



IMPLEMENTING AIR TRAFFIC FLOW MANAGEMENT AND COLLABORATIVE DECISION MAKING

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Introduction

The growth of air transport demands strategic measures to manage operations in a framework of operational security and efficiency. Air traffic flow management (ATFM) is a procedure that balances demand against capacity to create a more orderly and expeditious flow of traffic.

ATFM is an enabler of air traffic management (ATM) efficiency and effectiveness. It contributes to the safety, efficiency, cost-effectiveness, and environmental sustainability of an ATM system. It is also a major enabler of global interoperability of the air transport industry. Implementing ATFM is a high priority for CANSO, which produces best practice and conducts training and workshops across the regions to assist air navigation service providers to do so.

Annex 11 to the Convention on International Civil Aviation says, "ATFM shall be implemented for airspace where air traffic demand at times exceeds, or is expected to exceed, the declared capacity of the air traffic control services concerned." This is supported by ICAO Document 9971 *Manual on Collaborative Decision-Making (CDM)*, which states, "As a general rule, ATFM is needed whenever airspace users are faced with constraints on their operations, and in areas where traffic flows are significant".

The CDM process is a key enabler in any ATFM strategy, allowing for the sharing of all relevant information among decision-makers and supporting an ongoing dialogue between the various stakeholders throughout all phases of flight.

The impetus for ATFM/CDM may be driven by industry stakeholders, specifically airspace users. Increased flying times, airborne holding, extended radar vectoring, extended routings, extensive speed control, ground delays, and congestion on the ground and in the air are some of the key indicators of a need for ATFM/CDM. These conditions result in a lack of predictability for stakeholders, which the implementation of ATFM/CDM will address. The role of ATFM is to monitor demand, capacity, and constraints at airports and airspaces and where

imbalances exist; ATFM solutions are put in place so as to balance demand and capacity. In a strong ATFM environment, stakeholders share accurate and up-to-date information. This enables ATFM authorities to make appropriate decisions, taking all stakeholders' requirements into consideration to further improve flight and airspace efficiency. These ATFM processes optimise airport and airspace capacity. ATFM/CDM necessitates pre-planned and agreed procedures to ensure that decisions are made with all available information, expeditiously, equitably and in a transparent manner.

Collaborative decision making (CDM), often carried out through teleconferencing, is a very effective process ensuring all stakeholder needs are considered before decisions are made. Many air navigation service providers (ANSPs) which have implemented ATFM carry out this effective CDM process.

Another process of CDM is airport collaborative decision making (A-CDM). This manages the turnaround of aircraft at airports, improving the operational efficiency of all airport stakeholders by reducing delays, increasing the predictability of events and optimising the utilisation of resources at airports. A-CDM is about partners working together and making joint decisions based on more accurate and higher quality information, where every bit of information has the exact same meaning for every partner involved. More efficient use of resources, and improved event punctuality as well as predictability are the target results. A-CDM is not covered in detail in this publication; however, CANSO published *Airport Collaborative Decision-Making - Optimisation through Collaboration* in 2016 which provides guidance on the subject.

This CANSO document highlights the tremendous benefits of ATFM/CDM and A-CDM. It builds on and is complementary to ICAO Doc 9971 and provides practical examples of ATFM/CDM implementation by CANSO Members.

The CANSO ATFM Workgroup begins this publication with explanations about why ATFM

is important and how industry requirements can drive the need for it. It describes how ATFM will be carried out, in what form, the measures required, and the complexity of the implemented system. The publication goes on to describe how to determine what factors need to be considered in developing a concept of operations. These considerations, such as available resources and what initiatives could be done to improve declared airspace and airport capacity, could vary greatly.

This is further explored by providing guidance on determining airport and airspace, nominal and dynamic capacity. The document, through a series of charts and diagrams, defines and depicts the ATFM operational phases, and contrasts the roles of air traffic control (ATC) and ATFM. The document then discusses potential ATFM measures and how their use can optimise capacity.

After defining the various stakeholders, such as the ATFM unit, airspace users, airport authorities, and even weather services and the military, it defines their roles and responsibilities and how their participation is vital to the CDM process.

The document looks at the functions of ATFM, to include A-CDM, arrival management (AMAN) and extended arrival management (XMAN). The document shows methods of measuring ATFM performance to realise the benefits by performing post-operations analysis.

Finally, the document looks at the evolution of ATFM and some possibilities and a vision of the future of ATFM/CDM. As a wrap-up the document concludes with four examples where ATFM/CDM was successfully implemented.

Whether we are talking ATFM/CDM or A-CDM, transparency and the free exchange of information between all interested stakeholders are essential elements to efficiently coordinate and manage operations. With the help of this document, ANSPs can have a clear view of how to implement ATFM/CDM.

CANSO urges States and other stakeholders to ensure effective implementation of ATFM. The benefits are clear and this guide, when used in conjunction with ICAO Document 9971 *Manual on Collaborative Decision-Making (CDM)*, simplifies the process.

1

Why Air Traffic Flow Management (ATFM)?

Annex 11 to the Convention on International Civil Aviation says air traffic flow management (ATFM) shall be implemented for airspace where air traffic demand at times exceeds, or is expected to exceed, the declared capacity of the air traffic control services concerned.

As ICAO Doc 9971 *Manual on Collaborative Decision-Making (CDM)*, states, “As a general rule, ATFM is needed whenever airspace users are faced with constraints on their operations, and in areas where traffic flows are significant”. It goes on to state that “air traffic flow management (ATFM) is an enabler of air traffic management (ATM) efficiency and effectiveness. It contributes to the safety, efficiency, cost effectiveness, and environmental sustainability of an ATM system. It is also a major enabler of global interoperability of the air transport industry.”

ATFM is also referenced in several other ICAO Documents including Doc 9971 *Manual on Collaborative Decision-Making (CDM)*, Doc 9750 *Global Air Navigation Plan*, and Doc 4444 *Air Traffic Management*.

To assist ANSPs in identifying if there is a requirement for ATFM in their area of responsibility, CANSO is providing this document and in particular this chapter to demonstrate reasons for implementing ATFM.

As the practice of ATFM has grown since its first implementation, ICAO has recognised that it is necessary for all air navigation service providers (ANSP) to have a common understanding of what ATFM is. To that end, ICAO published the following definition: “ATFM is a service established with the objective of contributing to a safe, orderly, and expeditious flow of air traffic by ensuring that air traffic control (ATC) capacity is utilised to the maximum extent possible, and that the traffic volume is compatible with the capacities declared by the appropriate air traffic services (ATS) authority.”⁴

Creating balance between traffic demand and capacity can be done on a wide range of time scales (ATFM phases). In the event that traffic demand regularly exceeds ATC capacity, the ANSP should develop plans to increase capacity to meet the forecast demand. Examples of techniques to increase capacity are described in Chapter 6.

CANSO supports ATFM because even with long-term capacity and demand balancing, tactical approaches (the day of operations) are needed during off-nominal, capacity-reducing situations to meet the demand as efficiently as possible.

The need for pre-tactical and tactical ATFM procedures stems from the fact that optimal operating conditions are becoming increasingly rare. When airports or airspaces are running at or near capacity, any capacity reducing event will create a demand-capacity imbalance. With increased demand projections around the world, ATFM has become a widespread initiative in many regions.

1.1 Industry Requirements

1.1.1. Airspace Users

In some countries, ATFM implementation has been driven by industry stakeholders, specifically the airlines. In areas of the world experiencing traffic growth without an associated ATFM plan, there has been a subsequent increase in reported airborne and surface delays due to increased flying times, holding or surface congestion. These issues will lead to increased operating costs for the aircraft operators and increased safety risk. Recognition of these inefficiencies by the operators and/or the ANSP must result in a collaborative ATFM approach to analyse and identify the reasons for the delay and mitigation strategies to address the issues. Key for industry stakeholders is predictability, common situational awareness and input into decisions affecting their operations. These are the first steps in the ICAO Collaborative Decision Making (CDM) process. A stakeholder’s ATFM is a driver for CDM.

⁴ Doc 9971 *Manual on Collaborative Decision-Making (CDM)*

1.1.2. Airport Authorities

Just as airlines require common situational awareness, predictability and CDM, airport operators are realising the importance of their involvement in the overall ATM environment. If airport operators are not exposed to how ANSPs implement ATFM solutions and currently do not have a say in how these solutions are implemented, there is a requirement for expansion of ATFM.

1.1.3 Air Traffic Control

If ATC units are experiencing the following conditions, there is probably a requirement for ATFM (not an exhaustive list):

- No ability to predict with accuracy the anticipated demand on resources
- No common situational awareness with other stakeholders
- Unmanageable peaks in traffic demand
- Excessive airborne holding/diversions
- Excessive speed control
- Extended downwind legs
- Military exercises impacting on normal operations
- High workload, stress, and fatigue consistently experienced by controllers (ATCOs)

1.2 Aviation System Block Upgrades (ASBU)

ICAO Document 9750 (Global Air Navigation Plan or GANP) is ICAO's plan addressing global air navigation. GANP presented the Aviation System Block Upgrades (ASBU) methodology to achieve global ATM interoperability and harmonisation. ATFM is expressed as a "network operation" (or NOPS) in ASBUs and an important capability to be implemented where it is needed. ASBUs Block 0 (the initial set of capabilities matured to be implemented since 2013) describes NOPS Block 0 capabilities as:

- Sharing prediction of traffic load for next day
- Proposing alternative routings to avoid or minimise ATFM delays.

The ASBU NOPS description then expands to include more complex ATFM techniques such as user-driven prioritisation of ATFM solutions (Block 1, 2019), SWIM-based collaborative decision making (Block 2, 2025) and eventually towards full complexity management under the rich information environment of a system-wide information management (SWIM) -based ATM (Block 3, 2031+).

In addition to ASBU NOPS, ASBUs consist of airport collaborative decision making (A-CDM) that is the beginning and end portion of flight paths in the scope of ATFM. ACDM Block 0 capabilities are described as:

- Sharing of surface operations information amongst airport operator, aircraft operator, and ANSP systems
- Collaboratively managing departure queue.

2 Developing a Concept of Operations

An ATFM/CDM assessment is a service designed to ascertain the degree to which existing ATFM procedures and processes provide safe, orderly and expeditious flow of air traffic. A significant part of the service involves comparing existing ATFM practices to the principles outlined in the ICAO *Manual on Collaborative Air Traffic Flow Management* (Doc 9971) but it is also customised to the ANSP's needs and challenges.

Meeting the challenge of growing demand must be a priority for ANSPs and stakeholders. ANSPs continuously analyse their operations and identify when ATFM actions are required and if so, which concept (see those described in this document) should be applied. Use of CDM principles is most effective since the ANSP will have engaged all stakeholders before commencing with an ATFM plan. Should a State not have requirements for ATFM, it is expected to support other States that are implementing ATFM/CDM by adhering to agreed regional procedures. Cooperation and collaboration between all stakeholders in the region will ensure successful implementation of ATFM/CDM in the region.

Once the ATFM/CDM implementation requirements are established, the ANSP will need to develop a concept of operations (ConOps) for its area of responsibility. This ConOps could be limited to one measure or a combination of the ATFM/CDM measures described in the following sections.

2.1. Domestic ATFM

The State may identify a required number of domestic flights to make domestic ATFM effective without including regional and international flights. Experience by ANSPs and researched carried out by Civil Aviation Authority Singapore during the regional concept of operations development has shown that ideally 70% or greater participation by available flights in an ATFM programme, such as a ground delay programme (GDP), is required to gain operational and efficiency benefits. Should there be less than 70% participation, the

participating aircraft could be subjected to unfair and inequitable delays since they would be the only flights being subject to delays. In this chosen option, only domestic flights will be subjected to ATFM measures; regional and international flights may be exempt. While a State may have enough domestic flights for ATFM to be implemented, it is advisable that a concept including regional and international flights is considered to ensure the distribution of delay is equitable, and efficient. Most countries that have implemented a domestic ATFM solution recognise the benefits of including regional and international traffic into their programme and are working towards including all traffic.

2.1.1 Key Components of the Domestic ATFM/CDM Concept

- ANSP independently manages demand/capacity of its own airport and airspaces.
- Only domestic traffic is subject to ATFM measures.
- ANSP and stakeholders have the means to communicate and collaborate consistently throughout the ATFM execution.
- CDM is performed by stakeholders via various communication methods.
- Accurate demand prediction can be done either using flight progress via manual input or via an automated data feed such as a flight data processing system (FDP), aeronautical fixed telecommunication network (ATFN), or space-based ADS-B.
- Capacity can be determined by inputs from flow management positions (FMP) or the flight operations centre (FOC) via an ATFM web-based interface.
- Domestic aircraft operators manage the ATFM measure delay assigned to flights.
- ATFM measure(s) assigned, such as GDP slots or calculated take-off time (CTOT) should be easily accessible by stakeholders with appropriate notifications which could include, but is not limited to, Internet-enabled software tools such as web browsers, mobile applications, notifications and digital avionics.

2.2. Cross Border ATFM

Should an ANSP require flights from adjoining States to be included in an ATFM measure this will indicate that a cross border ATFM ConOps is required. It is not envisaged any State will implement cross border regional ATFM/CDM ConOps in isolation.

Key components of the cross border regional ATFM/CDM ConOps include the following:

2.2.1. Key components of Cross Border ATFM

- Regional acceptance of a regional concept of operations
 - o Stakeholders agree to the adoption of a regional ConOps irrespective of a ConOps adopted in their area of jurisdiction.
 - o States commit to planning and allocating resources for cross-border ATFM/CDM implementation.
 - o Impacted ANSPs, airport operators, and aircraft operators agree a common set of procedures for all.
 - o Maintain continued education of all stakeholders of the benefits, both qualitative and quantitative, of ATFM/CDM implementation.
- Cross Border Regional ATFM ConOps
 - o The ANSP has an independent ATFM System.
 - o An ANSP implements ATFM even though surrounding States have not done so.
 - o An ANSP independently manages demand/capacity of its own resources.
 - o Target to achieve 70% flight participation, regional, international, and possibly airborne flights are required to be included in ATFM measures.
 - o ANSPs agree to having flights depart from their airspace to an adjacent ANSP's airspace with cross border regional ATFM ConOps operating to respect ATFM measures issued such as calculated take-off time (CTOT) or calculated time-over (CTO).
 - o ANSPs, airport operators, and aircraft operators should agree a common set of procedures for departure, destination, and en-route.
- o Participating ANSPs are to initiate the effort to build their individual capabilities and practice ATFM in accordance with ICAO guidance to provide an ATFM service.
- o Participating stakeholders should be connected via information sharing network, e.g. Internet interfaces or SWIM-based communication network
- o Maintain continued education of all Stakeholders of the benefits both qualitative and quantitative of ATFM/CDM implementation.
- o Accurate prediction can be done either using flight progress via manual input or via an automated data feed such as an FDP, or space-based ADS-B.
- o ATFM measure(s) assigned such as GDP slots (calculated take-off time - CTOT) should be easily accessible by stakeholders with appropriate notifications which could include, but is not limited to Internet-enabled software tools such as web browsers, mobile applications, notifications and digital avionics.
- o Aircraft operators manage the ATFM measures delay assigned to flights.
- o Aircraft operators perform CDM with airport operators for ground/surface delay intent.

In addition to including airborne and international flights into ATFM measures, a regional concept has a future enhancement within which aircraft operators may specify their assigned programme delay to various stages of the flights; gate, surface (between gate and departure), or enroute. This ability for aircraft operators to specify their delay intent gives additional operational flexibility to achieve the same result.

2.3. Cross Border Multi-Nodal Regional ATFM/CDM

A State/ANSP implements and operates an ATFM system based on the application of remote CTOT delivery impacting multiple flight information regions (FIRs)/ sectors of airspace or airports coordinated via one single node within the country, illustrated below.

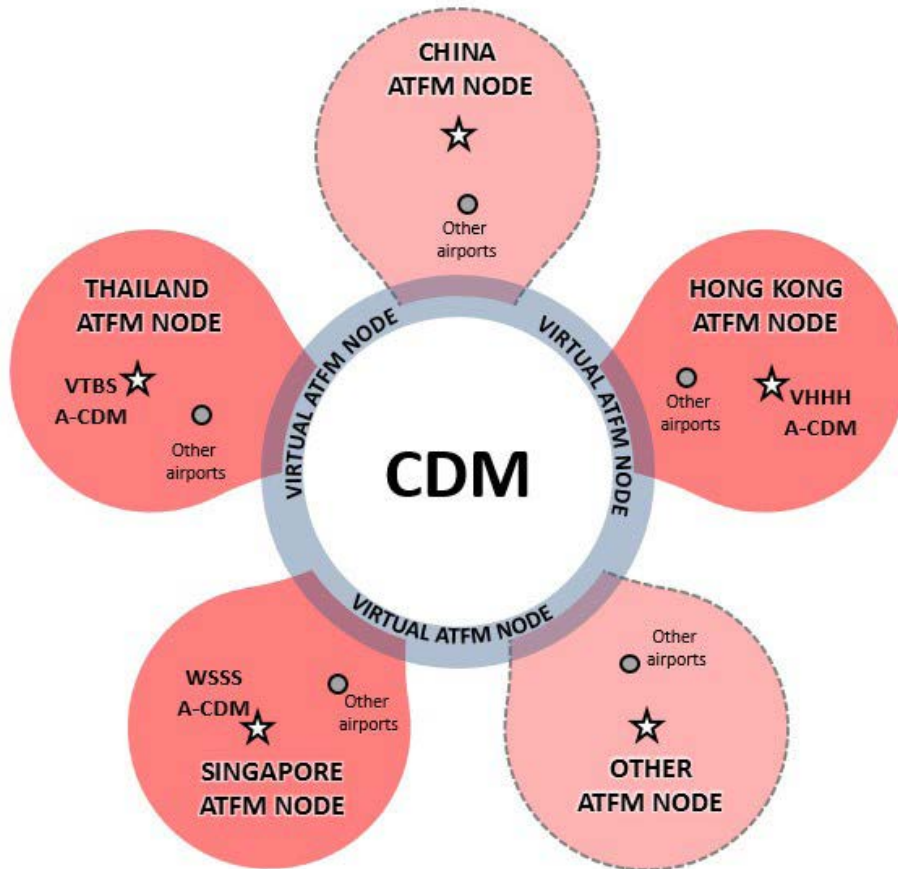


Figure 1 - Distributed Multi-Nodal ATFM Network Concept

In this concept, each ANSP operates an independent, virtual ATFM/CDM node, this is to say, it is responsible for ATFM/CDM within its area of responsibility. However, they are supported by an interconnected information-sharing framework. The flows of air traffic will then be effectively managed based on a common set of principles agreed among the participating ANSPs and airports. A node comprising the ANSP and associated airports will be able to manage the demand and capacity through adjustments in aircraft calculated landing times (CLDTs), which will in turn generate CTOTs for particular aircraft at the departure airport.

An ANSP performs demand and capacity balancing within its own area of authority and where ATFM measures require participation of regional and international flights, the flows will be managed by the agreed coordination procedures.

2.3.1. Key Components of the Cross-Border Multi-Nodal Regional Concepts

The concept of multi-nodal regional ATFM/CDM is being explored by States / ANSPs in Asia Pacific. Thus this section should be read in conjunction with Asia/Pacific Regional ATFM Concept of Operations and Asia/Pacific Framework for Collaborative ATFM. The two documents provide in-depth background to the concept. A case study on the implementation is in Appendix 4 of this document. The key components of the cross-border multi-nodal regional concept are as follows:

- Multi-nodal stakeholders are interconnected via a virtual communication framework
 - o Each ANSP has an independent ATFM system.
 - o Each ANSP independently manages demand/capacity of its own airport(s).
 - o There is a common agreement to share

- essential data for ATFM by all multi-nodal stakeholders.
- o Stakeholders and ANSPs in the network communicate via agreed / established communication network.
- o There is harmonised and integrated data exchange between all stakeholders in the multi-nodal network.
- o Accurate prediction can be done either using flight progress via manual input or via an automated data feed such as flight data processing system (FDP), aeronautical fixed telecommunication network (ATFN), or space-based ADS-B.
- o Capacity can be determined by inputs from flow management positions (FMP) or the flight operations centre (FOC) via an ATFM web-based interface. Aircraft operators manage the ATFM measures delay assigned to flights.
- o Aircraft operators perform CDM with airport operators for ground/surface delay intent.
- o ATFM measure(s) assigned such as GDP slots (CTOT) should be easily accessible by stakeholders with appropriate notifications which could include, but are not limited to, Internet-enabled software tools such as web browsers, mobile apps, notifications and digital avionics

3

Resource (Airport/Airspace) Capacity Enhancement

The actual operational capacity of an ATM resource (e.g. airport or sector of airspace) is determined by baseline (declared capacity) and dynamic factors. Baseline airport and airspace capacities are determined through capacity assessment process, which analyses – among other things – airport parking capacity, terminal building capacity, ATS operational procedure, static infrastructure such as navigation aids and surveillance systems, and airspace/route complexity. The dynamic factors deal mainly with tactical issues such as meteorological conditions, CNS and ATC equipment status, fleet mix, military operations, actual traffic complexity and staffing.

