

CANSO Guide on ATFM/A-CDM Integration



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Contents

Acknowledgements	2	6. SWIM and ATFM/A-CDM Information Exchange	26
1. Executive Summary	5	6.1. What Is SWIM and Why Is It Relevant?	26
2. Background Basics	6	6.1.1. SWIM Basics	26
2.1. Basics of ATFM	6	6.1.2. SWIM Layers	27
2.2. Basics of A-CDM	6	6.1.3. Further Details	30
2.3. ATFM/A-CDM Integration	7	6.2. SWIM and ATFM/A-CDM Information Exchange	30
3. Benefits of ATFM/A-CDM Integration	8	6.2.1. SWIM as the Most Viable Enabler for ATFM/A-CDM Integration	30
3.1. Purpose and Benefits of ATFM/A-CDM Integration	8	6.2.2. Information Exchange Models Supporting ATFM/A-CDM Information Exchange	30
3.2. Integration Benefits: The European Network Example	8	6.2.2.1 Asia/Pacific: APAC Flow Extension	31
4. ATFM/A-CDM Integration Concept	10	6.2.2.2. United States: Traffic Flow Management Data Service (TFMDa)	32
4.1. Conceptual Approach to the Integration	10	6.2.2.3. Future Development	34
4.2. Key Information Exchanges for Successful Integration	11	7. Recommendations for ATFM/A-CDM Integration	35
4.3. Exchange of ATFM Measure Information	13	7.1. Stakeholder Engagement	35
4.3.1. Purpose and Benefits	13	7.1.1. Key Stakeholders in ATFM/A-CDM Integration	35
4.3.2. Message Exchange in a Centralised Concept	13	7.1.1.1. Air Traffic Flow Management Unit (ATFM Unit)	35
4.3.3. Message Exchange in a Distributed Concept	13	7.1.1.2. Air Traffic Service Unit (ATS Unit)	36
4.4. Exchange of Flight Update Information	14	7.1.1.3. Airport Operators	36
4.4.1. Purpose and Benefits	14	7.1.1.4. Aircraft Operators	36
4.4.2. Message Exchange in a Centralised Concept	14	7.1.1.5. Ground Handling Unit	37
4.4.3. Message Exchange in a Distributed Concept	15	7.1.2. Example of Stakeholder Connections with Integrated ATFM/A-CDM	37
4.5. Exchange of Flight Departure Information	17	7.2. Establishment of Common Objectives	38
4.5.1. Purpose and Benefits	17	7.3. Integration Planning and Execution	38
4.5.2. Message Exchange	17	7.4. Data Quality and Testing	39
5. Sample Use Cases for AFTM/A-CDM Integration	20	7.4.1. Exchange of ATFM Measure Information	39
5.1. Use Case 1: Exchange of ATFM Measure Information	20	7.4.2. Exchange of Flight Update Information	39
5.1.1. Introduction	20	7.4.3. Exchange of Flight Departure Information	40
5.1.2. Pre-requisites	20	7.5. Success Measure Development	40
5.1.3. Step-by-Step Description	20	8. Case Studies	42
5.2. Use Case 2: Exchange of Flight Update Information	22	About This Section	42
5.2.1. Introduction	22	8.1. Australia: Planned A-CDM and ATFM Integration for Australia	42
5.2.2. Pre-requisites	22	8.1.1. Australian Operating Environment	42
5.2.3. Step-by-Step Description	22	8.1.2. Current Collaborative Decision Making Processes	43
5.3. Use Case 3: Exchange of Flight Departure Information	24		
5.3.1. Introduction	24		
5.3.2. Pre-requisites	24		
5.3.3. Step-by-Step Description	24		

8.1.3.	Benefits of A-CDM at Network level	44	8.3.1.	Project Background	56
8.1.4.	Principles for A-CDM and ATFM Integration	44	8.3.1.1.	A-CDM Implementation Project Steering Committee	56
8.1.5.	Collaborative Management of Flight Updates	45	8.3.1.2.	Governing Philosophy for the Integration	57
8.1.6.	Equity in A-CDM Pre-Departure Sequence	46	8.3.1.3.	Integration with the European ATFM Operations	57
8.1.7.	ATFM Compliance Management	47	8.3.1.4.	Supporting Systems	57
8.1.8.	Network Collaborative Decision Making	47	8.3.2.1.	Challenges in the Implementation Process	57
8.1.9.	Lessons Learned	48	8.3.2.2.	Benefits from Integrated ATFM/A-CDM at Warsaw Chopin Airport	58
8.1.9.1.	Lesson 1 – Change Management: don't underestimate the difficulty of explaining the interaction between ATFM and A-CDM	48	8.4.	United States: Surface Collaborative Decision Making and Terminal Flight Data Manager	58
8.1.9.2.	Lesson 2 – Identify the strengths of your local CDM implementation and leverage those to reduce complexity	48	8.4.1.	Overview of S-CDM and TFDM Surface Metering	59
8.2.	Thailand: ATFM/A-CDM Integration at Bangkok Suvarnabhumi Airport (VTBS)	49	8.4.2.1.	Electronic Flight Data (EFD)	61
8.2.1.	Contextual Background	49	8.4.2.2.	Traffic Flow Management (TFM)	62
8.2.1.1.	Brief History and Current Status of ATFM in Thailand	49	8.4.2.3.	Surface Management and Metering	62
8.2.1.2.	Brief History and Current Status of A-CDM in Thailand	50	8.4.2.4.	Systems Consolidation	62
8.2.1.3.	The Needs for ATFM/A-CDM Integration at Bangkok Suvarnabhumi Airport (VTBS)	51	8.4.3.	Demonstrated Benefits	62
8.2.2.	ATFM/A-CDM Integration Concept	52	8.4.4.	Challenges and Lessons Learned	63
8.2.2.1.	Integration at the Procedure Level	52	8.5.	China: ATFM/A-CDM Integration at Shanghai Pudong Airport (ZSPD)	64
8.2.2.2.	Integration at the System Level	53	8.5.1.	Background	64
8.2.3.	Planned Direction	55	8.5.2.	Project	64
8.2.3.1.	iFIMS: Expanded Airport Information Management and Full A-CDM Capability	55	8.5.3.	Integration Workflow of A-CDM and ATFM	65
8.2.3.2.	Connecting ATFM and A-CDM on SWIM-based Technologies	55	8.5.3.1.	Data Collection	65
8.2.4.	Lessons Learned	56	8.5.3.2.	Data interaction	66
8.2.4.1.	Early Planning for Integration	56	8.5.3.3.	Intelligent Decision-Making	67
8.2.4.2.	Integration at Procedure and System Levels	56	8.5.3.4.	Intelligent Guidance	67
8.2.4.3.	Stakeholder Engagement	56	8.5.4.	Main Points Summary of A-CDM and ATFM Integration	67
8.3.	Poland: ATFM/A-CDM Integration at Warsaw Chopin Airport (EPWA)	56	8.5.5.	Achievements	68
			8.5.6.	Lesson Learned	68
			8.5.6.1.	Establishment of Data Collection Rules	68
			9.	Acronyms	69

1. Executive Summary

In recent years, the aviation industry has seen rapid growth of air traffic all around the globe. In a continuous effort to ensure the ATM industry keeps pace with the growth and to ensure optimised and efficient use of resources, two concepts emerged and were quickly adopted in many regions. These are air traffic flow management (ATFM) and airport collaborative decision-making (A-CDM) processes.

Both ATFM and A-CDM are collaborative processes aimed at improving operational efficiency and optimising the use of resource capacities – at the airport and in airspace – in the face of ever-growing traffic demand. Both processes have been recognised as important enablers ensuring that air traffic continues to be managed as safely and efficiently as possible. Many documents have been published to guide their implementations including CANSO's [Implementing Air Traffic Flow Management and Collaborative Decision Making](#) (it is recommended that these documents be read in conjunction with this document).

With both processes aiming at improving efficiency and optimising resources, their integration can be expected. In fact, at the time of this writing, Europe has led the way with ATFM/A-CDM integration by having implemented A-CDM and linked the process with their regional ATFM operations at 28 airports with very good outcomes. Such integration of ATFM/A-CDM as shown in Europe can be expected in other regions around the world as ATFM and A-CDM are more widely adopted.

As a continuation of CANSO's educational publications on ATFM and A-CDM, and to guide ANSPs and regions in their integration efforts, this document discusses in detail the operational and technical concept for ATFM/A-CDM integration as well as recommendations for ANSPs and stakeholders in their work.

In [Section 2](#) and [Section 3](#), readers will be reminded what ATFM and A-CDM are and why their integration can be beneficial to the overall operations. [Section 4](#) and [Section 5](#) then expands into the operational and technical concepts for ATFM/A-CDM integration, with step-by-step use cases to demonstrate the use of inter-system data exchange. To conclude the descriptive portion of the document, [Section 6](#), discusses system-wide information management (SWIM) and how it can be a very important technological enabler to ATFM/A-CDM integration.

With the description of ATFM/A-CDM integration covered, the document moves from knowledge to guidance. [Section 7](#) provides recommendations for ANSPs or ATFM/A-CDM integration teams to consider when working on the integration effort, and finally [Section 8](#) provides case studies from various ANSPs with experience integrating the two systems.

2. Background Basics

2.1. Basics of ATFM

ATFM is a requirement for air navigation service providers (ANSPs) under ICAO Annex 11 to the *Convention on Civil Aviation for States*. It helps to monitor demand, capacity, and constraints at airports and airspaces, and enables stakeholders to share accurate and up-to-date information. With up-to-date information shared, appropriate decisions can be made when demand exceeds capacity which could lead to the implementation of ATFM.

These ATFM solutions could include capacity enhancement and implementation of ATFM measures. Essential to ATFM solutions is collaborative decision making (CDM), an effective process ensuring all stakeholder needs are considered before decisions are made in the ATFM process. Together, ATFM/CDM can optimise airport and airspace capacity and improve the efficiency and effectiveness of air navigation service provision.

Initial ATFM evolution was championed by the Federal Aviation Administration (FAA) in the U.S. and EUROCONTROL in Europe; however, over the past two decades, other air navigation service providers (ANSPs) around the world began developing ATFM competencies to address their local or regional problems.

Initial implementations of ATFM were meant to manage air traffic demand where and when it exceeded capacity of air traffic control (ATC) services. The modern concept of ATFM has evolved to facilitate the safe, orderly and expeditious flow of air traffic by not only ensuring that ATC capacity is optimised and utilised to the maximum extent possible, but also allows the traffic demand to be compatible with ATC capacity.

The level of an ATFM service required in a given setting will depend on a number of factors. An ATFM service is established to enable air navigation services providers (ANSPs) to effectively provide the required service based on the current and projected operational needs.

One key to the successful implementation of an effective ATFM service is achieving robust coordination among aviation stakeholders. It is envisioned that ATFM is performed as a collaborative decision-making (CDM) process where airport operators, ANSPs, aircraft operators and other stakeholders work together to improve the overall performance of the ATM system. It is likewise envisioned that such coordination will take place within a flight information region (FIR), between FIRs and, ultimately between ICAO regions.

As a general rule, ATFM is needed whenever aircraft operators are faced with constraints on their operations and in areas where traffic flows are significant. ATFM entails engagement firstly during the strategic phase, in the form of strategic airspace utilisation planning; secondly during the pre-tactical phase, where meteorological factors and other developing constraints are assessed and mitigation plans are considered; and thirdly, during the tactical phase, which includes the period during which the aircraft is in operations. Lastly the post operations phase assesses the actions that were taken, or not taken during the previous ATFM phases and continuous improvement can result after analysis.

For further information, in-depth knowledge of ATFM/CDM can be found in ICAO's *Manual on Collaborative ATFM* (Doc 9971) and CANSO's [Implementing Air Traffic Flow Management and Collaborative Decision Making](#).

2.2. Basics of A-CDM

Airport Collaborative Decision-Making (A-CDM) is a set of processes developed from the general philosophy of collaborative decision-making (CDM) in aviation and is applied to the operations at airports.

A-CDM can optimise airport operations by enhancing the turnaround process and improving flight predictability through real time data exchange for all A-CDM stakeholders. A-CDM also potentially helps to improve gate/ aircraft stand management, and to reduce congestion at aprons, taxiways and holding points. A-CDM involves

implementing a set of operational procedures supported by the sharing of timely and accurate information amongst A-CDM stakeholders. Overall, A-CDM is about making more efficient use of existing capacity and resources, as well as better managing recovery from disruptions. A-CDM can, in some cases, reduce airport operating cost attributed to fuel burn and contribute to environmental benefits.

Any implementation of A-CDM must be based on assessment of current operational constraints and the value an A-CDM implementation will generate to mitigate such constraints and/or improve current operations. There is a set of essential elements as well as best practices to consider when implementing A-CDM that will simplify and harmonise the implementation. However, each implementation must be based on careful engagement across all airport stakeholders, primarily the airport operator, aircraft operators, ground handling agents, air navigation service provider and air traffic flow management unit; the latter being of the utmost importance when considering integration between ATFM and A-CDM.

Prior to A-CDM, the stakeholders worked on the basis of 'first come, first served' in the start-up sequence of aircraft. A-CDM, on the other hand, works on the basis of 'best planned, best served' in which aircraft operators / ground handling units provide updated estimates of their target off-block times (TOBTs). ATC will then optimise the pre-departure sequence by issuing target start-up approval times (TSATs) based on the TOBTs submitted. It is a collaborative approach among all the A-CDM stakeholders and success is ultimately dependent on the accuracy of TOBTs managed by aircraft operators.

To aid the generation of accurate TOBTs and TSATs in the A-CDM process, timely and accurate information updates are very important. Key information needed are estimated landing times, i.e. Estimated Landing Time, Estimated In-Block Time, Actual Landing Time and Actual In-Block Time from the arriving flight that is linked to the departing flight. Timely update of this information is related to the A-CDM milestones.

For further information, in-depth knowledge on A-CDM can be found in CANSO's [Airport Collaborative Decision-Making – Optimisation through Collaboration](#).

2.3. ATFM/A-CDM Integration

ATFM and A-CDM are both collaborative processes aimed at improving operational efficiency and optimising the use of resource capacities – whether at the airport or in the airspace. Both processes rely on effective and timely exchange of data between stakeholders and across platforms/systems. The rest of this document explores how these two processes can be linked together to enhance their effectiveness and maximise benefits to all stakeholders.

3. Benefits of ATFM/A-CDM Integration

3.1. Purpose and Benefits of ATFM/A-CDM Integration

ATFM and A-CDM are two collaborative decision making (CDM) processes designed to facilitate more efficient operations within their domains. These processes do so by collaboratively involving multiple stakeholders in the decision-making chain, relying on the most accurate information available at a given point in time. Without the foundation for common accurate information sharing across all stakeholders, the decision-making process will be sub-optimised or in some cases counterproductive and not delivering the expected efficiency gain.

Both ATFM and A-CDM, once implemented, will independently deliver different benefits to the stakeholders. There are several good examples around the world where independent benefits have been achieved from ATFM and A-CDM implementation. However, it is widely recognised that integrated ATFM/A-CDM – with comprehensive information exchanges across systems and processes – will provide more benefits to stakeholders. For example, these benefits have been demonstrated in Europe with more than 28 A-CDM airports being integrated with the Network Manager's regional ATFM system, ranging from improved operational predictability to reduced delays and better demand-capacity balances.

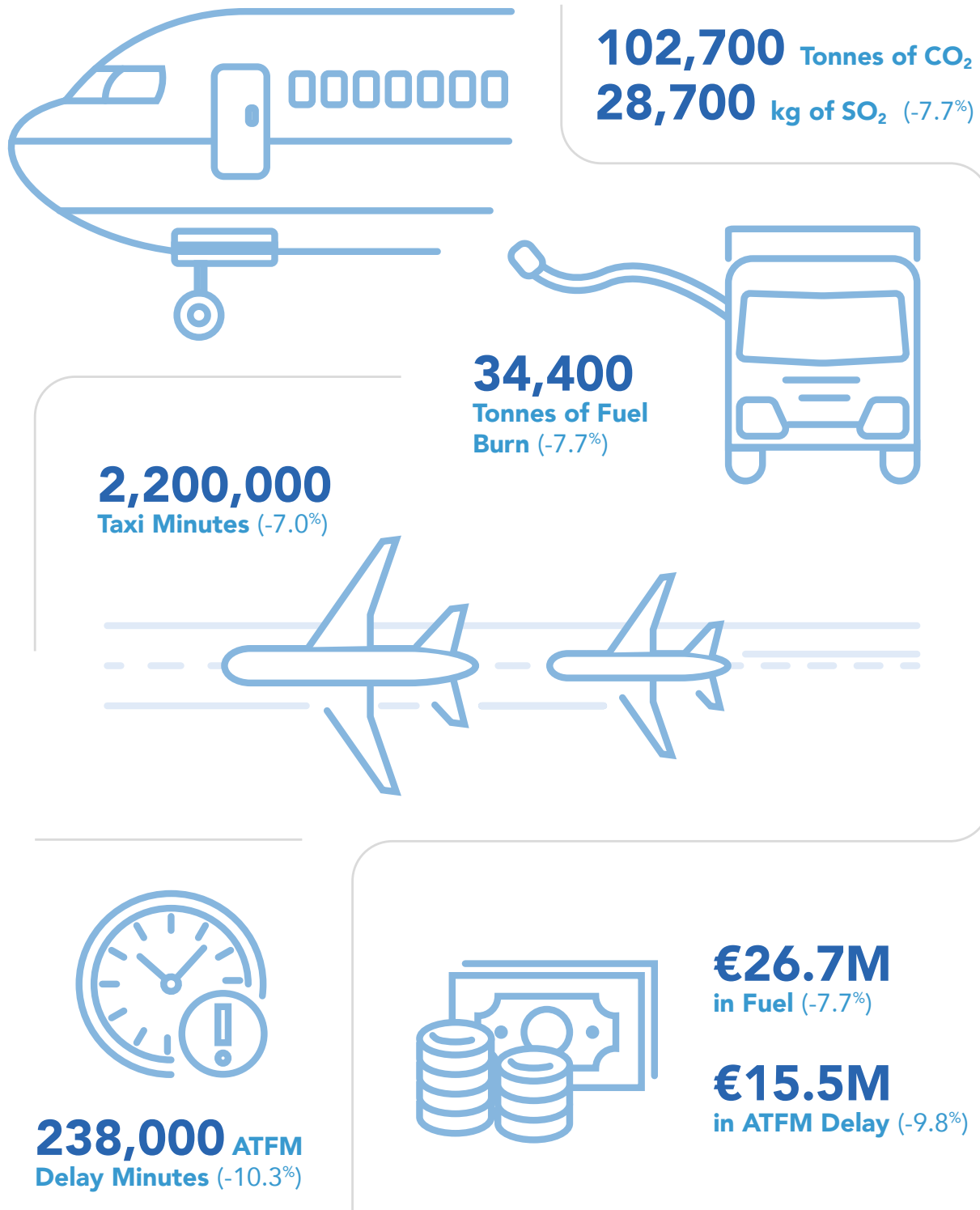
Conceptually, the following added benefits can be expected from integrated ATFM/A-CDM:

- The integration of information between ATFM and A-CDM systems will lead to better management of the network, thanks to the common situational picture enabling better understanding and enhanced CDM among stakeholders
- The ATFM system will be able to take into account A-CDM airport constraints impacting relevant flights when making demand-capacity balancing decisions
- The A-CDM airport will have access to more accurate flight updates from the ATFM system, enabling a more optimised aircraft turnaround process on the ground upon arrival
- Expanded information sharing will enable better traffic prediction and more accurate resource capacity declaration
- Stakeholders will have access to comprehensive information and better situational awareness, enabling more effective contributions in both the ATFM and A-CDM processes

3.2. Integration Benefits: The European Network Example

One of the best practices in ATFM/A-CDM integration, with clear demonstrated benefits, is the one done in Europe. At the time of this writing, Europe has 28 airports A-CDM enabled and integrated with the ATFM service and system provided by EUROCONTROL Network Manager. [Figure 1](#) illustrates the high-level benefits both at the local A-CDM airport and the European airspace network levels, based on EUROCONTROL's [Airport collaborative decision-making \(A-CDM\) impact assessment](#) (March 2016).

Based on **2.2 million** annual departures...



(Total relative savings across the 17 CDM airports in 2015 when compared to pre A-CDM premance)

4. ATFM/A-CDM Integration Concept

4.1. Conceptual Approach to the Integration

This document is written taking into consideration two well-defined ATFM concepts of operations being implemented. One is the centralised ATFM concept implemented regionally, such as in Europe. The other is the distributed ATFM network concept implemented regionally in regions such as Asia-Pacific (APAC Cross-Border Multi-Nodal ATFM Collaboration: AMNAC) and Latin America and the Caribbean (CANSO ATFM Data Exchange Network for the Americas: CADENA), and being explored in the Middle East.

Centralised and distributed regional ATFM have fundamental differences in their concepts of operations, namely:

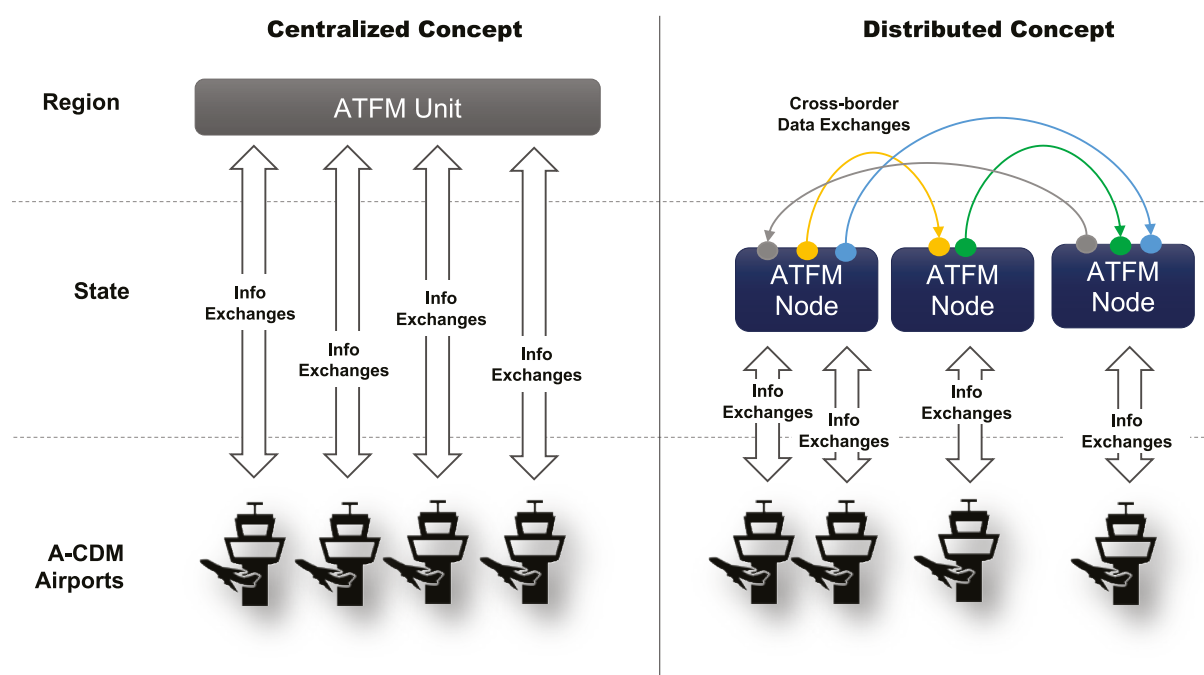
- The centralised ATFM concept utilises one centralised ATFM unit providing ATFM service in a regional network of countries or FIRs (e.g. Europe) based on a regional agreement.
- The distributed ATFM network concept utilises multiple ATFM nodes; each independently responsible for ATFM in their domain (e.g. country or FIR boundary), based on regionally agreed principles and information exchange network. Each node is able to implement ATFM measures that impact flights departing from other nodes in the network, with ATFM compliance facilitated by the nodes at the departure end; thus forming a regional network to enable cross-border ATFM without a centralised unit. This concept is referred to as the “Multi-Nodal Cross-Border ATFM” concept in *ICAO Doc 9971*. This document retains the use of ‘distributed ATFM concept’ to contrast it with ‘centralised ATFM concept’.

Irrespective of the ATFM concept being implemented, this document outlines the conceptual approach to the integration with the A-CDM process. To a large degree, best practices in A-CDM implementation demonstrated in Europe are used as references in this document.

Core conceptual principles for integration include:

1. The information exchanges are divided into three categories:
 - i. Exchange of ATFM information to A-CDM system (ATFM to A-CDM). This could be information about ATFM measures being implemented, e.g. ATFM slot times.
 - ii. Exchange of flight updates information to A-CDM system (ATFM to A-CDM). This could be expected arrival times estimated by the ATFM system.
 - iii. Exchange of departure information to ATFM system (A-CDM to ATFM). This could be updated times from the departure milestones in the A-CDM system.
2. The information exchanges to achieve integration should be scalable, allowing a phased expansion of functionality on both the A-CDM and ATFM systems.
3. The information exchanges should be aligned with some A-CDM milestones to ensure a common ‘baseline’ for the integration, and with that also a common set of functionality and benefits at both A-CDM and ATFM level. This is further detailed in [Section 4.2](#)
4. System-wide information management (SWIM) concept, with the common information exchange model such as Flight Information Exchange Model (FIXM) or FIXM Extension, is recommended to be used as the basis for information exchange as it is expected to enable most effective integration of the two systems. [Section 6](#) of the document discusses SWIM and its role in ATFM/A-CDM integration in more detail.

