shifts demand around a weather constraint to create a spatially balanced flow of traffic.
  - Fix balancing
  - Collaborative Trajectory Options Diversion of flows
  - Level capping (i.e., restricting the altitude of certain flight plans)
  - Alternative routings
- Ground Holding—Shifts predicted airborne holding delays to ground holding at the departure airport by controlling flights' departure times.
  - Ground Delay Program (GDP)
  - Airspace Flow Program (AFP)
  - Ground Stop (GS)
- Airborne Holding—In general, airborne holding is more costly than other methods, but Air Traffic Managers may plan for airborne holding when delays are predicted to be low.

ICAO Guidance on ATFM

The ICAO Manual on Collaborative Air Traffic Flow Management (document 9971 AN/485) provides recommendations for ATFM implementation. ATFM should be implemented in phases in order to build stakeholder knowledge as operations become more complex. It is also important for procedures to be developed in a harmonious manner among states in the region to reduce operational differences. The ICAO also recommends three communication methods for information sharing: scheduled telephone or web conferences, tactical telephone conferences, and an automated web page or ATFM operational information system.

The list below is a summary of the ICAO document's suggested initial steps to implement ATFM:

- Establish objectives, project management plan, and oversight of ATFM
- Identify personnel who will lead the development of ATFM
- Brief stakeholder groups on ATFM principles
- Define the ATFM structure that will be established
- Consider the facilities and equipment that will need to be procured
- Develop model for establishing AAR
- Identify points of contact for dealing with ATFM issues
- Define the elements of common situational awareness including: ▪ Meteorological information
- Traffic display tools
- Identify the appropriate means of ATFM communication
- Develop Letters of Agreement between adjacent FIRs
- Develop user manuals and training materials

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Attachment B: Participation Analysis – Changi Case Study

This following is a summary of an analysis conducted to determine a required participation level for effective implementation of TMIs.

A fast-time simulation was created to simulate the impact of various participation levels on TMI effectiveness, using scheduled takeoff times were from Changi arrival data on 3 March, 201. The flight progress was simulated with GDPs implemented with various reduced capacities at two participation levels. 1400 NM and 2400 NM radii around Changi provide approximately 50% and 75% participation levels, respectively. The map in **Figure B1** shows the airports that are included in the two radii explored.

Figure B1: Airports within Participation Radius

The results for the two participation levels are compared in **Figure B2**. As indicated by the plots, the total delay increases exponentially as the capacity is reduced. In the severe case of a 16 flights/hour airport capacity (about half of the nominal arrival capacity), participating flights receive an average of 2.3 hours of delay when participation is 50% and about 1.6 hours of delay when participation is 75%. Therefore, increasing the participating flights reduces the delay per participating flight by 0.7 hours. The reason for this reduction is that there are fewer exempt flights that get priority in the slot assignment.

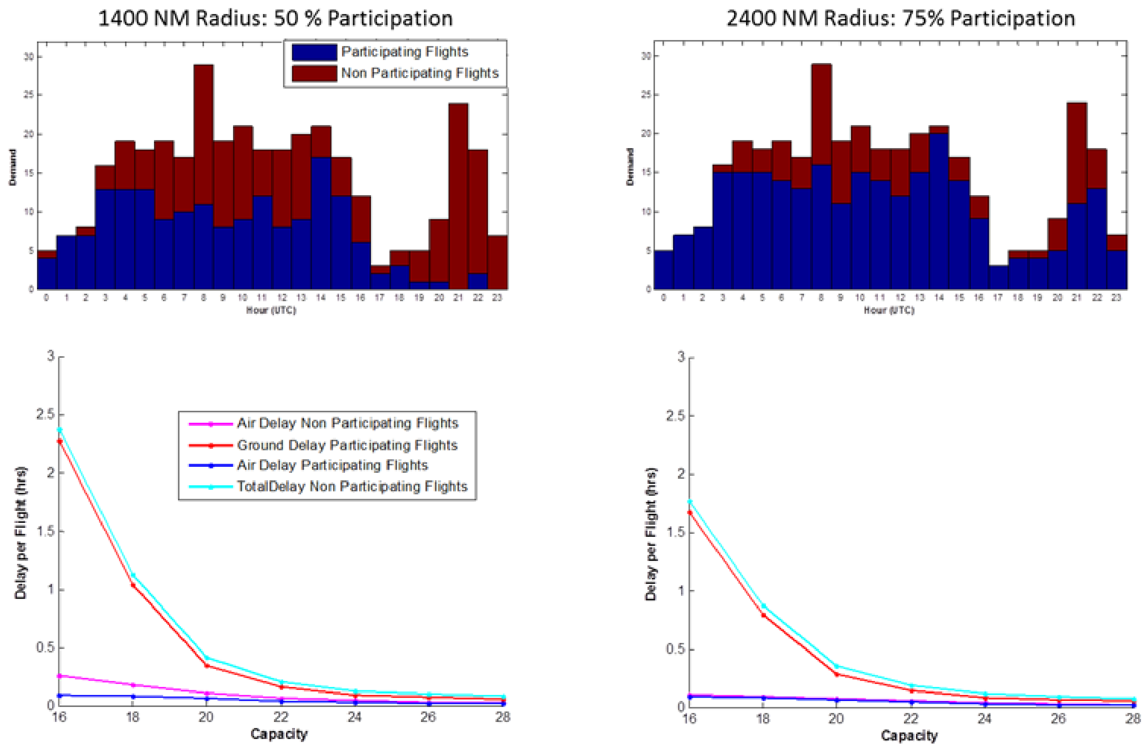

Figure B2: Participation Analysis

The delays for the non-participating flights are also reduced when the participation level is increased. In the example below, the airborne delay for non-participating flights is reduced from 0.3 hours to about 0 hours when increasing participation from 50% to 75%. This is because the demand of participating flights is generally lower than the capacity of 16 when the participation is 75%, whereas when the participation level is 50% there are a significant number of non-participating flights that need to be delayed in order to bring the total demand below capacity.

When the capacity reduction is less significant, the difference between the two participation levels is less pronounced. For example, when capacity is reduced to 20, the average delay for participating flights is reduced from 0.4 hours to 0.3 hours for 50% and 75% participation, respectively. The reason for this reduction in difference between the two participation levels is due to the fewer flights that receive delay. As shown in **Figure B2**, the demand is below 20 for most of the day, meaning a TMI is not needed for most of the day.

Based on these results and knowledge from currently implemented ATFM systems, high participation (>75%) is necessary to manage the flow of traffic during events with a relatively high reduction in capacity. If the capacity reducing event induces minor delays, the flow may be able to be managed with less than 75% participation.