The evaluation of initiatives aiming at improving the declared capacity of an ATM system might be considered an integral part of the ATM planning phase of the air traffic flow management (ATFM) process. Initiatives that can contribute to the improvement of the declared capacity range from the redesigning of airspace/airport layout to the modernisation of ATC procedures and automation tools.

The ATFM execution phase deals with the actual operational capacity and hence an ATFM platform should be designed to cope with its dynamic factors. During the ATFM execution phase, the operational capacity can be influenced by adopting initiatives such as modifying the sectors' arrangement or opening additional runways for the prevailing type of operations.

This chapter provides a non-exhaustive list of initiatives that can contribute to improving declared capacity and enhancing the robustness of the ATM system against the adverse effect of the dynamic factors.

3.1. Initiatives to Improve Declared Airspace Capacity

This section of the document deals with techniques that may be considered to improve airspace capacity, mainly focusing on emerging new concepts.

3.1.1. Routes Network Design

The en-route and terminal manoeuvring area (TMA) routes network should be designed to fit several factors such as traffic complexity, operational procedures, performance-based navigation (PBN) operations, ATC sectors' design and joint management of traffic volume with adjacent ATC units.

Besides the traditional design methods, relatively new concepts are emerging which aim to improve airspace capacity. These include:

- Delegation of airspace and sectors across FIRs: delegating the provision of ATS services of portions of national airspace to an adjacent ATC unit can bring advantages under specific operational conditions. For example, overflying traffic along a national border may exit and then re-enter the FIR. The airspace delegation can smooth the services for "re-entering" flights by managing them as a single overflight.
- Free-route airspace (FRA): some ANSPs have started operating FRA within specific time frames and above a given flight level. During that period the route network is retained, but its use is not mandatory. During the FRA operating hours, aircraft operators may plan a user-defined trajectory from FRA entry to FRA exit points with the optional use of one or more intermediate points. Cross-border FRA operations to/from adjacent FIRs are also planned.
- Point merge system (PMS) and trombones: today at many airports, the sequencing on final approach is achieved by vectoring aircraft onto the ILS. Although this enables flexibility and maximises runway throughput, it results in significant dispersion at low altitude with potentially long level-offs, heavy controller workload and radio communications, and limited pilot situation awareness in a critical phase of flight. In some cases, this may also lead to ILS interception in non-standard conditions and even to separation minima infringements in case of parallel approaches. The PMS technique aims primarily to improve the final part, in

particular securing ILS interception even under high traffic conditions, as well as optimising descents, reducing workload and improving communications. It does so by utilising a common merge point and several predefined legs, each equidistant from the merge point. The legs are used for path stretching or shortening in order to smooth peak load (simultaneous arrivals) upstream of the individual legs.

3.1.2. Sectors Design

The number of operable sectors, along with their shapes and vertical separations, strongly affect the capacity of the ATM system. Besides the delegation concept, another smart technique to make the sectors' arrangement adaptable to actual traffic complexity is dynamic, vertical, and horizontal shaping (dynamic airspace sectorisation). Sectors can be vertically split, using one or more division flight levels. Division flight levels are dynamically changed throughout the day to best respond to prevailing operational conditions. This technique also employs dynamic virtual volumes, sectors that never exist on their own, but are dynamically attached to one of the adjacent sectors in order to modify "on-the-fly" the sector shape (and hence capacity) in accordance with traffic flows, moving weather or other dynamic factors.

3.1.3. ATC Staff

When redefining airspace design and operational procedures, considering the human factors is important. Proper training of controllers is crucial to get the maximum benefit from a renewed working environment.

Another essential aspect is defining controllers' operational roles and their mutual interactions. For instance, assigning a dedicated role for coordinating the arrival flow in complex TMA environments can significantly smooth the traffic flow. Another example could be the adoption of multi-sector planner/coordinator roles for groups of sectors.

3.1.4. ATC Procedures

One of the key factors contributing to the improvement of ATM system capacity is an effective definition of ATC procedures.

Some examples of ATC procedures that, if properly tailored, can enhance airspace capacity are:

- Wake turbulence grouping (WTG): if arrivals and departures are sequenced according to wake turbulence category, the additional separation behind heavier aircraft can be avoided, enabling higher throughput. This technique is particularly effective when used for traffic approaching a runway dedicated exclusively for either take-off or landing traffic, or during peak periods of arrivals to a runway used for mixed mode (arrival and departure) operations.
- Runway optimisation: in cases of mixed mode runway operations, giving priority to departures or arrivals, depending on demand during a given peak, can maximise the utilisation of the runway.
- Minimum authorised spacing: applying the minimum authorised spacing between aircraft on final approach will ensure that capacity is not wasted. In order to consistently achieve minimum spacing, the runway mode of operation and the prevailing traffic must be taken into account. For example, in mixed mode operations, the wake vortex of departing aircraft need not be factored in when there is a gap in departures while minimum spacing based on radar surveillance, consistent with the wake turbulence category of subsequent aircraft, can be maintained at all times for arrival only runways. Communicating rapid exit taxiway (RET) numbers and positioning during the final approach supports reduced separations as well.
- Time-based separation on final approach: under historical final approach systems of fixed-distance separation, aircraft groundspeed drops when headwinds increase, reducing the landing rate – which in turn leads to extended airborne holding and increased delays. Time-based separation dynamically adjusts the separation between arrivals, maintaining the time separation

between aircraft at a constant equivalent to the distance separation required and in doing so, safely reduces approach separation to recover most of the capacity otherwise lost during strong headwind conditions.

- **Speed control:** speed control is essential for the optimum use of the runway and available airspace, as well as to enable terminal area and aerodrome controllers to accurately assess the intervals between aircraft. Use of standard speeds aids efficiency and removes unpredictability for both pilot and controllers. The use of speed control is related to aircraft performance and must have a policy to support this initiative. Poor performing aircraft should be operated outside peak periods of traffic.
- **Flight specific arrival runways:** assigning a specific runway according to the parking stand position or to the airline preferences can significantly smooth the subsequent ground movement once the flight lands. However, this initiative can complicate managing traffic while airborne and the initiative or measures which have the overall best effect on capacity should be used.
- **Aircraft-specific standard instrument departures (SIDs):** instructing departing aircraft to turn away from runway heading as soon as possible after take-off allows the number of subsequent departures in a given period of time to be maximised. Standard instrument departures should be designed with tracks diverging as soon as possible after departure. SIDs may be developed for aircraft meeting specified noise level requirements and/or light aircraft, facilitating their speedy departure. These may be used in conjunction with early turn departure and visual separation techniques.

3.1.5. Military Operations

The ANSP and the military authority should agree procedures and airspace usage. It is recommended to keep most of the military training activities within the limits of temporary segregated areas (TSA) and temporary restricted areas (TRA). This would allow proper activation planning and distribution

of advance information daily. Non-aviation military activities should take place in published danger areas, rarely affecting civil traffic flows. It is also recommended to apply the flexible use of airspace (FUA) concept, thus allowing preparation of a daily airspace use plan at pre-tactical level. The actual activation and deactivation of areas is then done on the day of operations at tactical level. Besides the permanent routes, several conditional routes should be defined to be managed in daily plans whenever there is a military exercise within danger areas.

3.1.6. ATM Automation System

The ATM automation system, when designed to support the specific ANSP concept of operations can significantly improve overall capacity. For instance, adopting any tool that reduces the controller's workload would improve the sector's capacity. The ATM automation system should also support a comprehensive exchange of information both among its internal components and to/from external entities.

For instance:

- Arrival manager (AMAN) and departure manager (DMAN) should support balancing among available runways and dynamic prioritisation among arrival and departure operations
- Multiple delays may be imposed on a flight at various stages by ATFM, ATM or its AMAN and DMAN components. ATFM and ATM should synchronise to ensure that a flight that was delayed earlier is not subject to further penalties
- The ATM system should be an integral part to the A-CDM milestone-based process
- The ATFM system should support the exchange of data with other multi-nodal flow management units and participate in the A-CDM information exchange as well
- The ATM system and the ATFM system should support the management of FUAs, CDR, TRAs, TSAs according to planned and unplanned military operations

Comprehensive and modern surveillance coverage of the whole controlled airspace is fundamental to improving the overall ATM operational capacity.

3.2. Initiatives to optimise Declared Airport Capacity

This section provides a non-exhaustive list of some techniques that may be considered to optimise airport capacity.

3.2.1. Runways and Taxiways Design

The following factors can be considered the most important for determining runway capacity which strongly influences overall airport capacity:

- Number and geometric layout of runways
- Separation requirements between aircraft imposed by the ATM system
- Mix of movements using the runway (arrivals only, departures only or mixed), sequencing of movements as well as traffic type
- Type and location of taxiway exits from the runway(s).

Building a new runway, when properly located with respect to the others (length, distance and direction) can significantly improve overall airport capacity. It can for instance enable simultaneous parallel approaches or departures, significantly improving overall capacity.

Since building a new runway has strong economic and operational impacts, other initiatives can be adopted to reduce runway occupancy time (ROT) and the holding time to access the runway, thus increasing the runway acceptance rate:

- Rapid exit taxiways (RETs) and rapid access taxiways (RATs) contribute to reduce ROT
- Multiple line-up aprons reduce holding time to access the runway
- Bypass taxiways lead to substantial capacity and safety gains as runway crossings are reduced

Improved navigational aids such as ILS systems, runway/taxiway lighting, and high-fidelity weather reporting systems can also increase an airport acceptance rate especially during low visibility procedures. All must be part of a collaborative plan to match design to the performance of the aircraft and pilots which compose the expected traffic mix.

3.2.2. Parking Stands and Holding Bays

Parking stands should be designed to minimise a cul-de-sac effect. When an aircraft moves away from a parking stand in a cul-de-sac area, other aircraft, even if ready to move, should wait until the area has been vacated. When aircraft are held on the parking stand a 'domino effect' on congestion can occur as traffic must wait for other traffic to clear, resulting in late stand changes for subsequent inbound aircraft. Freeing stands and using remote holding areas removes a 'bottleneck'. Remote holding areas are intended to allow freedom of movement on surface areas, runways and taxiways.

Departure capacity can be substantially improved through the adoption of holding bays. These are areas where aircraft can be held or bypassed. Holding bays are useful for last minute changes to the departure sequence whether initiated by ATC or the pilot.

3.2.3. Air Traffic Controller Factors

When redefining operational procedures, of equal importance to the technical design is the human element. Proper training and buy-in of controllers is crucial to benefit from a transformed working environment. Another essential aspect is the clear definition of controllers' operational roles and interactions. For instance, the use of a handoff or coordinator/watch manager provides greater situational awareness in the operational environment.

3.2.4. ATC Airport Procedures

One of the key factors to improve ATM system capacity is an effective understanding of the ATC procedures being utilised.

In addition to the examples above, properly applied ATC procedures that can enhance overall ATM capacity include:

- Pilot reaction time monitoring: continued monitoring of pilot reaction times (e.g. time it takes for a pilot to commence take off roll after being issued take off clearance).
- Early clearances: issuing the line-up and take-off clearance as early as possible, prompting

pilots to complete all necessary checks and move from the taxiway to the runway without stopping. Pilots should complete as many take off checks as possible to prepare for departure once line-up is authorised.

- Conditional clearances: this technique expedites traffic by allowing pilots to proceed immediately after the restricting condition has been satisfied. For example, an aircraft can be issued with a runway line-up, entry or crossing clearance that is conditional upon one other movement, be that a taxiing, landing or a departing aircraft/vehicle.
- CTOT compliance: early or late starts should be avoided (no preferential treatment). Controllers should never issue start-up clearance unless they are certain that the aircraft can make the departure slot time (CTOT).
- Enhance runway efficiency: intermediate holding points along the taxi path to the runway allows controllers to set a proper sequence, and can also be used to expedite matters when there is a possibility that an aircraft may miss its CTOT. The sequence of aircraft at the runway holding points should take into consideration wake vortex categories, aircraft speed and SIDs. These procedures must be supported by the slot process. The Multiple line-ups procedure ensures that an aircraft will be fully lined-up and ready to depart as soon as the take-off clearance is given. Aircraft with limited performance characteristics may be limited during peak periods.
- Enhance taxiway efficiency: where the taxiway infrastructure allows, a one-way traffic flow should be introduced. This makes taxi orientation better organised, safer and provides a consistent flow of traffic. Intersection departures have the potential to decrease taxi times and improve management of the departure sequence. Obliquely angled taxiways that limit the ability of the flight crew to see the runway threshold/final approach area should be avoided when using this procedure. Assigning a specific runway according to the parking stand position or to the airline preferences can significantly smooth ground movements.

3.3. ATC Automation Systems

The ATC automation system, when designed to support a specific ANSP concept of operations, can significantly contribute to overall capacity. For instance, adopting any tool that reduces controller workload, during any phase of flight, would likely result in an improvement of efficiency. The ATC automation system should also support a comprehensive exchange of information among all stakeholders. Listed below are some examples of supporting tools that help improve airport capacity.

3.3.1. Situational Awareness Enhancement

Implementing a ground surveillance programme and equipping all vehicles with 'transponders' significantly enhances the airport's situational awareness.

Comprehensive surveillance, in conjunction with a surface conflict detection tool, significantly improves airport capacity as controllers can focus on tasks related to the efficiency of ground movements.

3.3.2. Departure Management (DMAN)

DMAN is a key automation element to enhance airport capacity. It can contribute to:

- Creating a pre-departure sequence and optimising the runway departure sequence
- Balancing departing traffic among available runways
- Prioritising arrival and departure operations, in conjunction with AMAN, according to the actual traffic demand (pack and gap procedure)
- Participating in the A-CDM process by sharing milestone-related schedules (e.g. TSAT, TTOT), according to external planning (e.g. TOBT, CTOT)

3.3.3. Route Planning and Monitoring

For airports that have complex layouts and manage large traffic volumes, it is beneficial to implement automated solutions. The system can suggest optimised routes from gate to runway and vice versa. This feature also facilitates proactive planning of taxiway exits and routes prior to departure. The

system can also include a monitoring function to check adherence between planned and actual routes.

3.3.4. Communication and Information Transmission

The automation system should be designed to support comprehensive information-sharing according to the local implementation of the A-CDM process.

The adoption of CPDLC (controller-pilot data link communications) reduces verbal communication between ATC and pilots, improves awareness, almost eliminates misunderstanding of control instructions, all while improving safety and capacity.

Lighting guidance systems and stop-bar control systems are also effective means to improve airport efficiency in complex environments. This solution optimises traffic movement in low visibility conditions.

3.3.5. Turnaround Process Optimisation

The tracking and management of ramp equipment and vehicles can also result in improved apron operations e.g. reduction of turn-around times.

Specific tools can be adopted to support:

- Planning and monitoring of ramp activities
- Planning and monitoring of human resources tasked to the turnaround process
- Planning and monitoring of vehicles supporting ramp activities
- Message exchanging with operators
- Information sharing in the A-CDM environment

4

Determination of Capacity – Nominal/Dynamic

Capacity determination or declaration occurs in two areas: at airports where arrival and departure capacity is defined; and in airborne airspace. Additionally there is a nominal or baseline capacity which is determined assuming ideal conditions and then a real-time dynamic capacity that reflects weather, construction, staffing and other constraints that are of a temporary nature.

4.1. Airport Nominal Capacity

Many airports have multiple runway configurations and a capacity determination should be made for each configuration. The basic underlying principle is runway occupancy time. The presence or absence of high speed taxiways, intersecting runways, runways that are acceptable to certain types of aircraft due to runway length and complexity of surface operations are all factors that influence the declared airport arrival and departure capacity. This nominal capacity consideration should be used for long term strategic planning and as a baseline for the airport dynamic capacity.

4.2. Airport Dynamic Capacity

Many factors influence the actual real time airport capacity such as weather, winds, construction projects, equipment outages, fleet mix, winter weather operations, and availability of both ATC and service personnel. This airport capacity must be accurately evaluated and communicated to the ATFM system by ATC, airport authorities, and stakeholders so effective ATFM measures can be implemented. There are decision support tools which are able to take many of the above factors into consideration and show an indicative dynamic capacity.

4.3. Airspace Nominal Capacity

The nominal capacity for flights that can transit a defined area is determined by a number of factors including:

- Type of surveillance used
- Type of communication used
- Equipage of aircraft
- Airspace design
- Type of operation

One approach to determining capacity is the average time of aircraft in a sector. Once the average time in a sector is known, the average time a controller dedicates to each aircraft is determined. Multiplying the average time spent per flight by the number of flights allows a calculation of capacity.

Another, more sophisticated method is to take a years' worth of operational data and divide the type of operation up into various categories:

- Cruise operation with low separation assurance duties (parallel traffic with altitude separation)
- Cruise operation with high separation assurance duties (crossing traffic)
- Transitioning traffic with low and high separation assurance duties (arrival and departure traffic)
- Delay inducing traffic (airborne holding).

Once the ratio of each type of operation is established for each sector, and the average workload for each type of operation is assigned, capacity for each unique sector can be calculated.

4.4. Airspace Dynamic Capacity

Working from the baseline of nominal airspace capacity, dynamic adjustments take into account various factors such as impacts from the following:

- Convective weather
- Turbulence
- Equipment outages
- Special/flexible use airspace
- Staffing

There are decision support tools which are able to take many of the above factors into consideration and show an indicative dynamic capacity.

5

ATFM Timeline

The following charts and diagrams define and depict the ATFM operational phases, and contrasts the roles of ATC and ATFM.