[Figure 2](#) illustrates the high-level operational integration concept for both centralised and distributed ATFM concepts.



Credit: Saab

Figure 2 – ATFM/A-CDM Integration: Conceptual Diagram

From [Figure 2](#),

- In the centralised ATFM concept, A-CDM airports are connected to the single, regional ATFM unit.
- In the distributed ATFM network concept, A-CDM airports are connected to the ATFM node in which the airport is located (local ATFM Node). A given ATFM node may be connected to one or many airports within their domain.

IMPORTANT NOTE – Under the SWIM environment, there is no technical limitation preventing A-CDM airports from connecting to (i.e. subscribing for information from) multiple ATFM nodes in the distributed ATFM network concept. Based on the operational experience in Asia-Pacific at the time of this writing, however, it is advisable that A-CDM airports only act on the ATFM information that have already been reconciled by the local ATFM node. By ensuring that the local ATFM node has had a chance to reconcile the information from other ATFM node(s) before the information is being acted upon by the A-CDM airports, situations such as conflicting ATFM slots can be resolved at the ATFM level before they affect the A-CDM process. [Figure 2](#) is drawn with this operational recommendation in mind.

4.2. Key Information Exchanges for Successful Integration

As discussed in core principle (1) above, ATFM/A-CDM information exchanges are divided into three categories, demonstrating different purposes and benefits each category of exchanges can bring to the overall process. The division will also allow for scalability as discussed in the core principle (2), enabling the considerations of implementation priorities, objectives, and procedure and system readiness.

[Table 1](#) gives a high-level overview of the 3 categories of information exchanges, followed by detailed discussions in the sub-sections.

Category	Direction	Purpose and Benefit
Exchange of ATFM Measure Information	ATFM to A-CDM	<p>As ATFM system issues ATFM measure (e.g. ATFM slots or calculated take-off times: CTOTs), the measure will affect departing flights from the A-CDM airport. By exchanging ATFM measure information from the ATFM system to A-CDM system, the information can automatically be taken into account by the A-CDM pre-departure sequencer and help decision-making at the A-CDM airport.</p> <p>By sharing the ATFM information, stakeholders at the A-CDM airport can have increased predictability and awareness of the departure flow and restrictions.</p>
Exchange of Flight Updates Information	ATFM to A-CDM	<p>With ATFM measures implemented, profiles of the flights expected to arrive at the A-CDM airport (the inbound flights) could change. The updated estimates, e.g. estimated landing times (ELDTs) or calculated landing times (CLDTs), can normally be calculated by the ATFM system. By flowing such information from the ATFM system to the A-CDM system, it will help create predictability to downstream A-CDM events – landing, in-block, off-block, start-up, take-off – for the outbound flights.</p> <p>With higher level of predictability in the A-CDM process, better planning of resources can be achieved, ultimately by bringing better performance to the turnaround and departure process for flights.</p>
Exchange of Flight Departure Information	A-CDM to ATFM	<p>To enhance downstream demand-capacity prediction and balancing, it is important that the ATFM system obtains reliable information about the flights' progress at the airports. At the A-CDM airport, accurate updated departure planning information such as off-block, start-up, and take-off times will be available. By sharing such information to the ATFM node, and having it forwarded to other ATFM nodes in the network for the case of distributed ATFM concept, tactical demand-capacity balancing can be improved; leading to better capacity utilisation and less restrictions.</p>

Table 1 – ATFM/A-CDM Information Exchange Categories

The three categories of ATFM/A-CDM information exchanges are further discussed in detail in the following sections.

Note: in the following sections, the ATFM measure central to the discussion is a ground delay programme (GDP). GDP works by the assignment of take-off ATFM slots (calculated take-off times: CTOTs) to departing flights in anticipation of congestion in the airspace or arrival airport downstream. The central concept is for the flights to absorb anticipated delays on the ground predictably rather than while airborne. GDP is used as an ATFM measure central to the discussion because of its immediate effect on the airport's departure flows. Unlike other 'primarily manual' ATFM measures such as minimum departure intervals (MDI) or minutes-in-trail (MINIT), GDPs are normally implemented using automated ATFM system and thus will demonstrate clearly the system-level integration with A-CDM.

4.3. Exchange of ATFM Measure Information

4.3.1. Purpose and Benefits

When the ATFM system issues ATFM measures, e.g. CTOTs, the departure flows and departing flights from the A-CDM airport will be affected. By exchanging ATFM information such as CTOTs from the ATFM system to the A-CDM system, the information can be automatically taken into account by the A-CDM pre-departure sequencer and create increased predictability and decision-making at the airport.

4.3.2. Message Exchange in a Centralised Concept

In a centralised ATFM concept, only one ATFM unit is handling the generation of ATFM messages. This unit – and its system – will be responsible for sending relevant messages, e.g. CTOTs, to the A-CDM airport and system. Table 2 illustrates this concept.

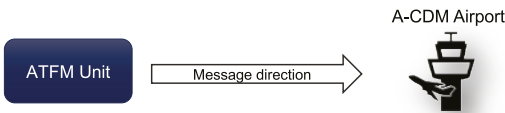
Description	
Message Exchange Overview	 <p>The diagram illustrates the message flow in a centralised ATFM concept. A dark blue box labeled 'ATFM Unit' is connected by a white arrow labeled 'Message direction' to an icon of an 'A-CDM Airport' which includes a control tower and a runway.</p>
Message Content	<p>This message is related to the departing flight, e.g. a CTOT message for the flight departing from the A-CDM airport.</p> <ul style="list-style-type: none"> Flight Identification, e.g. a combination of ACID and EOBT or a GUF^[1] if in a SWIM environment Calculated take-off time (CTOT)
Message Timing	<p>This message is recommended to be sent at least 2 hours before the Estimated Off-Block Time (EOBT) for the departing flight from the A-CDM airport.</p> <p>In the A-CDM process, this is related to Milestone 2^[2]. The information will be taken into account in TSAT calculation</p>
Message Format	<p>Message exchange format commonly agreed among stakeholders is recommended.</p> <p>EUROCONTROL uses Slot Allocation Message (SAM)^[3] for this purpose.</p> <p>In a SWIM environment, the use of the most current flight information exchange model (FIXM) or FIXM Extension is recommended for this purpose.</p>
Important Notes	<ul style="list-style-type: none"> If CTOT for a flight is changed, a new message needs to be sent to the A-CDM system. If CTOT for a flight is cancelled, a new message noting the cancellation needs to be sent to the A-CDM system.

Table 2 – ATFM (GDP) Message Exchange to A-CDM in Centralised ATFM Concept

4.3.3. Message Exchange in a Distributed Concept

In a distributed ATFM concept, CTOTs can be originated either by the ATFM node connected to the A-CDM airport (local ATFM node) or another ATFM node in a different country in the same network (cross-border ATFM node), depending on the location of constrained or congested ATM resource. In this concept, all CTOT information will be routed through the local ATFM node, which will then forward the information to the local A-CDM airport(s) connected to it. [Table 3](#) illustrates this concept.

¹ Globally Unique Flight Identifier (GUF^I) is a unique and unambiguous identifier assigned to a given flight and its “Flight Object” in SWIM environment. This will be discussed in later section of the document.

² EUROCONTROL A-CDM Implementation Manual (5th Edition, 2017)

³ EUROCONTROL Specification for Data Exchange Presentation (ADEXP) (v.3.2, 2017) and ATFCM Operations Manual (Ed.23.1, 2019)

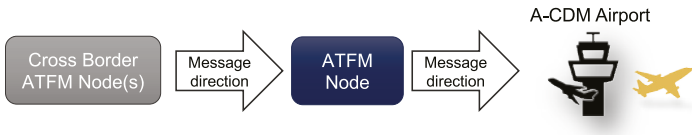
Description	
Message Exchange Overview	 <p>This message is related to the departing flight, e.g. a CTOT message for the flight departing from the A-CDM airport.</p>
Message Content	<ul style="list-style-type: none"> Flight Identification, e.g. a combination of ACID and EOBT or a GUF¹ if in a SWIM environment Calculated take-off time (CTOT)
Message Timing	<p>This message is recommended to be sent at least 2 hours before the estimated off-block time (EOBT) for the departing flight from the A-CDM airport.</p> <p>In the A-CDM process, this is related to Milestone 2. The information will be taken into account in TSAT calculation</p>
Message Format	<p>Message exchange format commonly agreed among stakeholders in the network is recommended.</p> <p>In Asia-Pacific, members of the APAC Multi-Nodal ATFM Collaboration have jointly developed a common standard to support ATFM/A-CDM message exchange via AFTN/AMHS network. Much of the messages are based on EUROCONTROL's ADEXP model.</p> <p>In a SWIM environment, the use of the most current flight information exchange model (FIXM) or FIXM Extension is recommended for this purpose.</p>
Important Notes	<ul style="list-style-type: none"> If CTOT for a flight is changed, a new message needs to be sent to the A-CDM system. If CTOT for a flight is cancelled, a new message noting the cancellation needs to be sent to the A-CDM system.

Table 3 – ATFM (GDP) Message Exchange to A-CDM in Distributed ATFM Network Concept

4.4. Exchange of Flight Update Information

4.4.1. Purpose and Benefits

With ATFM implemented, profiles of the flights expected to arrive at the A-CDM airport (the inbound flights) could change. The updated estimates, e.g. Estimated Landing Times: ELDTs or Calculated Landing Times: CLDTs, can normally be calculated by the ATFM system. By flowing such information from the ATFM system to the A-CDM system, it will help create predictability to downstream A-CDM events – landing, in-block, off-block, start-up, take-off – for the outbound flights.

With higher level of predictability in the A-CDM process, better planning of resources can be achieved, ultimately by bringing better performance to the turnaround and departure process for flights.

4.4.2. Message Exchange in a Centralised Concept

In a centralised ATFM concept, only one ATFM unit is handling the generation of certain ELDTs/CLDTs for the flights. This unit – and its system – will be responsible for sending relevant messages, e.g. ELDTs/CLDTs, to the A-CDM airport and system. [Table 4](#) illustrates this concept.

¹ Globally Unique Flight Identifier (GUF¹) is a unique and unambiguous identifier assigned to a given flight and its "Flight Object" in SWIM environment. This will be discussed in later section of the document.


Description	
Message Exchange Overview	 <p>The diagram illustrates the message flow from a 'Local ATFM Solution' (represented by a blue box) to an 'A-CDM Airport' (represented by an icon of an airport terminal). A white arrow labeled 'Message direction' points from the Local ATFM Solution to the A-CDM Airport.</p> <p>This message is related to the arriving flight, e.g. an ELDT message for the flight arriving to the A-CDM airport.</p>
Message Content	<ul style="list-style-type: none"> • Flight Identification, e.g. a combination of ACID and EOBT or a GUFI if in a SWIM environment • Estimated or calculated landing time (ELDT or CLDT)
Message Timing	<p>This message is recommended to be sent – at least – at 3 key points for the arriving flight:</p> <ul style="list-style-type: none"> • After take-off, • Entry into the local FIR of the destination airport. • ELDT has been changed by an agreed parameter, e.g. 5 minutes <p>However, if able, the information can be continuously updated and sent to the A-CDM airport.</p> <p>In the A-CDM process, this is related to Milestone 3 and Milestone 4.</p>
Message Format	<p>Message exchange format commonly agreed among stakeholders is recommended.</p> <p>EUROCONTROL uses Flight Update Message (FUM) for this purpose.</p> <p>In a SWIM environment, the use of the most current Flight Information Exchange Model (FIXM) or FIXM Extension is recommended for this purpose.</p>
Important Notes	N/A

Table 4 – Flight Update Message Exchange to A-CDM in Centralised ATFM Concept

4.4.3. Message Exchange in a Distributed Concept

In a distributed ATFM network concept, initial ELDTs – e.g. one generated right after take-off – may be estimated by another ATFM node outside of country in which the A-CDM airport is located. Such ELDTs will be routed from cross-border ATFM node to the local ATFM node, which will then be forwarded to the A-CDM airport(s) connected to it. [Table 5](#) illustrates this concept.


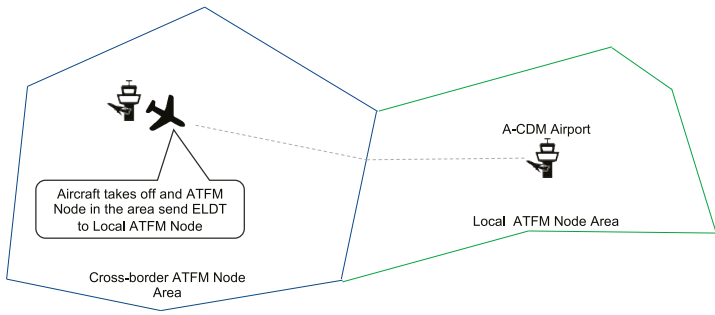
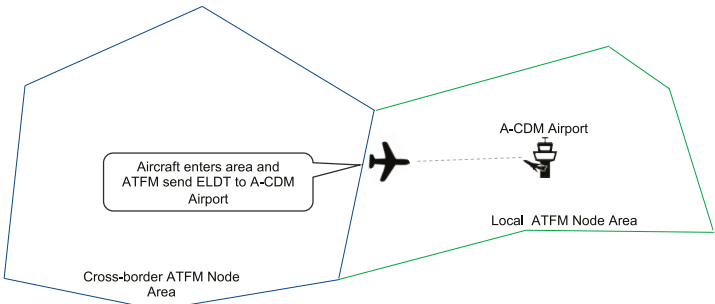
Description	
Message Exchange Overview	 <p>This message is related to the arriving flight, e.g. an ELDT message for the flight arriving to the A-CDM airport.</p>
Message Content	<ul style="list-style-type: none"> Flight Identification, e.g. a combination of ACID and EOBT or a Globally Unique Flight Identifier (GUFI) if in a SWIM environment Estimated or Calculated Landing Time (ELDT or CLDT)
Message Timing	<p>This message is recommended to be sent – at least – at 3 key points for the arriving flight:</p> <ul style="list-style-type: none"> After take-off Entry into the local FIR of the destination airport ELDT has changed by an agreed parameter, e.g. 5 minutes <p>Immediately after take-off, and before the flight's entry into destination FIR, ELDT message would be generated by cross-border ATFM node and delivered to the A-CDM airport via the local ATFM node.</p>
	
	<p>Once the aircraft enters destination FIR, the local ATFM node will take over the generation of ELDT and supply the information to the A-CDM airport.</p>
	 <p>In the A-CDM process, this is related to Milestone 3 and Milestone 4.</p>
Message Format	<p>Message exchange format commonly agreed among stakeholders is recommended.</p> <p>In a SWIM environment, the use of the most current Flight Information Exchange Model (FIXM) or FIXM Extension is recommended for this purpose.</p>
Important Notes	<p>N/A</p>

Table 5 – Flight Update Message Exchange to A-CDM in Distributed ATFM Network Concept

4.5. Exchange of Flight Departure Information

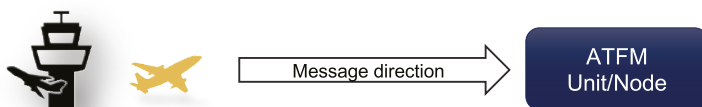
4.5.1. Purpose and Benefits

To enhance downstream demand-capacity prediction and balancing, it is important that the ATFM system receives reliable information about the flights' progress at the airports. At the A-CDM airport, accurate updated departure planning information such as off-block, start-up, and take-off times will be available. By sharing such information to the local ATFM system, and having it forwarded to other ATFM systems in the network for the case of distributed ATFM concept, tactical demand-capacity balancing can be improved; leading to better capacity utilisation and better ATFM measure implementation.

Note that not all events in the aircraft turnaround and departure process will be necessary for the ATFM system. Only major updates resulting in significant deviations from the flight's originally planned departure and subsequent entry into a constrained/congested resource may be necessary.

4.5.2. Message Exchange

A-CDM Airport



This message is related to the departing flight, e.g. departure planning information at various stages of the aircraft turnaround process for the flight departing from the A-CDM airport.

The exchange of departure planning information between the A-CDM and local ATFM node will be the same regardless of the ATFM concept in which the system operates. The forwarding of information from the local ATFM node to cross-border ATFM nodes in a distributed ATFM network concept will be subjected to the network's agreement on the utilities of information shared. Participants in the distributed ATFM network need to discuss and agree on what departure planning information should be shared across the borders and how they should be used in ATFM measure planning.

To clearly illustrate the types of departure planning information available for exchange between ATFM and A-CDM systems, a comprehensive model based on EUROCONTROL's practice – using Departure Planning Information Messages (DPIs) – is listed in [Table 6](#).

In keeping with the core principle (2) on scalability and phased approach to integration, and core principle (3) on a common baseline to deliver key benefits, not all of EUROCONTROL's DPI messages need to be exchanged in environments other than Europe. To deliver the key benefits, [Table 6](#) also lists a recommendation on which of the DPI messages should be considered mandatory for any ATFM/A-CDM integration.

A-CDM Milestones	DPI Message Name	Minimal Set
1. Flight Plan Activated	Early DPI (EDPI)	Mandatory
2. EOBT – 2 Hours	Target DPI-target (TDPI-t)	
3. Take-Off from Outstation	Target DPI-target (TDPI-t)	
4. FIR Entry	Target DPI-target (TDPI-t)	
5. Final Approach	Target DPI-target (TDPI-t)	
6. Landed	Target DPI-target (TDPI-t)	
7. In Block	Target DPI-target (TDPI-t)	Mandatory
8. Ground Handling Commencement	Target DPI-target (TDPI-t)	
9. TOBT Update	Target DPI-target (TDPI-t)	Mandatory
10. TSAT Issuance	Target DPI-sequenced (TDPI-s)	Mandatory
11. Boarding Starts	Target DPI-sequenced (TDPI-s)	
12. Call Ready	Target DPI-sequenced (TDPI-s)	
13. Start Up Request	Target DPI-sequenced (TDPI-s)	
14. Start Up Approval	Target DPI-sequenced (TDPI-s)	
15. Off-Block	ATC DPI (ADPI)	Mandatory
16. Take-Off		
No Applicable Milestone	Cancel DPI (CDPI)	Mandatory

Table 6 – Recommended Departure Planning Information

Based on the mandatory set of messages, [Table 7](#) outlines the triggering events for these mandatory message deliveries and associated contents.

A-CDM Milestones	DPI Message Name	Message Trigger	Message Content (Mandatory in bold)
1. Flight Plan Activated	EDPI	1. Milestone event MS1	<ul style="list-style-type: none"> • Flight Identifier • SOBT • TOBT • TSAT • TTOT
7. In Block	TDPI-t	1. Milestone event MS7 2. TTOT or TSAT significant changes, e.g. more than 5 minutes as applied in Europe 3. Change of aircraft type or registration	<ul style="list-style-type: none"> • Flight Identifier • SOBT • TOBT • TSAT • TTOT
9. TOBT Update	TDPI-t	1. Milestone event MS9 2. TTOT or TSAT significant changes, e.g. more than 5 minutes as applied in Europe 3. Change of aircraft type or registration	<ul style="list-style-type: none"> • Flight Identifier • SOBT • TOBT • TSAT • TTOT
10. TSAT Issuance	TDPI-s	1. Milestone event MS10 2. TTOT or TSAT significant changes, e.g. more than 5 minutes as applied in Europe 3. Change of aircraft type or registration	<ul style="list-style-type: none"> • Flight Identifier • SOBT • TOBT • TSAT • TTOT
15. Off-Block	ADPI	1. Milestone event MS 15 2. TTOT or TSAT significant changes, e.g. more than 5 minutes as applied in Europe 3. Change of aircraft type or registration	<ul style="list-style-type: none"> • Flight Identifier • AOBT • TTOT
No Applicable Milestone	CDPI	1. Flight Cancellation	<ul style="list-style-type: none"> • Flight Identifier • SOBT • TOBT • TSAT • TTOT

Table 7 – Departure Planning Information Triggers and Contents

5. Sample Use Cases for AFTM/A-CDM Integration

This section provides sample use cases related to the various ATFM/A-CDM information exchange scenarios. The use cases are not describing all underlying details on certain calculations made by the ATFM system, e.g. ELDTs, or A-CDM system, e.g. TSATs, but are rather describing the principles of what is happening in a step-by-step manner from an operational point of view. The step-by-step description clarifies how the exchange of information between ATFM and A-CDM can enhance stakeholders' operations.

5.1. Use Case 1: Exchange of ATFM Measure Information

5.1.1. Introduction

In this Use Case a step-by-step explanation outlines on how an A-CDM system can utilise the calculated take off time (CTOT) from an ATFM system in its calculations.

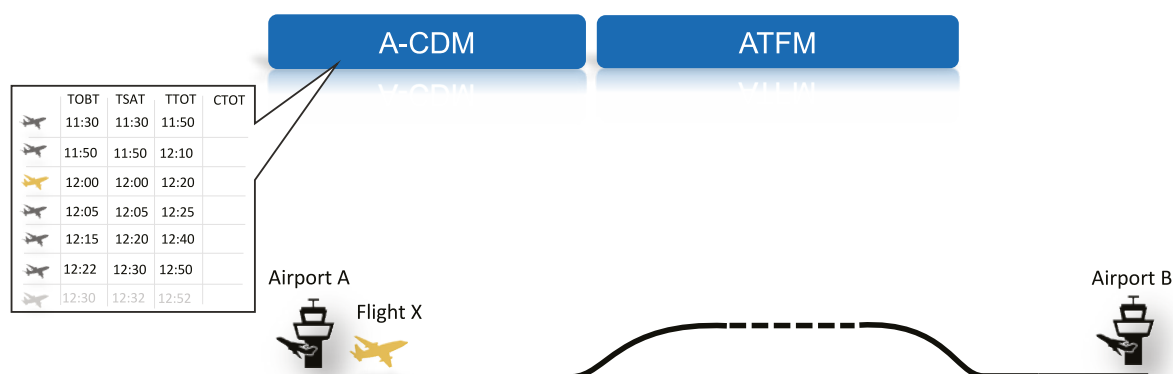
5.1.2. Pre-requisites

- Procedures for both the ATFM and A-CDM process are in-place
- The ATFM and A-CDM systems are integrated enabling the exchange of the ATFM CTOT information at a system level.
- The A-CDM system has a pre-departure sequence or DMAN capability.
- The A-CDM system has a variable taxi time (VTT) capability making it possible to calculate estimated taxi out times (EXOT) for any flight included in the A-CDM process.
- The A-CDM process for all flights included in the process starts at EOBT – three hours, and this is also when preliminary TOBTs, TSATs and TTOTs are calculated, i.e. a pre-departure sequence is calculated including all flights from about 3 hours into the future.

5.1.3. Step-by-Step Description

1. Flight X is flying from Airport A to Airport B. Airport A has an A-CDM system.
2. The A-CDM system at Airport A is calculating TTOTs and TSATs for flights based on available information from TOBTs and other parameters. This generates the Pre-Departure Sequence.

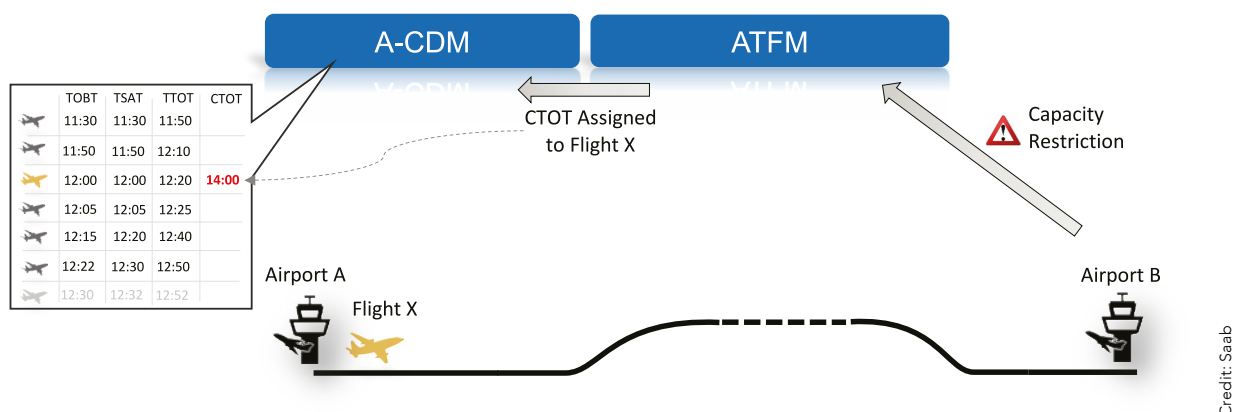
Note – The illustration below shows Step 1 and 2.



