APAC USE CASES AND USER REQUIREMENTS FOR SWIM-BASED MET INFORMATION SERVICES SUPPORTING ATFM

(First Edition, July 2024)

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Section 1

Introduction

Purpose

1.1 The purpose of this reference material is to document ATFM use cases and user requirements in the APAC region to promote the development of SWIM-based MET information services.

1.2 This reference document includes examples of conceptual use cases to illustrate and publicise how SWIM-based MET information services and the associated SWIM-enabled MET applications could benefit ATFM in the APAC Region in the future. These examples would increase the awareness and understanding of both MET service providers and ATFM users in APAC on the operational benefits to ATFM to be brought by the exchange of meteorological information together with aeronautical and flight information in SWIM.

1.3 This document would be a living reference under regular review by the MET/R WG ad-hoc group. The collection of use cases could be further expanded or improved with known events. States that wish to add or update the use cases should submit the proposal in the form of working paper for consideration by MET/R WG, and the ad-hoc group consolidate the adopted changes to seek endorsement by MET SG for updating the document.

1.4 This document does not infer any obligation on States to implement the SWIM-based MET Information Services described.

Background

1.5 The APAC Regional Framework for Collaborative ATFM has been developed and maintained by the Air Traffic Flow Management Steering Group (ATFM/SG) to provide, among other things, the performance improvement plan to address the ATFM implementation and operational issues in the region. The core concept of the Framework is the Distributed Multi-Nodal ATFM Network, i.e. a network of Air Navigation Service Providers (ANSPs) and/or Sub-Regional Groups leading independent ATFM operation within their area of responsibility and connecting to each other through information sharing framework. In the APAC region, the SWIM Task Force (SWIM TF) has been established since 2017 to develop SWIM-related components and supporting materials required for the implementation in the APAC region. The work of SWIM TF also includes the coordination with other Working Groups/Task Forces under APANPIRG to ensure that the operational requirements, particularly the ones specific to the region, are reflected and incorporated accordingly in the regional implementation strategies.

1.6 A SWIM Demonstration project was initiated in 2016 under the cooperation framework between Association of Southeast Asian Nations (ASEAN) and the USA. Since then, Singapore and Thailand had been working with the USA to plan out the Demonstration with the main objective to showcase the operational benefits enabled by SWIM in ASEAN and Asia/Pacific region. The SWIM in ASEAN Demonstration was conducted with great success in November 2019, in Bangkok, Thailand and Singapore, with wide participation of aviation stakeholders in ASEAN and Asia/Pacific region, including Civil Aviation Authorities (CAAs), Air Navigation Service Providers (ANSPs), airport operators, airlines, and international organizations such as ICAO APAC Office, IATA. The outcomes of the SWIM in ASEAN

Demonstration were captured in detail in the Demonstration Report which covered the details of the demonstration development, including (*i*) development of operational scenarios, including ATFM scenarios, (*ii*) SWIM infrastructure, information services, and SWIM-enabled applications design, development, and test, and (*iii*) observations and lessons learnt recorded.

1.7 SWIM TF/3 held in May 2019 agreed that the SWIM implementation to support cross-border ATFM operation should be given high priority. To prepare for the transition of the provision of MET information in a SWIM environment, a regional document for SWIM-based MET information services to support the specific operational mode of cross-border ATFM in APAC Region, as detailed in the aforementioned Framework, is proposed to be formulated at MET/R WG/8.

Section 2

Global Development

2.1 This section provides a brief introduction of globally standardized information exchange models to support the sharing of MET and ATFM information, exchange patterns, and relevant reference documents at global level.

Global and Regional SWIM Developments related to MET and ATM

2.2 According to the Sixth Edition of the ICAO Global Air Navigation Plan (Doc 9750 GANP) Aviation System Block Upgrades (ASBU) SWIM-B2 (2025-2030) [1], the communication based on System-Wide Information Management (SWIM) concept (refer to ICAO Doc. 10039 Manual on System Wide Information Management (SWIM) Concept) will improve the current human-to-human communication with machine-to-machine interconnection, enhancing efficiency in data distribution and accessibility through global interoperability among aviation stakeholders. In particular, dissemination of MET information using MET information services in SWIM is included as part of the Advanced Meteorological Information (AMET) thread in ASBU.