5.1. ATC and ATFM Definitions

ATC and ATFM Definitions	
Air Traffic Control (ATC)	Air Traffic Flow Management (ATFM)
Air Traffic Control is a service provided by ground-based controllers who direct aircraft on the ground and through controlled airspace, and can provide advisory services to aircraft in non-controlled airspace. The primary purpose of ATC worldwide is to prevent collisions, organise and expedite the flow of air traffic, and provide information and other support for pilots.	ATFM has the objective of contributing to a safe, orderly and expeditious flow of air traffic by ensuring that air traffic control capacity is utilised to the maximum extent possible and that the traffic volume is compatible with the capacities declared by the appropriate air traffic services authority". (ICAO Annex 11 Chapter 1)

5.2. ATFM Objectives

ATFM Objectives		
Balance demand with available capacity in airspace and at airports		
ATFM Activities	ATFM Solutions	Tactical ATC Procedures
Activities or procedures to support ATFM Measures and ATC Procedures <ul style="list-style-type: none"> • Daily planning meetings • CDM Meetings 	Procedures to ensure demand does not exceed capacity Capacity optimisation ATFM Measures <ul style="list-style-type: none"> • MIT, MINIT • GDP, AFP • GS • Time based metering • Level capping • Fix balancing 	Procedures to separate or sequence traffic <ul style="list-style-type: none"> • Radar vectors • Speed control • Airborne holding
Decision Support Tools		
Systems or tools that support ATFM activities and solutions as well as ATC procedures		

5.3. ATFM Operational Phases

ATFM Operational Phases					
Five ATFM Operational Phases					
Time 					
	ATM Planning	Strategic	Pre-Tactical	Tactical	Post Operations
Time Frame	Continual	Six month to two days prior	One day prior	Day of operation	Subsequent to operations
ATFM Role	Strategic long term planning	Demand capacity planning	ATFM daily coordination and next day planning	Tactical ATFM	Post-operation analysis
ATC Role	Improve procedures, sectorisation, staffing, technologies	Event planning, technology training and implementation	Input on staffing, equipment outage, weather impacts	Input as capacity changes, ensure safety	Input on results of demand capacity balance plan

5.3.1. ATM Planning



Infrastructure	Staffing	Airspace and Procedures
Organisational Structure <ul style="list-style-type: none"> • Develop concept of operations • Airspace infrastructure • Technical infrastructure • ATM procedures • Staffing practices • Training 	Employment and Training <ul style="list-style-type: none"> • Appropriate staffing levels • Develop staff practices 	Develop and implement organisational structure in both ATC and ATFM <ul style="list-style-type: none"> • Airspace design • STAR, departure point (DP) • PBN • Standard operating procedures

5.3.2. Strategic



Airport Slot	Capacity Growth	Major Event Planning	FUA/SUA Facilitation
<ul style="list-style-type: none"> Allocate airport slots based on capacity of airport IATA World Scheduling Guidelines 	<ul style="list-style-type: none"> Activities involved in capacity enhancement and optimisation 	<ul style="list-style-type: none"> Planning for events expected to impact demand or capacity Plan for significant weather events Collaborate with stakeholders 	<ul style="list-style-type: none"> Facilitate flexible use of special use airspace Engage airspace users (AUs)

5.3.3. Pre-Tactical



Constraints, Capacity, Demands	Potential Demand/ Capacity Issues and Solutions	Develop Plan	CDM Collaboration
<ul style="list-style-type: none"> Consider weather and system constraints Determine capacity and resources Assess demand 	<ul style="list-style-type: none"> Evaluate demand capacity balance requirements Assess potential solutions or traffic management measures 	<ul style="list-style-type: none"> Develop and document constraints and mitigations in daily plan 	<ul style="list-style-type: none"> Conduct CDM teleconferences with stakeholders All stakeholders commence optimising operations through CDM

5.3.4. Tactical



Demand	Capacity	CDM	ATFM Measure
<ul style="list-style-type: none"> Scheduled operations On-demand operations 	<ul style="list-style-type: none"> Weather <ul style="list-style-type: none"> Snow clearing De-icing Convective thunderstorms Equipment <ul style="list-style-type: none"> Outages New technology New procedures Implementation Staffing 	<ul style="list-style-type: none"> Collaborate on which ATFM solution (capacity optimisation or ATFM measure) to implement and timing 	<ul style="list-style-type: none"> Departure manager Arrival manager Capping/tunnelling MIT/MINIT GS/GDP/AFP Fix balancing Holding Required routes Time-based metering

5.3.5. Post Ops



Impact	Compliance	Effectiveness	Benefit Analysis	Lessons Learned
<ul style="list-style-type: none"> Evaluate the impact of ATFM programme(s) on stakeholders (e.g. participation, ATFM delay analysis) 	<ul style="list-style-type: none"> Evaluate compliance with ATFM measures 	<ul style="list-style-type: none"> Measure key performance metrics to determine effectiveness of ATFM measures 	<ul style="list-style-type: none"> Determine delay savings, on-time performance, environmental impact 	<ul style="list-style-type: none"> Formulate lessons learned from what worked and what did not Data patterns over time should drive changes to procedures, sectorisation, technologies or concept of operations

6

Classification of ATFM Solutions

When demand exceeds capacity at a resource, whether it is at an airport or within a given airspace, a solution needs to be found to correct the imbalance. Traffic managers and stakeholders should adopt the least restrictive mitigation and exit strategy for the situation. Typically, ATFM solutions can be categorised into capacity optimisation and ATFM measures. An explanation will follow each solution.

6.1. Capacity Optimisation

Capacity optimisation is the process of identifying additional capacity to meet the demand placed on the resource; usually by doing this, little or no impact is borne by the airspaces users. Typical capacity optimisations used in ATFM are as follows.

6.1.1. Sectorisation

Should it be identified that demand is going to exceed capacity in a particular sector of airspace, active measures such as splitting the sector into two or more sectors or changing the configuration of the sector to spread the demand may be warranted.

6.1.2. Flexible Usage of Airspace

Flexible usage of airspace is one of the most effective ways of increasing capacity. Should demand exceed capacity, CDM discussions should take place with authorities which "own" danger, restricted and/or prohibited airspace. This is typically the military or recreational airspace users. By negotiating the use of this airspace during peak demand, additional routings or vertical airspace can be affected and sectors can be amended to facilitate optimisation of airspace.

6.1.3. Balancing Arrival and Departure Capacity

At airports where one runway is used for arrivals and another for departures (segregated mode), advance planning and facility directives should dictate establishment of a "shared" use runway.

This mixed mode operation can significantly increase airport capacity and minimise delay.

6.1.4. Staff Optimisation

Additional ATC operational staff can be appointed to assist a controller should demand exceed capacity. For example, an executive controller can be appointed to a sector to assist with coordination, clearance creation and delivery.

6.2 ATFM Measures

ATFM mitigation strategies, when needed, are necessary measures for managing the flow of air traffic. Use of ATFM initiatives is considered based on both the level of intervention needed and the impact on stakeholders. The measures should only be implemented when other solutions to optimise the capacity of a resource have been exhausted. An explanation and recommendation for when each ATFM measure should be implemented is given below.

6.2.1. Minutes-in-Trail (MINIT) and Miles-in-Trail (MIT)

MINIT and MIT are tactical ATFM measures expressed as the number of minutes or miles between successive aircraft at an airspace or airport boundary point. If MINIT or MIT are consistently implemented for extended periods of time to manage a particular flow of traffic, it could indicate that a more restrictive ATFM measure should be implemented or a capacity optimisation analysis should be conducted.

6.2.2. Minimum Departure Intervals (MDIs)

MDIs are tactical ATFM measure applied by setting a MINIT or MIT rate to departure flow. They are typically applied for short periods when a departure sector becomes excessively busy, when sector capacity is suddenly reduced (e.g., equipment failure, meteorological conditions), or to support a short-term demand capacity imbalance. MDI is

useful when the traffic to be managed all depart from the same origin.

6.2.3 Rerouting

Route-based ATFM measures (horizontal or vertical) aim to remove a number of flights scheduled to arrive at a constrained ATM resource. Reroutings are usually organised in scenarios and can be mandatory or advisory.

6.2.3.1 Mandatory Rerouting Scenarios

Mandatory diversion of flows to offload traffic from constrained areas:

- Ensure that aircraft operate along with a required flow of traffic
- Remain clear of constrained airspace
- Avoid areas of known meteorological conditions of such nature that aircraft have to avoid it.

6.2.5 Alternative or Advisory Routing Scenarios

Alternative routing scenarios are routes which are made available to airspace users on an optional basis to offload traffic from certain areas. It is important to note that where such “optional” routing scenarios are not taken up by airspace users, mandatory ATFM measures will normally be required.

6.2.3 Rerouting Scenarios Catalogue

The authors of the catalogue develop and compose a set of collaboratively developed, published, and pre-defined routes to address reoccurring route scenarios. The set of options is an assistance tool that allows efficient route coordination among all stakeholders during periods of system constraint.

6.2.7 Level Capping Scenarios

These scenarios are carried out by means of flight level restrictions limiting climbs or descents to avoid congested areas.

6.2.8 Fix Balancing

Fix balancing is a tactical ATFM measure usually applied during flight that aims to distribute demand and avoid holding and delays. The aircraft is assigned a different arrival or departure fix than the one indicated in the flight plan. Fix balancing can also be used during periods of convective meteorological conditions where a standard instrument arrival (STAR) or a standard instrument departure (SID) is unusable.

6.2.9 Ground Delay Programmes (GDP)

A ground delay programme is a pre-tactical or tactical ATFM measure used to manage capacity and demand in a volume of airspace or at an airport. Aircraft are issued departure times (ATC slots) which correspond to entry times at the constrained airspace or arrival time at the airport. A GDP aims to reduce costly airborne holding and tactical ATC actions (radar vectoring, speed control, etc.) by delivering a manageable flow to the point of constraint for the conditions. By transferring the delay time from the airborne phase of flight to the ground phase, safety and efficiency are increased. Modelling of GDPs and stakeholder consultation should take place prior to implementation as this ATFM measure can have a significant impact on stakeholder operations. Once a GDP is implemented continuous monitoring of the effectiveness of the GDP is critical. Air traffic managers should ensure that rates are appropriate for conditions. A good CDM process should be in place for distribution of slot times and to facilitate airspace user schedule optimisation through a substitution process.

6.2.10 Ground Stop (GSt)

GSt is an ATFM measure implemented when a severe unpredicted constraint is encountered in a sector of airspace or at an airport. This could be the result of an aircraft accident or significant CNS failure. Aircraft may be held on the ground with the delay being undetermined until more information becomes available. Ground stops are usually followed by a GDP so as to manage flows of traffic during the recovery process back to normal operations.

6.3 ATFM Measure Selection Flowchart

Figure 2 shows the information to be taken into consideration in deciding whether an ATFM flow measure is required and the measure to be applied. The flow chart is divided into the two resources which are monitored during the ATFM process – airports and airspace. The flow chart will assist flow managers in their decision-making process to manage the resource with least effect on airspace users.

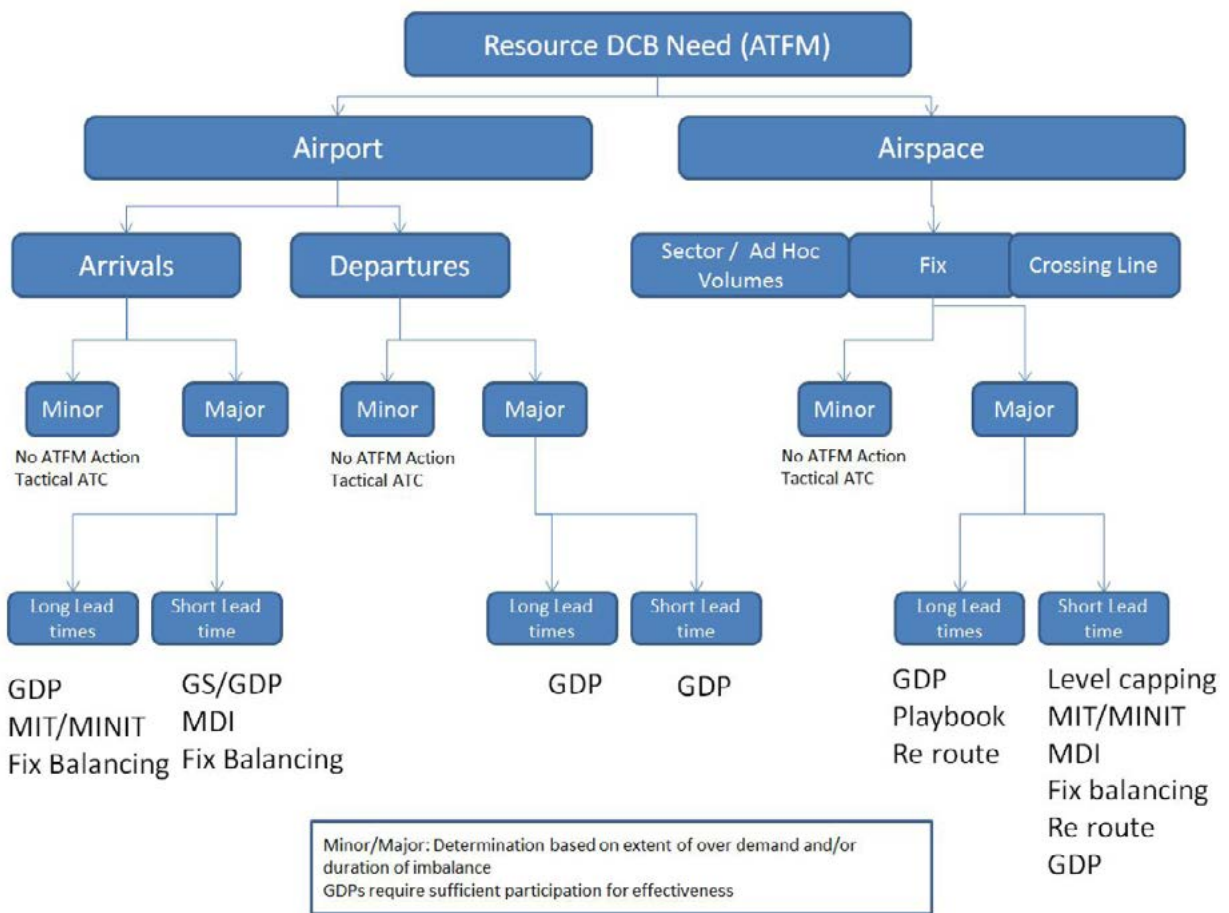


Figure 2 – ATFM Measure Selection Flow Chart

7 Roles and Responsibilities of Stakeholders

7.1. ATFM Unit (ATFMU) and flow management position (FMP)

The following charts and diagrams define and depict the roles and responsibilities of the various stakeholders in the ATFM process.



Gathering Information	ATFM Daily Plan	Demand and Capacity Balancing
<ul style="list-style-type: none"> • ATC Providers – domestic and regional • Airspace users • Weather • Military • Airport authorities 	<ul style="list-style-type: none"> • Create • Distribute • Execute • Amend 	<ul style="list-style-type: none"> • Monitor demand and capacity • Implement ATFM measures • Conduct teleconferences • Conduct post operational analysis

7.2. Airspace Users



Airline	Military	Business	Sport
<ul style="list-style-type: none"> • Participate in CDM • Airport slot • Aircraft utilisation • Update schedule • File RPLs • File FPLs • Update changes to flights • Participate in teleconferences • Communicate ATFM measures to relevant operational units, e.g. flight crews and flight operations 	<ul style="list-style-type: none"> • Military exercises • FUA CDM • VIP flight coordination 	<ul style="list-style-type: none"> • Participate in CDM • File FPLs • Update changes to flights • Participate in teleconferences • Communicate ATFM measures to relevant operational units, e.g. flight crews and flight operations 	<ul style="list-style-type: none"> • Air show coordination • FUA CDM

7.3. Air Traffic Control



ATC

- Participate in teleconferences
- Capacity declarations
 - o Nominal
 - o Dynamic
- Monitor resources
- Compliance with ATFM Measures
- Participate in post event analysis

7.4. Airport Authority



Airport Authority

- Participate in CDM
- Participate in teleconferences
- Capacity declarations
 - o Nominal
 - o Dynamic
- Schedules
- Maintenance / runway inspections
- Snow removal – de/anti icing
- Participate in post event analysis

7.5. Weather Services



Weather Services

- Participate in CDM
- Participate in teleconferences
- Create and disseminate
 - Terminal area forecasts
 - METARs
 - Long range forecasts
- Volcanic ash advisories
- Participate in post event analysis

8

CDM Process

Stakeholders should share accurate and up-to-date information in order to make more appropriate decisions. Air traffic managers should take all stakeholders requirements into consideration to further improve flight and airspace efficiency. Teleconferencing is a very effective way to do this and most ANSPs which have implemented ATFM have a process of teleconferencing. A description of teleconferencing follows. A description of various elements of CDM process is included in this section.

8.1. The ATFM Daily Plan

The ATFM daily plan (ADP) establishes the process, structure, and responsibilities for developing, managing, and implementing a plan for air traffic operations in the region. The ADP is a plan for the management of the region's airspace. The ADP should be a collaborative process including all stakeholders.

8.2. Use of ATFM CDM Teleconference

The ANSP, based on its concept of operations, should decide if/when to conduct ATFM teleconferences. In mature and large complex airspace environments, it could be necessary to conduct ad-hoc strategic and pre-tactical teleconferences in addition to scheduled teleconferences. In less busy regions, teleconferences can be held as infrequently as once a week. The operational requirement should drive the frequency of teleconferences.

8.3. Required Participants

Required participants are all ATFM units, area control centres (ACCs) not represented by an ATFM unit and any terminal manoeuvring area (TMA) or tower that may have significant constraints. Having an aviation weather service participating is highly recommended. Optional participants are airspace users (airlines, business, general, and sport

aviation), airport authorities, military organisations, and other aviation stakeholders.

8.4. Host: The Role of the Teleconference Host ATFMU

8.4.1 The Host Should in General

- Act as the chair of the meeting, setting the agenda and facilitating the teleconference
- Facilitate development of traffic management strategies and formulate the ADP
- Track teleconference participants
- Take notes
- Accept relevant information from others during the teleconference
- Develop a teleconference summary and issue an email containing the ADP

8.4.2. Pre-Teleconference

- Review the weather forecast products or inquire about weather information to meteorological service provider
- Obtain impacting conditions from the ACC and/or TMUs including:
 - Expected air traffic demand
 - Staffing
 - Combined sectors
 - Anticipated ATFM measures
 - Equipment issues / outages
 - Constraints /FUA (flexible use of airspace)/ other
- As needed, obtain input from the TMAs (terminal manoeuvring areas) / towers:
 - Current configuration and airport arrival rate (AAR)
 - Anticipated configuration and AAR
 - Local weather conditions
 - Constraints / other
- Miscellaneous:
 - VIP movements
 - Military activities

- o Special events / security events
- Check NOTAMs on key airports for runway closures, etc.
- Review ATFM measures
 - o Current
 - o Anticipated
 - o Triggering event *

* A triggering event is a specific event that causes an ATFM measure to be implemented. It is for planning purposes and is used to reduce coordination when an ATFM measure is needed. They can be identified in the ADP as "if ...then" statements.

8.4.3. In-Session Teleconference (Recording is Highly Recommended)

- Greeting and introductions
 - o Clearly state the teleconference time and covered period
 - o For example: 1415Z Telecom. Covering the timeframe from xxxx UTC to xxxx UTC

8.4.4. Current Situation

- Provide information on the general weather constraints
- Significant weather and atmospheric conditions.
 - o For example, thunderstorm activity, turbulence, volcanic ash plumes
- Tactical Updates
 - o A brief explanation of pertinent information, for example:
 - Current ATFM measures in place
 - Known current delays: facility/minutes of delay/reason

Note: This is general information. Discussion items will be addressed later in the body of the plan.

8.4.5. Discussion

- Provide brief overview of the topics that will be addressed
- There should be an established order (e.g. East to West flow, airports with initiatives, regional, etc.)
- TMA/tower
 - o Review of impacted airports, one at a time with input from each controlling facility
 - o Additional discussion from customers and overlying ACC as appropriate

- New TMA/tower ATFM measures added to the ADP in geographical order.
- Anticipated ATFM Solutions/measures – TMA/tower
 - o Expanded miles-in-trail
 - o Potential airborne holding
 - o Potential ground stops/GDPs
- En-route
 - o Sector capacities
 - o Constraints; weather, CNS outages
 - Provide an opportunity for discussion, as needed; start by asking affected ACCs
 - Provide an overview of routes already in place with associated end times
 - Identify any new routing concerns.
 - Provide an opportunity for discussion, as needed; start by asking affected ACCs
 - o Anticipated ATFM solutions/measures
 - Expanded miles-in-trail or minutes-in-trail
 - Potential delays
 - Airspace flow programmes
 - o Additions to the ADP, including any pertinent tactical updates
- Determine triggering elements for ATFM measures (reroutes, ground stops)
- Facilitate alternate solutions when appropriate
 - o VIP movements
 - o Obtain input from airspace users – are there any potential disruptions to their operations? What will be the impact of ATFM solutions/measures?
 - o Stakeholder input, comments, and questions
- Synopsis by the planner:
 - o Provide synopsis of ATFM solutions/measures decisions.
 - The goal is to ensure all parties are clear about the issues and solutions that were agreed.
- Closing
 - o Include statement terminating the current teleconference and the time for the next teleconference
 - For example: "This concludes the 1415 Z Telecon. The next Telecon will be at 1415 Z on (date)."
- Post-Teleconference
 - o Prioritise activities, based on ADP changes and outcomes
 - Prepare and review the ADP email before transmitting

- The body of the ADP should identify facilities where air traffic delays and traffic management measures are possible or expected
- o TMA/tower/en-route constraints
- o Date and times are correct
- o TMA/tower issues
- o Traffic management measures
- o Routes
- Write a summary in the host operational log. Documentation should include:
 - o Significant tactical changes/diversions from previous ADP
 - o Discussion leading to addition/deletion of traffic management measures
 - o Alternatives discussed and/or significant dissension to the ADP

8.5. Traffic Management Units (TMUs)

- Facility TMUs should address:
 - o ATFM solution concerns and possible trigger events
 - o Implementation of agreed ATFM solutions and provide updates on effectiveness of the measures
 - o Equipment outages/maintenance having an operational impact
 - o Internal ATFM solutions
 - o Terminal constraints
 - o Route closure/recovery information
 - o Anticipated ATFM solutions necessary to manage the airspace and airports
 - o Other issues (staffing, special events, FUA)

8.6. Airspace Users

- Airspace users should:
 - o Ensure that the latest schedule information and flight planning information are supplied to the ATFM
 - o Advise if any major changes to the schedule are anticipated (e.g. cancellations);
 - o Provide tactical input into capacity/demand scenarios and the selection of required appropriate ATFM measures;
 - o Advise if any flights require priority

8.7. Military

- The Military should:
 - o Advise if there have been any changes to pre-arranged military activities
 - o Advise if there are any short term requirements for military activity
 - o Advise if FUA can be used to optimise operations
 - o Advise if any of the military flight cannot comply with ATFM solutions (VIP flights etc.)