Credit: Saab

3. Due to capacity restrictions at Airport B the ATFM system assigns a CTOT for Flight X. The assigned CTOT for Flight X is 14:00. This happens 2 hours before the departure for Flight X (i.e. Flight X's EOBT – 2 hours)

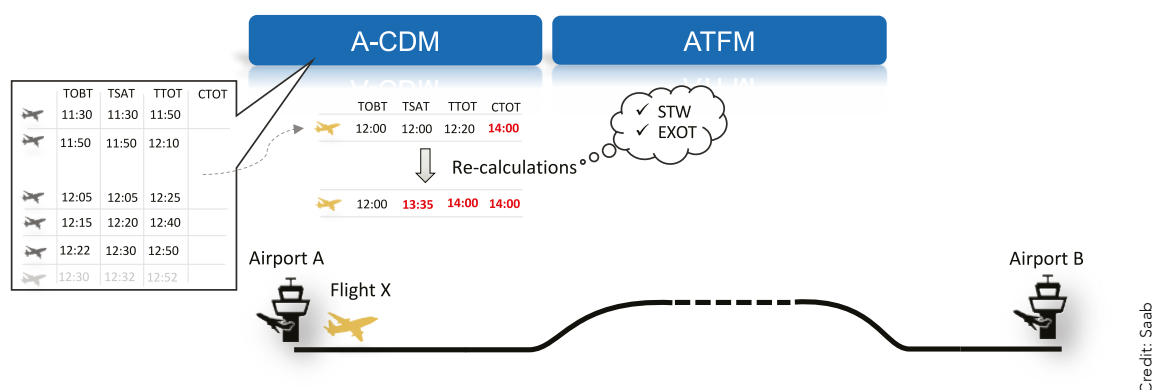
Note – The illustration below shows step 3.



4. Once CTOT is received by the A-CDM system, it will re-calculate certain key times as follows:

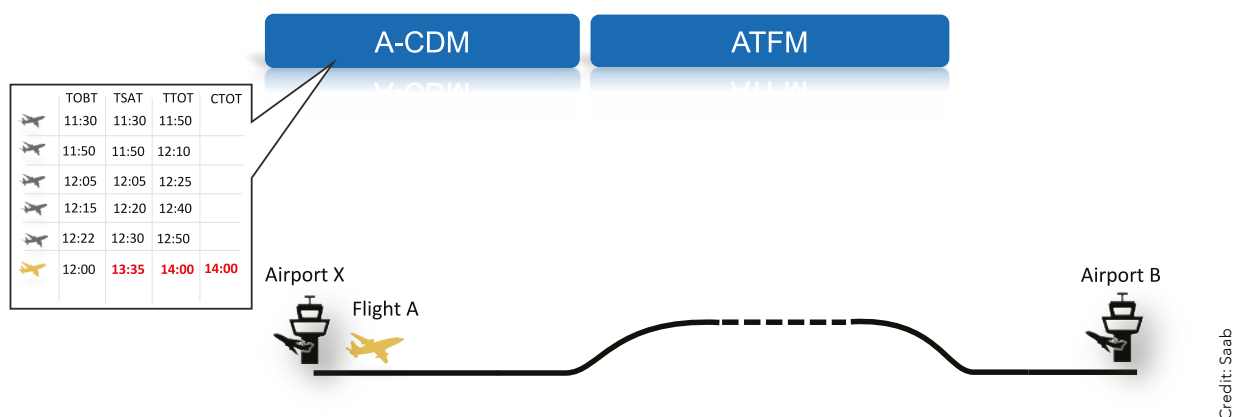
- a. CTOT and its Slot Tolerance Window ^[4] (STW) sets the boundaries for the TTOT and TSAT Calculations.
- b. Based on the CTOT and the EXOT into account, the TSAT is recalculated to be 13:35. Example formula for TSAT
 - i. $TSAT = [\text{Earliest time in the STW when Flight X must be at Runway Entry Point}] - [\text{EXOT}]$,
i.e. $13:35 = [14:00 - 5 \text{ min}] - 20 \text{ min}$.
- c. After the A-CDM system completes the calculation Flight X will have the following key times:
 - i. TOBT = 12:00
 - ii. TSAT = 13:35
 - iii. TTOT = 14:00
 - iv. CTOT = 14:00

NOTE – The illustration below shows step 4.



5. Based on the new TSAT, TTOT and CTOT Flight X has a new place in the pre-departure sequence which the A-CDM stakeholders are made aware of 2 hours in advance in this example. This allows the Aircraft Operator to make decisions on how to manage its TOBT in relation to the delay of 1 hour 35 minutes Flight X has received.

Note – The illustration below shows step 5.



5.2. Use Case 2: Exchange of Flight Update Information

5.2.1. Introduction

This use case is a step-by-step explanation on how an A-CDM system can utilise the estimated landing time (ELDT) sent from an ATFM system.

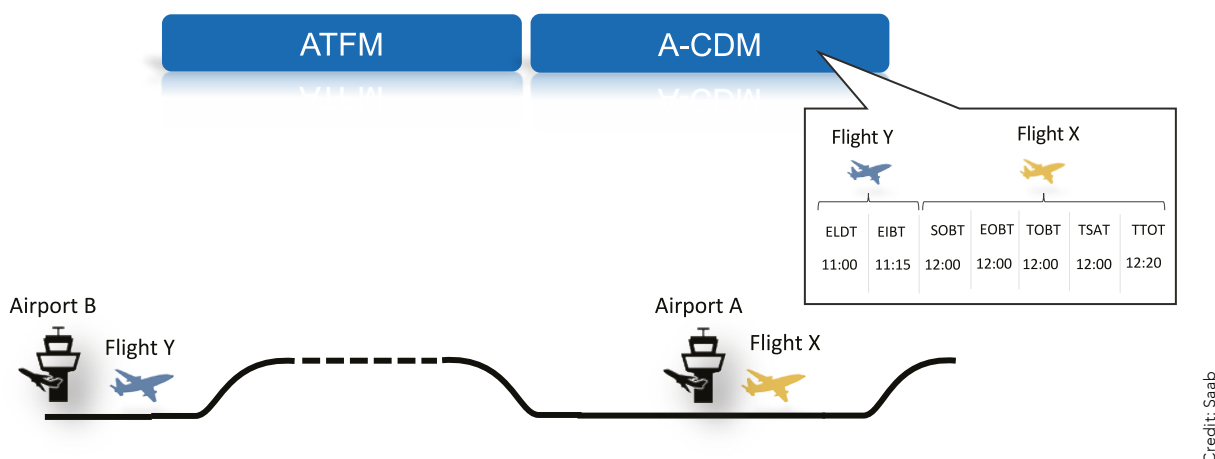
5.2.2. Pre-requisites

- Procedures for both the ATFM and A-CDM process are in-place
- ATFM and A-CDM systems are integrated enabling the exchange of the ATFM ELDT information at a system level
- The A-CDM system has the capability to calculate Target Off Block Times (TOBTs) based on information inputs, e.g. ELDTs
- The A-CDM system has a pre-departure sequence or DMAN capability
- The A-CDM system has a Variable Taxi Time (VTT) capability making it possible to calculate Estimated Taxi In Times (EXIT) and Estimated Taxi Out Times (EXOT) for any flight included in the A-CDM process
- The A-CDM process for all flights included in the process starts at EOBT – three hours, and this is also when preliminary TOBTs, TSATs and TTOTs are calculated, i.e. a pre-departure sequence is calculated including all flights from about 3 hours into the future

5.2.3. Step-by-Step Description

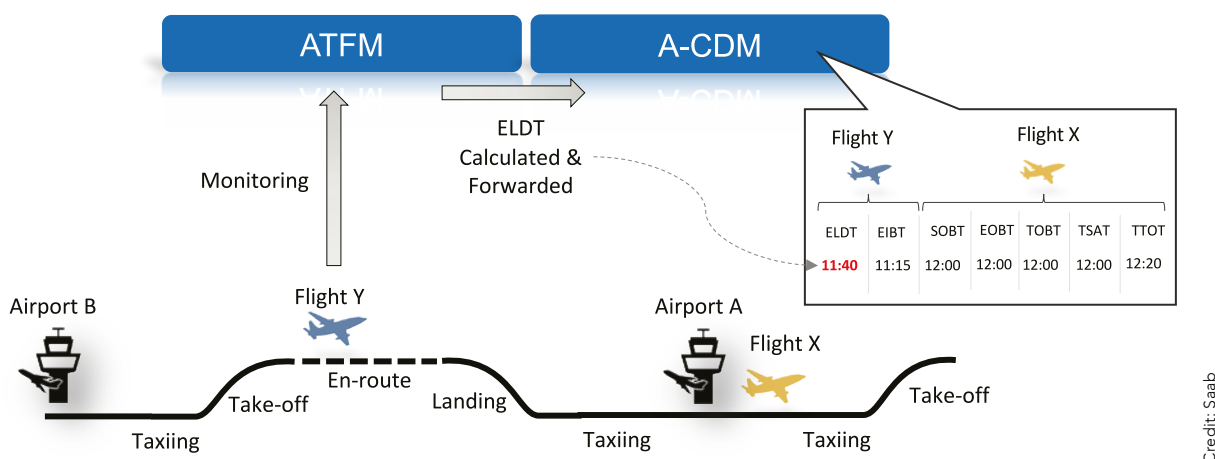
1. Flight Y is flying from Airport B to Airport A, will subsequently go through a turnaround process and fly out of Airport A as Flight X. Airport B has an A-CDM system.
2. For Flight X and Flight Y (at Airport Y) the A-CDM system has generated the following key information at Flight X's EOBT -3 hours
 - a. ELDT = 11:00 (Flight Y)
 - b. EIBT = 11:15 (Flight Y)
 - c. SOBT = 12:00 (Flight X)
 - d. EOBT = 12:00 (Flight X)
 - e. TOBT = 12:00 (Flight X)
 - f. TSAT = 12:00 (Flight X)
 - g. TTOT = 12:20 (Flight X)

Note – The illustration below shows step 1.



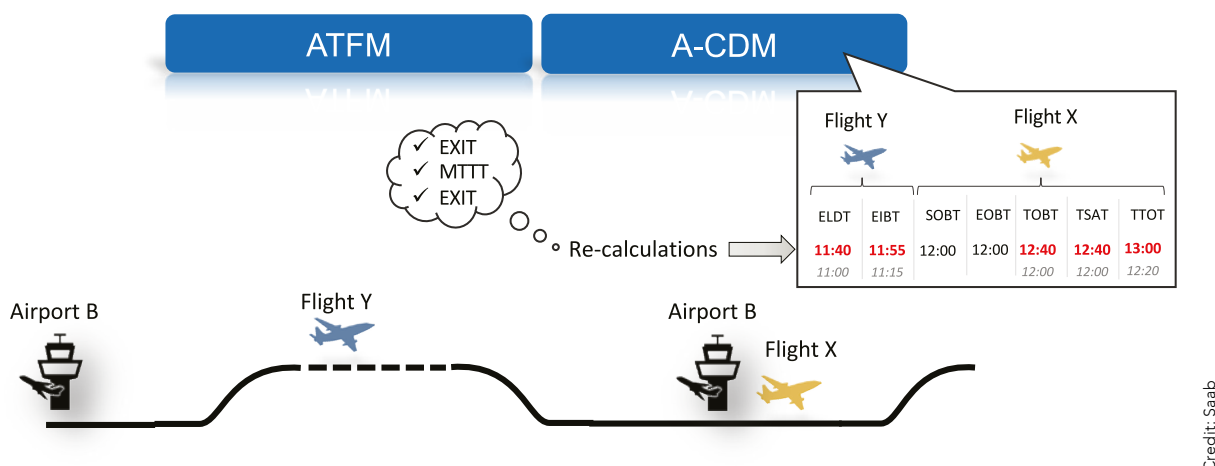
3. Flight Y is now en-route on the way to Airport B. The ATFM system is calculating the ELDT for this flight and based on agreed information exchange principles the ATFM system sends the ELDT to the A-CDM system at Airport B.
4. The ELDT that the ATFM system sends is 11:40, i.e. a later ELDT than then A-CDM system currently has.

Note – The illustration below shows step 2 and 3.



5. Once the A-CDM system receives the new ELDT (=11:40) it re-calculates EIBT, TOBT, TSAT and TTOT. The result of these re-calculations are:
 - a. ELDT = 11:40 (Flight Y)
 - b. EIBT = 11:55 (Flight Y) $EIBT = 11:40 + 15 \text{ min (the EXIT)}$
 - c. SOBT = 12:00 (Flight X)
 - d. EOBT = 12:00 (Flight X)
 - e. TOBT = 12:40 (Flight X) $TOBT = EIBT + 45 \text{ min (the MTTT)}$
 - f. TSAT = 12:40 (Flight X)
 - g. TTOT = 13:00 (Flight X) $TTOT = TSAT + 20 \text{ min (the EXOT)}$

NOTE – The illustration below shows step 4.



- Based on the ELDT from the ATFM system and the re-calculation by the A-CDM system the Airport CDM stakeholders have access to the latest information about Flight Y and Flight X and the impact the late ELDT will have. As updates to the ELDTs are sent the A-CDM will continue to update the related information as shown in step 4 above.

5.3. Use Case 3: Exchange of Flight Departure Information

5.3.1. Introduction

This Use Case is a step-by-step explanation on how an A-CDM system will provide Flight Departure Information to an ATFM system

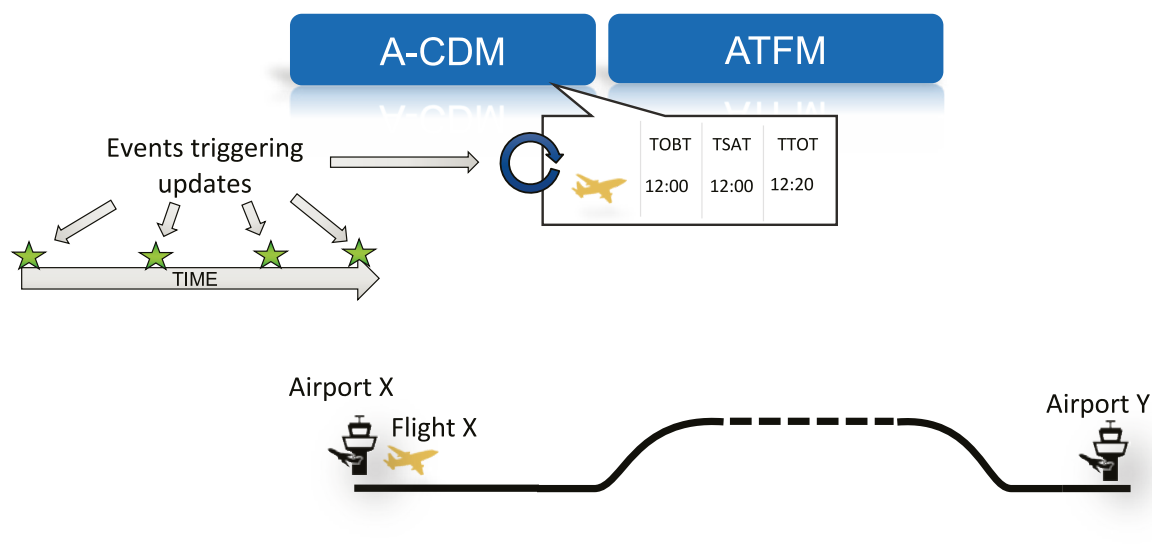
5.3.2. Pre-requisites

- Procedures for both the ATFM and A-CDM process are in-place
- The ATFM and A-CDM systems are integrated enabling the exchange of the A-CDM Flight Departure Information at a system level
- The A-CDM system is capable of generating the Departure Flight Information messages at various events and with content as described in Section 4.5.2
- The A-CDM System has the capability to calculate target off block times (TOBTs) based on information inputs
- The A-CDM system has a pre-departure sequence or DMAN capability
- The A-CDM system has a variable taxi time (VTT) capability making it possible to calculate Estimated Taxi Out Times for any flight included in the A-CDM process
- The A-CDM process for all flights included in the process starts at EOBT – three hours, and this is also when preliminary TOBTs, TSATs and TTOTs are calculated, i.e. a pre-departure sequence is calculated including all flights from about 3 hours into the future

5.3.3. Step-by-Step Description

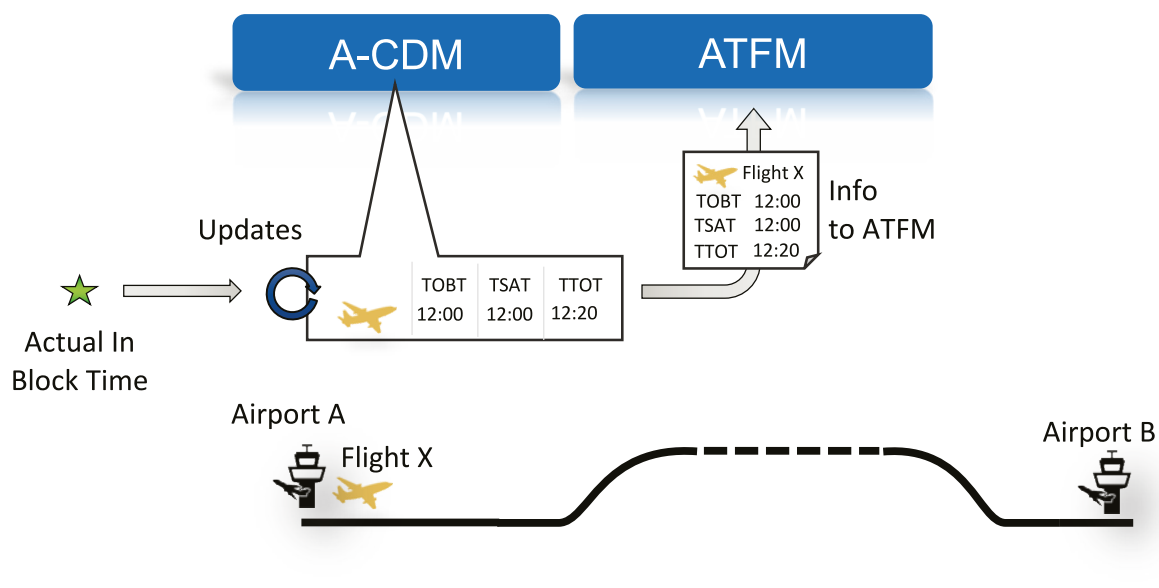
- Flight X is flying from Airport A to Airport B. Airport X has an A-CDM system.
- The A-CDM system at Airport A is calculating TTOTs and TSATs for Flight X based on available information like TOBT. These calculations and subsequent re-calculations are happening from Flight X's EOBT -3 hours all the way up Flight X's actual off block time (AOBT). Specific events in-between will trigger re-calculations.

Note – The illustration below shows Step 1 and 2.



3. At these Milestones the A-CDM system will update information and some of this information will be sent to the ATFM system. The recommended content per Milestone is described in [Section 4.5.2](#). In this Use Case example Flight X has received an Actual In Block Time (AIBT) which triggers updates to TOBT, TSAT and TTOT. The A-CDM System send the TSAT and TTOT to the ATFM System.

Note – The illustration below shows 3.



4. Once the information received by the ATFM system this will be used in its demand and capacity calculations and allocation of CTOTs.

6. SWIM and ATFM/A-CDM Information Exchange

6.1. What Is SWIM and Why Is It Relevant?

The integration of ATFM and A-CDM requires efficient information exchange between the two systems, as discussed in Section 3. However, information exchange provisions for ATFM/A-CDM integration based on conventional messaging systems (e.g. AFTN) are sparse. Most of the ATFM/A-CDM data elements have not been included in the existing message exchange provisions, and new provisions will be required to support the integration effort.

System wide information management (SWIM) is a concept to enable structured machine-to-machine communication and to support enhanced data exchange across ATM systems. Chief benefits of SWIM is its flexibility and scalability, designed into the concept through the principles of loose system coupling and service-oriented architecture (SOA). By separating the ‘applications’ – e.g. specific software used – from “information services” – i.e. what and how data are exchanged, SWIM bypasses the limitations in message sizes, types, and accessibility otherwise present in the conventional information infrastructure. SWIM allows new users, additional systems, new contents and changed formats to be developed and implemented as new requirements emerge.

With its promise to support improved information exchange and new concepts, SWIM is a viable candidate to enable an integrated ATFM/A-CDM. This Section discusses the basics of what SWIM is, and how it can be used in ATFM/A-CDM integration.

Note: This document is not a SWIM manual and the discussion of SWIM in this Section covers just sufficient basics to discuss its relevance in ATFM/A-CDM Integration. It should not be used as a comprehensive guide to SWIM and its implementation in lieu of SWIM-specific ICAO guidance.

Reference information and graphics used for this Section are from *ICAO Manual on System Wide Information Management Concept (Doc 10039)*. For detailed information on SWIM and SWIM implementation, readers should consult that document.

6.1.1. SWIM Basics

SWIM Concept

Based on ICAO Manual on System Wide Information Management Concept (Doc 10039), the definition statement of SWIM is as follows:

“SWIM consists of standards, infrastructure and governance enabling the management of ATM-related information and its exchange between qualified parties via interoperable services.”

The concept is represented in [Figure 3](#), which shows SWIM-enabled applications providing information services using SWIM standards. The scope of SWIM is in the middle three layers, providing infrastructure, exchange models, service definitions, and governance for system-to-system information exchange. The SWIM layers are created to support applications that enable improved ATM operations and are based on (typically) dedicated and secured IP networks as underlying basic connectivity.

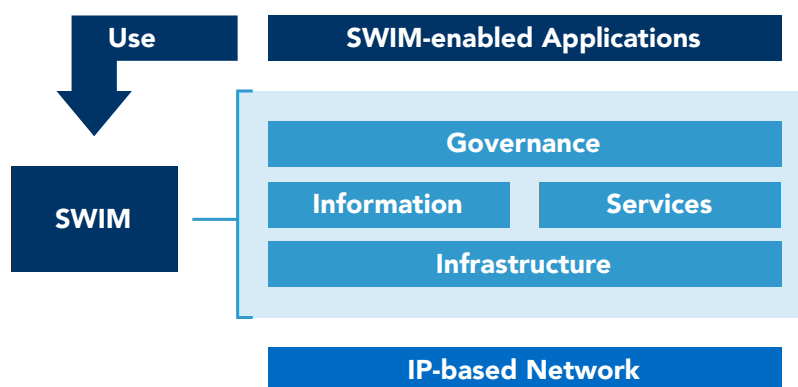


Figure 3 – Scope of SWIM

Service-Oriented Architecture

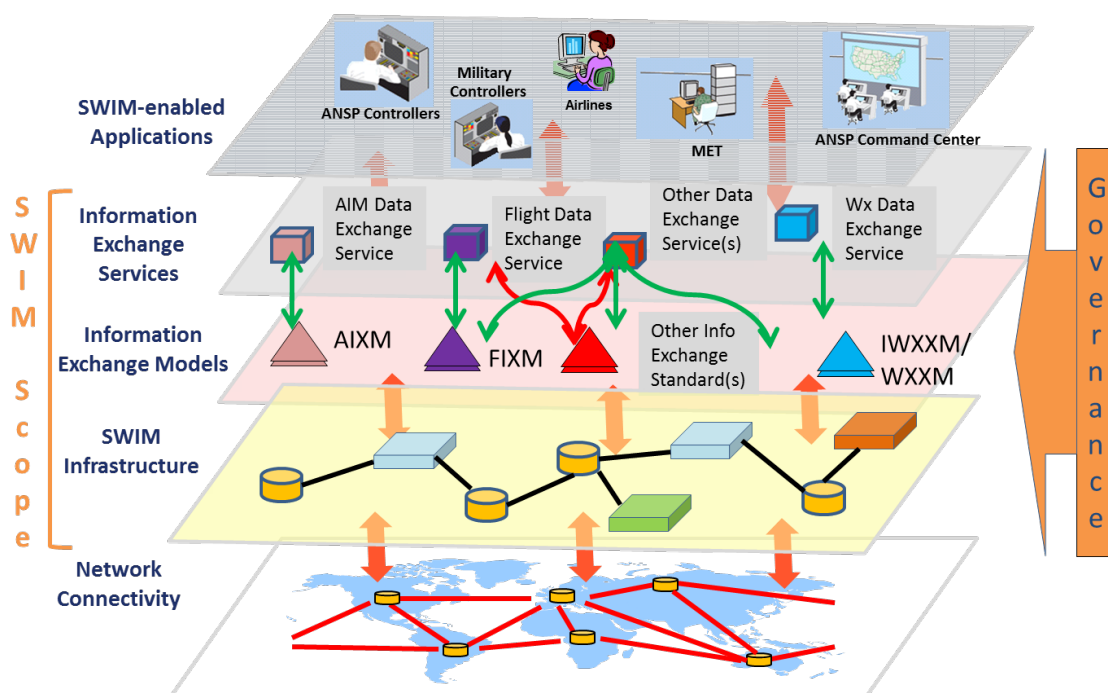
Central to SWIM is service-oriented architecture (SOA) concept, a style of software design where services are provided across applications through a communication protocol over a network. An SOA service is a discrete functionality; unassociated, self-contained, reusable, and accessible by users. A large software application can make use of different services to achieve desired functionalities. This [article](#) describing SOA on Medium provides further explanation.

Take, for example, an integrated ATFM/A-CDM process where TOBT update is supplied to the ATFM system while CTOT assignment is delivered to the A-CDM system. In a SWIM environment, both the A-CDM and ATFM systems can use flight information service – defined with definitions of TOBT and CTOT – to exchange the information. The application layer – i.e. A-CDM and ATFM systems – are separated from the information exchange infrastructure – i.e. the underlying IP network. In this sense, further applications such as ATFM slot negotiation can be added to the process either by using existing data elements defined in the flight information service or defining a new service and elements for the purpose, all without altering the underlying infrastructure.