SWIM-based MET Information Services as described in MET-SWIM Plan

2.3 According to the MET-SWIM Plan, being developed by the ICAO Meteorology Panel Working Group on Meteorological Information Exchange (WG-MIE), the exchange of MET information between information producers and information consumers in the SWIM environment can be achieved using two main messaging mechanisms, namely request/reply and publish/subscribe information exchange patterns (Figure 1).

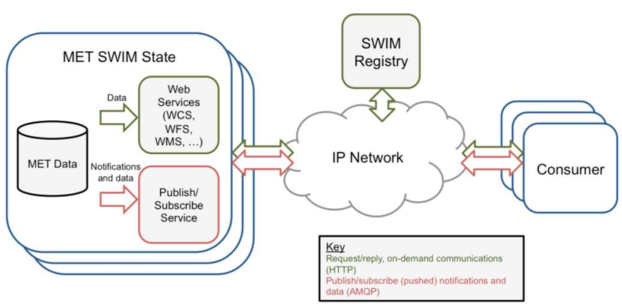

Figure 1: Possible mechanisms of SWIM-based MET Information Exchange Services.

2.4 MET information to be exchanged in SWIM includes ICAO Meteorological Information Exchange Model (IWXXM) messages, gridded products and imageries. IWXXM is the model for exchange of MET information including volcanic ash advisory information, tropical cyclone advisory information, space weather advisory information, METAR and SPECI, TAF, SIGMET and AIRMET. The METP WG-MIE has proposed actions with regards to harmonization of IWXXM with other Exchange Models (XMs) and with the ATM Information Reference Model (AIRM) to support interoperability in SWIM.

[1] Note that the current version of ASBU can be referred to https://www4.icao.int/ganpportal/ASBU

Section 3

Use Cases and User Requirements for SWIM-based MET Information Services to Support ATFM Operation in APAC

3.1 Overview

(i) This section provides examples of user requirements and use cases for SWIM-based MET information services to support ATFM operation in APAC. Use case refers to a specific operational scenario in which MET information or service could potentially be used in a real-world environment, including the details of activities conducted by each actor involving in the operation identified.

(ii) Some examples of use cases involve integration of MET and ATFM information in SWIM environment and its potential benefits in supporting cross-border ATFM in APAC. With the MET and ATFM data to be made available via SWIM-based Information Exchange Services, relevant MET data and ATFM data could be integrated to provide new fit-for-purpose information to better support ATFM in the region.

(iii) The following paragraphs provide seven examples of use cases:

- USE CASE 1: Reduced airport arrival capacity due to tropical cyclone, and the need for ground delay ATFM measure
- USE CASE 2: Airborne rerouting due to turbulence
- USE CASE 3: Volcanic ash avoidance based on digital Volcanic Ash Advisory and Volcanic Ash SIGMET
- USE CASE 4: Flight diversion due to fog
- USE CASE 5: Use of Quantitative Volcanic Ash Concentration Information in Trajectory-based Operation
- USE CASE 6: Weather impact assessment based on actual air traffic volume over Standard Terminal Arrival Routes (STARs)
- USE CASE 7: (potential future use case) Aircraft spacing management based on MET information and real-time surveillance information shared in SWIM

USE CASE 1: Reduced airport arrival capacity due to tropical cyclone, and the need for ground delay ATFM measure

3.1.1 In this use case, MET information in IWXXM is ingested in the decision supporting tool together with aerodrome information in Aeronautical Information Exchange Model (AIXM) to assess the crosswind at destination aerodrome within a specific time period. This can be used to evaluate the impact on airport capacity and the need for applying traffic regulating ATFM measure at the affected aerodrome. (Figure 2).