8.8. Airport Authorities

- The Airport Authorities should:
 - o Supply information which could affect arrival and departure rates at airport
 - o Advise of any unexpected outages
 - o Provide tactical input into capacity/demand scenarios
 - o Select of required appropriate ATFM measures
 - o Advise if and how ATFM measure will impact operations at airport (gate constraints etc.)

8.9. Weather Services

- The Weather services should:
 - o Supply updated actual weather and forecasted weather
 - o Advise if any significant weather would affect the ATFM Solution if being implemented.

9

Slot Allocation Processes

There are two slot allocation processes, strategic airport slot and air traffic control slot allocation, which needs explanation.

9.1 Strategic Airport Slot Allocation

9.1.1 Coordinated Airport

The International Air Transport Association (IATA) has produced a set of rules contained in the Worldwide Slot Guidelines (WSG) Edition 8.1 (English version) to aid airports around the world in managing their capacity through the strategic slot coordination process. WSG stipulates that, should the demand at an airport be such that it needs to be managed, the airport needs to be “coordinated”. Coordination involves the allocation of constrained or limited airport capacity to airlines and other aircraft operators to ensure a viable airport and air transport operation. Coordination is also a process to maximise the efficient use of airport infrastructure.

Coordination is not a solution to the fundamental problem of insufficient airport capacity. In all instances, coordination should be seen as an interim solution to manage congested infrastructure until the longer term solution of expanding airport capacity is implemented.

9.1.2 Airport Coordination Levels

For the purposes of airport coordination, airports are categorised by the responsible authorities according to the following levels of congestion:

- Level 1 are airports where the capacity of the airport infrastructure is generally adequate to meet the demands of airport users at all times.
- Level 2 are airports where there is the potential for congestion during some periods of the day, week, or season which can be resolved by schedule adjustments mutually agreed between the airlines and a facilitator. A facilitator is appointed to facilitate the planned operations of airlines using or planning to use the airport.
- Level 3 are airports where capacity providers

have not developed sufficient infrastructure, or where governments have imposed conditions that make it impossible to meet demand. A coordinator is appointed to allocate strategic airport slots to airlines and other aircraft operators using or planning to use the airport as a means of managing the declared capacity.

9.1.3 Strategic Airport Slot

To manage traffic at a Level 3 airport, strategic airport slots are issued to airlines. An aircraft operator with an airport slot is given permission by a coordinator for a planned operation to use the full range of airport infrastructure necessary to arrive at or depart from a Level 3 airport on a specific date and time.

9.1.4 Airport Slot Allocation Process

The strategic slot allocation process is shown in Figure 3. The capacity of an airport is determined every six months for the next season (the seasons are based on Northern Hemisphere summer and winter seasons). The capacity of an airport is declared after consultation with stakeholders including but not limited to ATC, airport authorities, ground handlers, customs and immigration and aircraft operators. Once the capacity is set, airlines will apply for slots to operate in the upcoming season. Airlines are entitled to historic slots if they have operated at least 80 percent of their allocated flights during the corresponding previous season. Once airlines have received confirmation of their slots, they will then publish their schedules and supply this information to third party entities such as Official Airline Guide (OAG).

9.2 Air Traffic Control Slots

9.2.1 Balancing Demand and Capacity

During the pre-tactical and tactical phases of ATM, should the demand at an airport or a sector of airspace exceed the capacity of that resource, an ATFM measure may need to be implemented to balance demand and capacity.

9.2.2 Slot Based ATFM Measure Implementation

As shown in this document there are many ATFM measures which can be utilised to achieve a balance. One of the most effective ATFM measures is a slot-based ATFM measure (GDP, AFP, departure GDP). Slot-based ATFM measures involve slots being created at the constrained resource and converted to calculated off-block times (COBTs) or calculated take-off times (CTOTs) from points of origin. COBTs and/or CTOTs are then assigned to the flights to which they comply. These slots should not be confused with strategic airport slots, which would normally have been assigned prior to the commencement of the flying season based on declared (strategic) resource capacity. Slot-based ATFM measures such as GDP are implemented when the actual operational capacities get reduced or are not sufficient for the demand at the time, be it due to unforeseen circumstances (e.g. inclement weather, accidents) or special disruptions (e.g. military activities).

9.2.3 Air Traffic Control Slot

CTOTs (or COBTs) issued to a flight as part of the slot-based ATFM measure become the ATC slot. Flights will need to ensure that they take off (or push back) within the specified compliance window. Compliance windows can vary but are typically -5 minutes and +10 minutes of the ATC slot assigned. Should a flight be unable to comply with the issued ATC slot, a CDM process needs to be in place for the aircraft operator to swap with other flights or substitute into an empty ATC slot. When an ATC slot is issued, it will always take precedence over the strategic airport slot. The allocation process of ATC slots is shown in Figure 3.

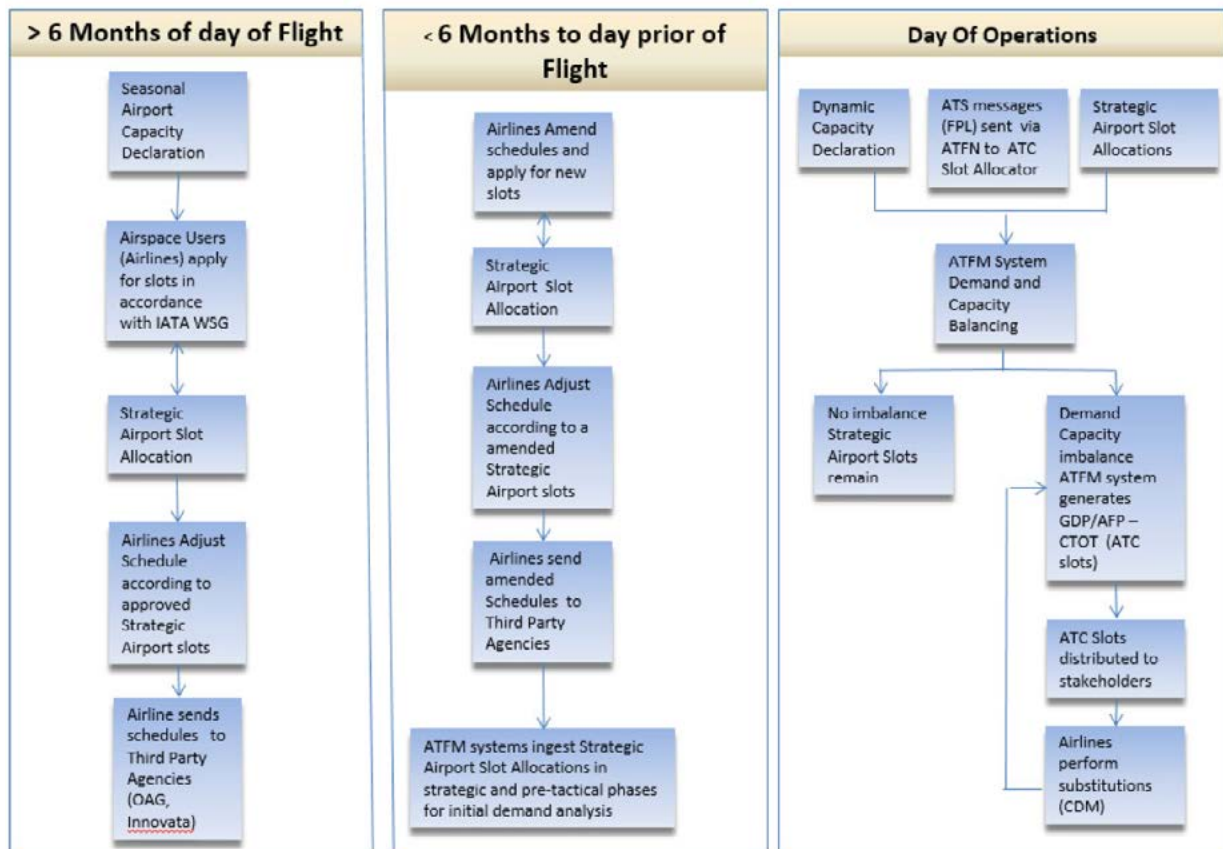


Figure 3 - Slot Allocation Process

10

ATM Functions

There are various functions within the ATM process which ensure the safe and expeditious flow of traffic. However, there is often confusion about the roles and expected outcomes of each function and where they fit into the ATM process and a flight life cycle. ATFM is a function that takes place across all phases to provide appropriate level of traffic demand into the tactical ATC operations, where other functions such as A-CDM, DMAN, AMAN help to further enhance the safety and smoothness in the traffic flow. There may be some overlap in the functionalities of each component, but they cannot fully replace the other. Each ATM function is important to optimised operations, and ANSPs are encouraged to undertake needs analysis to assess which functions are appropriate and how they may be used for their operations.

This section describes what some of the most familiar ATM functions do, how they are applied within the ATM lifecycle, and what they can (and cannot) achieve

10.1 Air Traffic Flow Management Process

As has already been described in other sections of this document, ATFM takes place during all phases of the ATM process.

In the strategic phase, long-term planning and monitoring of resource capacities takes place. Where possible, long-term measures are implemented to match resource capacities to foreseen traffic demand. Examples include strategic airport slot allocation, military exercises, sporting events, air shows, significant weather

systems, planned sectorisation, and ATC roster adjustment. In certain cases, such as planned large-scale airspace/airport disruption (runway/taxiway rehabilitation, CNS maintenance), traffic demands are adjusted via strategic means such as airport slot allocation or flight schedule adjustment long before the day of operations.

This process of demand-capacity monitoring continues in the pre-tactical phase, taking into consideration plans developed in the strategic phase, short-term constraints such as weather and equipage serviceability as well as updated traffic demands from adjusted airline schedules, flight permissions, and early submitted flight plans. If demand - capacity imbalance is apparent in the pre-tactical phase, ATFM solutions/measures can be prepared and communicated before execution.

In the tactical phase, any plans formulated in the strategic and pre-tactical phases are refined, demand-capacity monitoring and balancing continues with the execution of various ATFM solutions/measures such as capacity enhancements, ground delay programme (GDP), Ground Stop (GSt), or other measures prescribed elsewhere in this document and in ICAO Doc 9971. Management of the ATFM solutions/measures are normally led by ATFM unit in coordination with all stakeholders.

Following execution of an ATFM programme, post-operational analyses, with data and information from relevant logs and systems, are performed for continuous improvement of operations.

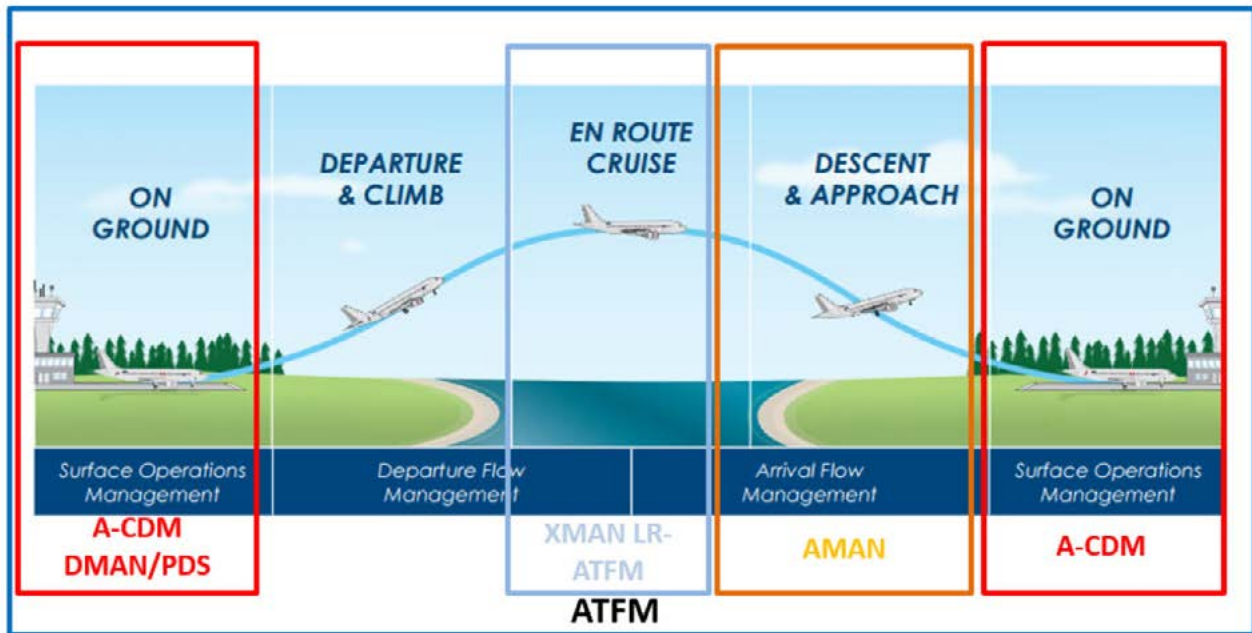


Figure 4 - Air Traffic Flow Management Process

10.1.1 Departure Flow Management – Departure Ground Delay Programmes (D-GDP)

Some airports have implemented departure ground delay programmes (D-GDP) where a PDS is not available and metering of departing traffic is required as a result of airport closure for a period of time. Some ATFM automation systems have the ability to issue COBTs and CTOTs to departing flights to enable optimised departure process at the airport as well as to ensure appropriately metered traffic departing the TMA. Similar to a PDS, D-GDP can help improve operational predictability of the push-back process taking into account runway and terminal airspace capacity constraints.

10.1.2 Long Range ATFM (LR-ATFM)

When a demand-capacity imbalance is predicted at an airport, an ATFM measure such as a ground delay programme (GDP) helps meter inbound demand by allocating ground delays for flights to be absorbed pre-departure and is allocated to

domestic flights to meter demand. This method usually works for domestic and short-/medium-haul international flights, with operating horizon of 4-6 hours. Long-haul international flights from outside the region are in general exempted from being allocated ground delays. In an environment or time period when the long-hauls make up a large proportion of the inbound demand, this exemption results in domestic and short-haul flights encountering an unfair proportion of the delay. In such an environment, there is a requirement for long haul international flights to be included in ATFM measures at an arrival airport. This will entail long haul flights being issued either a CTOT at the point of departure or a calculated time over (CTO), sometimes referred to as required time of arrival (RTA), at a pre-determined waypoint. This CTO can be passed to the aircraft and the responsibility falls on the flight crew to ensure the flight arrives at the waypoint within an acceptable CTO window. Figure 6 shows how LR-ATFM is expected to operate together with conventional GDP.

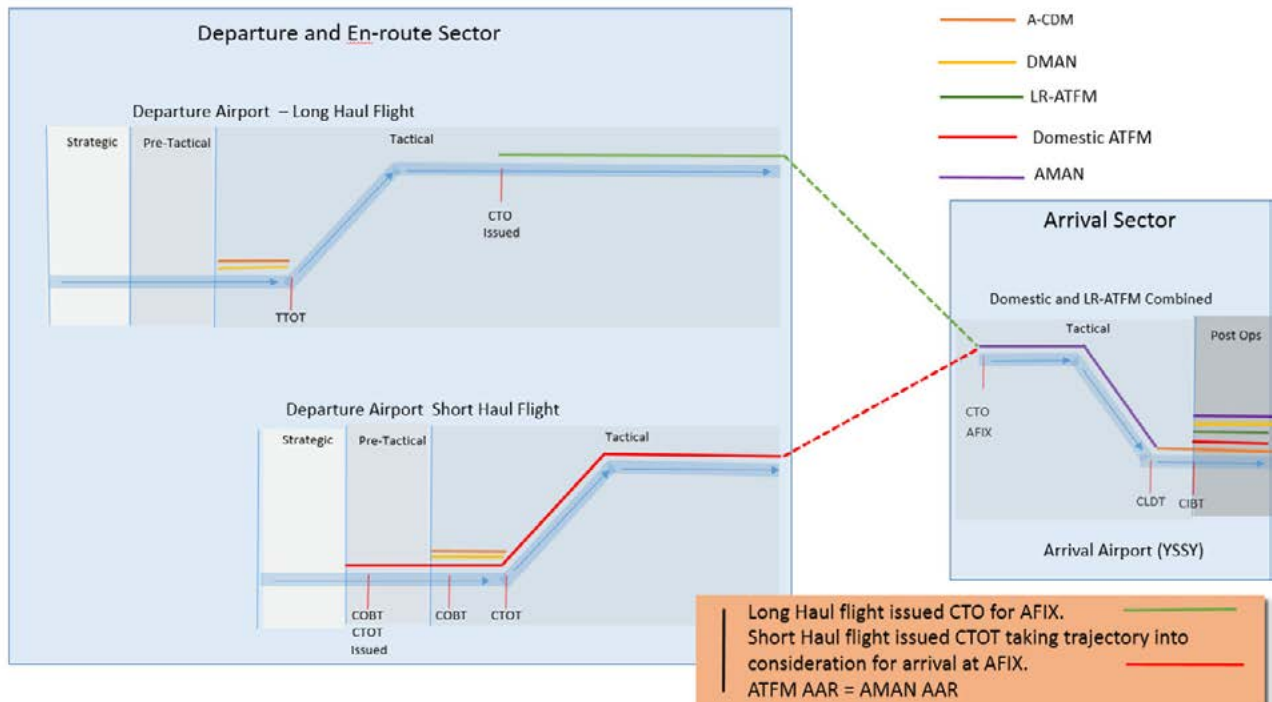


Figure 5 – Long Range ATFM

10.2 Airport Collaborative Decision Making (A-CDM)

Airport collaborative decision making (A-CDM) aims to improve the turnaround process of flights by increasing the operational efficiency at airports. The enhanced efficiency can aid airport operators and stakeholders in reducing delays, increasing the predictability of events, and optimising the utilisation of resources. Inevitably this will lead to an increase in capacity at airports with properly implemented A-CDM. A-CDM is a process based on improved real-time information sharing between all stakeholders, i.e. airport operators, aircraft operators, ground handlers and air traffic control unit, allowing better decision-making and more efficient handling of an aircraft while on the ground.

A core element of the A-CDM concept that many airports have deployed is a pre-departure sequencer (PDS). Pre-departure sequencer optimises a flight’s departure planning process by continuously sequencing take-offs, taking into account aircraft readiness for departure, runway capacity, surface constraints, as well as variable taxi times (VTT) based on specific parking stands. The

sequencing results in target start-up approval times (TSATs) and target take-off times (TTOTs) which can be shared among all stakeholders to help improve operational predictability of the pushback process for everyone. A well-deployed PDS, with associated procedure to support timely information exchange between stakeholders, enables reduction in taxi times, queue lengths on taxiways and runway holding times, therefore saving fuel and emissions while improving predictability of the outbound traffic even in adverse conditions.

Where an A-CDM and ATFM system have been implemented, integration of the two systems should be ensured. As an example, A-CDM system’s TTOT calculation process should take into account published CTOTs where relevant. This ensures that airport departure restrictions are factored in while downstream ATFM measures are also respected.

10.3 Arrival Management (AMAN)

An AMAN is a tactical ATM system that provides automated sequencing support for air traffic controllers in sequencing arrival traffic to an airport. AMAN automatically and continuously

calculates arrival sequences and times for flights using trajectory prediction capability. Taking into account locally-defined landing rate, the required spacing for flights arriving to the runway, weather information, airspace situation, route information and aircraft performance, AMAN issues CTOs for flights to reach a feeder waypoint. CTO to the waypoint is passed to the flight deck, and flight crews are expected to arrange their flight to arrive at the waypoint at the appropriate time. Should the arrival rate at the feeder waypoint be greater than the arrival rate for the airport being serviced, flights may need to undertake airborne holding. If a GDP is in place for an airport that is operating an AMAN, both systems should have the same airport arrival rate set. This will enable the correct rate to be "fed into" the AMAN resulting in minimal airborne holding.

10.4 Extended Arrival Management (XMAN)

Extended arrival management (extended AMAN/ XMAN) allows early sequencing and managing of arrival traffic. The solution extends the arrival management coordination beyond the airspace surrounding the airport to neighbouring en-route airspace, and even across ANSP boundaries. This allows controllers upstream to give early instructions to pilots to adjust their speed before initiating descent towards the destination airport - an effective means for reducing fuel costs and lowering emissions for airlines.