Among other benefits, SOA promotes ‘loose coupling’ via a separation between an application’s functionality and the many underlying modules – or services – required to realise it. Loose coupling reduces dependencies among various systems and platforms, allowing flexibility, greater security and scalability to deploy new applications without changing the underlying information exchange infrastructure. The flexibility and scalability are two of the key benefits of introducing SWIM to ATM operations, especially as new ATM enhancements are continually being developed and deployed around the world.

6.1.2. SWIM Layers

As shown in [Figure 3](#), SWIM is often represented by a five-layered Global Interoperability Framework describing how information is shared between applications in a SWIM environment. [Figure 4](#) illustrates this concept with more detail.

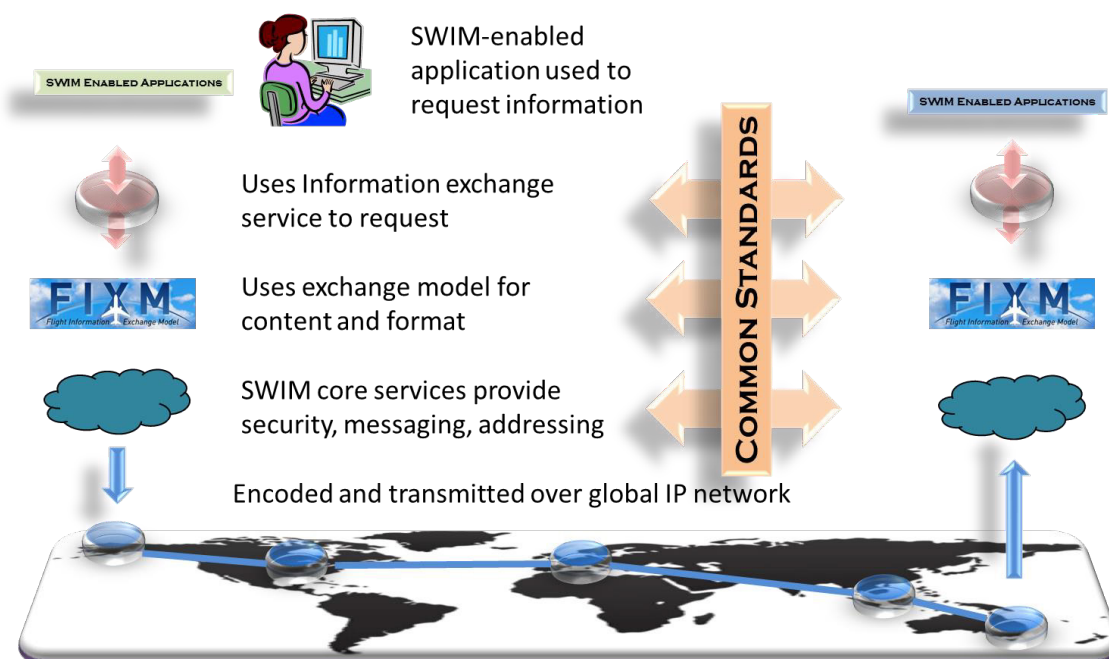


Credit: ICAO Doc 10039 (Advanced edition – unedited)

Figure 4 – SWIM Global Interoperability Framework

Figure 5 further illustrates how different layers are used by SWIM-enabled applications to exchange information. The layers operate thusly:

- a. The application at the top layer is used to request an information service for the transmission of information
- b. The Information Exchange Services layer describes the characteristics of the information package to be exchanged, e.g. TOBT update has to be sent with a flight identifier
- c. The Information Exchange Models layer prescribes the characteristics of the data to be exchanged, e.g. TOBT has to be sent with a specific format (ISO 8601);
- d. The SWIM Infrastructure layer adds the core information management services to the information package, e.g. security and addressing;
- e. The information package is then transmitted over a global network in the Network Connectivity layer to the recipient.



Credit: ICAO Doc 10039 (Advanced edition – unedited)

Figure 5 – Example of SWIM-based Information Exchange

From the example above, the application and the information exchange network are separated by the three SWIM layers. New applications can be developed and deployed without disrupting the underlying information network, so long as the applications ‘understand’ and can make use of the SWIM layers for information exchange with other applications.

Information Exchange Services and Information Exchange Models

Central to SWIM’s objective of making the right information available to the right stakeholders at the right time in an organised manner is the use of defined Information Exchange Services and agreed Information Exchange Models.

An information service defines for applications (1) what the service provides, (2) the structure of the message to be exchanged as part of the service, (3) the behaviour of the message, (4) the performance levels, and (5) how the service can be accessed. These are provided in a *Service Description Document* for application developers to utilise.

To ensure interoperability when information is provided by many different participants, common Information Exchange Models are defined. The Models clearly and unambiguously provide detailed definitions of the information to be exchanged, both at the conceptual level (i.e. what the data element means) and at the data level (i.e. how the data ‘parts’ are structured).

In simple terms, the Information Exchange Models act as common dictionaries for application developers to understand the data elements being exchanged. The use of common formats leads to high quality information exchange between key stakeholders.

The information exchange services and information exchange models are based on open standards and open-source message protocols. This opens the market for software solution providers, benefiting ATFM and A-CDM providers with a choice of higher quality services at more competitive prices.

At the time of this writing, core exchange models have been globally defined for three major domains of ATM operations:

- ICAO Meteorological information exchange model, IWXXM
- Aeronautical information exchange model, AIXM
- Flight Information Exchange Model, FIXM

These information exchange models are based on eXtensible Markup Language (XML) and can be extended to suit local or regional needs. The format of the exchange models is enforced with XML Schema Definition (XSD) files which has standardised mechanisms for extensions. Examples include APAC Flow Extension developed by Asia/Pacific States and US NAS Extension developed by the U.S., both extending the existing FIXM Core (v4.1.0) provision.

If the extensions to exchange models are deemed globally applicable, they may be considered for inclusion in future releases of the core provisions.

6.1.3. Further Details

There are many more components important to SWIM and its implementation, including – inter alia – the concept of SWIM Registries and SWIM Governance. Readers are invited to consult *ICAO Manual on System Wide Information Management (Doc 10039)* for in-depth details.

6.2. SWIM and ATFM/A-CDM Information Exchange

6.2.1. SWIM as the Most Viable Enabler for ATFM/A-CDM Integration

Integrated ATFM/A-CDM is a process that requires comprehensive information exchange across systems and with many stakeholders, and SWIM is the most viable enabler for the following reasons:

1. Existing infrastructure does not support ATFM/A-CDM data exchange – The existing infrastructure, especially the AFTN/AMHS messaging, does not support the exchanges of ATFM/A-CDM data elements described in Section 3. While EUROCONTROL has an existing means to exchange A-CDM messages (DPIs) with their regional ATFM system, such arrangement is not common in the rest of the world. Asia/Pacific has adopted a subset of EUROCONTROL's ATFM message sets^[5] to exchange information within their distributed ATFM network via AFTN messaging, but it is seen as an interim protocol until SWIM-based information exchange becomes available in the region. Other regions with emerging regional ATFM network and expanding adoption of A-CDM do not yet have any means to effectively exchange data across systems either.
2. ATFM and A-CDM are evolving concepts, requiring flexibilities from support infrastructure – In most regions, ATFM and A-CDM are still in their early implementation phase and the concepts are still evolving. Unique requirements on data exchange will continue to be developed, necessitating flexibilities in the support infrastructure. Unlike the rigid conventional information exchange network, SWIM will allow new applications, information services, and information models to be continually developed in response to emerging requirements.
3. ATFM can span beyond borders and possibly regions – As the world becomes more connected and more flights fly trans-region, ATFM may need to be expanded to manage long-haul flights across regions. With the expanded reach, common information exchange infrastructure and standards become necessary. SWIM is recognised by ICAO and the aviation community as that common global concept for efficient ATM information exchange and should be used as the core information enabler for cross-border ATFM.

6.2.2. Information Exchange Models Supporting ATFM/A-CDM Information Exchange

Work has been ongoing in various places to ensure SWIM standards and infrastructure can support ATFM/A-CDM information exchange. Specifically, extensions to flight information exchange model (FIXM) have been developed in Asia/Pacific and the US to enable the exchange of flight-specific ATFM and A-CDM data elements.

6.2.2.1 Asia/Pacific: APAC Flow Extension

ATFM development in Asia/Pacific has been based on the Distributed Multi-Nodal ATFM Network concept specified in the Asia/Pacific Regional Framework for Collaborative ATFM. As briefly discussed in Section 3, the distributed ATFM concept utilises multiple ATFM nodes, each independently responsible for ATFM in their domain based on regionally agreed principles and information exchange network. In this concept, each node is able to implement ATFM measures – specifically ground delay programmes with CTOT assignments – that impact flights departing from other nodes in the network, with ATFM compliance facilitated by the nodes at the departure end, thus forming a network to enable cross-border ATFM without a centralised unit.

The core technical enabler to this concept is an efficient and common information exchange infrastructure and standards, which gives rise to the task of Asia/Pacific SWIM Task Force to find or develop appropriate Information Exchange Model in support of the operations in a SWIM environment ([Figure 6](#)).

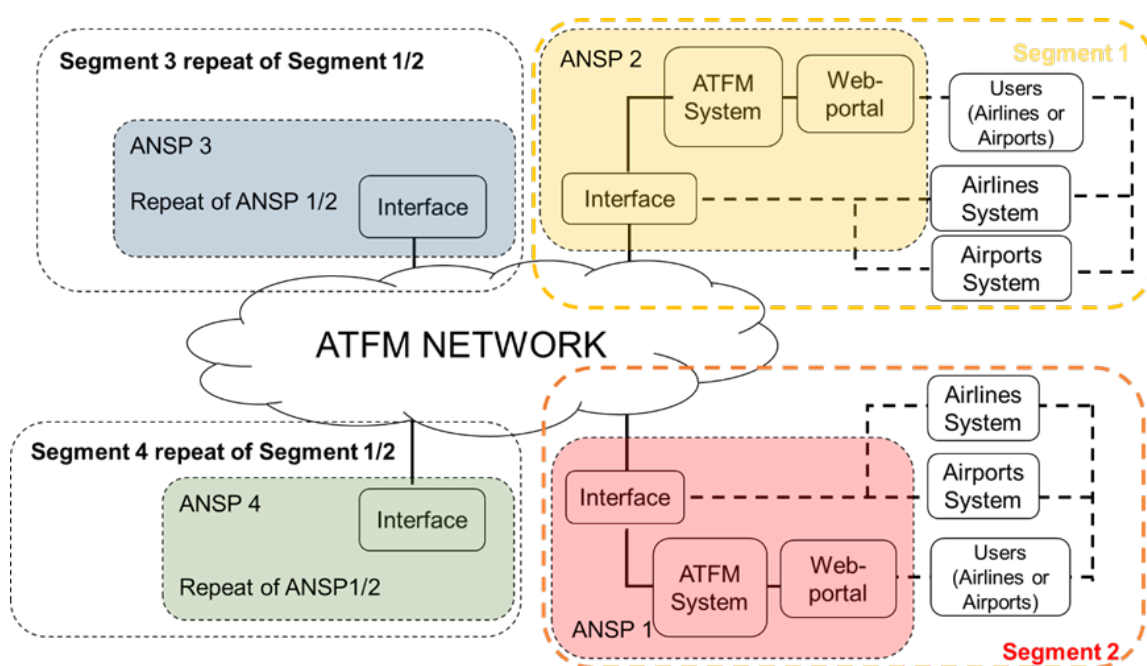


Figure 6 – Distributed ATFM in SWIM Environment

The work spanned a few years between 2016 – 2018 and culminated in a functioning APAC Flow Extension that extends FIXM v4.1.0. The Extension supports the exchange of data elements shown in [Table 8](#).

These data elements, when used with other data elements within the core FIXM v4.1.0 provision, support the exchange of recommended ATFM and A-CDM data elements specified earlier in [Table 6](#) under SWIM environment.

This development marked an important step toward bringing ATFM, A-CDM, and ATFM/A-CDM Integration onto SWIM environment in the region.

Estimated	Calculated (ATFM)	Target (A-CDM)	Actual
–	–	TOBT	AOBT
–	–	TSAT	–
–	CTOT	TTOT	–
ETO	CTO	–	–
ELDT	CLDT	–	ATO
Other			
Trajectory		Aircraft Track	
<ul style="list-style-type: none"> • ETO • CTO • ATO • Flight level or Altitude • Waypoint 		<ul style="list-style-type: none"> • Ground Speed • Bearing • Flight level or Altitude • Position (Designator or LAT/LON or Relative Point) • Time over position 	

Table 8 – APAC Flow Extension Data Attributes

Further information can be found at: https://fixm.aero/release.pl?rel=APAC_Flow_Ext-1.00.

6.2.2.2. United States: Traffic Flow Management Data Service (TFMData)

The United States is one of the most matured nations in terms of collaborative ATFM, with the notion of Collaborative Decision Making (CDM) introduced as part of their ATFM operations since early 1990s. CDM in the United States is predicated on the benefits of updated information sharing between national airspace system (NAS) users and traffic flow managers, and has been an ongoing programme led by the Federal Aviation Administration (FAA) since 1995.

An important part of the CDM programme is the Traffic Flow Management Data Service (TFMData Service). TFMData service distributes traffic flow management data to users via SWIM's National Airspace System Enterprise Messaging Service (NEMS). It is a JMS service that provides streaming data updates as well as a variety of request/reply functions, and covers the following services:

- Flight data
- Flow information
- Request/reply
- Terminal flight data
- International data
- Traffic flow management system (TFMS) status

Of particular interest to ATFM/A-CDM integration are the Request/Reply and the Terminal Flight Data services.

The request/reply service provides access to all TFMS services, as well as a mechanism for Aircraft Operators to submit ground and terminal data to TFMS in support of A-CDM and ATFM operations.

From data received, the terminal flight data service then feeds them to the FAA's Terminal Flight Data Manager (TFDM) system and CDM participants. TFDM uses the data feed to provide Surface Collaborative Decision Making (S-CDM, equivalent to A-CDM) capabilities. TFDM system also interacts with the traffic flow management system (TFMS) via the terminal flight data service, which adheres to the FIXM standard.

To support S-CDM and ATFM operations via TFDM and TFMS, Aircraft Operators in the U.S. NAS are able submit their Terminal Flight Data elements via Request/Reply service. [Table 9](#) describes the data elements available for this service.

Data Elements	Description
Earliest Off Block Time	Earliest time a flight operator would be able to push back or taxi from its parking stand for departure in the absence of metering. Ramp control personnel may provide this information.
Actual In Block Time	Time a flight has reached its gate or parking stand. Flight Operators or aircraft surface surveillance may provide this data.
Actual Landing Time	Time the arriving aircraft actually lands. Flight operators may provide actual landing time.
Actual Take-Off Time	Time a flight becomes airborne from the up-line airport. Flight operators may provide actual takeoff time or TRACON automation may provide this data.
Actual Off-Block Time	The time when an aircraft pushes back from its assigned gate or parking location or when it commences movement with the intent to taxi for departure.
Initial Off Block Time	The initial off-block time provided by the Flight operator.
Aircraft Registration Number	Flight operator provided alphanumeric string that uniquely identifies an aircraft e.g., N1237A.
Flight Intent	Flight Intent information providing common situational awareness about a specific flight with regard to de-icing at ramp/AMA or gate, holding at ramp/AMA, expected gate return or pushback times.
Gate Assignment	Flight or airport operator gate assignment and arrival stand availability for a flight.
Departure Data	Flight operator provided departure readiness indication (ready to depart but unable to pushback) and lists of acceptable/unacceptable runways for a flight.
Flight Cancellation	Message that indicates a flight has been cancelled. This message does not contain specific terminal flight data fields however; TFMS distributes this message back to NEMS in FIXM format via the TFDM Outbound feed.
Target Movement Area Data	Flight Operator provided TMAT related information that indicates a flight's TMAT is returned to the general community and also the marking of a delayed or cancelled flight prior to assignment of TMATs to indicate the operator will manually redistribute metering hold reductions to the flight operator's other flights via substitutions.

Table 9 – FAA TFDM and TFMS Data Exchange

For more information on FAA's TFMDData service and CDM program, visit <https://cdm.fly.faa.gov/>

For more information on the FAA's FIXM Extension to support TFMDData services, visit https://fixm.aero/release.pl?rel=US_Ext-4.2.1

6.2.2.3. Future Development

Given that ATFM spans beyond ground delay programmes and that there is an expectation for enhanced implementation per the ASBU framework, future ATFM information services will likely have to pull data from across domains to support all phases of ATFM operations from strategic planning to tactical ATFM execution and post-operations analysis. Singapore, Thailand, and the United States, SWIM development leaders in Asia/Pacific, have begun exploring the development of ATFM-specific information exchange model separate from FIXM, AIXM and IWXXM.

One of the first use cases of the potential new model is the exchange of ATFM Daily Plan (ADP), as it presents a unique requirement not fitting within FIXM (flight-specific information), AIXM (aeronautical information), nor IWXXM (meteorological information). ADP covers several information domains and does not yet have a globally common format; however, most ADP formats used in various regions cover similar information and generally include description of resource constraints, expected ATFM measures, and in some cases weather briefings. The commonality of information provided is a starting point in the design of the new information exchange model.

The ability to develop new information exchange model specific to ATFM requirements is yet another evidence of SWIM concept's flexibility. As ATFM and other future ATM concepts evolve, new requirements will emerge. Without the flexibility present in SWIM concept, such requirements may never be accommodated, inhibiting the evolution of ATM to keep up with the future air travel demand.

7. Recommendations for ATFM/A-CDM Integration

Some of the key enablers of successful integration between ATFM and A-CDM are:

1. Effective stakeholder engagement
2. Established common objectives on what the integration can achieve
3. Careful planning and step-by-step approach to the integration
4. Comprehensive data quality testing and assurance
5. Established success measures

The following sub-sections elaborate further on these topics.

7.1. Stakeholder Engagement

A-CDM and ATFM are both collaborative processes by definition, requiring engagement from several key aviation stakeholders. ICAO's Manual on Collaborative ATFM (Doc 9971) highlights the importance of engaging stakeholders throughout the ATFM process, from strategic implementation to day-to-day operations. Similarly, CANSO's [Airport Collaborative Decision-Making – Optimisation through Collaboration](#) highlights the roles of key stakeholders in the A-CDM process and prescribes stakeholder engagement as the first step to A-CDM implementation.

By the same spirit, stakeholder engagement should also be an important part of introducing the integration of ATFM and A-CDM, particularly at the operational procedure level where stakeholders' work process could change. Early engagement and education can help smooth and expedite the integration process. This section gives a guideline on the work areas that could change for key stakeholders ([Figure 7](#)) with the introduction of integrated ATFM/A-CDM.



Figure 7 – ATFM/A-CDM Stakeholders

Credit: Aerothai & Saab

7.1.1. Key Stakeholders in ATFM/A-CDM Integration

7.1.1.1. Air Traffic Flow Management Unit (ATFM Unit)

ATFMU, normally co-existing or having direct data linkage with ATS units, manages ATM resource capacities based on traffic demand profiles estimated from flight intents (schedules and flight plans) supplemented by

updates from ATS units (movement messages and surveillance updates). With integrated A-CDM, however, ATFMU can obtain additional flight data – e.g. target times (TOBT, TSAT, TTOT) – to supplement the demand profile and create a more accurate picture of demand-capacity balance at various ATM resources. A more accurate picture can then aid the ATFMU in assessing if ATFM measures are required and in implementing the most appropriate measure(s) if one is required.

On the other hand, ATFM information – e.g. departure requirements, CTOT, MDI or other ground ATFM measures – should also be provided to the A-CDM system to further enhance the A-CDM process and decision making among A-CDM partners. The A-CDM process and supporting system focus on effective calculation of target start-up approval time (TSAT) that would enable aircraft to taxi out and depart efficiently, taking into account various information including aircraft readiness (i.e. target off block time: TOBT), flight intent, ground situation, and various departure requirements. If an ATFM measure is in place, affecting the departure rate and/or departure times of flights, the information should thus be included in the A-CDM calculation and optimisation.

7.1.1.2. Air Traffic Service Unit (ATS Unit)

Air Traffic Service units play crucial roles in both the ATFM and A-CDM processes. With ATFM, ATSU generally coordinates resource capacity figures with the ATFMU as input into the ATFM system. The units can also provide situational updates to ATFMU and ATFM system, both through automated flight data updates and manual coordination. With A-CDM, on the other hand, ATSU provides information on departure restrictions and ground movement situations to the A-CDM system and partners; again, both in the form of automated data connection and manual coordination.

With the integrated ATFM and A-CDM, different ATS units within the same ANSPs will begin to interact with different processes and data sources. As an example, when a ground delay programme (ATFM measure) is activated – thus regulating departure times from airports (A-CDM process) – an area/enroute control centre may interact directly with the ATFM system, obtaining CTOTs and associated CTOs/CLDTs for their resource planning; while a terminal unit (GND/TWR/APP) may interact instead with the A-CDM system, pulling TSATs and TTOTs for their ground and departure management. The goals are ultimately linked though; that of optimising ground process on one end and ensuring balanced demand and capacity on the other.

With different ATS units interacting with different systems and using different terminologies, misunderstanding and miscommunication can occur. It is vitally important that the various units are educated on different processes in the integrated ATFM/A-CDM operations, and how the processes work together to achieve a common goal.

7.1.1.3. Airport Operators

Airport operators are generally thought to be the driver of A-CDM, as the operations' key objective is to optimise airport infrastructure planning and ground processes. Without A-CDM, the airport operator may sometimes have very limited link to ANSPs (ATS units and ATFM unit) and are sometimes not included in the ATFM conversation. With integrated ATFM/A-CDM, however, information relevant to the use of airport resources – be it an airspace restriction requiring extended use of parking bay or a ground issue preventing ATFM slot compliance – can be communicated much more closely between the airport operator and other stakeholders. This communication is generally reflected in the updates of 'target' times (T-times) in the A-CDM system. By interacting with the A-CDM system that is integrated with the ATFM system, the Airport Operator can make better resource planning for their ground operations.

Educating airport operators on their roles in the A-CDM process and how they can be linked with ATFM operations will be crucial for them to benefit the most from the integrated operations.

7.1.1.4. Aircraft Operators

Aircraft operators are key partners in both ATFM and A-CDM implementation. Their crucial role should not be diminished in the ATFM/A-CDM Integration work. Depending on the order of implementation and

past experiences, certain aircraft operators – and/or units within them – may be more familiar with ATFM operations while others more comfortable with A-CDM process. In an integrated ATFM/A-CDM environment, aircraft operators will begin to interact with both systems using a wider range of terminologies. Similar to ATS units, different aircraft operator units may also begin to interact with either ATFM or A-CDM system depending on their operational focus; e.g. an operations control centre may focus on ATFM measures (such as CTOTs, CTOs/CLDTs) for their fleet planning while a ground station and flight crews may focus more on managing A-CDM parameters (such as TOBTs, TSATs).

In engaging and educating Aircraft Operators on the integration of ATFM and A-CDM, emphasis should be placed on clarification of ATFM and A-CDM key objectives, and how their seemingly differing operations work together. Aircraft operator's roles in the ATFM and A-CDM, and their importance to successful operations, should also be emphasised.

7.1.1.5. Ground Handling Unit

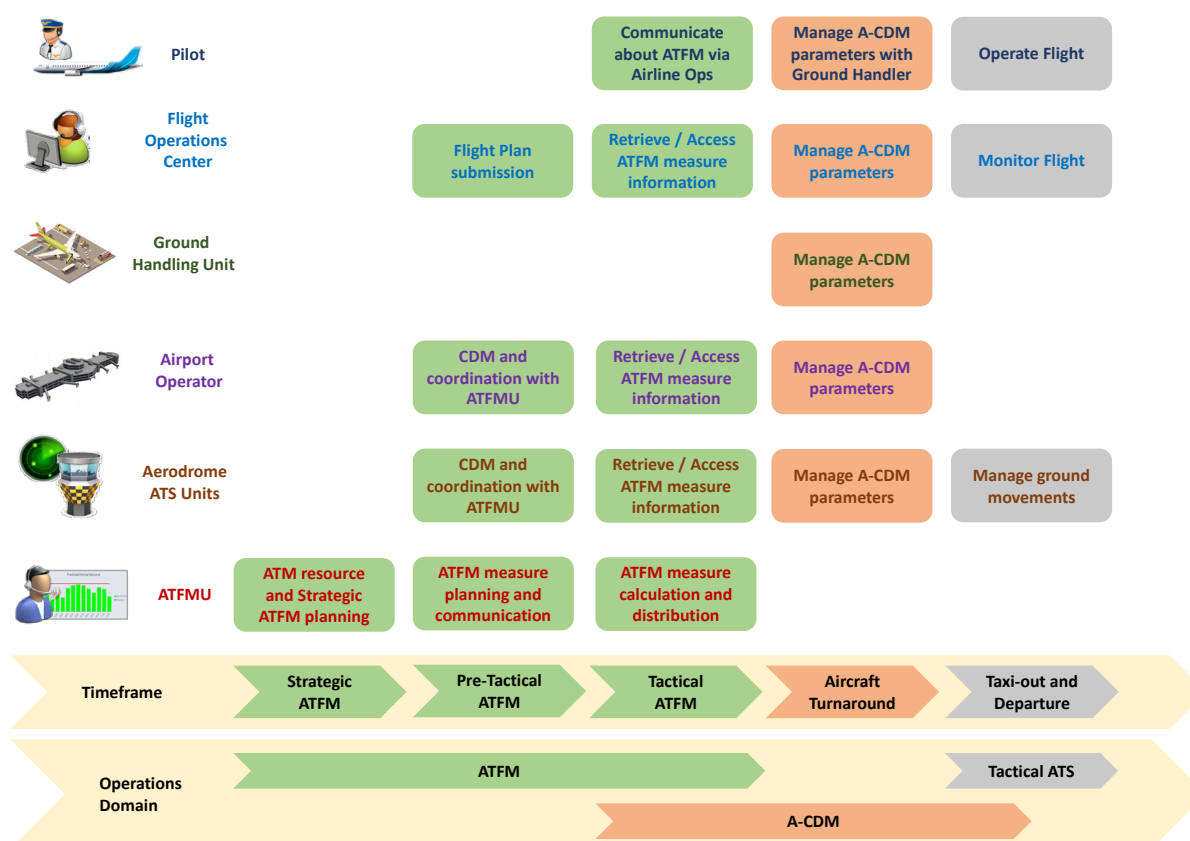
Ground handling unit is another stakeholder generally thought to be more connected to airport and airline operations with limited linkage to ANSPs (ATS units, ATFM unit). In most cases, they are not heavily involved in the ATFM operations but play a key-role in the A-CDM process by supplying target off-block time (TOBT) to the A-CDM system on behalf of the aircraft operators when applicable. The ground handling units are also generally more closely connected to flight crew on the ground than their airline operations control counterpart, and thus can significantly aid the crews in compliance with target start-up approval time (TSAT) and/or calculated take-off time (CTOT) as well.