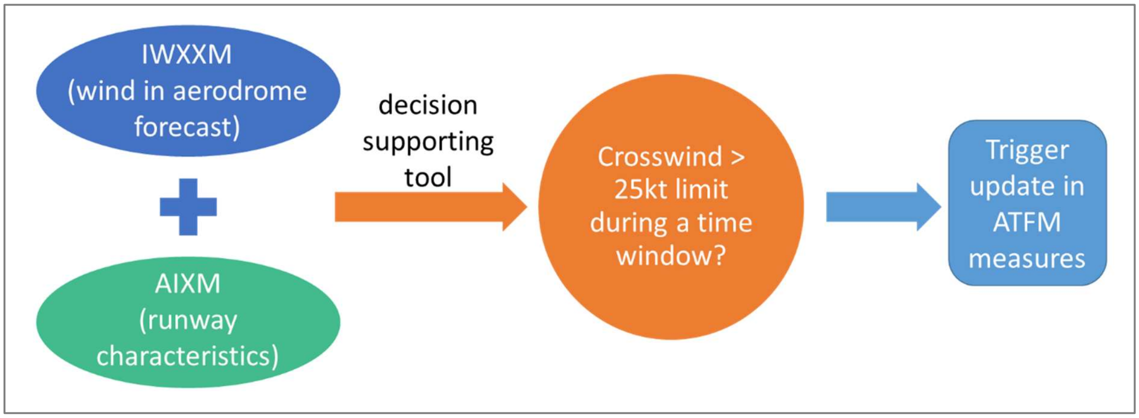

Figure 2: Integration of IWXXM and AIXM data.

3.1.2 Figure 3 shows an example of SWIM-enabled MET-ATM Display. It provides a regional overview to allow Air Traffic Flow Management Units (ATFMUs) and airlines to monitor the change in weather impact over the region. It makes use of request/reply information exchange mechanism in SWIM and display how weather change based on users' requested time and flight level.

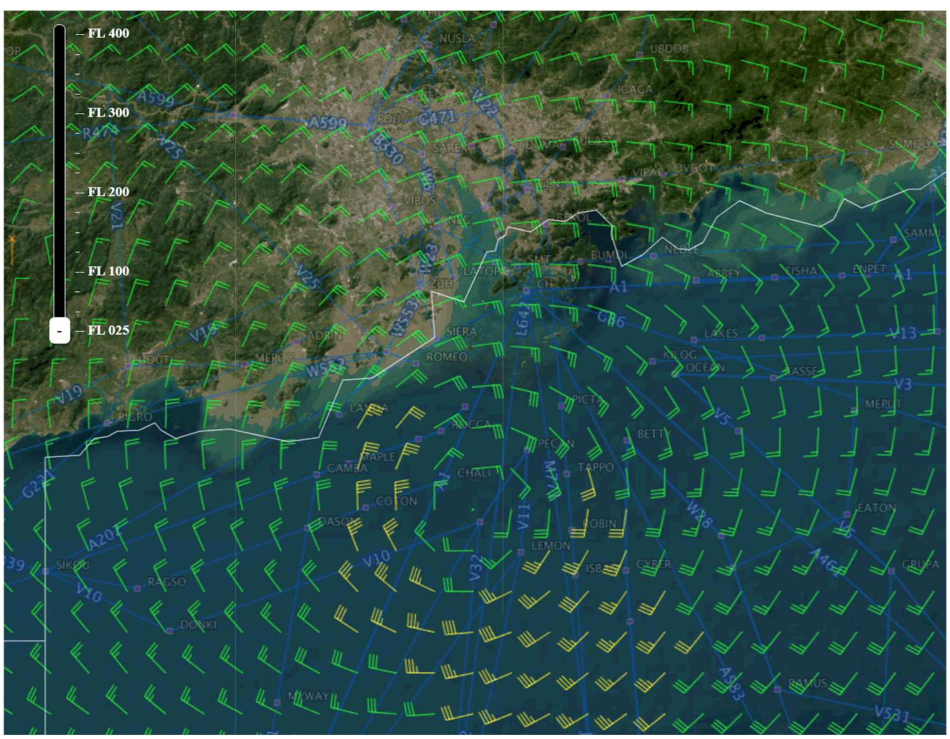

Figure 3: SWIM-enabled MET-ATM display with overlaying visualisation of gridded forecast wind data exchanged via request/reply web services.