11

ATFM Information Exchange Standards

While implementation of domestic ATFM does not present any major challenges in exchanging ATFM information, implementing regional or cross border ATFM, does present a major challenge for information exchange since adjacent ATFM programmes may not easily link. This is exacerbated when there are multiple ATFM systems employed by the ANSPs in the region. There are initiatives to develop an efficient and harmonised information framework to support the operational requirements for ATFM data exchange. Some of the work being done includes, but is not limited, to:

- Developing common minimum user interface requirements for ATFM systems
- Developing an information exchange framework based on the system-wide information management (SWIM) concept to support the operational requirements
- Supporting the implementation of the ATFM system-to-system connection based on the information exchange framework developed
- Supporting the relevant regulatory/development bodies to ensure SWIM-format data provisions are appropriate for inter ANSP communications
- Draft interface control documents (ICD) are being produced to enable vendors to develop their connection and communication with systems to a common standard

As this is a work in progress, it is recommended that ANSPs continue to monitor the various initiatives currently in development and apply them appropriately.

12

Measuring ATFM Performance

12.1. Performance-Based Approach to ATFM Implementation

The aviation system today is more complex than ever, with performance determined by a diverse group of stakeholders from ANSPs to airspace users and airport operators. In an exponentially growing aviation market and globally interconnected route network, new concepts and technologies are being implemented across the globe, requiring significant efforts and investments from all stakeholders. In managing these investments and improving the safety and efficiency of the aviation system, ICAO has recommended a performance-based approach to technology adoption and operational change. A performance-based approach, in which a carefully chosen set of performance indicators is used to monitor operational improvements, allows decision makers to set priorities and determine appropriate plans to ensure the highest level of benefits from the investments. This recommendation forms the basis for ICAO's Global Air Navigation Plan (GANP), in which a focus set of key performance areas (KPAs) are used to develop a framework for aviation system improvements and a technology 'roadmap' for the coming decades.

Within GANP, ATFM is one of the key implementation priorities as an enabler of safe and efficient air traffic operations in the face of growing demand. Successful ATFM relies on efficient information exchange and collaboration across all stakeholders, making it a service that requires the balancing of diverse performance needs. ATFM,

by nature, also transcends borders and frontiers as the management of traffic in one airspace often sends ripple effects across the region or beyond. This adds another level of consideration to the operations. In establishing an ATFM service, it is important to recognise that its far-reaching nature means the balancing of performance targets across stakeholders will be crucial in ensuring their engagement and cooperation. A performance-based approach, taking into account stakeholders' diverse operational needs, should form the basis for implementation.

Often, ANSPs looking to implement ATFM focus mainly on operational concept and procedure design, while putting performance targets development on the side. While developing concept and procedure is fundamental to operationalising new ATFM service, implementing it without clear performance targets can cause issues and reduce stakeholders' trust in the work in the future. Performance target development should thus be given the same priority as operational concept and procedure development, and should be conducted early in the implementation process.

A performance-based approach to ATFM implementation begins with understanding stakeholders' different performance targets, and defining common / complementary targets that can guide implementation. Table 1 below shows examples of performance targets that may be adopted by aviation stakeholders.

Key Performance Areas	ANSP	Airspace Users	Airport Operators
Schedule Integrity	Accurate traffic capacity determination	Consistency in operations and passenger notification	Optimal service scheduling and gate/bay usage
Resource Utilisation	Appropriate scheduling of ATCOs – position staffing	Maximum aircraft utilisation Optimal flight/ground crew utilisation Minimum fuel usage	Optimal service scheduling and gate/bay usage
Predictability	Minimal variation of demand profile	Minimal disruption due to ATC – less need for ATC assistance in completing daily operations	Optimal service scheduling and gate/bay usage
Customer Satisfaction	Less complaints from stakeholders and flying public	Improved customer experience results in higher stakeholder ratings less regulatory oversight and positive social media	Improved passenger experience may result in more concession and shopping traffic

Table 1 - Examples of Performance Targets

The different performance targets above can be balanced through collaborative discussion between stakeholders. ANSPs should thus ensure that the stakeholder engagement process is incorporated into performance target development from the beginning. In many cases, an activation of ATFM measures as a result of demand-capacity imbalance will produce an adverse effect on one or more performance targets of the airspace users and/or airport operators. A ground delay programme, for example, may adversely affect a flight’s on-time performance (OTP) against its scheduled off-block time and reduce airline passenger satisfaction. A trade-off for the OTP is the programme’s promise to reduce significantly airborne delay and fuel consumption; however, to be able to demonstrate the benefit, ANSPs and airspace users need to have a means – developed collaboratively – to quantifiably compare the trade-offs.

With transparent information exchange and collaborative engagement between stakeholders throughout the performance target development and analysis process, ANSPs and stakeholders can ensure that the ATFM programmes implemented can truly improve air traffic operations and the investment can be justified.

The next section provides overview suggestions on developing targets and analysing operational performance of an ATFM programme.

12.2. Realising ATFM Benefits with Post-Operations Analysis

A performance-based approach to implementing ATFM relies on having an established set of key indicators and the means to measure data against them. This approach requires ANSPs to be data-driven, with established processes of data collection and analysis in the overall ATFM workflow. The data collection and analysis process, namely the post-operations analysis phase of ATFM, enables ANSPs and stakeholders to understand what has happened during a given ATFM programme, and also assess its quality based on the data collected against the desired performance indicators.

12.2.1. Key Questions for Post-Operations Analysis

The key focus of an ATFM execution is to balance traffic demand against resource capacity using different measures. One of the ways to methodically conduct post-operations analysis and subsequently measure performance is to develop a set of questions that address each of the three key elements of ATFM – the demand prediction and monitoring, the capacity determination, and the ATFM measure execution. Table 2 provides an example set of questions and their associated performance areas that can be used as a starting point.

ATFM Elements	Post-Ops Analysis Questions	Performance Areas
Demand Prediction and Monitoring	What's the degree of demand information availability (at various time horizons)?	Operational Predictability
	What are the sources of demand information? How reliable are they?	Reliability of Information
	How accurate are the demand prediction and modelling (at various time horizons)?	Reliability of Information
Resource Capacity Determination	How predictable are the various capacity reduction events?	Operational Predictability
	How accurate are capacity numbers, both under normal and constrained conditions?	Reliability of Information
ATFM Measure Execution	Who is involved in the CDM conference?	Stakeholder Engagement
	Who is involved in the ATFM measure? Which ones are actively cooperating and complying?	Stakeholder Engagement
	How are the compliances to ATFM measure?	Compliance Analysis / Stakeholder Engagement
	How soon are the ATFM measures communicated to stakeholders?	Operational Predictability
	How is the delivered traffic when compared to available capacity?	ATFM Delivery
	How are the delays at different phases of flights?	Delay Analysis

Table 2 - Questions and their Associated Performance Areas

The set of questions shown in the table can then form the basis for sets of data to be collected pre, during, and post-operations for analyses. Accurate traffic count, capacity models and numbers, and operational timing parameters (off-block, take-off, landing times; among other timestamps along flight routes) are some of the key data elements that are needed to answer the above questions. It is important for ANSPs to be able to form these questions and know where to locate data that can be used to develop answers, which can then be used to derive performance indication of the implemented ATFM programmes. Questions can start from a basic set as shown above, and evolve to include more complex and telling questions – e.g. degree of network optimisation, route extension analysis – as data analysis workflow matures.

12.2.2. Delay Analysis and Benefit Derivation

In the table, delay analysis is highlighted because it is the one with possibly the most direct link to ATFM benefit analysis in measuring performance. The key objective of an ATFM programme is to

balance traffic demand against resource capacity, thereby creating the smoothest flow of traffic possible. A smooth flow of traffic has direct linkage to overall system delay reduction and, depending on the ATFM measure used, a reduction in costly airborne delays. These delay reductions can then be used to derive quantifiable ATFM benefits in terms of operating cost saved for stakeholders.

For a given flight, delay analysis can be carried out for any phase as shown in Figure 6. Delays can be incurred on any of these flight phases, and each will have different associated costs. For example, an airborne delay en-route may incur heavy fuel cost but low impact on cost of ground operations; on the other hand a ground delay at departure may save significant fuel consumption but incur extra ground cost and disutility of airport ground infrastructures. Developing mechanisms to measure and attribute delays accurately to different phases of flights can greatly enhance an ANSP's ability to discern specific benefits (or lack thereof) from the implemented ATFM programme.

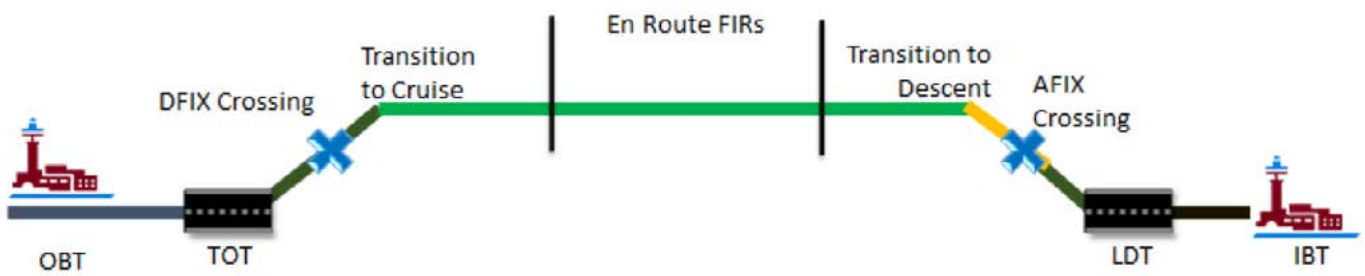


Figure 6 – Flight Profile

In linking delays with operational benefits for stakeholders, it is important to understand the different cost models associated with delays in the different phases of flights. ANSPs often lack this insight into airline and/or airport operations, and this is where engagement with stakeholders can truly add value to the performance analysis. Airlines and airport operators can be involved in the performance measurement process by lending insights on their operating models and improving the accuracy of cost-benefit analysis based on delay measurements. As will be discussed in the subsequent considerations section, each phase of flight has different associated costs and impacts that need to be considered by ANSPs when thinking about air traffic management. Thus delays in different phases should be viewed and weighted differently in the ATFM benefit analysis.

12.2.3. The Use of Performance Measurement

Performance measurement results can be used to improve ATFM operations. The core of a performance-based approach to implementation is the use of performance results to drive operational improvement. Results obtained should always be transparently shared with all stakeholders in the system and can be used as a basis for discussions on improvements. By identifying and scrutinising areas where unexpected or undesirable results occur, ANSPs and stakeholders can together design mechanisms and procedures to prevent the same results from happening again in the future.

12.3. Considerations in the Performance Analysis Process

ATFM performance analysis can be a complex process involving large post-operations data and extensive stakeholder engagement. This section provides some additional considerations when measuring ATFM programme performance.

12.3.1 Airline/Airport Operations and Their Stakeholders

Airline operations involve a wide range of stakeholders; some of those are often overlooked by ANSPs when considering air traffic management. In most ATM operational improvement efforts, ANSPs tend to assume fuel consumption is the driving force behind airlines' operational decisions and thus, measures that focus on fuel efficiency are often favoured across different scenarios. The common argument for the use of ground delay programmes (GDP) - that the programme shifts inevitable airborne delay to pre-departure ground delay and thus reduces inflight fuel consumption - is a good example of this possible fallacy. While GDP works well in severe demand-capacity imbalance cases such as airport closure, its impact on other parts of airline operations can be disruptive when applied to less severe cases that could otherwise be managed with tactical ATC techniques. As mentioned above, airline operations need to consider not just fuel consumption but also crew time, aircraft utilisation, ground cost, as well as passenger perception and discomfort. A GDP, while saving airborne fuel consumption, can negatively impact passenger satisfaction with the airlines; in

cases where GDP is unnecessarily applied, the long-term impact from passenger dissatisfaction may cost the airlines more than extra airborne fuel.

Similarly, airport operations also involve a wide range of stakeholders and should not be overlooked by ANSPs and air traffic management; these can range from gate assignments and ground equipment use plan to landside operations when aircraft are forced to occupy a gate longer than expected.

A development of a performance measurement scheme for ATFM operations should thus include considerations of operations outside the traditional scope of air traffic management as well. A study conducted in 2011 by the Department of Transport Studies at the University of Westminster provides a good example of delay-associated cost incurred by airlines; it takes into account not just fuel but also other aspects of flight operations such as crew resource management and passenger time value⁴. A study conducted in 2014 by PricewaterhouseCoopers Australia (PwC) for Airservices Australia then took the extensive delay cost study and converted into a benefit statement of ATFM implementation in Australia⁵. These are great examples of when performance analyses were done with considerations of all stakeholders and their operations. While conducting such extensive analyses can be a difficult task for ANSPs beginning with ATFM, it is worth keeping in mind the far-reaching impact of ATFM operations and the importance of understanding stakeholders' needs and balancing their performance targets with those of ANSPs.

12.3.2. Big Picture, Data-Driven Analysis versus Individual Anecdotal Feedback

In ANSPs starting with ATFM, operational expectations can sometimes be confused with what can be expected from air traffic control services. In developing an appropriate performance measurement scheme, importance should always be placed on the ATFM service's ability to manage the appropriate amount of traffic demand against available capacity. A possible fallacy is looking at ATFM just as a service to provide aircraft

separation, and marking ATFM as ineffective when flights arrive over constrained resource without the expected separation. This fallacy occurs when performance measurement is focused on individual occurrence, e.g. a pair of flights with less-than-desired separation, rather than big-picture view driven by data.

By nature, ATFM works with large amounts of flights entering or passing through a constrained ATM resource, with the goal of balancing the number of flights against available capacity. A performance scheme should thus reflect that goal, with the measurement based on collected data and indicators such as degrees of capacity overload, flight delays in various phases, and overall flight efficiency with and without ATFM. It is inevitable that some flights will suffer inefficient or undesired operations – extensive ground delays, additional airborne holding, and lack of desired spacing – but the important focus should be placed on the overall picture of network efficiency.

Part of the root cause for the fallacy mentioned above is the different frames of reference between ATFM operations, air traffic control services, and flight operations from the perspective of a flight crew. While ATFM operations focus on overall delivery of traffic demand against capacity, an ATC giving air traffic control service will focus on safe delivery of flights with required separation within their sector and a flight crew will focus on safe delivery of their flight from origin to destination. With the different frames of reference, performance issues noticed by different stakeholders will differ. It is important to clarify these differences when implementing ATFM and developing an associated performance scheme. The message that ATFM focuses on overall system efficiency, not individual aircraft separation nor individual flight routing and timing efficiency, should be communicated and understood among stakeholders early in the process.

12.3.3. Different Environment = Different Operations = Different Performance Targets

ATFM is quickly becoming more common in

⁴ Department of Transport Studies, University of Westminster (2011). *European airline delay cost reference values*. London.

⁵ PricewaterhouseCoopers Australia (2014). *Metron traffic flow benefits realisation*.

air traffic service systems around the world. Most ANSPs are considering, at minimum, domestic ATFM; many are joining together to form cooperation for sub-regional or regional ATFM implementation. Discussions on inter-regional ATFM harmonisation and long-range ATFM are also becoming widespread to support the growing connectivity of air travel. These different environments will require different ATFM operational concepts and procedures, as well as different performance measurement schemes. While it is easy to look at another ANSP or region with a mature ATFM programme in place and hope to mimic their performance targets, they will likely not be suitable in a different environment. ANSPs should consider, in their implementation effort, what specific operational improvements they are hoping to achieve with ATFM in their environment and set the performance indicators that allow them to analyse appropriate degrees of achievement. Best practices by mature ANSPs and regions can be good guidelines for adaptation, but should not be treated as a required standard when they do not fit with the specific operational environment.

12.3.4. Step-by-Step Development of Performance Measurement Scheme

It is easy for ANSPs starting out with ATFM to look at those with mature ATFM implementation in place, hoping that their ATFM performance measurement scheme can be mimicked. Often,

ANSPs with mature ATFM in place will have developed data collection infrastructure and analysis workflow that support extensive and comprehensive performance measurement which can seem overwhelming to ATFM 'newcomers'. It is important to remember that, similar to ATFM operational implementation, a performance measurement scheme cannot be developed in a single day or through a single iteration. ANSPs can start out with a simpler target that focuses on, for example, stakeholder engagement through participation in CDM conferences and ATFM measures compliance. As their data collection infrastructure and workflow become more mature, other aspects of performance measurement can be added ranging from delay figures to flight efficiency. With enough variance of measurements and data in place, ANSPs can begin to derive quantifiable benefit and benefit statements from their ATFM implementation.

The key point to consider is that performance measurement schemes should be developed along with the operationalisation of ATFM from the beginning. A step-by-step approach, beginning with simpler data collection and performance analyses then moving to more complex data workflow and measurements, can be adopted to ensure that the maturity of ATFM operations goes hand-in-hand with performance measurement.

13

Evolution of ATFM/New Possibilities

13.1. ATFM to Trajectory Based Operations (TBO)

Effectively managing the projected growth of air traffic is vital to ensure the global air transport system continues to drive the world's economy. IATA forecasts that the number of global air passengers will double to 8.2 billion by 2037⁴. This growth highlights the need for efficient, globally harmonised, and interoperable ATM across the globe.

Reflecting this air traffic growth, the ATM industry is also growing. According to Statistics Market Research Consulting, the global air traffic control market for equipment was \$30.93 billion in 2017 and is expected to reach \$105.20 billion by 2026, growing at a compound annual growth rate (CAGR) of 14.6% during the forecast period. The system of air traffic management will radically change as air navigation service providers (ANSPs) manage this projected growth and ATM moves from clearance-based to trajectory-based operations (TBO).

The ICAO Global Air Traffic Management (ATM) Operational Concept (GATMOC, Doc 9854) describes this change;

“Air traffic management (ATM) considers the trajectory of a manned or unmanned vehicle during all phases of flight and manages the interaction of that trajectory with other trajectories or hazards to achieve the optimum system outcome, with minimal deviation from the user-requested flight trajectory, whenever possible.”

It is not the intention of this CANSO paper to chart the transition to trajectory-based operations, but for TBO to succeed and to deliver its anticipated benefits, it is important that air traffic flow management processes and procedures enable a seamless migration path to trajectory-based operations.

When planning the implementation of ATFM, States and ANSPs should consider the future migration capability of each of the components contributing to the facilitation of air traffic trajectory management, in particular data and communications - e.g. the needs for real time data and datalink communication.

It is expected that ICAO will publish future planning guidelines for implementing trajectory-based operations and ANSPs will be encouraged to consider the future operations concepts while implementing today's solutions.

13.2. Long Range ATFM

While ATFM is not a new concept, its application in the global industry is not widely utilised.

Predominately, ATFM resides in more mature ATM service providers, and most target domestic or short haul traffic movement. There are developments in cross-border ATFM operation through collaborative decision-making processes like in the ATFCM in Europe, and a more recent development of Distributed Multi-Nodal ATFM in Asia Pacific. These operating concepts can include regional or mid-haul flights during the ATFM process. However, the ability to include long haul flights effectively into the CDM process for delay management would still need to be developed. In the absence of such, the disparity of delay allocation means long haul flights enjoy priority landing.

There are various long range ATFM initiatives, such as the Bay of Bengal Cooperative ATFM System (BOBCAT), which manages the high traffic demand of westbound aircraft from Asia to Europe and which operates through the limited route options in Kabul FIR during the busy night time period. Another example is the XMAN initiative by NATS in the UK as part of the SESAR concept which focuses on regulating the arrival flow into Heathrow by slowing down the arrival stream en-

⁴ <https://www.iata.org/pressroom/pr/Pages/2018-10-24-02.aspx>

route when the flights are still beyond London FIR. While these mature ATFM initiatives have been in operation, they operate independently of each other. This results in the possibility of subjecting a flight from Asia, bound for Heathrow, to multiple flow restrictions.

In the current context, a single robust concept for application that has the ability to regulate cross regional/longer haul flights (> 600NM) have been missing in the picture. A holistic approach towards regulation of all traffic flow will bring about equity in delay management and greater efficiency in resource management. The capabilities of cross regional ATFM would also be working towards the goal of harmonising and achieving global interconnectivity and interoperability.