In an integrated ATFM/A-CDM environment, ensuring that ground handling units understand the A-CDM process and can interact with the system effectively is crucial to successful A-CDM. Giving the units basic understanding of how A-CDM connects and complements ATFM operations can provide a good network-view picture of how their actions on the ground can affect the operations and efficiency of overall traffic network down the stream.

7.1.2. Example of Stakeholder Connections with Integrated ATFM/A-CDM

[Figure 8](#) shows an example of how ATM stakeholders can connect to an integrated ATFM/A-CDM environment. In the figure, ATFM and A-CDM systems are connected to enable integrated operations. ATS units and aircraft operators' operations control coordinate with the ATFM unit to exchange flight intent, traffic demand, and ATFM measure information. ATS units at the airport, airport operator, and ground handling units can have data linkage with A-CDM system to exchange "estimate" and "target" times such as E/TOBT, TTOT, TSAT. The A-CDM system, being connected to ATFM system, can in turn provide information such as departure restrictions or ATFM measures. The figure also provides a timeline in which events in the process are happening.

Note that this figure is not the only possible configuration to link between various systems and stakeholders, but it shows the crucial roles played by stakeholders and thus the importance of stakeholder engagement and education in the implementation and integration process.



Credit: Aerothermal

Figure 8 – Stakeholders' Connections to Integrated ATFM/A-CDM

7.2. Establishment of Common Objectives

ATFM and A-CDM are both collaborative processes involving many stakeholders as discussed in sub-section 7.1. Their integration will also bring together stakeholders across the industry, with possibly different operational targets and expectations. To ensure successful integration effort, it is important to establish common objectives among all stakeholders involved and to develop common metrics to evaluate success.

One of the key benefits that can be expected from ATFM/A-CDM integration is the improvement in both ATFM and A-CDM processes. With enhanced data exchange between the two systems, as discussed in sections 4 and 5, parameter calculations in both ATFM and A-CDM can be more accurate, leading to improved decision-making among stakeholders. Subsequent sections recommend some indicators, targets, and success measures that can be used to quantify the improvements seen from the integration effort.

7.3. Integration Planning and Execution

Addressing ATFM or A-CDM as standalone initiatives is the most common way of implementing the two concepts. Typically, ATFM implementation is led by an ANSP while A-CDM implementation is led by an airport operator. However, recognising that these two concepts will need to eventually be integrated, appropriate planning for the integration should be a part of the both ATFM and A-CDM implementation plans.

As extensively discussed in Section 4 and Section 5, the integration of ATFM and A-CDM will require appropriate data interfaces as well as the desired functionalities of the two systems. Prescribing such requirements in the initial system specifications will greatly benefit both ATFM and A-CDM implementation leads when it comes to system integration down the road. Concepts and use cases covered in **Section 4** and **Section 5** can be used as bases for the requirements.

As with the implementation process; the procurement, or development, of ATFM and A-CDM systems may be done separately (e.g. ATFM system by ANSP and A-CDM system by Airport Operator). It is advisable that the two implementation leads establish an integration team in the planning stage to ensure aligned procurement/development targets, especially on system integration requirements.

Insofar as the execution, the full integration as discussed in Section 4 does not need to occur all at once. A stepwise approach, following the three categories of ATFM/A-CDM information exchange outlined in sub-sections 4.3, 4.4, and 4.5, is strongly recommended. The stepwise integration can take into account operational needs, technical maturity, and system and stakeholder readiness.

The stepwise approach to integration is recognised by Member States of ICAO Asia/Pacific and is the basis for the three-phase Performance Improvement Plan covered in the *Asia/Pacific A-CDM Implementation Plan*.

7.4. Data Quality and Testing

With the processes integrated and information being exchanged, one very important question to be asked is “can I rely on this information to be accurate?”. To ensure that the decision-making process and automations are effective, the data used in both systems must be as accurate as possible.

In the following sub-sections, recommendations on data quality and testing are outlined for the three information exchange categories occurring between ATFM and A-CDM systems.

7.4.1. Exchange of ATFM Measure Information

If a flight is assigned an ATFM slot (e.g. CTOT), the A-CDM system needs to take this into account in its automated calculations of TSATs and TTOTs. Process should be put in place to monitor and evaluate the alignment between TSATs/TTOTs and CTOTs. [Table 10](#) recommends an indicator to evaluate such alignment.

Indicator name	Formula	Target Value	Acceptable Range
TSAT+VTT inside CTOT STW	$CTOT [STW \min] < TSAT + VTT < CTOT [STW \min]$ <p>*STW = slot tolerance window or CTOT compliance window. Its value should be agreed upon among stakeholders in the network. Normally, STW are prescribed as:</p> <ul style="list-style-type: none"> • STW[min] = -5 min • STW[max] = +10 min 	Agreed value, e.g. 100% in Europe	Agreed value, e.g. >=90% in Europe

Table 10 – TSAT/TTOT and CTOT Alignment

7.4.2. Exchange of Flight Update Information

As outlined in sub-section 4.4, the A-CDM system can benefit from receiving ATFM-generated ELDTs at A-CDM Milestones 3 and 4. The ELDTs can then be used to trigger automatic updates to EIBTs, TOBTs, TSATs and TTOTs in the A-CDM process. If these ELDTs are inaccurate, the resulting information provided to A-CDM stakeholders can also be inaccurate and lead to poor decision-making.

It is therefore vitally important when utilising ELDTs in the A-CDM process that the ELDTs’ accuracy is constantly monitored and measured to ensure acceptable level of accuracy. If the agreeable accuracy is not met, not using the data may prove to be more beneficial. [Table 11](#) recommends indicators to evaluate ELDT accuracy.

Indicator name	Formula	Target Value	Acceptable Range
ELDT Accuracy at Milestone 3 (MS3)	ELDT [MS3] – ALDT	Agreed value, e.g. <15 mins	Agreed value, e.g. <=30 mins
ELDT Accuracy at Milestone 4 (MS4)	ELDT [MS4] – ALDT	Agreed value, e.g. <10 mins	Agreed value, e.g. <=20 mins

Table 11 – ELDT Accuracy

Note that, in most A-CDM airports, the early calculations of EIBT, TOBT, TSAT, and TTOT based on advanced ELDT may not yet play as crucial a role in planning and decision-making as the calculations made after the inbound aircraft has landed (i.e. calculations based on ALDT). However, in an integrated ATFM/A-CDM environment, the early EIBT/TOBT/TSAT/TTOT can be fed back into the ATFM system and trigger updates in demand prediction and ATFM slot calculations. The accuracy of advanced ELDT provided by the ATFM system can therefore influence the quality of ATFM measure distributed.

7.4.3. Exchange of Flight Departure Information

Receiving more accurate information about departure flights can be beneficial for the ATFM system. As outlined in sub-section 4.5, the A-CDM airport will generate Flight Departure Information messages at specific points (i.e. Milestones) in time prior to the flight's departure.

For the TTOTs provided to be usable by the ATFM system, it has to meet specific accuracy criteria. [Table 12](#) recommends indicators to evaluate TTOT accuracy. Note that this only applies for the mandatory messages as specified in sub-section 4.5.2.

Indicator name	Formula	Recommended Target Value [min]	Recommended Acceptable Range [min]
EDPI_TTOT	TTOT [MS1] – ATOT	0	<=15
TDPI-t_TTOT	TTOT [MS7] – ATOT	0	<=12
TDPI-t_TTOT	TTOT [MS9] – ATOT	0	<=12
TDPI-s_TTOT	TTOT [MS9] – ATOT	0	<=10
ADPI_TTOT	TTOT [MS15] – ATOT	0	<=5

Table 12 – TTOT Accuracy

7.5. Success Measure Development

One key aspect often overlooked in the implementation of both ATFM and A-CDM is success measurement – how to determine whether the implementations have been successful. Without clearly defining and measuring the success measures, implementers cannot be sure that the objectives set have been met.

For both ATFM and A-CDM, many guidance materials exist that outlines what the respective processes can help to achieve and how to actually measure the effectiveness of processes. [CANSO Guidelines on Airport-Collaborative Decision Making \(A-CDM\) Key Performance Measures](#) is one example. The document outlines a framework on what and how to measure the success of A-CDM implementation. Some of the A-CDM indicators included in the document is also helpful for ATFM/A-CDM integration and will be discussed further in this document.

At the core, ATFM/A-CDM integration aims to improve the respective processes by enhancing the information flow across the two processes. Therefore, many of the existing success measures for ATFM and A-CDM can be used to assess the success of ATFM/A-CDM integration as well. The challenge lies in identifying which areas of the two processes can be improved even further after the integration.

One example is the A-CDM's aim to increase predictability through provision of target times (e.g. TTOTs, TSATs). With the process integrated with ATFM, allowing accurate and reliable ELDTs to be supplied from the ATFM system (as outlined in Sections 4.4 and 5.2), more accurate TTOTs and TSATs can be calculated and thus improving predictability performance.

Another example is the ATFM's aim to improve demand-capacity balance by achieving high compliance to ATFM slots (e.g. CTOTs). By integrating CTOTs into the A-CDM process and system (as outlined in Sections 4.3 and 5.1), high-quality TSATs that ensures aircraft can be at the departure runway in time to meet their CTOTs can be produced; thereby improving ATFM slot compliance rate.

[Table 13](#) and [Table 14](#) are some examples of ATFM and A-CDM performance areas that can be improved with integration.

Key Performance Objective	Improved predictability of TSAT and TTOT
How Integration Helps	ATFM can supply advance ELDTs to A-CDM, giving it an ability to improve the calculation of TSAT and TTOT based on more accurate and updated flight information.
KPI Name	TSAT and TTOT Predictability
Purpose/Value	This KPI assists stakeholders to optimise pre-departure sequence and the departure queue.
Expected result	More reliable TSAT and TTOT values for flights earlier in the A-CDM process.
Data requirement	<ul style="list-style-type: none"> • TSAT at Milestones 3 and 4 • TTOT at Milestones 3 and 4 • ASAT • ATOT
Formula	Compare: <ul style="list-style-type: none"> • TSAT at Milestones 3 and 4 with ASAT • TTOT at Milestones 3 and 4 with ATOT
KPI Format	Descriptive statistics on time deviations

Table 13 – ATFM/A-CDM Integration KPI: Target Time Accuracy

Key Performance Objective	Increased compliance to ATFM slots
How Integration Helps	With ATFM slots (e.g. CTOTs) integrated into A-CDM process, more accurate TSATs can be issued enabling aircraft to better meet their ATFM slots.
KPI Name	ATFM slot compliance
Purpose/Value	This KPI assists stakeholders to assess the compliance to ATFM slots (e.g. allocated CTOTs). This will potentially help to identify trends of non-compliance that can lead to improvements of departure procedures and PDS enhancements.
Expected result	High rate of compliance or low rate of non-compliance.
Data requirement	<ul style="list-style-type: none"> • ATFM slots (e.g. CTOTs) • ATOTs • Number of departures with assigned ATFM slots • Number of departures compliant / non-compliant with ATFM slots
Formula	Compare: <ul style="list-style-type: none"> • CTOT to ATOT
KPI Format	Descriptive statistics on ATFM slot compliance, e.g. compliance and non-compliance rates taking into account allowable compliance window, and average deviations from ATFM slots

Table 14 – ATFM/A-CDM Integration KPI: ATFM Slot Compliance

8. Case Studies

About This Section

This section features case studies on ATFM/A-CDM integration in various countries around the world. These countries are at various stages of the integration process, from initial trials to fully operational and integrated process. In reading through the cases, differences between the implementations may become apparent. This is expected, as local environments differ from one country and region to the next and the approaches to implementation need to be adapted. A recommendation in reading these case studies is to focus on what can be learned from their approaches and experiences, rather than the specific procedures or systems adopted. Before each case study, an editor's note will provide a guide on what to focus on for the case.

8.1. Australia: Planned A-CDM and ATFM Integration for Australia

Editor's Note

This case study features the planned A-CDM implementation and ATFM/A-CDM integration at 4 major airports in Australia, an effort led by Airservices Australia. The case provides a real-world application of the core ATFM/A-CDM integration concepts covered in Section 4 of the document, while also highlighting the importance of taking into account local context and environment to ensure effective implementation and stakeholders' buy-in.

8.1.1. Australian Operating Environment

The Australian ATM Network comprises of a single state with operations managed by Airservices Australia. The airspace assigned by ICAO to Australia covers 11% of the earth's surface, divided into two Flight Information Regions (FIRs) controlled from two major centres as shown in [Figure 9](#). The Melbourne FIR (YMMM) covers the southern part of the Australian continent and large parts of the Indian and South Pacific Oceans, the Brisbane FIR (YBBB) covers the northern part of the Australian continent and half of the Tasman Sea (with the other half administered by New Zealand).

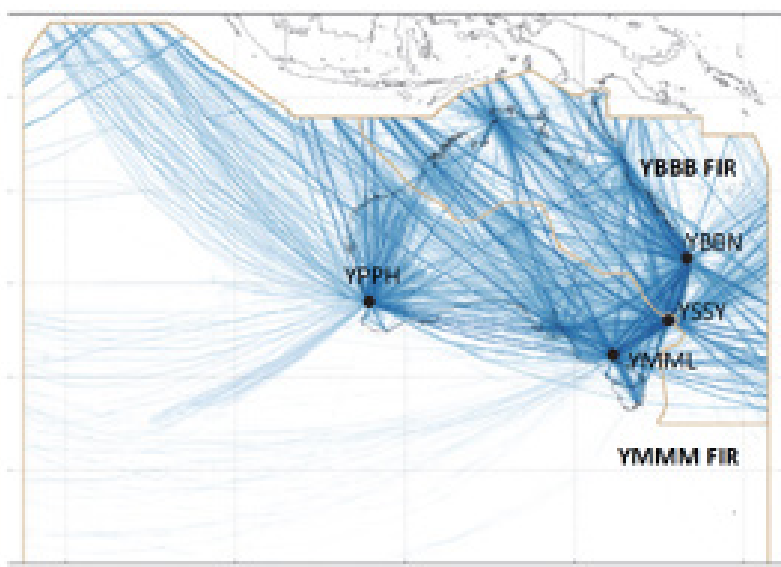


Figure 9 – Australian Flight Densities, FIRs and Top Airports.

Due to vast travel distances and population concentration to only a few metropolitan areas, air transportation is the major form of inter-city travel in Australia, with approximately 1.4 million flights and 156 million passengers

per year. While these numbers are a lot lower compared to the US and Europe, relative to Australia's smaller population, it represents an air transportation system roughly twice the size per capita.

Despite its large airspace, the Australian ATM Network has a unique characteristic in that a relatively high proportion of air traffic occurs between just three major airports within a relatively short flying time: Sydney (YSSY), Melbourne (YMML) and Brisbane (YBBN), often referred to as "The Triangle". Approximately 30% of the flights from these three airports depart towards the other two. These three city pairs are in the top 15 busiest city pairs in the world (by aircraft movement), with a flight taking off between Sydney and Melbourne (and vice versa) approximately every 10 minutes during peak hours.

Due to runway configurations and constraints on airport layout, Melbourne and Sydney airports in particular can experience large fluctuations in declared capacity. Even in visual conditions, wind can have a significant impact on capacity dropping the maximum arrival rates from 50 and 40 for dual runway operations, to 23 and 22 for single runway operations at Sydney and Melbourne respectively, essentially halving the available capacity.

Demand and capacity challenges in the Australian ATM Network therefore generally originate from capacity reductions at one or more of three major airports, which quickly propagate to the other two and affect the flow of traffic in and out of The Triangle.

Australia will therefore be implementing A-CDM at Sydney (YSSY), Melbourne (YMML), Brisbane (YBBN) and Perth (YPPH) as a Partnership between Airservices (ANSP), Australia's four major domestic airline groups and the respective four airport corporations, with the ANSP (Airservices) as the lead organisation. The aim of the partnership is to reduce cost and complexity of the A-CDM implementation by ensuring a single technology solution and consistent A-CDM procedures across the country. Further, as a partnership, buy-in to the A-CDM concept by the main stakeholders is ensured from the very start, and implementation across multiple airports raises the benefits of A-CDM from an individual airport level to an ATM Network perspective.

8.1.2. Current Collaborative Decision Making Processes

Australia has a mature implementation of Collaborative Decision Making (CDM) between ATC and the major domestic airlines to mitigate the impact of disruptions across the Australian ATM Network through the use of Air Traffic Flow Management (ATFM) – in particular Ground Delay Programs (GDPs) – managed by the Network Coordination Centre (NCC) in Canberra.

Planning for the ATFM measure – specifically the GDP – occurs the day prior to operations to provide airlines early notice of any constraints that may be present for the day of operations through the publication of the ATFM Daily Plan (ADP).

To support the ATFM planning process to start the day prior, the Australian ATFM systems works off schedules in first instance, which get updated by flight plans once filed on the day of operations. The planning follows a 3-step process:

1. As the first step in this planning process, airlines upload their confirmed flight schedules to ATFM system the day prior to operations to inform of the demand for the following day.
2. In the second step, the NCC establishes available capacity through a collaborative process with major domestic airlines and the Australian Bureau of Meteorology, in a process referred to as Meteorological Collaborative Decision Making (MET-CDM). The major aim of the MET-CDM process is to assess any weather risks that may affect capacity of the ATM Network and mitigate operational impact.
3. In the third step, if deemed required, the NCC publishes a GDP – with CTOTs assigned to flights based on the uploaded confirmed schedule – to balance the demand with the available capacity, as established in the first two steps.

By publishing the GDP the day prior, airlines have the opportunity to optimise their fleet operations and inform passengers of changed departure times the night before they travel.

8.1.3. Benefits of A-CDM at Network level

Australia's ATFM system tracks active, flight-planned and scheduled flights, but flights are considered independent (i.e. no "tail tracking" between the different GDPs). A single aircraft is likely to operate many sectors (legs) between Australia's four major airports a day, and therefore requiring multiple slots across the different GDPs. A delay on any of these sectors quickly propagates and requires new slots to be negotiated for downstream sectors. The propagation of these sector delays are inherently difficult to estimate beyond the current airborne flight, partly due to limited (data) visibility on airport operations and low predictability of taxi-out and take-off time for the subsequent sector as schematically shown in [Figure 2](#).

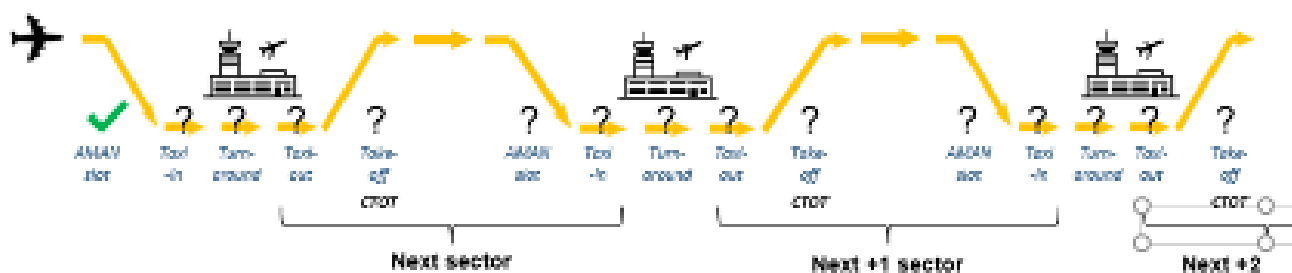


Figure 10 – Uncertainty in sector delay propagation

The benefits of A-CDM at individual airport level are well understood and demonstrated at various locations around the world. By implementation at Australia's four major airports, Airservices is further aiming for benefits at a Network level through integrating A-CDM with the centralised ATFM system in order to 'link' individual GDPs at the respective airports, and to improve the ability to predict sector delay propagation.

To realise maximum benefits of A-CDM within the context of the entire ATM Network, the integration of A-CDM and ATFM in Australia has been considered both from a technical and CDM process perspective.

8.1.4. Principles for A-CDM and ATFM Integration

The implementation of A-CDM needs to complement the existing CDM processes, and prevent significant complexity from requiring aircraft operators to comply with departure constraints provided by an A-CDM implementation at the departure airport (through assigning a Target Start-up Approval Time (TSAT)), with arrival constraints for ATFM at the destination airport (through a Calculated Take-off Time (CTOT)) ([Figure 11](#)).

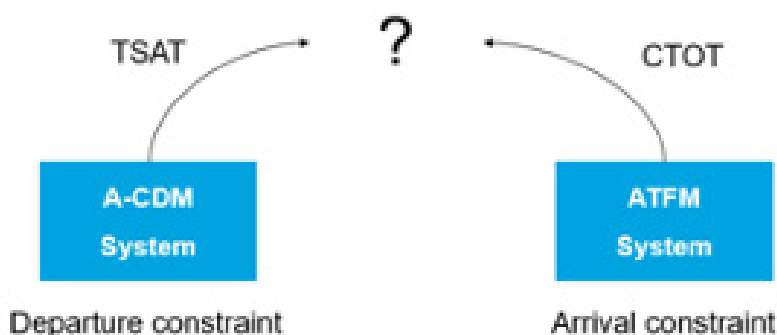


Figure 11 – Potential for conflicting constraints.

The Australian A-CDM and ATFM integration is guided by the following main principles:

1. Arrival ATFM slot is nominally of higher priority than position in A-CDM Pre-Departure Sequence (PDS).
2. PDS at the departure port is a dynamic sequence (order) rather than fixed slot allocation (times).
3. A change in ATFM arrival slot at the arrival port (CLDT/CTOT) automatically results in a nominally compliant position in the PDS at the departure port (TTOT/TSAT)

Principle 1 states that within the overall ATM Network, nominally, arrival constraints are of higher importance than departure constraints, i.e. nominally delays should be incurred on the ground rather than in the air. Practically, this means that within the A-CDM PDS, priority is assigned to flights with a CTOT assigning a TSAT that ensures an ATFM-compliant departure (refer to 8.1.6. on PDS equity).

Principle 2 states that the PDS is more tactical tool than an ATFM slot manager; the PDS needs to respond to operator changes in Target Off Block Time (TOBT) close to departure. Rather than assigning fixed time slots (like an ATFM slot manager), focus should therefore be on delivering the right pushback sequence.

Principle 3 states that ATFM slot changes performed by CDM stakeholders are automatically send to the PDS and actioned; i.e. a change of CLDT/CTOT in ATFM system results in automatic re-assignment of TSAT aiming for ATFM compliance. On the other hand, a (significant) change to TOBT (and potentially TSAT) in the A-CDM system does not result in an automatic ATFM slot re-assignment. The A-CDM system will show an alert that based on the TOBT update by the operator, a new TSAT was assigned that will result in departure time non-compliant with the assigned ATFM slot. Manual action is required in line with pre-existing CDM processes where an operator is required to apply for a new ATFM slot, if the original slot cannot be operated to.

8.1.5. Collaborative Management of Flight Updates

Collaborative Management of Flight Updates is one of the EUROCONTROL A-CDM Concept Elements, and it is implemented within the Australian context as follows.

Anticipated airport configurations (and departure rates) will be pre-set in the four A-CDM implementations the day prior as part of the development of the overall plan for the Network (same configurations that are used to plan for any possible GDPs). Schedule information and any ATFM constraints (CTOTs) for the day of operations will be sent from the ATFM system to the four A-CDM implementations as soon as available. This combination of anticipated airport configurations, schedules and ATFM constraints allows for pre-processing of TOBTs (as driven by schedule) and TSATs (driven by departure demand vs capacity and CTOTs).

On the day of operations, real-time arrival time updates are being send from the ATFM system to the A-CDM implementations to provide an accurate estimate of arrival time at the destination airport, taking into account operator supplied schedule, ATFM slots, and tactical in-flight updates.

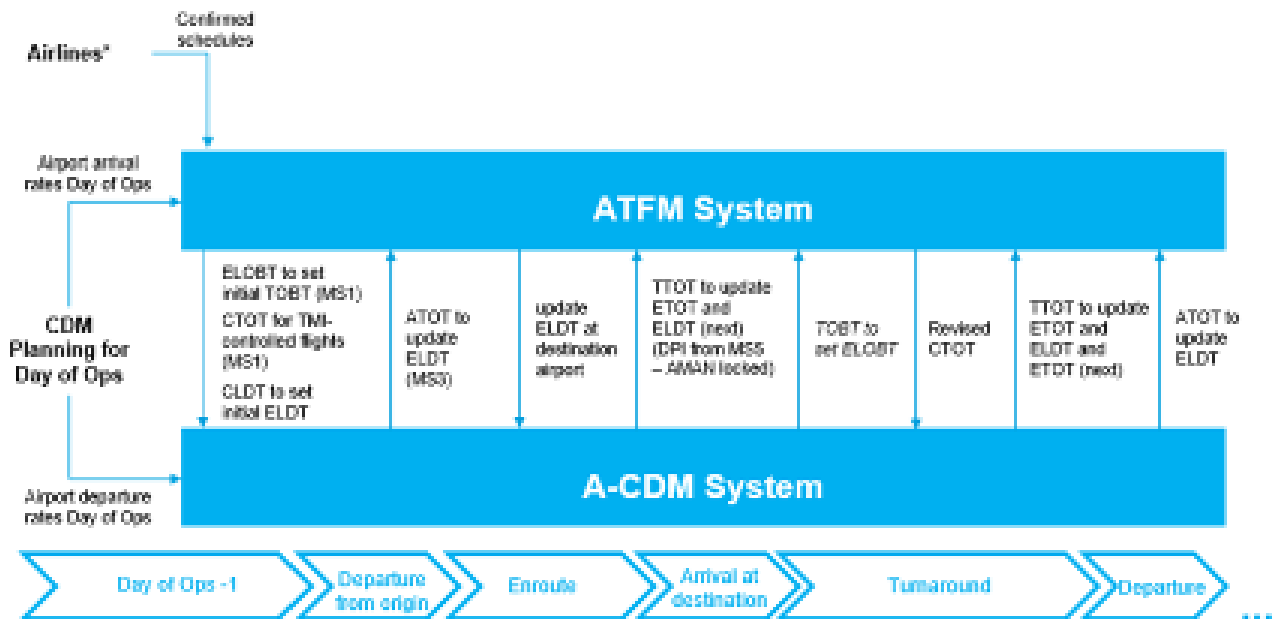
In the Australian implementation, TOBTs for subsequent sectors will be automatically updated whenever a local A-CDM implementation determines that based on an updated arrival time of the inbound flight and minimum turn-around time, the original schedule of the outbound flight (next sector) cannot be met. This automatic update of the TOBT ceases whenever an airline performs a manual TOBT update, or when the aircraft has arrived at the destination airport (whichever occurs first). The philosophy behind this implementation choice is that prior to arrival of the inbound flight, the variables that impact TOBT of the outbound flight are within the ANSP domain (e.g. enroute and arrival delays) and not directly transparent to the aircraft operator; while when the aircraft has arrived at the gate, the variables that subsequently impact TOBT are within the aircraft operator domain (e.g. late passengers etc.), and thus the aircraft operator becomes responsible for keeping the TOBT updated.

From A-CDM Milestone 5 'Final Approach' (referred to as 'Sequenced in AMAN' in Australian implementation), Departure Planning Information (DPI) is being send from the local A-CDM implementation to the centralised ATFM system. From this Milestone, the flight is locked in the arrival sequence for landing, ensuring an accurate Estimated Landing Time (ELDT), Estimated In-Blocks Time (EIBT) for the inbound flight and therefore TOBT and TTOT for the outbound flight (next sector).

DPI messaging in the Australian context is the sending of updated estimated Target Take-Off Times (TTOTs) and TOBTs from the A-CDM PDS to the centralised ATFM system:

- TTOTs send by the A-CDM system update the departure time estimate in the ATFM system to update the demand prediction across the network for both airport and airspace resources.
- TOBTs send by the A-CDM system can set Earliest Off-Block Times (ELOBT) in the ATFM system to ensure that upon a GDP activation or revision, flights will not get assigned an unachievable ATFM slot.

A schematic overview of the Collaborative Management of Flight Updates in the Australian A-CDM-ATFM context is shown in [Figure 12](#).



* Integration of Airlines system with ATFM and A-CDM system during Day of Ops not displayed

Figure 12 – Collaborative Management of Flight Updates

The combination of departure (DPI) and arrival time updates allow to estimate the propagation of network delay. E.g. a flight on arrival into Melbourne triggers a DPI for its next sector to Sydney. The ATFM system subsequently updates the departure time to Sydney, as well as the arrival time in Sydney. This updated arrival time in the ATFM system for Sydney is send to the Sydney A-CDM implementation and triggers an automatic (preliminary) TOBT update for the following sector to Brisbane.

8.1.6. Equity in A-CDM Pre-Departure Sequence

As previously stated, a relative high proportion of departures from especially Sydney (YSSY), Melbourne (YMLL), and Brisbane (YBBN) departs to the other two. This means that when GDPs are active at any of these airports, the PDS at the departure airport may have a high proportion of flights with a CTOT that will be automatically prioritised (to ensure ATFM compliance). As a result, during times of high departure demand (or times of low departure capacity), inequitable TSAT delay distribution may occur where flights without a CTOT receive more delay.

To ensure delay distribution within the PDS is as equitable as possible, the PDS uses the CTOT compliance window (when required) to ensure that flights departing within vicinity of one another, are allocated balanced TSAT delays.

Further, as part of the Network CDM concept (see 8.1.8.), CTOT compliance from a certain departure airport may be suspended if it has been determined that departure capacity at that airport is the limiting factor of the ATM Network. For example, if strong crosswinds at Sydney (YSSY) dictate the use of a single runway only (less than 50% of normal capacity), Sydney (YSSY) capacity becomes the limiting factor of the ATM Network; CTOT compliance for flights departing Sydney (YSSY) may subsequently be suspended to ensure the PDS can deliver the most optimal pushback sequence given the limited available capacity.

8.1.7. ATFM Compliance Management

Upon implementation of A-CDM at an airport, the local tower ATC will no longer be presented with COBT/CTOT information. Instead, Tower ATC will be shown TOBT/TSAT on their strips and will manage TOBT and TSAT compliance (-5/+5 minutes).

ATFM compliance will be embedded in the TSAT assigned by A-CDM. The A-CDM system will not allow a TSAT that results in a $TTOT < CTOT - 5$ minutes. Early non-compliance with ATFM is therefore prevented through the TSAT allocation logic, and TSAT compliance management.

Preventing late non-compliance with ATFM will become the responsibility of the aircraft operator. Up to pushback, the aircraft operator will be required to perform an ATFM slot change when a TOBT updates results in a TSAT and TTOT update outside of the ATFM compliance window (aircraft operator will receive warning from A-CDM system). After pushback, compliance is no longer measured and referred to as 'departure accuracy' as the aircraft operator is no longer solely responsible for achieving the CTOT. The only exception is during a ground stop enforced by ATC.

Placing the responsibility of ATFM compliance (i.e. preventing late non-compliance) with the aircraft operator has been possible due to a mature CDM environment and a mature relationship between ANSP and aircraft operators where all parties understand that a predictable network is a responsibility by all stakeholders. This is further enabled through transparent post-operational reporting available to all CDM stakeholders, driving a culture of accountability by all.

8.1.8. Network Collaborative Decision Making

The proposed integration of the multiple A-CDM systems with the centralised ATFM system provides improved predictability 'beyond the airport turnaround' into the next sector (see [Figure 13](#)). Aircraft operators benefit from predictability for the next two or more sectors of an airframe as it performs multiple back-and-forth sectors on the East Coast per day. While the accuracy on an individual flight level reduces beyond the next sector, it is anticipated to remain sufficient on flow level. This allows for an earlier warning of network delay propagation, allowing timely action to be coordinated with the CDM stakeholders.

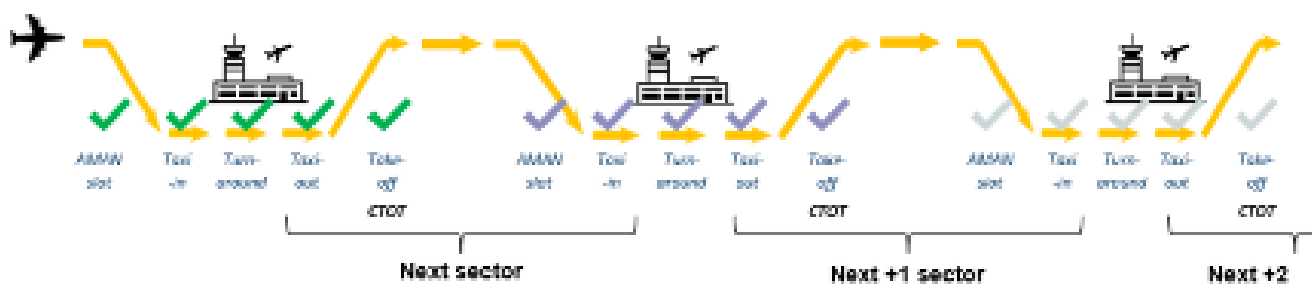


Figure 13 – Improved predictability of sector delay propagation

Current CDM is predominately focused at managing arrival demand through adjusting airport arrival acceptance rates and associated GDP revisions. The impact of departure demand is often not adequately

considered. For example, when recovering from adverse events, often large departure delays occur as arrival demand has been prioritised. Departure delays subsequently impact on the arrival flows at the destination airport. In some cases, the tactical arrival rate is lowered in order to clear (some of the) departure queue, which increases airborne delays. The impact of an adverse event at one airport, may therefore ripple unpredictably throughout the network and lengthen the time it takes for all stakeholders to recover.

A-CDM provides improved visibility of real-time arrival and departure demand throughout the network. Collaborative decision making will be able to include considerations of arrival and departure balancing, to ensure a smoother recovery from an adverse event, and mitigate the impact on the remainder of the network.

Integrating A-CDM into network management provides common and real-time situational awareness of local/network pain points, allowing to make collaborative decisions in the context of stakeholder priorities, to enact the right controls to unlock latent airspace, runway and gate capacity, thereby improving customer experience: Network-CDM ([Figure 14](#)).

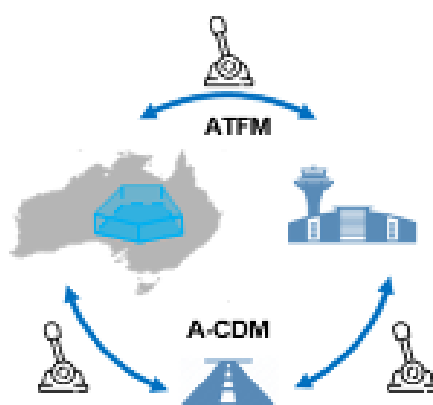


Figure 14 – Network CDM: unlocking latent airspace, runway and gate capacity

8.1.9. Lessons Learned

8.1.9.1. Lesson 1 – Change Management: don't underestimate the difficulty of explaining the interaction between ATFM and A-CDM

Despite the mature CDM environment in Australia and the mature relationship between the ANSP, airlines and airports, it took considerable effort to explain to operational SMEs across the different organisations how ATFM and A-CDM would work together. The establishment of the core Integration Principles presented earlier significantly assisted to convince key stakeholders that no such situation would occur where an aircraft operator would be confronted by conflicting ATFM and A-CDM constraints.

8.1.9.2. Lesson 2 – Identify the strengths of your local CDM implementation and leverage those to reduce complexity

Within the Australian context, the ANSP and airlines were able to agree on a shared responsibility on ATFM compliance management. This significantly reduced the integration complexity by simplifying the changes to ATC tower technology. It is noted that each operational environment is different due to different traffic patterns, different airlines, and different cultures. What works for one environment does not necessarily work for another environment; but the key lesson is to leverage local strengths to keep things as simple as possible.

8.2. Thailand: ATFM/A-CDM Integration at Bangkok Suvarnabhumi Airport (VTBS)

Editor's Note

This case study features the early part of ATFM/A-CDM integration effort at Bangkok Suvarnabhumi International Airport (VTBS) led by AEROTHAI. The case highlights the benefits of system-level integration, with AEROTHAI ensuring that their ATFM and A-CDM systems can exchange the most important data elements – CTOT and TOBT – from the system design phase.

8.2.1. Contextual Background

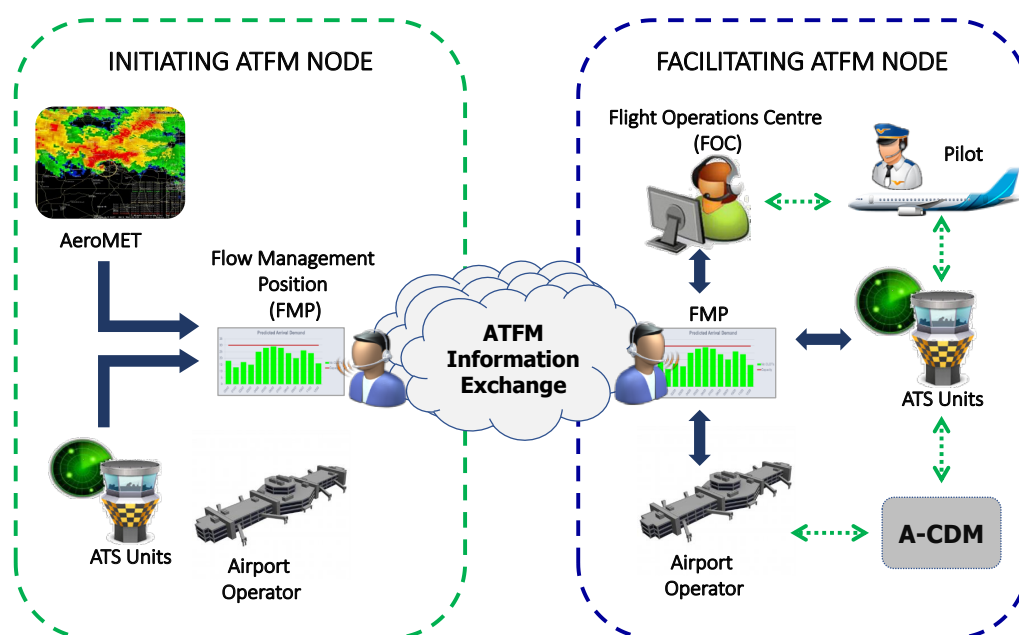
8.2.1.1. Brief History and Current Status of ATFM in Thailand

Air traffic flow management was first explored in Thailand in 2006/2007, when AEROTHAI volunteered to provide slot allocation services for overnight westbound flights transiting Kabul FIR to Europe. The task was motivated by constant congestion between 2000 – 2359 UTC in the Afghanistan airspace; a congestion contributed by peak flow of traffic from Asia-Pacific / South Asia aiming to arrive in Europe first thing in the morning. To solve the issue, AEROTHAI developed the Bay of Bengal Cooperative ATFM System (BOBCAT) and provided the early form of long-range ATFM service under ICAO Asia-Pacific Regional Office's oversight.

To provide BOBCAT slot allocation service, AEROTHAI established Bangkok Air Traffic Flow Management Unit (Bangkok ATFMU) in 2006 and developed a procedure – jointly adopted by relevant Asia-Pacific States – governing the operations. The procedure is based on ATFM slots – both the departure times (Calculated Take-Off Time: CTOT) and airspace entry times (Calculated Time Over: CTO) – being assigned to flights intending to overfly Kabul FIR between 2000 – 2359 UTC nightly. The operation, in a way, is an early form of ground delay programme (GDP) with the constrained location being Kabul FIR.

After the first decade focusing almost entirely on BOBCAT services, AEROTHAI turned the attention inward and explored ATFM implementation within Bangkok FIR; looking toward ATFM measures such as Minimum Departure Intervals (MDI) and Ground Delay Programs (GDP). This came as air traffic began to grow rapidly in Asia and Thailand in the early 21st century, while BOBCAT operations became more static and routine.

Recognising that using ATFM measures on domestic flights alone would not suffice, AEROTHAI participated in CANSO Whole-of-Flight CDM Project, an initiative that would later expand and become the Distributed Multi-Nodal ATFM Network implementation project. The project, born out of a distributed ATFM network concept ([Figure 15](#)), allows network members to manage traffic – domestic and international – into their constrained/congested ATM resources using common ATFM measure(s) without the needs for a centralised regional ATFM unit.



Credit: APAC Cross-Border Multi-Nodal ATFM Collaboration (AMNAC)

Figure 15 – Distributed Multi-Nodal ATFM Concept

One of the main ATFM measures explored in the Distributed Multi-Nodal ATFM Network project is ground delay programme (GDP), an ATFM measure that works by assigning CTOTs to flights in hopes of regulating their arrival times at a constrained/congested resource without undue burden of extensive airborne holding. AEROTHAI's experience with BOBCAT slot allocation lent itself well to this work, and the organisation found itself at the helm of the project along with CAAS, Hong Kong CAD, and CAAC ATMB.

The participation in the Distributed Multi-Nodal ATFM Network project drove AEROTHAI to significantly expand Bangkok ATFMU's scope of operations from 2015 onward. Previously operating out of a small office, Bangkok ATFMU is now housed in the expanded Air Traffic Management Network Management Center (ATM-NMC); providing operational (pre-tactical and tactical) ATFM, supported by a team of specialists responsible for Strategic ATFM planning. ATFM Daily Plans (ADP) are published daily, with CDM web-conferences as coordination channels between the ATFMU and ATS units. Minimum departure interval (MDI) and GDP are activated regularly to manage situations ranging from routine congestions in the ACC sectors to special air activities and emergency runway outages. Continuous improvements, both in the operating procedure and ATFM support systems, are being explored to enhance the ATFM services and prepare AEROTHAI for the consistent growth in the years to come.

8.2.1.2. Brief History and Current Status of A-CDM in Thailand

Airport Collaborative Decision Making (A-CDM) was first explored in Thailand in 2016, with the initial objective of managing ground congestions and improving efficiency for flights departing from Bangkok Suvarnabhumi International Airport (VTBS). Ground congestions and departure delays at VTBS are particularly problematic during the morning peak traffic hours and in adverse conditions (e.g. runway and taxiway closures, severe weather). The main reference for this exploration was EUROCONTROL's 16-milestone approach to A-CDM.

In 2017, AEROTHAI conducted gap analysis with all key stakeholders – airport operators, aircraft operators, and ground handling units. The analysis resulted in an agreement to focus the initial A-CDM effort on the sharing of target off-block time (TOBT) and target start-up approval time (TSAT), without yet touching the rest of the milestones.

The gap analysis also highlighted various challenges, one of which was the lack of A-CDM platform to share information. At the time of the analysis (2017), Airport of Thailand (AOT) – Airport Operator responsible for major airports including VTBS – was in the process of procuring and upgrading airport information management system. AEROTHAI then decided, as an interim solution, to develop Intelligent Departure Enhancement Program (iDEP). iDEP was designed to serve as a Departure Manager (DMAN) and A-CDM portal for the sharing of TOBT and TSAT, with a high-level concept shown in [Figure 16](#).

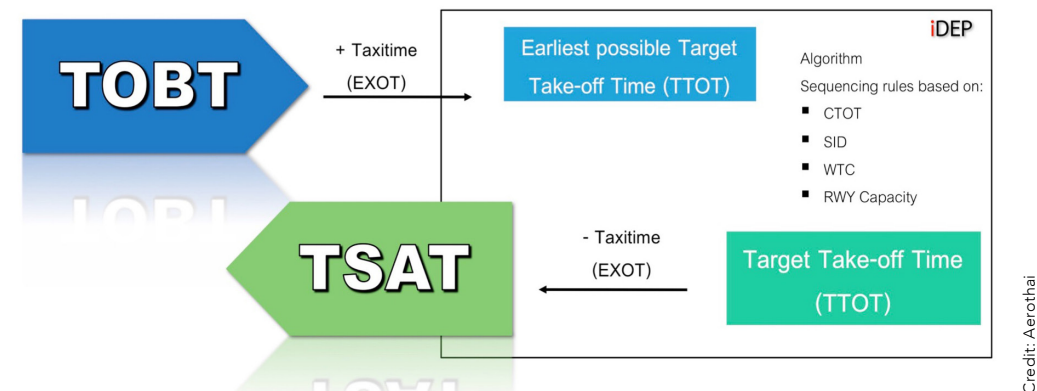


Figure 16 – iDEP Concept Diagram

Sharing TOBT and TSAT between stakeholders are now conducted through web-based application or SMS service via digital trunked radio, as the visual docking guidance system (VDGS) at VTBS are still being upgraded to support A-CDM data. The use of digital trunked radio is designed to serve ground handling units with existing regulations preventing the use of unapproved electronics at the aircraft stand and in the apron area.

Following the development of iDEP, AEROTHAI has been leading A-CDM operational trial with stakeholders at VTBS during the peak hours of 0700 – 1000 local time (0000 – 0300 UTC), with the trial split into 2 phases:

1. Phase 1 – Focus on familiarising stakeholders with the iDEP user interface and developing internal procedures to exchange TOBT and TSAT
2. Phase 2 – Focus on TSAT compliance management

The operational trial is ongoing at the time of this writing, with regular performance report and feedback mechanism. The project has received good support from stakeholders with strong push for A-CDM operations on a 24-hour basis.

8.2.1.3. The Needs for ATFM/A-CDM Integration at Bangkok Suvarnabhumi Airport (VTBS)

A-CDM is in its initial phase of implementation at VTBS, while at the same time the use of ATFM measures is becoming more common and more frequent for flights in Thailand. This is a prime time to ensure integration between the 2 systems and operations. Experience in managing CTOT-regulated flights from a busy terminal such as VTBS, without A-CDM support, has taught AEROTHAI that ATFM and A-CDM need to be integrated both at the operating procedure and the support system levels.

Integrating ATFM and A-CDM at the procedure level is about ensuring that stakeholders are familiar with both the A-CDM and ATFM operational procedures, and how they are used at places where both operations are active.

Integrating ATFM and A-CDM at the system level is about ensuring that both ATFM system and A-CDM platform are able to exchange and utilise information across platforms, with established data connectivity and prescribed methods for data use.

As ATFM operations in Thailand is focusing on GDP and MDI primarily, the integration between ATFM and A-CDM at VTBS is focused on the relationship between TSAT and CTOT or departure interval requirements; with operating procedure governing stakeholders' interactions and system algorithm supporting the linkage across platforms.

8.2.2. ATFM/A-CDM Integration Concept

8.2.2.1. Integration at the Procedure Level

The chart in [Figure 17](#) describes an overview of A-CDM process at VTBS, focusing on the exchange of TOBT and TSAT. The exchange of TOBT begins as soon as the aircraft operator is able to determine their operational status, while the distribution of TSAT begins at approximately 40 minutes prior to the flight's EOBT.

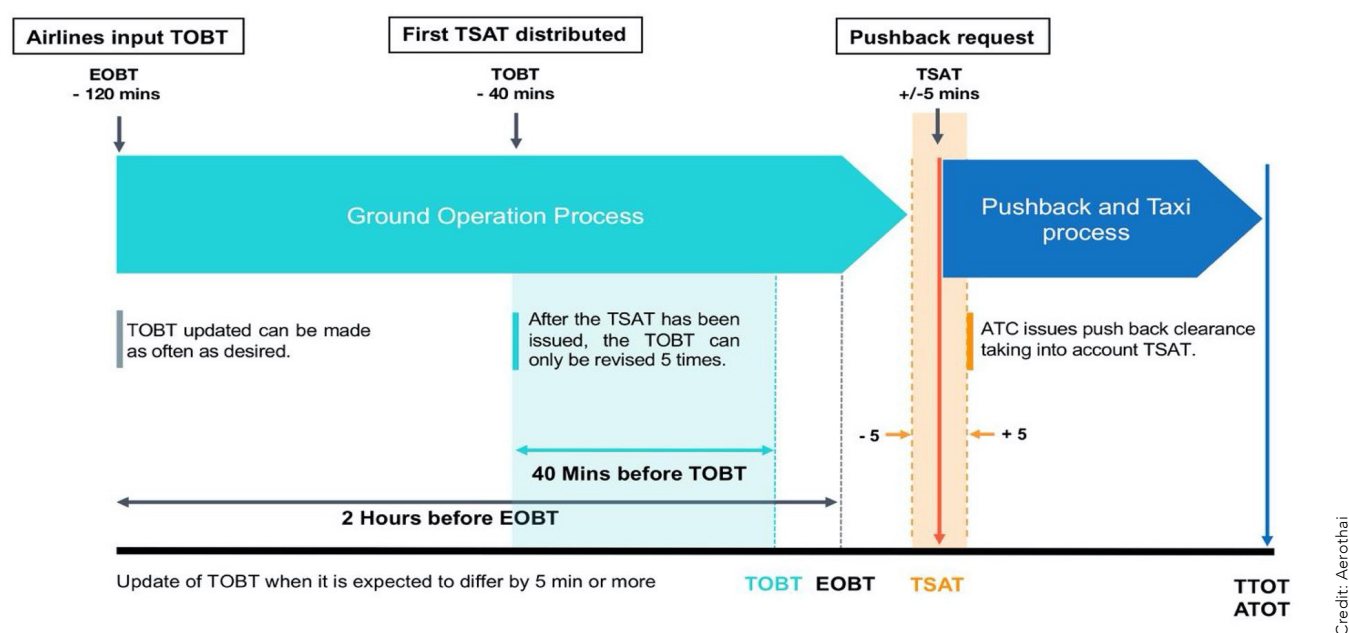


Figure 17 – VTBS Initial A-CDM Procedure

When a GDP is activated, CTOTs are published at least 90 minutes before EOBT. The published CTOTs are automatically pulled from AEROTHAI's ATFM support system into the A-CDM platform (iDEP) for calculation of TSAT and a suggested TOBT for aircraft operators / ground handling units, with appropriate warning when aircraft operators / ground handling units attempt to input TOBT that would cause the flight to miss their CTOT compliance window.