13.2.1. Considerations for Implementing Long Range ATFM

The objective of long range ATFM (LR-ATFM) would be to derive an operating concept that is able to provide flow regulation to flights that operates beyond the effective range of regional ATFM collaboration. ATFM operates best with updated trajectory information to achieve an enhanced level of demand prediction. This is currently the most challenging aspect of regional ATFM operations and it is more apparent when attempting to acquire trajectory information of cross regional flights.

The LR-ATFM operating concept would generally revolve around the flight arranging to meet a time-over-fix. As the flight time increases, the aircraft can be subjected to a multitude of trajectory-altering instructions and weather conditions that can change the arrival time of the aircraft. It would be futile to regulate the departure time of longer haul flights alone as a primary means of flow regulation. Its trajectory during the departure and climbing phase, coupled with the uncertainties that follow from a long flight time would most likely place the aircraft in an arrival slot beyond the comprehensible operating parameter of an ATFM

system. Thus, the LR-ATFM operating concept would work best with time-over-fix restrictions supplemented by departure time restrictions.

Due consideration will need to be given to the environment that the arrival ANSP operates in, as this will alter the LR-ATFM operating concept. As the concept of the regulation of time over fix would result in the aircraft altering its flight profile to meet the time over fix restriction, speed changes and altitude alteration would be the most common method. However speed and altitude changes would require concurrence from ATC. For example, in the Asia Pacific region, which consists of smaller FIRs with lower transit times, a flight will be subjected to ATC from multiple ANSPs throughout its phases of flight. With due consideration not to request for speed reduction too far from an aircraft optimum operating envelope, speed reduction would most likely have to take place in upstream FIRs for a substantial amount of airborne delay to be possible. Multifaceted coordination process might be needed between the individual ANSPs, but it might complicate the planning and implementation process.

13.2.2. Requirements for LR-ATFM

A robust information exchange network needs to be established to support LR-ATFM CDM processes. Although system-wide information management (SWIM) can be an enabler to this information exchange architecture and provides a promising future, SWIM itself is still very much in its infancy.

Another aspect for consideration is the establishment of an effective means of communication with the flight crew with regards to fix-over-time restrictions. In the current context, this can be achieved through relaying information from the airlines operation centre (AOC) to the flight deck using ACARS. If the LR-ATFM process was extended to the entire fleet, it would be a highly laborious process for the AOC.

14

Visions for ATFM

CANSO will continue to support effective implementation of ATFM. Increasing intercontinental traffic will continue to drive the need for ATFM stability and data exchange. It is critical that States collaborate to implement cross-border ATFM procedures that consider the whole route of flight.

ATFM measures have developed as ground and airborne delays have become intolerable. As illustrated in this paper, many States and regions are working together, cross border, to improve system performance to meet ever increasing air traffic demand.

To further improve the effectiveness of ATFM a concept is required that creates a globally harmonised method for sharing information before and during flight and which recognises the ICAO mandate of 'no country left behind'. Countries in this category may have less operational capability but are nevertheless critical to the success of global ATFM.

ATFM is most effective when it covers a logical ATM region. Sub-regional/regional ATFM must contribute to global ATFM. ATFM requires precise and accurate airspace data and flight plans. While use of this data is a function for air traffic

management we are likely to see third party data aggregators emerge which will offer such ATFM data as a service to ATMs. This data will be extracted from current sources plus global position data, including aircraft avionics, combined with artificial intelligence and machine learning to improve the integrity of prediction.

This data set will enable ATMs to better leverage avionic capability to contribute directly to the efficiency of ATM.

Additionally, all stakeholders need to be more directly involved in ATFM, specifically airport authorities beyond ACDM applications.

The vision for ATFM requires regional connectivity that drives global harmonisation to ensure maximum efficiency of airspace is realised.

The CANSO ATFM Workgroup must review its 'road map' (work plan) at least annually and actively contribute to global development to ensure the integrity of air traffic management is maintained while measures to improve global performance are implemented.

Acronyms

AAR	Airport arrival/acceptance rate
ACC	Area control centre
A-CDM	Airport collaborative decision making
ACARS	Aircraft communications addressing and reporting system
ADP	ATFM daily plan
ADS-B	Automatic dependent surveillance broadcast
AFIX	Approach fix
AFP	Airspace flow program
AFTN	Aeronautical fixed telecommunication network
AMAN	Arrival management
ANSP	Air navigation service provider
AO	Aircraft operator
AOC	Airlines operation centre
APAC RSO	Asia and Pacific Regional Sub-Office
ARR CAPA	Arrival capacity
ARTCC	Air route traffic control centers
ATC	Air traffic control
ATCS	Air traffic control specialists
ATCSCC	Air traffic control system command center
ATFCM	Air traffic flow and capacity management
ATFM	Air traffic flow management
ATFM IR/SWG	ATFM Information Requirement Small Working Group
ATFMU	ATFM Unit
ATM	Air traffic management
ATMRPP	Air Traffic Management Requirements and Performance Panel
ATMC	Air traffic management centre
ATS	Air traffic services
ASBU	Aviation System Block Upgrades
AU	Airspace user
BOBCAT	Bay of Bengal Cooperative ATFM System (Thailand)

CADENA	CANSO ATFM Data Exchange for the Americas
CANSO	Civil Air Navigation Services Organisation (CANSO)
CARATS	Collaboration Actions for Renovation of Air Traffic Systems
CCB	Change Control Board
CCO	Continuous climb operations
CDM	Collaborative decision making
CDR	Conditional routing
CLDT	Calculated landing times
CNS	Communication, navigation and surveillance
COBT	Calculated off-block times
ConOps	Concept of operations
CPDLC	Controller pilot datalink communications
CRACP	Cross Region ATFM Collaborative Platform
CTO	Calculated time-over
CTOT	Calculated take-off time
DFIX	Departure fix
D-GDP	Departure ground delay programmes
DMAN	Departure management
DP	Departure point
EDCT	Expected departure clearance times
EET	Expected elapsed time
ELDT	Estimated landing time
EMA	Equity metric for airlines
FDP	Flight data processor
FIR	Flight information region
FIXM	Flight information exchange model
FLIPCY	Flight plan consistency
FSM	Flight schedule monitor
FMP	Flow management position
FOC	Flight operations centre
FPL	Flight plan
FRA	Free-route airspace
FUA	Flexible use airspace

GANP	Global Air Navigation Plan (ICAO)
GDP	Ground delay program
GSt	Ground stop
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICD	Interface control documents
IDAC	Dominican Institute of Civil Aviation
ILS	Instrument landing system
JCAB	Japan Civil Aviation Bureau
KPA	Key performance area
LOA	Letters of agreement
LR-ATFM	Long range ATFM
MDCS	ICAO Code – Santo Domingo FIR
MDI	Minimum departure interval
METARs	Meteorological aerodrome reports
MINIT	Minutes-in-trail
MIT	Miles-in-trail
NARAHG	Northeast Asia Regional ATFM Harmonization Group
NAS	National Airspace System (USA)
NATS-UK	National Air Traffic Services – United Kingdom
NAVAID	Navigational aid
NMOC	Network management operations centre
NOPS	Network operation
NOTAM	Notice to Airmen
OAG	Official Airline Guide
OSC	Operations Standing Committee (CANSO)
OSC SC	Operations Standing Committee Steering Committee
OTP	On-time performance
PBN	Performance based navigation
PDS	Pre-departure sequencer
PMS	Point Merge System
RAT	Rapid access taxiways
RET	Rapid exit taxiway

ROT	Runway occupancy time
RPL	Repetitive flight plan
RTA	Required time of arrival
SB ADS-B	Space-based automatic dependent surveillance-broadcast
SESAR	Single European Sky ATM Research
SID	Standard instrument departure
SMAN	Surface management
STAR	Standard instrument arrival
SUA	Special use airspace
SWIM	System wide information management
TBO	Trajectory based operations
TF	Task force
TMA	Terminal manoeuvring area
TOBT	Target off block time
TOR	Terms of reference
TMC	Traffic management coordinators
TRA	Temporary restricted areas
TRACON	Terminal radar approach control
TSA	Temporary segregated areas
TMU	Traffic management unit
TSAT	Target start-up approval time
TTOT	Target take-off time
UDP	Unified delay program
VHHH	ICAO Code - Hong Kong International Airport
VIP	Very important person
VTBS	ICAO Code – Bangkok Suvarnabhumi Airport
VTT	Variable taxi times
WG	Workgroup
WSG	Worldwide Slot Guidelines (IATA)
WSSS	ICAO Code – Singapore Changi Airport
WTG	Wake turbulence grouping
XMAN	Extended arrival management

Appendix 1

FAA – The Use of a Ground Delay Program in the National Airspace System

1. General

The Traffic Management System mission is to balance air traffic demand with system capacity to ensure the maximum efficient utilisation of the National Airspace System (NAS). A safe, orderly, and expeditious flow of traffic while minimising delays is fostered through continued analysis, coordination, and dynamic utilisation of traffic ATFM measures and programs. One such program is the Ground Delay Program (GDP); a traffic management process administered by the Air Traffic Control System Command Center (ATCSCC). A GDP is used when other measures are decided by consensus, through collaborative discussions, to not be enough to support the traffic management mission and limit airborne holding.

2. History/Background

In the United States, demand began to exceed the capacity of airports and airspace initially in the north-eastern US in the 1970s. That decade saw the first central flow control office begin to control departure times and routes to make the system more efficient. Up until the creation of a central flow office, each air traffic control facility; towers, TRACONS (terminal radar approach control), and centers were initiating their own restrictions which were often conflicting with each other and actually causing the flow to slow down too much. In the decades which followed, collaborative discussions to increase efficiency yet allow the air traffic to flow safely, led to what we have today known as the CDM process. CDM is an innovative concept designed to enhance NAS safety and efficiency by transitioning from a centralised command and control system to a distributed planning system. It is a joint government/industry initiative aimed at improving air traffic management through increased information exchange, common situational awareness, equitable resource allocation, and performance

3. The Definition of a GDP

A GDP, which in its first form, began in the 1970s, is an initiative whereby aircraft are held on the ground in order to manage capacity and demand at a specific location, by assigning arrival slots. Today, it is a flexible program and may be implemented in various forms depending upon the needs of the air traffic system. The GDP's flexibility is possible because of the software platform which is utilised throughout the entirety of the program; from the analysing stage through the termination and documentation phase, the Flight Schedule Monitor (FSM) is the tool which is used by everyone involved in the collaboration throughout the day in which GDPs are in use.

4. What is the Flight Schedule Monitor?

The FAA uses the FSM tool that compiles scheduled flight information and flight plans from the Air Route Traffic Control Centers (ARTCC) to calculate and then display graphically the known demand for arrival and/or departures at airports. When an overage of demand (arrivals) versus capacity is noted for an airport, a GDP is modelled through the FSM software. FSM assigns arrival "slots" to aircraft based on the available capacity and flight arrival times, and adds delays in sequential order until demand equals capacity. As a result of this process (fig. 1.1), expected departure clearance times (EDCTs) are issued to individual flights to ensure they arrive at the constrained destination airport when they are supposed to (in other parts of the world EDCTs are referred to as calculated take off time or CTOTs). EDCTs are printed on each aircraft's flight progress strip. Air traffic control specialists (ATCS) ensure that flights with an EDCT depart within five minutes (+ or -) of their EDCT.

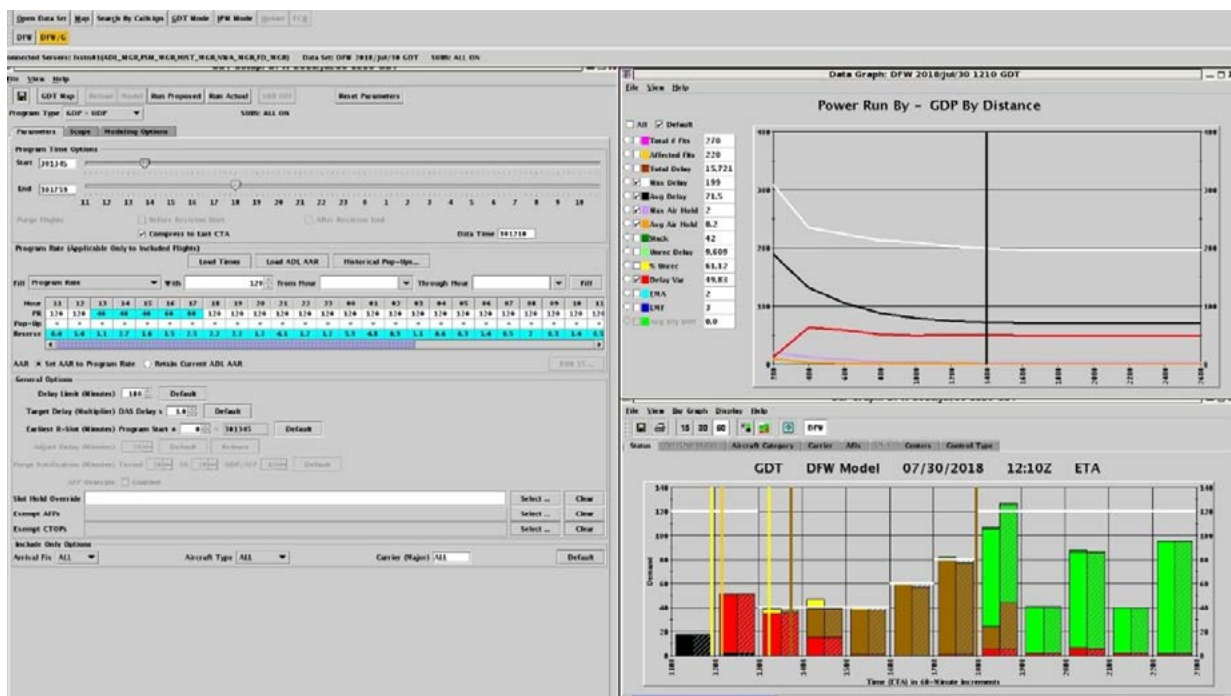


Fig.1.1 - Flight Schedule Monitor (FSM) was used in CDM's first major thrust, Ground Delay Program Enhancements, and the FAA has continued to use it since it went in to prototype operations in January 1998.

5. EDCTs Further Explained

The EDCT is calculated based on the estimated time en-route and the arrival slot. It is basically the runway release time assigned to an aircraft in a ground delay program and shown on the flight progress strip. For the GDP to succeed, it is important for aircraft to depart as close as possible to the EDCT to ensure accurate delivery of aircraft to the impacted location. The entire system of air traffic controllers is involved in ensuring each aircraft assigned an EDCT departs within an acceptable window (11 minutes) of the assigned time. The software programming, however, does allow for airlines to make substitutions among their flights and there are other considerations which can be dealt with in direct conversations with specialists at the ATCSCC. Again, it is a flexible program; EDCTs generated by GDPs provide for equitable assignment of delays to all system users.

6. How Do GDPs Work?

With so many conditions that impact the ATC system, Traffic Management Coordinators (TMCs) must use programs that not only balance capacity and demand, but also distribute delays equally to all customers. A GDP definitely does this. As explained later, there are metrics displayed in FSM which show exactly how equitable the program is behaving. Transparency and flexibility are key to a successful program. As mentioned above, the FAA uses software called Flight Schedule Monitor (FSM) that compiles scheduled flight information and flight plans to determine when an overage of demand versus capacity exists for a specific airport.

7. How is a GDP Implemented?

The first step is for an Airport Acceptance Rate (AAR) to be set. The AAR is the number of aircraft an airport can accept in a one-hour time frame. The AAR is determined by the Aviation System Airport Performance Metrics, which takes into consideration the runways in use, weather conditions, and NAVAID limitations to determine the AAR. By rule, it is the tower/terminal TMC's job to take all into consideration and set and adjust the rate. TMCs employed at towers and terminals are almost always chosen for their positions based on the amount of experience they have as an ATCS (controller) at their specific facility. It is their experience which can greatly enhance their ability to choose an accurate rate based on the known factors constraining the airport.

A GDP is then modelled through the FSM software and arrival "slots" are assigned to aircraft, based on the available capacity and flight arrival times. Delays are then issued in sequential order until demand equals capacity for each hour of the program. This is best illustrated using screenshots from the FSM software. In the image below (fig. 1-2), flights indicated in black have already arrived, those in red are airborne, those in light green are scheduled, and those in dark green are past their scheduled departure time. As can be seen in this screenshot, spikes in demand can be seen at EWR (Newark, New Jersey) beginning in the 1600z hour. In the 1800z hour, for example, EWR is expecting 47 arrivals while the Airport Acceptance Rate (the horizontal white line) is only 32. Something needs to be done to even these spikes out.



Fig.1.2 - Bar graph screenshot from the FSM – pre GDP

In the next image (fig. 1.3), a Unified Delay Program (UDP) mode GDP has been implemented at EWR beginning in the 1700z hour. The AAR has been set at 34, increasing to 38 in the 2000z hour. Now that the program has been run, the demand spikes have been levelled out by spreading the demand over the program hours into the future. Those flights in the GDP (indicated in brown) have all been issued EDCTs. You may ask why the rate (white horizontal line), during the 8+ hour GDP, changes from 34 to 38 aircraft at 2000z. This dynamic input was most likely decided upon collaboratively with all Stakeholders and TMCs at EWR tower, NY TRACON, NY Center and the ATCSCC coming to a consensus that the airport would be able to land a few more aircraft per hour after that time. The software also allows for a few open slots in this screenshot, placed there by the UDP programming in the FSM to allow equally delayed space for aircraft who file their flight plans after the start of the GDP.

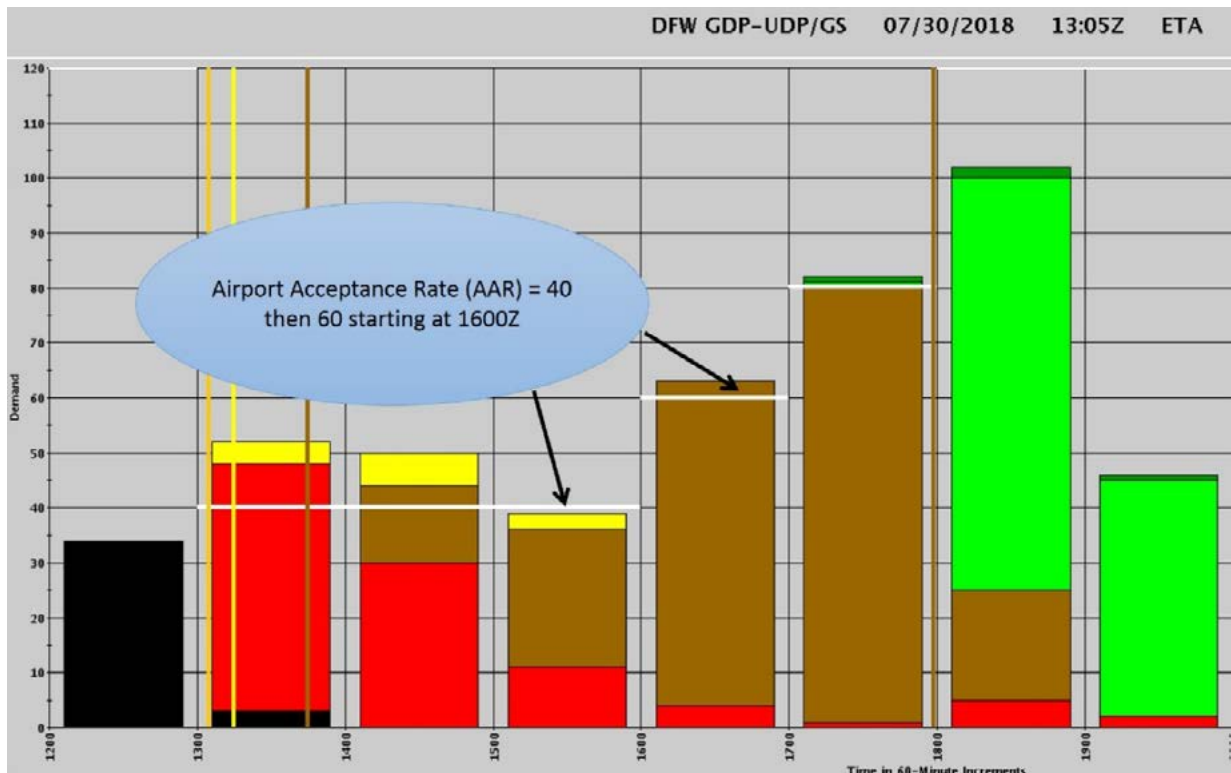


Fig. 1.3 - Bar graph screenshot from the FSM – post GDP initial workup.