Stakeholders familiar with GDP activated in Thailand know the standard CTOT compliance window of either (-5/+10) minutes or (-5/+5) minutes. With A-CDM in place at VTBS, stakeholders are asked to comply with TSAT which will have been calculated with the CTOT compliance window taken into account. Standard compliance window to TSAT is (-5/+5) minutes, which is more stringent than standard CTOT compliance window. The tighter TSAT compliance window gives VTBS ATC room to manage the flight around other ground traffic and ensure CTOT-compliant departure.

When an MDI is activated, with the requirements communicated through ATFM Daily Plan (ADP), VTBS ATC responsible for setting up the Intelligent Departure Enhancement Program (iDEP) platform is able to input the requirements into the platform's configuration. The platform will then use the requirements as basis

for TSAT calculations. In this case, again, stakeholders are asked to comply with TSAT within the standard compliance window.

In both GDP and MDI, integrating ATFM and A-CDM in the operating procedure allows airport stakeholders to focus their attention on the A-CDM element that they can best comply with, the TSAT. By complying with TSAT, airport stakeholders will have played their roles in assisting ATC for complying with the ATFM requirement(s) in place.

8.2.2.2. Integration at the System Level

The main system AEROTHAI is using (at the time of this writing) for initial A-CDM operations is the iDEP internally developed by ATS Research and Development team. iDEP is designed as an initial software to enhance ground movement and departure operations at Bangkok airports (VTBS and VTBD), focusing on a few A-CDM milestones – TOBT, TTOT, TSAT – and where they can enhance compliance to key ATFM measures – GDP and MDI.

iDEP begins its calculation when airline, or ground handling unit representing the flight, submits TOBT and parking bay. Based on TOBT and variable taxi-out time (VTT, previously defined^[6]), the flight's TTOT will be established and adjusted based on factors from a departure management function built as part of iDEP. Once the adjusted TTOT is established, TSAT is calculated based on the TTOT and is delivered to subscribers for the flight's information via web portal and trunk radio message^[7].

The calculation of final TTOT is where iDEP has connection to AEROTHAI's ATFM support system, the Air Traffic Flow Advisory System (ATFAS), which is also internally developed by the same ATS Research and Development team. Specifically, iDEP caters to three types of ATFM measures in-used in Bangkok FIR today:

1. Ground delay programme – When a flight is subjected to CTOT as part of the ground delay programme, the assigned CTOT will take precedence over all other departure restrictions. iDEP automatically pulls CTOT information from ATFAS, treats it as TTOT, and calculates TSAT accordingly. The system will also provide suggested TOBT to the airline user (airline operations or ground handling unit) when inputting TOBT into the iDEP. The airline user has the option to input suggested TOBT, or submit a different one.
 - If the airline's submitted TOBT is later than suggested TOBT, a warning flag will be shown to all users related to the flight and ATCO may require the flight crew to obtain new CTOT before releasing departure clearance
 - If the airline's submitted TOBT is earlier than suggested TOBT, TSAT will remain that calculated based on CTOT and no warning is provided
2. Minimum departure interval – MDI is one of the ATFM measures activated often to relieve congestions at various ACC sectors in Bangkok FIR. Bangkok ATFMU generally activates MDI for departures from Bangkok airports when ACC sector congestion is imminent, and notifies stakeholders through ATFM Daily Plan (ADP).
 - MDI requirements are coordinated between ACC and VTBS TWR/APP, who can input the requirements as departure flow configurations in the departure management (DMAN) function of iDEP. TTOT calculated will be based on the flow configurations

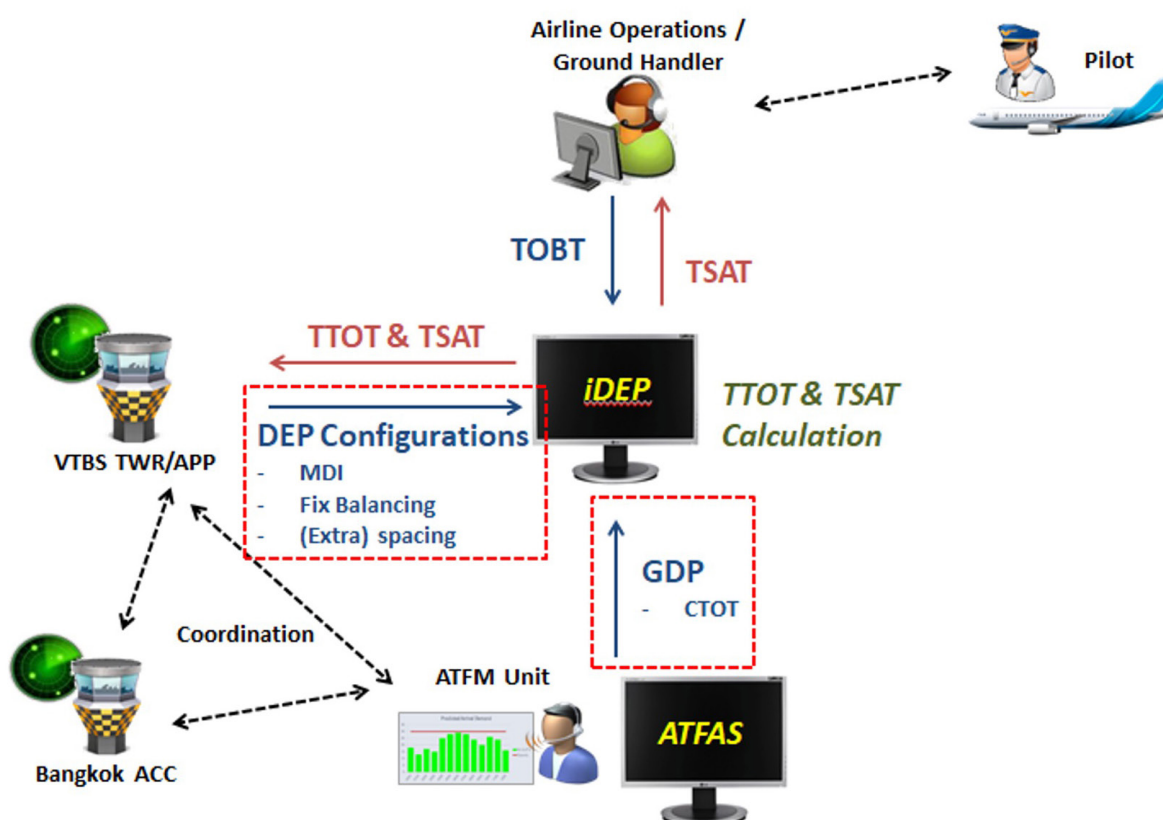
⁶ VTTs have been previously defined for all parking bays through statistical analysis; the information is stored in the iDEP system and is configurable.

⁷ Trunk radio message is a way to deliver TSAT to ground handlers working in the apron, with restriction against the use of hand-held equipment connected to the internet. Note: At the time of this writing, iDEP system is not connected to the visual docking guidance system (VDGS) at Suvarnabhumi Airport.

3. (Tactical) (Departure) Fix balancing – One of the causes for congestions in Bangkok TMA and surrounding ACC sectors is having closely-spaced departures going the same directions. Bangkok APP and Bangkok ACC sometimes solve the issue by assigning extra spacing between common-direction / common-SID departures, e.g. prescribing four minutes between consecutive aircraft at the northeast and southwest waypoints.

- The requirements can be input into iDEP as part of the departure flow configurations, and the system will optimise departures by ensuring the requirements are not violated while maximising departure throughput in all directions

Table 15 and Figure 18 summarise how iDEP (A-CDM support) works with ATFAS (GDP support) and other ATFM measures at the system level



Credit: Aerothai

Figure 18 – ATFM/A-CDM Integration at System Level

ATFM element (ATFM measure)	Enters iDEP by:	Treated by iDEP as:	Result
CTOT (GDP)	Automatically processed from ATFAS	Overriding restriction	TTOT = CTOT TSAT calculated accordingly
Departure Interval (MDI)	Manual input	Departure flow configuration	TTOT based on flow requirements
Fix Spacing (Tactical Fix Balancing)	Manual input	Departure flow configuration	TTOT based on flow requirements

Table 15 – iDEP Data Element Input

The design of iDEP, especially with automatic connection with ATFAS and configurable departure flow restrictions described above, fully supports seamless integration between ATFM and A-CDM operations at Bangkok Suvarnabhumi Airport. The system has significantly reduced ATCO workload and enhanced ground movement efficiency, especially when complexity level rose due to necessary ATFM requirements.

8.2.3. Planned Direction

8.2.3.1. iFIMS: Expanded Airport Information Management and Full A-CDM Capability

Airport of Thailand (AOT), major Airport Operator responsible for key international airports in Thailand, has been preparing to install Integrated Flight Information Management System (iFIMS). The iFIMS will serve as an upgraded airport operational database (AODB) system for all major airports under the care of AOT. The system is expected to be equipped with A-CDM capability and platform.

At the same time, AEROTHAI is undergoing a major ATM system transition as well. The new and enhanced ATM system will be linked with AOT's iFIMS and will allow for extensive data sharing across platforms and across all phases of flight. The linkage will thus allow for more expansive A-CDM operations, possibly spanning most of the 16 milestones recommended by EUROCONTROL.

8.2.3.2. Connecting ATFM and A-CDM on SWIM-based Technologies

One of the key upcoming technological developments in the ATM industry is system-wide information management (SWIM), an industry-wide initiative to harmonise ways in which information is exchanged across stakeholders and services. ATFM and A-CDM, being collaborative in nature, will greatly benefit from using SWIM-based technologies to enable more efficient communication across their platforms.

Recognising the importance of SWIM; AEROTHAI has been at the helm of SWIM development in Asia-Pacific, championing several tasks at the ICAO Asia-Pacific SWIM Task Force and co-led SWIM in ASEAN Demonstration Project in 2019. The project demonstrated the possibilities and benefits of SWIM, as well as a possible implementation model for the region. At the core of the demonstration project is showcasing how SWIM can enhance various aspects of ATM operations – including ATFM, A-CDM, and integrated ATFM and A-CDM – by maximising the flexibility and efficiency of data communication across platforms.

As part of supporting the demonstration project and getting ready for SWIM implementation in the near future, both ATFAS and iDEP are designed to be able to communicate with one another as well as interfacing with external systems digitally, using agreed XML standards and information exchange models such as FIXM and associated extensions. A key target in the development of the systems is to ensure they are ready for quick transition to SWIM-based communication as soon as SWIM is implemented.

8.2.4. Lessons Learned

8.2.4.1. Early Planning for Integration

The integration of ATFM and A-CDM requires proper planning. While ATFM and A-CDM implementations do not need to occur concurrently, it is important to recognise that – when both are implemented – they should be integrated and/or interoperable. Having been familiar with ATFM operations has helped AEROTHAI A-CDM implementation team realise that the A-CDM operations at VTBS, and elsewhere in the future, should take into account ATFM. As a result, the A-CDM implementation team has set out early to design A-CDM operating procedure that works with both GDP and MDI. The iDEP development team, having also understood the needs for integration, has also designed the software so that it can connect and process data from the ATFM system. The early realisation of the needs for integration, and the proper planning at both procedure and system levels, have helped made the link between ATFM / A-CDM (ATFAS / iDEP) at VTBS. This link is now the best practice for future ATFM/A-CDM integrations at other airports in Thailand.

8.2.4.2. Integration at Procedure and System Levels

ATFM and A-CDM both require effective procedures and support system to carry out the operations. Integrating ATFM and A-CDM should also happen at both the operating procedure and system levels.

- a. Integration at operating procedure level involves writing procedure that ensures stakeholders are clear on how to interact with the different ATFM and A-CDM requirements
- b. Integration at system level involves designing both ATFM and A-CDM support systems that can interact and share data across platforms, and able to utilise the greater array of data available

The integration at both of these levels require proper planning and close collaboration between the operations and the engineering teams.

8.2.4.3. Stakeholder Engagement

Stakeholder engagement should be an important part of introducing the integration of ATFM and A-CDM, particularly at the operational procedure level where stakeholders' work process could change. Early engagement and education can help smooth and expedite the integration process. AEROTHAI A-CDM implementation team has placed great importance on stakeholder engagement from the very beginning of the project, and this has helped ensure all stakeholders are clear on the operating procedure with minimal confusion even when their work process is changed.

8.3. Poland: ATFM/A-CDM Integration at Warsaw Chopin Airport (EPWA)

Editor's Note

This case study features the ATFM/A-CDM integration at Warsaw Chopin Airport. The case demonstrates how a local A-CDM system connects and exchanges data elements with the regional ATFM system in a centralised regional ATFM environment, and how the exchanged data can be used to improve predictability and accuracy of the entire process.

8.3.1. Project Background

8.3.1.1. A-CDM Implementation Project Steering Committee

The Warsaw Chopin Airport Collaborative Decision Making (A-CDM) implementation project started in 2007, with the kick-off meeting taking place on 29 November 2007. A steering committee comprising focal points from PANSa, Warsaw Chopin Airport Authority, LOT Polish Airlines, and major ground handling agencies was created. In April 2008, the committee conducted gap analysis. Subsequently, a memorandum of understanding (MOU) governing the implementation was signed by all partners in March 2009 and updated in 2010.

8.3.1.2. Governing Philosophy for the Integration

Warsaw Chopin Airport A-CDM implementation is based on the European standard for A-CDM. It is recognised as a harmonised method to enable optimal aircraft turnaround process, covering a flight's lifecycle starting from flight planning (EOBT – three hours) through landing, turnaround process, and outbound departure. The concept brings substantial benefits to all stakeholders by improving the availability and quality of information, upon which operational decisions can be made.

With A-CDM implemented, the improved availability and quality of operational information is used to optimise the process chain from arrival to departure. The focus of the process is on a determination of target start-up approval time (TSAT), an essential factor for a smooth departure sequence on the ground. TSAT calculation by pre-departure sequencer takes into account operational requirements from all relevant parties, including the airspace user's target off-block time (TOBT), local terminal area and airspace capacities, and the European airspace network capacity.

It was recognised that the A-CDM implementation at Warsaw Chopin Airport would need to be integrated with the European Air Traffic Flow and Capacity Management (ATFCM) process managed by the European Network Manager Operations Center (NMOC).

8.3.1.3. Integration with the European ATFM Operations

To enable the integration of Warsaw's A-CDM procedure with the European ATFCM process, a permanent and fully automated data exchange between Warsaw's A-CDM system with NMOC's ATFCM system was established. The connection enables Warsaw's A-CDM to receive ELDTs from the NMOC, while in turn supplying the NMOC with TTOTs – through DPI messages – that can be used in optimising ATFM slots (CTOTs). In addition, alert messages (CDM messages) would also be exchanged. These alerts can be triggered either by local occurrences and coherency checks or as a reaction to error/warning messages in the process of message exchange with the NMOC. The alerts are displayed in Warsaw's A-CDM Portal and require responses from relevant recipients, otherwise the A-CDM process will be interrupted and start-up approval not issued.

8.3.1.4. Supporting Systems

To support the A-CDM operations at Warsaw Chopin Airport, an A-CDM portal with TSAT generator has been designed and developed by PANSA as an internal product. The system covers departure management (DMAN), arrival management (AMAN), A-CDM process, and advanced tower capabilities.

8.3.2 Challenges and Benefits

8.3.2.1. Challenges in the Implementation Process

The following are some of the most significant difficulties encountered during the A-CDM implementation at Warsaw Chopin Airport:

- Having consistent representatives from stakeholders in the steering committee throughout the process
- Finding a common understanding of A-CDM among all stakeholders
- Insufficient planning process as a pioneering project
- Making appropriate decisions in the software specifications
- Integrating information across platforms between ANSP's and airport operator's systems
- Governing data exchange and preventing commercial view toward data sharing
- Unification of data communication systems
- Needing to carry out specialist training for a large number of operational staff in a short period of time

8.3.2.2. Benefits from Integrated ATFM/A-CDM at Warsaw Chopin Airport

The following are some of the benefits seen from integrated ATFM/A-CDM implementation at Warsaw Chopin Airport:

- Predictable traffic leading to reduced workload
- Reduced probability of errors
- Better pre-departure traffic sequence and reduced workload for TWR controller
- Higher service quality
- Reduced number of false TACT Activated status of the flight
- Accurate tactical information about the airport situation
- Reduced number of traffic congestion
- Elimination or reduction in flight plan suspension
- Better predictability in the various milestones, resulting in a significant reduction of emissions and positive environmental impact
- Better allocation of human and hardware resources due to better information flow
- More effective decision-making in relation to ATFCM based on accurate and real-time flight information
- Smooth airport operations even during adverse weather conditions, and efficient recovery to normal operations
- Better compliance with ATFM slots

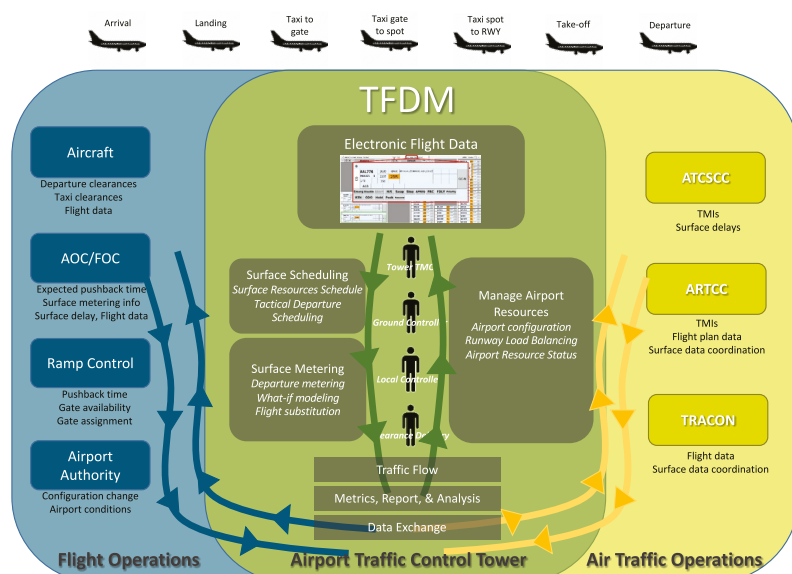
8.4. United States: Surface Collaborative Decision Making and Terminal Flight Data Manager

Editor's Note

This case study features the FAA's Terminal Flight Data Management (TFDM) system, which supports the agency's Surface CDM operations. The case demonstrates the importance of comprehensive information sharing among stakeholders beyond just the ANSP, as TFDM enables efficient data exchange between all aviation stakeholders in the environment. Note that a number of terms may be different from those commonly used in ATFM/A-CDM concepts elsewhere; insofar as possible, clarifications on those terms are included either in-text or as footnotes.

Terminal Flight Data Manager (TFDM) is a Federal Aviation Administration (FAA) Next Generation Air Transportation System (NextGen) initiative and Trajectory Based Operations (TBO)-enabling system to improve surface efficiency and stakeholder collaboration. TFDM is the FAA's future surface management solution that will be deployed to 89 airports and Air Traffic Control Towers (ATCTs) across the National Airspace System (NAS) starting in 2020. TFDM is a tower-based system that will provide tower controllers automation and displays to improve efficiency in operations, improve situational awareness of airport traffic and conditions, and replace certain systems and guide operations utilised today.

TFDM will provide improvements to flight data coordination and management for ATCT users, as well as enhance surface traffic flow management (TFM) capabilities. TFDM's objectives include improved surface management and efficiency, reduction of taxi delays, carbon emissions and fuel burn, and increased sharing of surface information with other TFM systems in the NAS. The use of surface metering will be enabled by a new Surface Collaborative Decision Making (S-CDM) partnership between the FAA and non-FAA stakeholders (e.g., airport operators, flight operators, and ramp operators) to collaborate, exchange data, and execute surface metering.



Operational View of the TFDM System and Stakeholders:

TFDM provides ATCTs automation to increase tower and surface efficiency. TFDM relies on data exchange and collaboration with other FAA stakeholders and systems, as well as non-FAA stakeholders.

Credit: FAA

Figure 19 – TFDM Operational View

8.4.1. Overview of S-CDM and TFDM Surface Metering

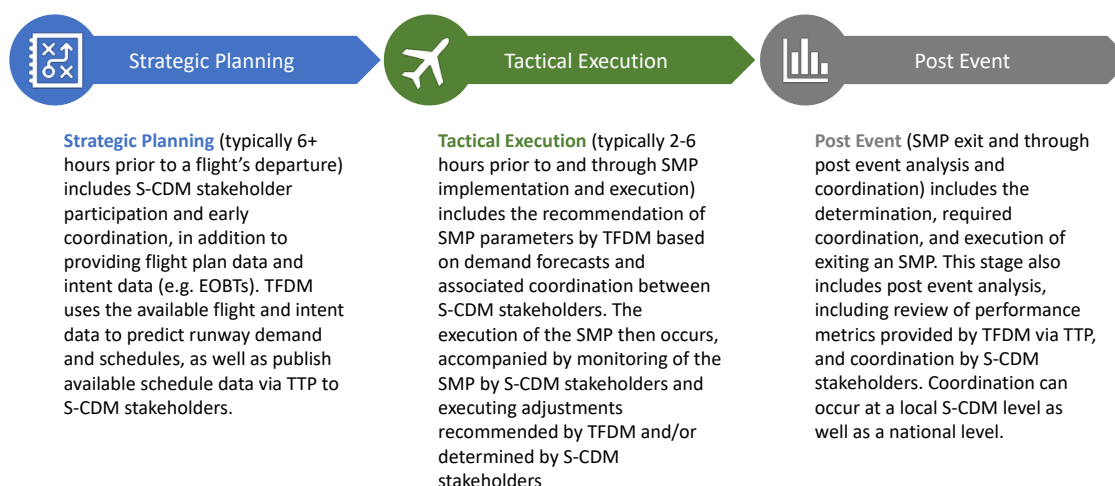
Surface metering is enabled using the TFDM system and S-CDM processes, procedures, and policies to help flight operators, ramp operators, airport operators, and other stakeholders efficiently use available airport surface capacity. Surface metering allows flights to absorb delays normally taken on the movement areas at the gate. This can lead to a reduction in fuel burn, engine emissions, and cycles, while improving stakeholder situational awareness and providing predictability of surface use to the ATCT.

The S-CDM concept has been an important topic for research and development by the FAA and its partners since the 2000s. In 2010, the Surface CDM Team (SCT), a joint government/industry collaboration group, formed and documented the FAA's S-CDM concept and vision. The goal of the concept was to improve the predictability and efficiency of surface operations in a collaborative manner to incorporate and meet different stakeholders' objectives, constraints, and data. The FAA established operational increments (OIs) to ensure this goal was met through development of automation to support surface metering and exchange of information between FAA and non-FAA stakeholders. Due to TFDM's existing planned capabilities for electronic data exchange, traffic flow management (TFM), and surface scheduling, the S-CDM concept was integrated into the system's automation capabilities.

"Surface CDM is the sharing of flight movement and related operational information among Airport Operators, Flight Operators, Flight Service Providers, and FAA Stakeholders to improve demand and capacity predictions, thereby enabling those who practice the Surface CDM concept to maximise the use of available airport and airspace capacity, while minimising adverse effects on Stakeholders, passengers, and the environment."

Surface Collaborative Decision Making (CDM) Concept of Operations (ConOps) in the Near-term (FAA), 2013

TFDM's surface metering functionality provides the ability to tactically manage departure queues based on predicted demand and available surface capacity. Surface metering relies on TFDM's predicted schedule to identify periods where departure queues continuously exceed desired queue length. Surface metering processes, tasks, and responsibilities will span three phases of a surface metering programme (SMP) 'lifecycle' depicted in [Figure 20](#). For these periods, TFDM recommends an SMP, during which flights will receive metering times, or Target Movement Area entry Times (TMATs⁸), to assist in maintaining desired queue lengths and reduce the time flights spend in the queue waiting to take off. TFDM provides these recommendations and programme details to all stakeholders, both FAA and non-FAA, to create common situational awareness for surface operations. The system will also provide stakeholders monitoring and analysis data during and after SMP events.



Credit: FAA

Figure 20 – SMP Timeline and Phases

Successful implementation of TFDM's surface metering functionality relies on stakeholder agreement for local processes, procedures, and policies (P3). This includes local policies to establish the use of surface metering at TFDM airports as well as local processes and procedures to implement SMPs that complement national-level policies and procedures. Local surface metering agreements are necessary due to the differences between operations and stakeholders across the TFDM airports. These agreements can be satisfied by local Letters of Agreement (LOAs) established by local stakeholders and may include processes for implementing SMPs, policies for post-event analysis, and procedures for certain operational events. National-level surface metering P3 will assist in governing available data, national delay reporting policies, and processes for performing operations that do not differ across local operations (e.g., substitution rules).