8. How Do We Know the Distribution of Slots is Equitable?

Instantaneously, the FSM runs numbers for display so each stakeholder and TMC can see certain metrics as the GDP is being built. Notice the information shown in the screenshot below (fig. 1.4); in numerical display on the left, and as an axis graph on the right. Total affected flights, total minutes of delay, average minutes of delay, and the Equity Metric for Airlines (EMA) are just a few metrics shown. The EMA is a metric that indicates (as a whole) how equitable, or fair, the proposed initiative is for the airlines. The lower the EMA value, the better.

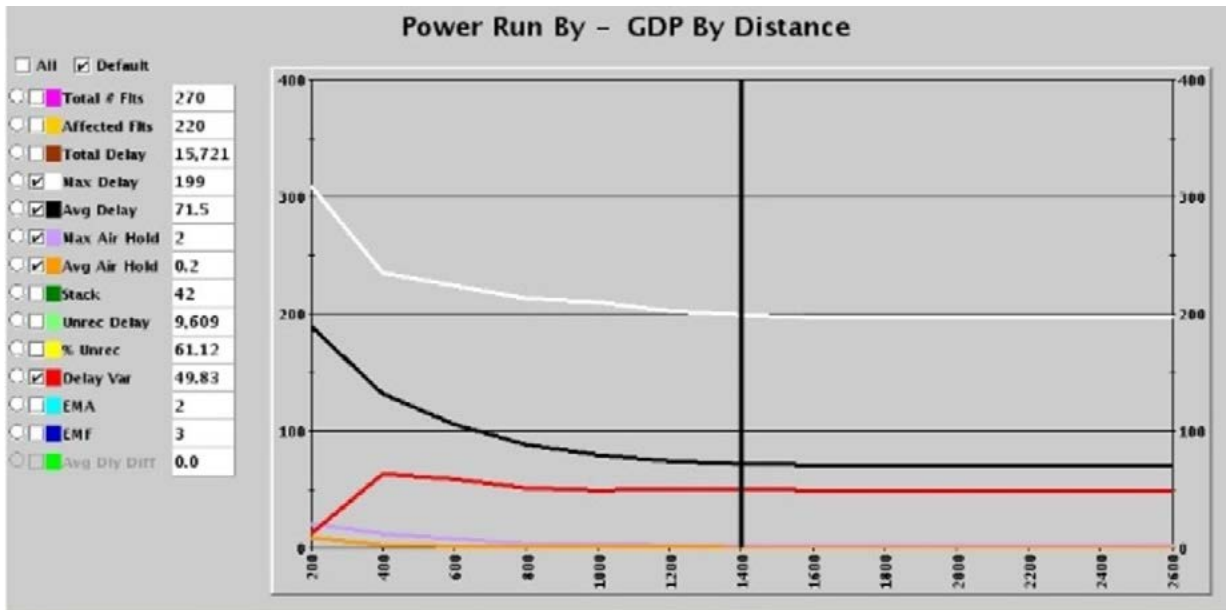


Fig.1.4 - GDP Delay Statistics change as a GDP is worked up to allow the collaborators to pick the most favorable length and scope of the program in relation to desired outcomes.

9. Continually Monitored GDP – The Purpose and Scope of FSM

In Monitored Live mode, the ATCSCC can monitor airport/airspace capacity and demand information for flights in various FSM components. FSM updates demand data approximately every five minutes. FSM provides information that supports detailed flight data and various types of demand count lists. A GDP is continually monitored, discussions are held with field facilities, users, and weather specialists throughout the duration. When conditions improve, or when demand decreases, the ATCSCC begins running compressions. This causes EDCT times to change and decreases delays. The ATCSCC can send out immediate advisories to the Stakeholders to check for updated EDCT times (fig. 1.5).

ATCSCC Advisory

ATCSCC ADVZY 017 DFW/ZFW 07/30/2018 CDM GROUND DELAY PROGRAM

MESSAGE: CTL ELEMENT: DFW
 ELEMENT TYPE: APT
 ADL TIME: 1024Z
 DELAY ASSIGNMENT MODE: UDP
 ARRIVALS ESTIMATED FOR: 30/1345Z - 30/1759Z
 CUMULATIVE PROGRAM PERIOD: 30/1345Z - 30/1759Z
 PROGRAM RATE: 40/40/40/60/80
 FLT INCL: ALL CONTIGUOUS US DEP
 DEP SCOPE: (ALL) ZLA ZAU ZLC ZTL ZDC ZNY ZHU ZJX ZFW ZOB ZDV ZOA ZSE
 ZBW ZMA ZKC ZME ZID ZAB ZMP
 CANADIAN DEP ARPTS INCLUDED: NONE
 DELAY ASSIGNMENT TABLE APPLIES TO: ZFW
 MAXIMUM DELAY: 100
 AVERAGE DELAY: 56
 IMPACTING CONDITION: WEATHER / THUNDERSTORMS
 COMMENTS: SOUTH FLOW, LOW POP UP.

EFFECTIVE TIME: 301025 - 301859
SIGNATURE: 18/07/30 10:26

Fig.1.5 – Program Revision Complete Advisory: New EDCTs are automatically sent out if weather dramatically improves and through discussions it is deemed to be useful to compress the program.

Advisories such as the one above are also transmitted when a GDP is proposed and in its planning stages, and when it is terminated. A GDP usually ends when planned; however, it may be terminated early depending on the circumstances.

10. Summary

GDPs have been used in the US since the mid 1970s. Technology in place today allows for them to be utilised almost daily now for whatever the NAS constraint may be. When deciding to use a GDP, TMCs and Stakeholders utilise the many functions of FSM to analyse the situation at an airport, develop the plan, and implement it by making it "go live" at the push of a button, monitor how it's going, and finally document outcomes and telecons via the use of writing space on the FSM cover sheets. The whole package for the day's GDPs can be stored and used later in quality assurance discussions.

Appendix 2

ATFM Implementation in Japan

1. Introduction

Fukuoka Flight Information Region (FIR) is surrounded by nine FIRs. The traffic from North America including Hawaii enters the Fukuoka FIR, then forks to the Asian continent and South East Asia region. Traffic flying in the opposite direction, from South East Asia enters the Fukuoka FIR and forks to Hawaii and North America. Therefore, Fukuoka FIR is the most important intersection between the American and Eurasian continents.

The economy in Asia, especially in South East Asia has been developing in recent years resulting in a significant growth in air traffic movements. The aviation industry plays a significant part in the economic growth countries; however this significant growth is causing demand and capacity imbalances in airspace and airports.

Capacity growth, safe and efficient air traffic flow management at the global and regional level is important in order to maintain the growth and vitality of civil aviation. Advanced air traffic flow Management (ATFM) measures with support from an ATFM system are essential to manage, utilise and optimise the limited airspace resources to the maximum extent.

Japan Civil Aviation Bureau (JCAB) Air Traffic Management Centre (ATMC) monitors traffic flows and adjusts traffic volume in Fukuoka FIR, using an ATFM system to balance the traffic demand and capacity of airspace and airports with minimum impact on operations while coordinating with relevant stakeholders.

2. Domestic ATFM

If it is expected that traffic demand in domestic airspace exceeds the capacity of a sector or an airport, the traffic flow of the sector or the airport is regulated.

3. Capacity Management

The ATMC implements ATFM measures when demand is expected to exceed the capacity at airports and airspace.

3.1. Airport Capacity

In Japan, airports are operated in two different ways: first, both arrivals and departures using one runway: and second, arrivals using one runway and departures another. Taking runway configuration, and airspace capacity into consideration an arrival capacity (ARR CAPA) and departure capacity is declared for the airport per 30 minute intervals. These capacity declarations are variable depending on the time of the day. A spacing time is calculated by taking into consideration the approach area entry time, the ARR CAPA and the estimated landing time (ELDT) is calculated based on the ARR CAPA and the flight plan of each flight. Should the spacing time exceed an acceptable time, an overcapacity situation exists at the airport. For example, Tokyo International Airport can manage 15 arrivals per 30 minutes as it has a dedicated runway for arrivals which means the ARR CAPA is 15 and in this approach area it can accept nine minutes holding, which means spacing time is nine.

Fukuoka Airport can handle 10 arrivals per 30 minutes because arrivals and departures should utilise the same runway, and Fukuoka approach can accept 15 minutes hold, which means that ARR CAPA is 10 and spacing time is 15.

3.2. Sector Capacity

Sector capacity is evaluated by direct assessment of ATC workload taking into consideration the time summation of ATC tasks, and is set in 30 minute time periods. Many factors are considered when determining capacity. Workload is not necessarily equal to the amount of traffic. Each sector has various characteristics, for example, airspace structure (size and form), airspace complexity (airways, route, intersections, and traffic flow concerning airports). The consideration time for planning and decision-making and work time for communication also affect the capacity of the airspace.

4. ATFM Measures

In Japan, ATFM measures are roughly categorised into two phases: pre-flight and in-flight phase (tactical phase). In 2016 ATMC implemented ATFM measures 1,252 times at airports, and 2,790 times at airspace sectors. Below are some examples of ATFM measures implemented in Japanese airspace.

4.1. Techniques/Measures for Pre-Flight

4.1.1 Re-Routing

To decrease congestion at the departure airport, reduce overall delay and optimise airspace, ATMC recommends that AO either takes delay on the ground (ground delay programme – GDP) or alternate routings. AOs can then select either ground delay or re-routing considering the total benefit to their operation. The lists of coded alternative routes are shared among related stakeholders to simplify the coordination procedures.

4.2.1. GDP

When a GDP is applied, the time to enter a sector of airspace or landing time is calculated for each flight. Taking the expected elapsed time (EET) into consideration with the entry or landing time an expected departure time is calculated. Delay is assigned at the departure airport's EDCT (this is the same as a CTOT, as used in other countries). This EDCT is shared with AOs and related ATC facilities. In 2016 the average ATFM delay apportioned as a result of GDPs was 10.8 minutes a delayed flight and majority of ATFM delays were as a result of saturation of metropolitan airports.

4.2.2 Minutes in-trail and Miles in-trail (MINIT and MIT)

MINIT and MIT are implemented when there is a requirement to increase the spacing between aircraft to manage the flows of aircraft into an airspace sector or airport which is anticipated to have a demand and capacity imbalance.

4.2.3 Ground Stop (GSt)

When there is a zero acceptance rate declared at an airport due to runway closure, severe weather or airport gridlock a GSt is implemented meaning that all aircraft departing for the constrained airport are held on the ground until further notice.

4.2. Techniques/Measures for In-Flight

4.2.1 MINIT and MIT

MINIT and MIT are implemented when there is a requirement to increase the spacing between aircraft to manage the flows of aircraft into an airspace sector or airport which is anticipated to have a demand and capacity imbalance

4.2.2. Speed Adjustment

Assign a specific speed to the aircraft entering an airspace that is congested.

4.2.3. Airborne Holding

Implementing airborne holding outside the congested airspace until the congestion is cleared.

5. International ATFM

JCAB ATMC started international ATFM in 2007, based on a bilateral agreement between ATMC and Air Traffic Command Centre (ATCC, Korea), and Taipei Area Control Centre. In addition ATMC concluded an agreement with Shanghai ATCC ATFM in 2017. These bilateral agreements introduced procedures in accordance with the policies in the letters of agreements (LOAs), resulting in maximising airspace capacity, and minimising restrictions. When JCAB ATMC receives restrictions from ATCC (Korea), Taipei ACC or Shanghai ACC ATFM as per the LOAs, JCAB ATMC implements domestic ATFM in Japan (only domestic traffic in Japan is affected by this ATFM measure) assisting ACCs to comply with restrictions. The main ATFM measure implemented in these situations is a GDP assigning EDCT (expected departure clearance time) to departure traffic.

The contents of a LOA

- Information sharing - runway closure of main airport, severe weather, malfunction of ATC.
- Flow control coordination - time of implementation.
- Flow control application - specifying restrictions at the FIRs.

The restrictions implemented by the adjacent FIR

- Minimum longitudinal interval by time or distance (MINIT or MINT).
- The number of aircraft which is acceptable in a specific time frame.
- Limitation of acceptable altitude (level capping)

6. Northeast Asia Region ATFM Harmonisation Group (NARAHG)

NARAHG, supported by ICAO Asia and Pacific Regional Sub-Office (APAC RSO) consisting of ANSPs from Japan, South Korea and China aims to develop a harmonised ATFM/CDM implementation within North East Asia. Japan, the Republic of Korea and China are the founding members and it is expected that neighbouring states will be involved in the future as harmonised regional ATFM coordination grows into a framework for the region. China and the Republic of Korea are developing ATFM centres, while Japan continues to enhance its already established ATMC and ATFM capability which it already has been carrying out for many years.

The three States agreed NARAHG Terms of Reference (TOR) which includes provisions that States share information including: the capacity of airports and airspace sectors; factors affecting capacity; runway closures, weather; and ATFM daily plans (ADP). Some of the information, exchanged twice a day, in an ADP should include information on ATFM measures in progress and planned ATFM measures.

NARAHG meets twice a year to discuss harmonised ATFM concepts and specific ATFM issues such as traffic flows on ATS route A593 and other routes.

Another major topic of discussion is the operational procedure of Cross Region ATFM Collaborative Platform (CRACP) which is a new cross-region ATFM operating concept designed for the States which already have ATFM systems. CRACP is an ATFM/CDM tool for sharing data, monitoring and managing the cross region traffic between two or more States which are directly connected by FIRs. Using CRACP, three States can improve situational awareness, prediction accuracy and effectiveness of traffic flow.

7. Additional Information

7.1 Traffic Management Units

Traffic management units (TMU) are the 'branch offices' of the ATMC to manage the high-density and complex operations around metropolitan areas, which has a great impact on the traffic flow in the entire Fukuoka FIR. TMU officers are situated in the operation room at Tokyo ACC and Tokyo Approach. ATMC officers and TMU officers share information with each other such as bad weather and runway capacity constraints. If the constraints are expected to affect capacity they will strive to minimise the impact on ATC operations and operators through implementation of ATFM solutions.

7.2 Collaboration Actions for Renovation of Air Traffic Systems (CARATS)

7.2.1 Background

Considering that FAA and EUROCONTROL formulated long-term plans based on ICAO recommendations (NextGen and SESAR), in response Japan has started to plan the long-term vision for future air traffic growth in Asia Pacific to manage the anticipated growth in air traffic in Japan.

A study group consisting of representatives from the aviation industry, academia and government held discussions to draw up a long-term vision for air traffic management and to consider how the air traffic systems should be in future.

As a result the CARATS concept was formed. The CARATS concept will include:

- Collaboration among industry, academia and government
- Collaboration between operators and air navigation service providers (ANSPs)
- International collaboration to realise seamless air traffic operations
- Collaboration among co-users of airspace (civil, Japan Self-Defence Forces, US Forces)
- Collaboration with local communities

7.2.2 Objectives of CARATS

JCAB defines specific numeric targets for 2025 to promote policies effectively, taking into account the uniqueness of air traffic in Japan and global issues such as global warming.

- Enhance safety to improve safety fivefold.
- Cope with the increase in air traffic volume; double air traffic control capacity in congested airspace.
- Improve user convenience; improve service level (punctuality and reduction of flight time) by 10%.
- Increase operational efficiency; reduce fuel consumption per flight by 10%.
- Improve productivity of air traffic services; improve productivity of air traffic services by 50% or more.
- Address environmental issues; reduce CO2 emissions per flight by 10%.
- Enhance the international presence of Japan in the aviation field.

8. Visions of ATM

CANSO ATFM Workgroup decided its 'road map' to construct the air traffic system by 2025 will include items such as:

- Implement continuous climb operations (CCO)
- Progress the advisory system to avoid conflict
- Implement FLIPCY (flight plan consistency)
- Implement departure clearance and data link taxi clearance by using CPDLC
- Progress A-CDM
- Progress departure management (DMAN) and surface management (SMAN)

The Workgroup reviews the road map at every meeting.

Appendix 3

Asia-Pacific Multi-Nodal ATFM Operational Trial Project

1. Introduction

Asia Pacific is one of the fastest-growing aviation regions and has been experiencing rapid and sustained increase in air traffic demand, especially intra-regional flights. This puts a heavy load on various air navigation service resources – airports and airspace sectors – that are already operating at or near maximum capacity. When situations such as adverse weather or closures result in reduced capacity, ANSPs traditionally impose conventional flow restrictions such as larger minutes-in-trail spacing requirements to regulate inbound air traffic flow, though such measures often result in negative impact on operations, produce a ‘knock on effect’ over multiple FIRs, and seldom solve the problems.

Recognising the region’s need for a better means to collaboratively manage the large traffic demand at resources where demand exceeds capacity, and also understanding the geopolitical environment of Asia Pacific, the ANSPs of Hong Kong China, Singapore, and Thailand seeded the idea of a networked collaborative decision-making (CDM) framework that could support the implementation of cross-border air traffic flow management (ATFM) in the region. The seed was further developed into the Distributed Multi-Nodal ATFM Network concept and was endorsed by the regional ICAO ATFM Steering Group as a viable foundation for cross-border ATFM in the region.

2. Concept of Operations

The Distributed Multi-Nodal ATFM Network concept is based on a network of ANSPs leading independent ATFM operations within their domain and connected to other ANSPs and stakeholders through effective information sharing mechanism. This can be established with two operational bases:

- a. Common operating procedures are common ATFM operational guidelines and procedures, detailing responsibilities to be borne by ANSPs and stakeholders involved
- b. An interconnected information sharing framework is a fully interconnected information sharing mechanism or protocols between stakeholders that ensure efficient communication of ATFM information. This could include simple e-mails and AFTN message exchanges up to automated system-to-system information sharing based on the system-wide information management (SWIM) concept.

Through these operational bases, an ANSP can independently implement ATFM measures to regulate both domestic and international traffic into resources where demand exceeds capacity, while other ANSPs and stakeholders in the network can effectively comply with the measures by following the common operating procedure developed. Additionally, an effective communication and information sharing framework allows stakeholders to be involved in the decision-making process during all four phases of ATFM.

Figure 1 shows a graphical representation of the operational environment under this concept. In this environment; an arrival ATFM unit (arrival ATFMU) responsible for the constrained resource would implement and publish ATFM measure(s) on a cloud-based information sharing network, while the departure ATFMU and relevant stakeholders subscribe or receive the information and adjust their operations accordingly. The information sharing network also allows for a collaborative decision-making (CDM) process to take place between all relevant parties during the operations.

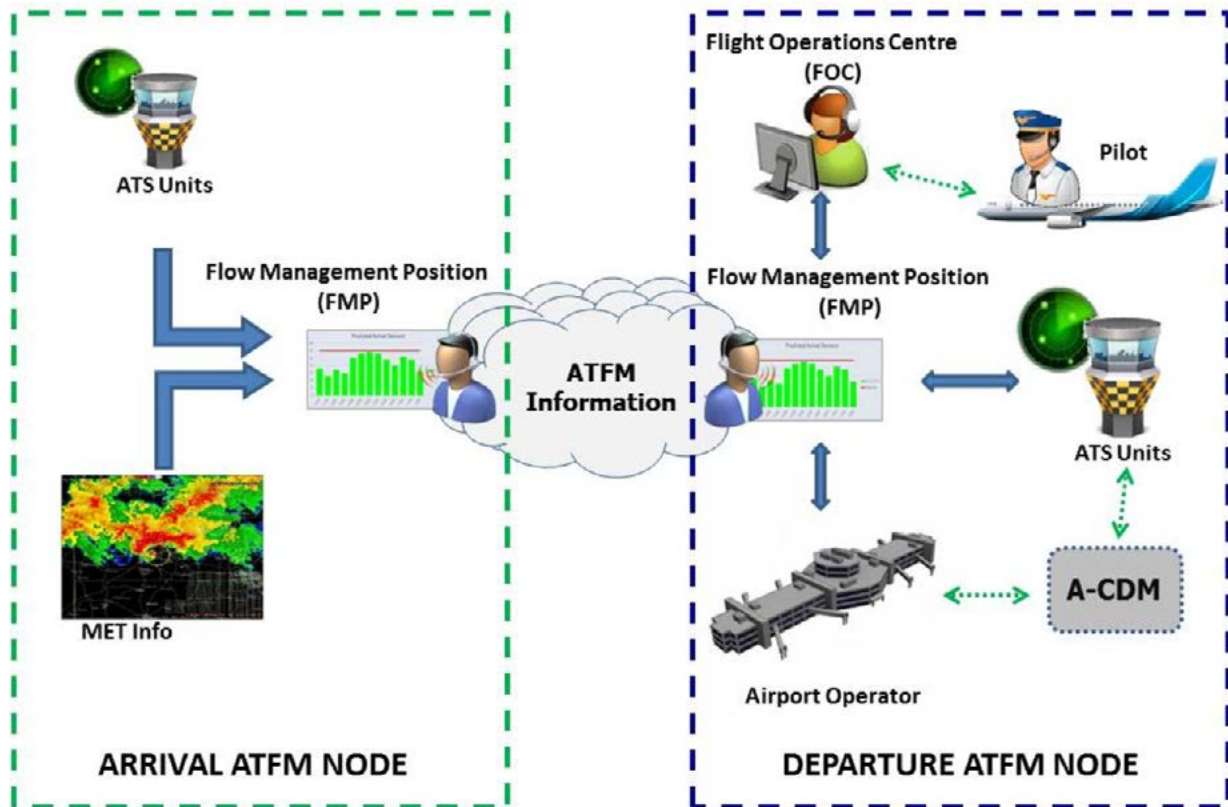


Figure 1 – Distributed Multi-Nodal ATFM Network Operational Environment

3. The Operational Trial

Following concept development led by the ANSPs of Hong Kong China, Singapore, and Thailand along with other industry partners, an operational trial project was established in 2014 to develop and validate the common operating procedure as well as to introduce the use of distributed ATFM programmes in regulating air traffic flow between constrained resources in the region.

3.1. ATFM Measure Explored

The main ATFM measure explored during this project to regulate traffic at the resources where demand exceeds capacity is a ground delay programme (GDP) through provisions of calculated take-off time (CTOT). In addition, the concept of combining various ATFM measures such as minimum departure intervals (MDI) with GDP when GDP participation does not constitute a majority of affected traffic is also being explored. The key reason for using other measures is when there is a need to include long-haul inbound flights (e.g. those from other regions) into the ATFM programme for it to be effective.

3.2. Project Participation

Since the inception of the project, many Asia Pacific ANSPs have joined the activities. These include, aside from the original three, the ANSPs of Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, and Viet Nam; with Australia lending its expertise as an advisor and project coordinator, and with support from CANSO and IATA from the inception. Recognising the different ATFM capabilities and readiness of ANSPs, the project adopted a multi-tiered participation level shown in Table 1.

Tiered Level	Capabilities and Membership
Level 3	Capable of generating, distributing, receiving and complying to ATFM Measures
Level 2	Capable of receiving and complying to ATFM Measures
Level 1	Observe and participate in the trial progress
Project Advisor	Provide advice to the project

Table 1 – Tiered Level of Participation

3.3. Project Plan

The project splits the development and implementation into two main phases to allow an incremental approach to the implementation of ATFM in the region. ANSPs are encouraged to join the network as and when they are ready. Table 2 shows the two main phases in the project.

Phase	Key Focus
Phase 1 (2015 – 2016+)	Airport Programme: Distributed GDP / CTOT to regulate traffic into constrained arrival airports
Phase 2 (2017 onward)	Airspace Program: Distributed GDP / CTOT to regulate traffic into constrained airspace sectors

Table 2 – Operational Trial Main Phases

3.3.1 Phase 1 Plan, Progress, and Contributions

Phase 1 of the project, with a focus on regulating traffic into constrained arrival airports, took place in 2015 – 2016 and followed a stage approach as shown in Table 3.

Phase 1 Stage 1	Phase 1 Stage 2	Phase 1 Stage 3
<ul style="list-style-type: none"> - Development of communication linkage and protocols - Validation of ATFM information dissemination capability 	<ul style="list-style-type: none"> - Validation of demand prediction accuracy - Development of cross-border ATFM procedure - Validation of the procedure and awareness campaign through demonstration flights 	<ul style="list-style-type: none"> - Limited-scope operational service: providing ATFM service for planned and ad-hoc airport disruptions

Table 3 – Phase 1 Stage Plan

By late 2016, the project had progressed to Phase 1, Stage 3 and operational ATFM measures – GDP/CTOT – began to be used to regulate traffic flows into constrained airports. The implementation of live operations started from planned events such as special airport closures during Singapore’s National Day Parade and Thailand’s Royal Thai Air Force Special Air Display, and expanded into ad-hoc events such as traffic surge and inclement weather conditions in Singapore. In 2017 GDP/CTOT were also

implemented in response to emergency situations in Singapore (fire in the terminal) and Hong Kong (aircraft accident and runway outage). During all the operations, originating ATFMUs distributed ATFM information, including CTOT, through agreed communication channels; e-mail, AFTN messages, and web portals. The management and discussion of CTOTs assigned were done via phone calls or web-conference facilities.

The success of the initial rounds of distributed ATFM operations in the region shows the potential of the Distributed Multi-Nodal ATFM Network concept to be fully implemented and scaled for global interoperability. However, the work is far from completed in Phase 1, with significant room for improvement in project participation and ATFM measure compliance. The project will continue to expand operations and garner support from stakeholders in the Asia Pacific region, to ensure high ATFM measure compliance rate whenever a programme is put in place. Stakeholder engagement, outreach campaign, and educational partnerships all form part of the effort going forward.

3.3.2. Phase 2 - Plan and Progress

Phase 2 of the project, with a focus on regulating traffic into airspace sectors, where demand is exceeding capacity, started in 2017 with a similar stage approach as shown in Table 4.

Phase 1 Stage 1	Phase 2 Stage 2	Phase 3 Stage 3
<ul style="list-style-type: none"> - Capability-building for airspace operational capacity assessment - Validation of traffic demand monitoring and prediction of flight trajectory 	<ul style="list-style-type: none"> - Implementation of single-constraint demand-capacity balancing - Exploration of combined ATFM measure approach 	<ul style="list-style-type: none"> - Implementation of multi-constraint demand-capacity balancing

Table 4 – Phase 2 Stage Plan

In the beginning of 2017, two major airspace disruptions due to large-scale joint military air exercises took place in Thailand (Bangkok FIR) and presented an opportunity for the ANSP of Thailand to put in place trial airspace ATFM programmes. The programmes succeeded in smoothing the traffic through congested waypoints, and provided a basis on which the project can continue to develop its operational concept.

Phase 2 presents a unique challenge to the project, with the potential for more complicated scenarios such as competing ATFM measures as flights transit through multiple airspace sectors and FIRs across the region. The guiding principle for this phase of the project is to ensure that the various ATFM measures implemented can help create the smooth and optimised traffic flow throughout the network, without adversely affecting flight operations.

4. Technical Challenge and the Technical Subgroup

4.1. Technical Challenge to Implementation

One key difference between the Distributed Multi-Nodal ATFM Network concept used in this project and the Centralised Regional ATFM Unit used in Europe (Network Management Operations Centre – NMOC) is the absence of a single ATFM unit overseeing the entire region with a single technical support tool. The distributed concept provides ANSPs in the network with independence in terms of an ATFM support system developed or procured. However, for operational efficiency, all the differing systems must be able to connect and exchange information efficiently to one another. This system-to-system linkage

has been a major challenge for the project. Throughout Phase 1 of the operational trial, stakeholders were asked to access various ATFM systems with different interfaces depending on the unit responsible for the programme implemented. In the long run, this is not a viable and scalable solution especially for airspace users with flights operating from many different countries and potentially simultaneous ATFM programmes in place.

4.2 Technical Subgroup

To address the challenge, the project set up a technical subgroup comprising technical leads from core ANSPs to fulfil the job of developing an interface control document (ICD). The ICD will specify how different ATFM systems would connect and exchange information to allow stakeholders to access any ATFM system and be able to see the entire network's ATFM statuses. Additionally, the group will also chart a development 'roadmap' – from system specification to testing and implementation – to enable such linkage between core ANSPs in the project.

The work of this group will also be fed to relevant ICAO forums, ranging from ICAO Asia-Pacific ATFM Information Requirement Small Working Group (ATFM-IR/SWG) and System-Wide Information Management Task Force (SWIM/TF) to FIXM Change Control Board (FIXM CCB) and ICAO Air Traffic Management Requirements and Performance Panel (ATMRPP). The objective is to affect change in how ATFM systems across the globe can efficiently exchange information and enable globally-interconnected ATFM networks, especially in the upcoming SWIM environment.

5 Post-Operations Analysis Framework

5.1. Framework Objective

As the project progresses with more live ATFM measures implemented, post-operations analysis becomes more important. The activation of ATFM measures directly impacts air traffic operations, and should thus always be reviewed for potential improvements. Core ANSPs in the project recognise this, and began developing a common post-operations analysis framework in early 2017.

Prior to 2017, each ANSP would perform its own analysis work after the programme but the numerical results often varied from one ANSP to the next and provided an incomplete picture of the situation. The objective of the framework is then to standardise the post-operations analysis work across member ANSPs, and to ensure that each ATFM programme implemented is properly assessed against its performance objective. In addition, the framework also seeks to recommend best practice for ANSPs in exchanging ATFM operational feedback with their stakeholders following a programme.

5.2. Key Elements for Post-Operations Analysis

To ensure post-operations analysis carried out can provide a view of how a chosen ATFM measure(s) have achieved the desired performance objective, the framework provides recommended sets of numerical analyses that can be performed in the following areas:

- Traffic Demand Prediction Accuracy – assessing the completeness and accuracy of traffic demand prediction used as a basis for ATFM measure computation. Examples include traffic count, trajectory model accuracy, flight information accuracy.
- Resource Capacity Analyses – assessing the capacity situation at various resources, utilising indicators such as average ATFM delay and trends over time, with results used to determine strategic capacity

enhancement plans.

- ATFM Measure Compliance and Effectiveness – assessing the compliance level with ATFM measure(s) implemented, and the effectiveness of the programme through comparing actual outcomes and the desired impact.

Recognising the importance of collaboration between stakeholders to analyse the ATFM operations both quantitatively and qualitatively, the framework also provides a recommended set of responsibilities of different ATFM stakeholders and the workflow guiding the conversation in a joint post-operations analysis effort.

It is intended that this work will eventually be integrated or appended to the Asia-Pacific Regional Framework for Collaborative ATFM for use by ANSPs and stakeholders in 2019.

6. Path Forward

The project is at a juncture where distributed airport ATFM programmes have been tested and are moving towards implementation, while at the same time starting to chart the path towards more complex distributed airspace ATFM programmes. The project will continue to evolve and explore different ATFM measures – including combining several of them – to handle the complexities arising from both airspace and airport demand and capacity imbalances. The project will also continue to share its lessons learned at appropriate forums and continue widening its scope to include more members in the network. The ultimate aim is to enable the concept to be fully-implemented in Asia Pacific and allow for global interoperability with other regions.

Supplementary work to the operational development, including technical system linkage and post-operations analysis framework, will also continue. The project team hopes that the outcomes of these tasks will be beneficial to the advancement of ATFM globally.

7. Lessons Learned

Since the beginning of the operational trial in 2015, the project has accumulated many lessons in regional cross-border ATFM implementation. Below are a few key learnings.

7.1. Collaboration is Key

ATFM is a highly collaborative process and involves stakeholders agreeing and working together to ensure safe and smooth metering of air traffic. This collaboration applies to ANSPs working together when cross-border ATFM is implemented at a regional level. The Multi-Nodal Operational Trial project began as a collaborative project between three ANSPs, and expanded through a network of organisations and stakeholders willing to work together for a common goal. It is this willingness to collaborate that forms the core of the Distributed Multi-Nodal ATFM Network concept.

7.2. Balance stakeholders' needs

Stakeholders' needs in a flight operation environment generally differ, and need to be balanced. For an ATS unit, a safe and expeditious flow of air traffic is paramount; while for an airline or a set of flight crews, on-time delivery of passengers and cargo and predictability of operations take precedence. It is important to keep in mind these differing needs when choosing the right ATFM measure(s) to implement, taking into account the operational situation at hand. Thus far, the project has been focusing on the use

of ground delay programme (GDP) as the ATFM measure of choice, due to its ability to distribute delays evenly among participating flights and to provide predictability to stakeholders. However, concepts such as combined ATFM measures and delay absorption options are also being explored to balance the needs of long-haul flights and airport operators' ground infrastructure limitation. The project has also focused on ensuring the involvement of stakeholders in the decision-making process every step of the way.

7.3. Tiered approach to implementation

One of the driving reasons for adopting a tiered approach to participation is the recognition that ANSPs and stakeholders in the region are at different levels of readiness or operational requirement for ATFM implementation. By allowing ANSPs and stakeholders to join the project at their appropriate readiness level, the project allows members to incrementally learn and adopt the operations with support from others in the network.

7.4. Performance-based approach to operational analysis

ATFM, by nature, is implemented to solve demand-capacity imbalance problems. Without properly assessing the situation before and after ATFM measure activation, the impact of the measure cannot be determined. The project has started to develop a framework to perform this post-operations analysis, and adopts a performance-based approach to do so. By outlining clear performance objectives for each ATFM programme, and quantitatively measuring the outcome against them, ANSPs implementing the programme can assess its success (or lack thereof) definitively and determine steps to improve the operations in subsequent rounds.

7.5. Importance of personnel awareness and education

Introducing ATFM creates changes in air traffic operations, and requires a paradigm shift among personnel involved; requiring a strong awareness effort and education process for all stakeholders. Understanding and facilitating the ATFM process requires personnel involved to understand the importance of network-wide traffic optimisation and the need for some changes in their operations. In addition, clear understanding of the reach and limitations of ATFM should also be highlighted. By committing resources and effort to the awareness raising and education process, ANSPs will be able to obtain support and buy-in from their personnel and stakeholders which will prove crucial in the implementation.

Appendix 4

ATFM/CDM Implementation in the Dominican Republic

1. General Overview

ICAO Code: **MDCS**
 ANSP: **IDAC**
 Number of Airports: **8 international**
 Major Hub: **MDPC**
 Major Gateway: **MDSO**

The Dominican Republic is a world tourism destination with a continuous annual passenger increase of 6.4%. Tourism and related economic activity contributed 17% to the country's gross domestic product, in 2016..

This tiny Caribbean island operates eight international airports, Punta Cana being the busiest with 62% of the country's air traffic, the second being Las Americas.

The Dominican Institute of Civil Aviation (IDAC) is the air navigation service provider in Santo Domingo Flight Information Region (FIR) and delivers air traffic services.

Since 2013, IDAC has aimed to consolidate major projects of cooperation with the international aviation community, working together with neighbouring States. One of the major projects was the opening of an ATFM/CDM unit in January 2016.



Figure 1- Santo Domingo FIR with North Sector heavy traffic

Due to air traffic growth resulting in demand exceeding capacity, ATFM measures have been put in place to manage the airspace and airports with the safest and most efficient approach.

With ATFM/CDM being a new concept in the Caribbean and Latin America region the ATFM implementation in the Dominican Republic encountered several challenges.

2. Challenges

- Staffing - is one of the major issues. For best results the staff assigned to perform a task in the unit must have an ATC background, usually being an active or former air traffic controller (ATCO) in order to understand how traffic is impacted with flow measures. Air traffic controllers are not always available at any ANSP; the shortage of ATCOs is a delaying factor.
- ATFM Suites and Tools - technology is expensive. The software and hardware available in the market are costly, so it is difficult to sell as a project to top management.
- Stakeholders Integration - bringing people on board was not an easy task, the hardest to convince were our internal customers, air traffic controllers, supervisors, managers and others. The external customers embraced the concept with commitment and were able to participate and share information in the meetings and web conferences through a CDM system platform.



Figure 2 - ICAO-IDAC 2015 ATFM Go-Team with Stakeholders

3. Work Plan

The Work Plan of the Unit was prepared to comply with the ATFM Implementation Roadmap.

- The successful implementation of ATFM Unit working sessions with stakeholders were arranged to introduce them to all ATFM concepts, LOAs, ATFM procedures and implementation process for collaborative decision making. Stakeholders included airlines, government authorities, the military and airport management.
- Air navigation personnel were also involved in the process through several working sessions in collaboration with FAA and ICAO teams. The IDAC Team was able to receive a global vision of the ATFM concept and the collaborative activities in the region
- Since its opening, the IDAC ATFM/CDM unit has supported primarily Santo Domingo ACC and all towers and approach facilities within the FIR, and have also developed a strong ATFM coordination and information exchange in the region
- This step was based in the installation of hardware equipment.

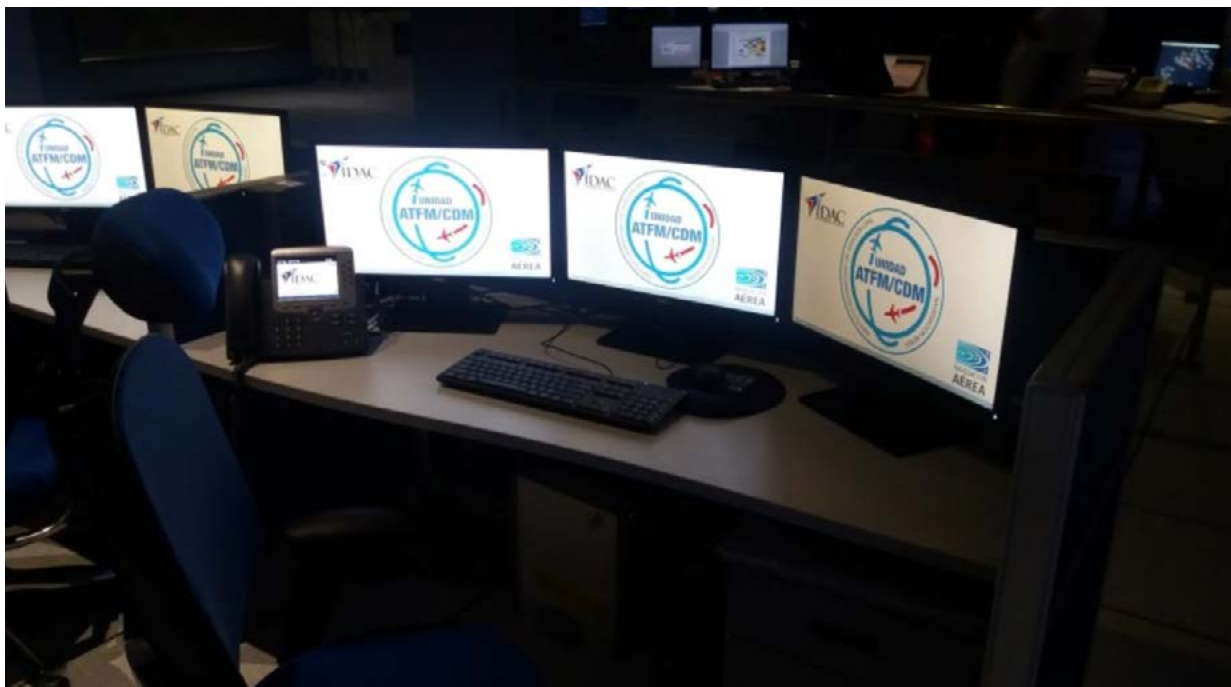


Figure 3 - IDAC ATFM/CDM Unit Workstation

3. Key Factors for the ATFM/CDM Unit Opening

- Support of the IDAC General Director and Air Navigation Directorate
 - o Training opportunities to develop the abilities to perform ATFM/CMD tasks and qualifications to start this ATFM/CDM project
 - o Resources and facilities for developing the project since the beginning.
 - o Benchmarking opportunities with ICAO and FAA and different States to acquire best practices.
- Continuous Support from ICAO and CANSO.
 - o Foster relationship with ICAO NAM/CAR Office
 - o Opportunities for IDAC to be part of an ICAO Go Team of ATFM/CDM missions that have improved the relationship and collaboration between States
 - o Inclusion and creation of CANSO ATFM Data Exchange Network for the Americas (CADENA) Regional Implementation Group (RIG)
 - o Workshops, meetings and training opportunities.
- Integrated Collaboration between FAA and IDAC.
 - o Benchmarking opportunities for IDAC managers to exchange best practices and experiences
 - o Continuous collaboration with the FAA has provided all required assistance for the strategic planning and initiatives for the success of the project.

In January 2016 the IDAC ATFM/CDM unit was opened, with the support of FAA and ICAO authorities such as Anthony Tisdall, ATCSCC General Manager, Carlos Gonzalez, ICAO Regional Officer ATM, and Rommy Gallego, ICAO Regional



Figure 4 - IDAC ATFM/CDM Opening





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