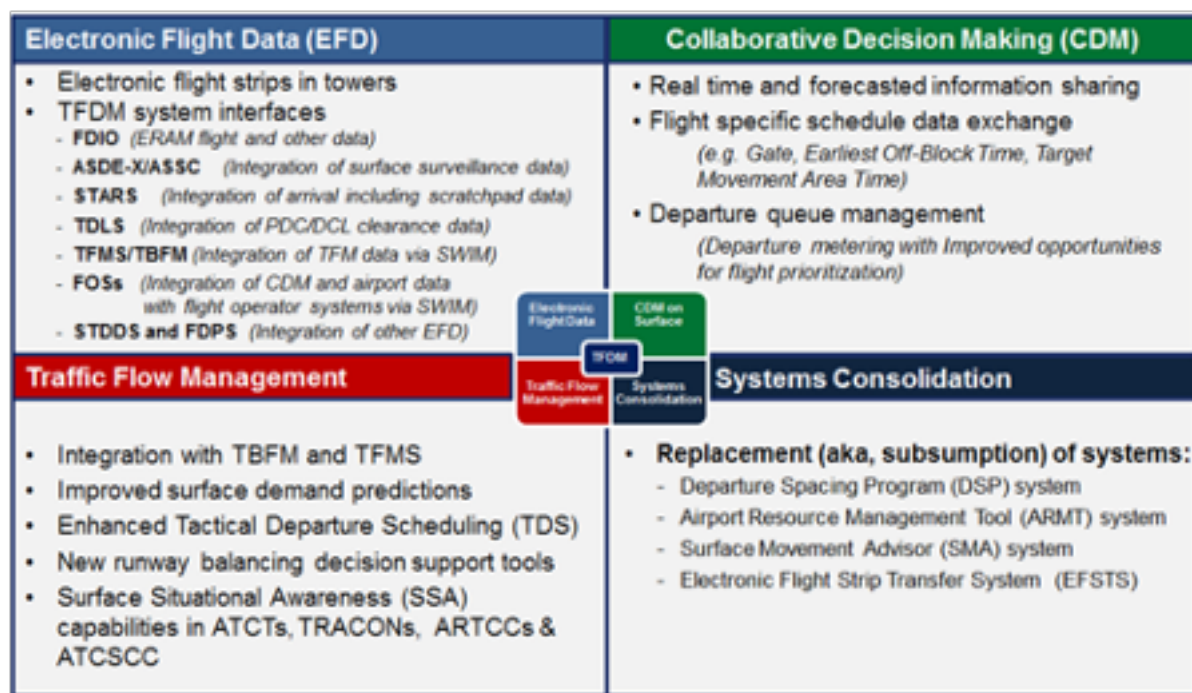
Goals of Surface Metering

- Manage queue lengths to reduce excess delay spent actively taxiing on the surface
- Reduce fuel burn and emissions associated to longer queue wait times
- Improve predictability on the surface for both FAA and non-FAA stakeholders
- Provide automation capabilities to support surface metering

TFDM will distribute surface schedule and operational data among stakeholders involved in surface metering, including flight operators, ramp control facilities, and local S-CDM stakeholders via system wide information management (SWIM). This data publication allows stakeholders to have a shared view of surface operations beyond just SMPs. The operational data includes current and predicted operations, airport performance, traffic management initiatives (TMIs) affecting flights, SMP information, and other data for the TFDM airport and flights operating to and from the airport. Additionally, TFDM will ingest data provided by these stakeholders, as well as other FAA systems, to improve surface predictions, inform an estimated surface schedule, and enable strategic and tactical TFM planning. This data sharing will enable collaborative decision making between the FAA and non-FAA stakeholders regarding the airport surface, departure, and arrival operations.

8.4.2 Key Terminal Flight Data Manager Capabilities

TFDM provides 4 core capabilities as part of the automation suite, identified in figure 18.



Credit: FAA

Figure 21 – TFDM Capabilities Overview

8.4.2.1. Electronic Flight Data (EFD)

TFDM will replace ATCT paper flight strips with electronic flight strips, provide automation for electronic flight and airport data management, and interface with other NAS systems to share electronic flight data. Key subcomponents of EFD include:

- a. **Electronic flight strips (EFS):** TFDM will provide software, displays, and interface mechanisms (e.g., mouse, keyboard) to replace paper flight strips used in ATCTs today. EFS will utilise flight data from existing FAA systems to provide flight data to ATCT controllers and managers as well as data sourced from TFDM, non-FAA stakeholders (e.g., flight operators), and other FAA systems (e.g., Tower Data Link Services [TDLS]). EFS will provide real-time updates of flight data to controllers, reduce guide flight strip actions (e.g., guide runway notations), and provide enhanced situational awareness about flight intent and airport conditions to controllers and managers.
- b. **Airport resource management:** TFDM will provide ATCTs with improved electronic management and coordination of airport resources. This function will allow electronic scheduling and management of airport configurations, including managing in-use runways and associated rates, and distribute this information to users at the airport and to other NAS systems via the TFDM Terminal Publication (TTP) SWIM service. TFDM will also provide ATCTs with enhanced automation to better manage airport resource efficiency through modeling tools, including runway load balancing.
- c. **Electronic flight data management:** Through SWIM, TFDM will consume and distribute FAA and non-FAA data amongst stakeholders. TFDM will ingest data from other TFM systems (e.g., traffic flow management system [TFMS], time-based flow management [TBFM]) and stakeholders (e.g., flight operators) to inform TFDM components, including electronic flight strips displayed data, modeling tools, and airport resource management tools. TFDM will distribute metric data, airport resource statuses, estimated schedule information, and other predictive and tactical surface information via SWIM interfaces.

8.4.2.2. Traffic Flow Management (TFM)

TFDM will provide a suite of capabilities designed to improve TFM, including:

- a. Surface Scheduling:** New surface scheduling capabilities will improve the strategic surface demand predictions that are provided to NAS automation systems and flight operators. TFDM will use adapted rules, data from external systems and stakeholders, historical data captured by TFDM, and controller input to generate a predicted airport surface schedule and runway schedule for each available runway. The schedule information, including estimated time of takeoff for each flight, will be published for use by other NAS systems and non-FAA stakeholders.
- b. Runway Load Balancing:** This tool's capabilities will assist controllers in balancing demand when multiple departure runways are in use at busy airports. This tool will increase efficiency of runways and support the ATCT in meeting available runway capacity and reducing delay to the airport demand.
- c. Surface Situational Awareness (SSA):** This capability (hosted on TFMS displays) will provide insight into surface operations for terminal radar approach control (TRACON) and air route traffic control centre (ARTCC) facilities with a visual representation of the surface movement area with live flight traffic depicted, associated traffic flow metrics, and departure flight lists. SSA will utilise both TFMS and available TFDM data to provide insight into the airport environment to facilitate better collaborative decision making between FAA facilities.
- d. Electronic Call for Release (CFR) Coordination:** TFDM will provide controllers and managers the ability to use TFDM to automatically request release times from TBFM. This capability will streamline the request process used today and improve efficiency in coordination between the surface and en route schedules and constraints.

8.4.2.3. Surface Management and Metering

TFDM will provide a departure queue management capability (a.k.a., surface metering) to allow for more efficient strategic scheduling and metering of the airport surface. Surface metering benefits are achieved with TMATs provided to flight operators that will better manage the flow of traffic on the surface. This capability will provide enhanced data sharing between the FAA and flight operators allowing flight operators to provide more information to the FAA in return for the FAA providing more predictable surface scheduling and metering data.

8.4.2.4. Systems Consolidation

TFDM will subsume end-of-life ATCT systems including the airport resource management tool (ARMT), departure spacing programme (DSP), and the ATCT portion of electronic flight strip transfer system (EFSTS) ensuring those legacy system capabilities are still provided to facilities and integrated with other NAS systems.

8.4.3. Demonstrated Benefits

The benefits of surface metering are not just theoretical. NASA, in collaboration with the FAA, is running the Airspace Demonstration Technology 2 (ATD-2) prototype programme demonstrating the TFDM concept of operations.

The first baseline phase for ATD-2 began in September 2017, in cooperation with American Airlines at Charlotte/Douglas International Airport. NASA and American Airlines began running surface metering during one of the nine departure banks of flights per day, and have now increased to eight of the nine departure banks. Of those flights subject to metering, only 10-17 percent of flights experienced a metering time constraint, and then for an average of only 6.1 minutes.

Even with slight adjustments as those made during ATD-2, the benefits are promising—in efficiency, and in environmental and financial savings. Since implementation in Charlotte, surface metering with ATD-2 has

saved more than a million pounds of fuel and approximately 2.3 million pounds of carbon dioxide, which is the equivalent of planting almost 38,000 urban trees.

ATD-2 has provided a glimpse into the benefits expected with TFDM.

TFDM benefits include:

- Improved predictability
- Collaborative decisions
- Environmental friendliness
- Real-time accuracy
- System modernisation
- Consolidated systems
- Improved safety

The system is expected to save 313 million gallons of fuel and reduce over 3 million metric tons of carbon emissions during its lifetime.

8.4.4. Challenges and Lessons Learned

Each airport will determine their own parameters for programmes such as queue length and under which conditions a surface metering programme would be initiated. Stakeholders at these sites will participate in setting those parameters. As such, one key challenge for TFDM is engaging with the appropriate stakeholders at the local airport level.

To assist local coordination and to prepare sites and flight operators for implementation, the FAA has formed a Collaborative Site Implementation Team to act as a liaison between the TFDM programme office and external stakeholders. The team's tasks include running orientations for airports and flight operators on how TFDM works, providing reference materials to guide local stakeholders in setting local parameters, and solving challenges in submitting new data elements.

Another challenge is the implementation of TTP. This SWIM service is critical to the information flow at the local airport. The FAA is working with airline and airport partners to assist in establishing the necessary infrastructure for this flow of information to be available to all the necessary stakeholders.

8.5. China: ATFM/A-CDM Integration at Shanghai Pudong Airport (ZSPD)

Editor's Note

This case study features the ATFM/A-CDM integration at Shanghai Pudong International Airport (ZSPD). The case demonstrates the benefits from utilising advanced technologies such as Internet of Things (IoT) at the airport to automatically gather and process real-time operational data during the ATFM/A-CDM operations, enabling high operational accuracy.

8.5.1. Background

China's air traffic flow is characterised by rapid growth and uneven distribution. In recent years, the rapid growth of air traffic has put great pressure on air traffic control system, with flow concentrated at airports in political, economic and tourist centres, especially in the developed areas of eastern China.

Recognised as a 4F civil airport and one of the top 3 aviation hubs in China, Shanghai Pudong International Airport is located approximately 30 kilometers from downtown Shanghai, the economic and cultural centre of eastern China. In 2019, Pudong Airport handled 511,846 aircraft movements, with 76.15 million passengers. With the view of further optimising resource utilisation and airport operation, as well as improving data accuracy and timeliness, Pudong Airport has commissioned VariFlight to actively apply new technology to facilitate the integration of A-CDM and ATFM.

VariFlight has helped over 100 airports in China to build A-CDM systems and has extensive experience in installing collaborative decision-making systems for various airports. Starting in 2019, under the guidance of Civil Aviation Administration of China, VariFlight's A-CDM team has participated in the preparation of the Technical Specification for A-CDM System, which is the first national industry standard. It is proposed to realise ground-air coordinated operation through data integration in A-CDM and ATFM systems, including real-time interactions of TOBT and COBT. In the meantime, by optimising the sequence of departing flights, the system will improve the accuracy and practicability of air traffic flow and ATFM measures.

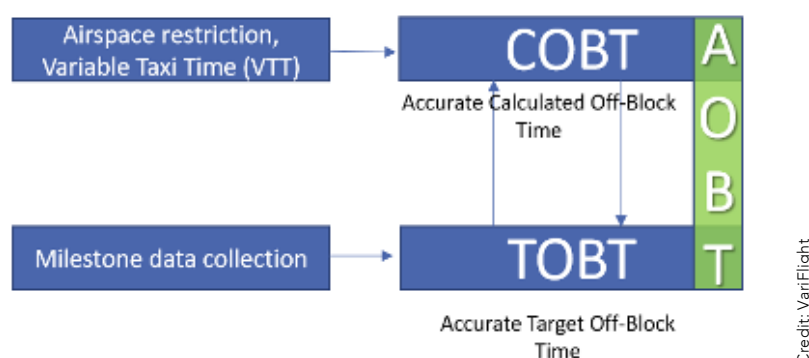


Figure 22 – Real-Time Interaction of TOBT and COBT

8.5.2. Project

The integration of A-CDM and ATFM at Pudong Airport is currently in its initial trial phase. VariFlight actively uses the experience in constructing airport intelligence system, ADS-B data and data computing capabilities, the Internet of Things (IoT), 5G communications network, and other technical expertise to creatively implement a set of A-CDM system workflow. The A-CDM system workflow includes data collection, data interaction, intelligent decision-making and intelligent guidance. The system features real-time TOBT calculation to realise the data interaction between TOBT and COBT, which form the core basis for the integration of A-CDM and ATFM.

8.5.3. Integration Workflow of A-CDM and ATFM

8.5.3.1. Data Collection

IoT connects things with the Internet through information sensing devices such as Radio Frequency Identification (RFID), infrared sensors, GPS, laser scanners, etc. With China's existing IoT platform and intelligent hardware devices, automatic acquisition of operating data can be realised, thereby enhancing the accuracy and timeliness of data collection in the A-CDM process. By applying IoT technology into electronic blocks at the parking bays, actual in/off-block times can be obtained.



Credit: VariFlight

Figure 23 – Electronic Block

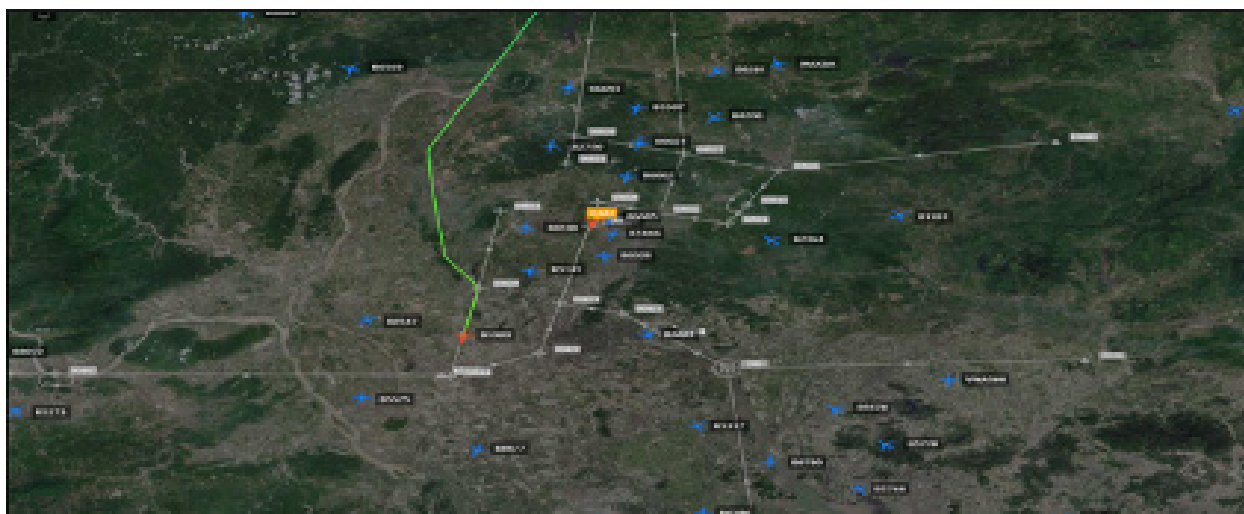
At the same time, based on computer vision and deep learning, video analysis technology enables fully automated and real-time extraction, recording and publication of key milestone data related to in/off block, cabin door close/open and push in/back.



Credit: VariFlight

Figure 24 – Video Analysis Technology for Data Collection

In addition, ADS-B and radar jointly update ELDTs to achieve more accurate ELDT data. Records have shown that 88% of the data achieved less than 1-minute errors. Real-time monitoring of aircraft passing through waypoints helps to monitor, predict and manage air traffic flow.



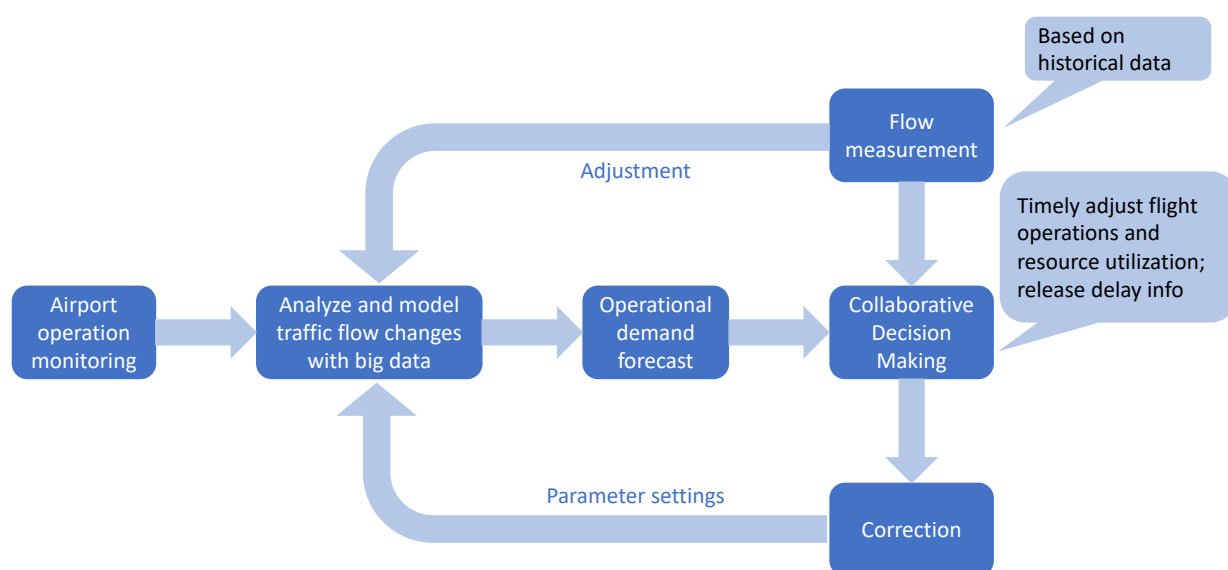
Credit: VariFlight

Figure 25 – ADS-B and Radar Data

8.5.3.2. Data interaction

Operational data sharing is the core element of A-CDM and the basis for implementing the integration of A-CDM and ATFM. Therefore, we need to build an operational data sharing platform for airports, airlines, ATC, ground handlers and CAAC operation monitoring centre to realise data interaction among stakeholders and improve the predictability of ground operations and departure times. [Figure 26](#) shows how the interactions of data can help adjust operational plans for better accuracy, where:

- a. Visualised passenger flow data for real-time monitoring of passenger distribution and flight movements
- b. Big data applied to passenger flow measurement and simulation to analyse airport operational demands
- c. Timely decisions to adjust operational plans and take remedial action against operational bottlenecks



Credit: VariFlight

Figure 26 – Operational Data Sharing for Decision-Making Intelligent decision-making

8.5.3.3. Intelligent Decision-Making

With operational data interaction, the A-CDM system provides a collaborative decision-making platform for stakeholders to identify and adjust TOBT and COBT, reduce conflicts and improve resource utilisation efficiency.

Ground delay programme (GDP): prior to eight hours of STD, the AOC releases restrictions on outbound waypoints (restricted direction, flow and time slots), adopting two algorithmic rules (hourly traffic allocation, total traffic allocation) to calculate flight volumes that need to be adjusted, based on which airlines make decisions of flight cancellation or delay.



Figure 27 – Flight Delay Monitoring

8.5.3.4. Intelligent Guidance

In this stage, ground resources are fully handed over to the airport system for automated management. VariFlight has established a technical team for data maintenance and algorithm update to ensure continuous improvement in the intelligent processing capacity of the system and share data with pilots through ground and air data chains.

8.5.4. Main Points Summary of A-CDM and ATFM Integration

- A-CDM improves TOBT accuracy through the collection of on-ground milestone data, which in turn improves the efficiency of flight operations through the interaction with ATFM data
- Airlines (or airport under the authorisation of airlines) calculate TOBT based on status of pre-flight process and airport handling capacity and submit it to the ATFM system; ATC calculates COBT and releases it through the ATFM system based on the TOBT submitted by the airline, combining other factors such as weather, airspace restrictions and air traffic service capacity
- A-CDM system receives and shares the COBT with stakeholders for the planning of ground resource utilisation and flight handling
- According to the handling progress, airports, airlines and ground handlers can coordinate to modify the TOBT
- If the modified TOBT is within the valid range of the COBT released by the ATFM system, airport, airlines and ground handlers shall strictly enforce the COBT
- If the modified TOBT time is not within the valid range of the COBT released by the ATFM system, ATC shall reassign COBT based on the latest TOBT provided by the A-CDM system and air traffic capacity

8.5.5. Achievements

Since the full implementation of A-CDM, Pudong Airport has reached an on-time departure rate of 80.25% in 2018, with 22.7% improvement from 2017. The integration of A-CDM and ATFM in Pudong Airport highlights:

- **Timeliness** – data analysis and processing in real time ensures smooth air traffic
- **Distributivity** – distributed and parallel processing of big data supports high concurrent multi-user access and collaboration in emergencies
- **High efficiency** – efficient big data excavation ability enhances ATC efficiency and dramatically reduces delays
- **Predictability** – route capacity prediction model shares air traffic data and realise real-time flow monitoring

During COVID-19 outbreak, A-CDM and ATFM integration enhances the capacity to respond to emergencies and saves the ground handling time for about 20%.

- Integrating epidemic data into operation system to focus on flight epidemic control, and arranging special stands, arrival areas, gates and disinfection for flights from epidemic countries and regions.
- Anticipating slot schedule and airport capacity for the next 15 days to cut costs and making full use of limited handling resources, as well as to avoid passengers gathering in terminals.
- Getting the most out of airport parking by improving PBB utilisation to reduce passenger contact and enhancing collaboration with remote stands.

8.5.6. Lesson Learned

8.5.6.1. Establishment of Data Collection Rules

- Building data advantage for the airport by collecting necessary data
- Clarifying data ownership that the system providers shall make all data available to aviation entities to accelerate wider application and more values of data

9. Acronyms

A-CDM	Airport Collaborative Decision Making	CTO	Calculated Time Over
ACID	Aircraft Identification	CTOT	Calculated Take-Off Time
ADEXP	EUROCONTROL Specification for ATS Data Exchange Presentation	DMAN	Departure Manager
ADP	ATFM Daily Plan	DPI	Departure Planning Information
AFTN	Aeronautical Fixed Telecommunication Network	EIBT	Estimated In-Block Time
AIBT	Actual In-Block Time	ELDT	Estimated Landing Time
AIXM	Aeronautical Information Exchange Model	EOBT	Estimated Off-Block Time
ALDT	Actual Landing Time	ETO	Estimated Time Over
AMHS	Automated Message Handling System	ETOT	Estimated Take-Off Time
ANSP	Air Navigation Service Provider	EXIT	Estimated Taxi-in Time
AOBT	Actual Off-Block Time	EXOT	Estimated Taxi-out Time
AODB	Airport Operation Database	FIR	Flight Information Region
APAC	Asia-Pacific	FIXM	Flight Information Exchange Model
ASAT	Actual Start-up Approval Time	FUM	Flight Update Message
ASBU	Aviation System Block Upgrades	GDP	Ground Delay Program
ATC	Air Traffic Control	GUF	Globally-Unique Flight Identifier
ATFCM	Air Traffic Flow and Capacity Management	IWXXM	ICAO Meteorological Information Exchange Model
ATFM	Air Traffic Flow Management	MDI	Minimum Departure Interval
ATFMU	ATFM Unit	MINIT	Minutes in Trail
ATM	Air Traffic Management	MIT	Miles in Trail
ATO	Actual Time Over	NAS	(U.S.) National Airspace System
ATOT	Actual Take-Off Time	NMOC	(EUROCONTROL) Network Manager Operation Center
ATS	Air Traffic Service	PDS	Pre-Departure Sequencer
CDM	Collaborative Decision Making	S-CDM	Surface Collaborative Decision Making (equivalent to A-CDM)
CLDT	Calculated Landing Time	SAM	Slot Allocation Message

SIBT	Scheduled In-Block Time	TMI	Traffic Management Initiative (equivalent to ATFM Measure)
SOA	Service-Oriented Architecture	TOBT	Target Off-Block Time
SOBT	Scheduled Off-Block Time	TSAT	Target Start-up Approval Time
STW	(ATFM) Slot Tolerance Window	TTOT	Target Take-Off Time
SWIM	System-Wide Information Management	VTT	Variable Taxi Time
TBO	Trajectory-Based Operations	XML	Extensible Markup Language
TFDM	(FAA) Terminal Flight Data Manager	XSD	XML Schema Definition
TFMS	(FAA) Traffic Flow Management System		

Flight Event Times						
	Scheduled	Estimated (Flight Plan)	Estimated (ATFM system)	Target (A-CDM)	Calculated (ATFM Measure)	Actual
Off-Block (OBT)	SOBT	EOBT		TOBT		AOBT
Start-Up (SAT)				TSAT		ASAT
Take-Off (TOT)			ETOT	TTOT	CTOT	ATOT
Time Over (TO)			ETO		CTO	ATO
Landing (LDT)			ELDT		CLDT	ALDT
In-Block (IBT)	SIBT		EIBT			AIBT



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