3.1.3 In the SWIM-enabled MET-ATM display, the constrained aerodromes could be highlighted if the weather conditions exceed user-specified operational landing thresholds (such as visibility, cloud base, wind gust, crosswind) (Figure 4). This facilitates ATFMUs and airlines to also monitor the landing condition also at alternate aerodromes.

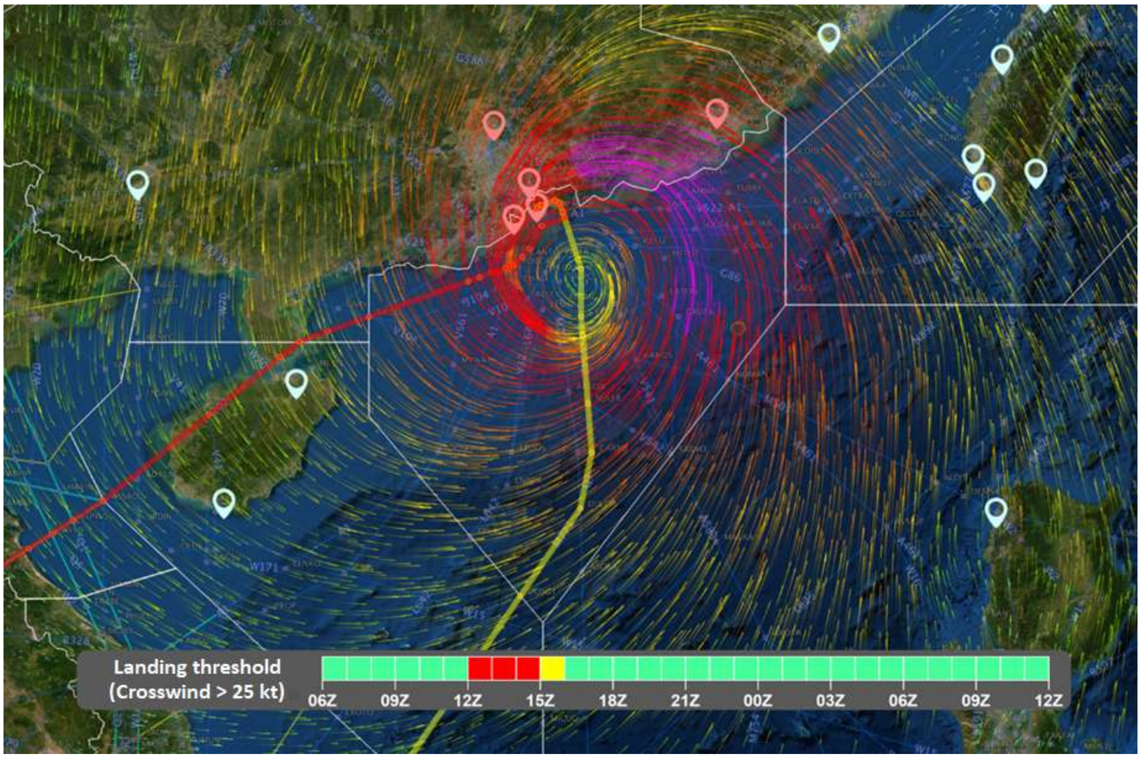

Figure 4: SWIM-enabled MET-ATM display highlighting aerodromes with landing thresholds exceeded due to tropical cyclone. Timeline showing alerts of exceeding user-defined landing threshold at selected aerodrome.

3.1.4 With the TAF messages exchanged in IWXXM, one of the benefits is that the automatic decision supporting tool could be developed to create awareness of the impact on the landing thresholds of aerodromes affected by weather, based on specific weather elements extracted from IWXXM. Figure 4 shows the timeline alerting the time window with expected crosswinds greater than 25 kts. This information would be used to estimate when the airport arrival rate would be reduced due to the TAF.

USE CASE 2: Airborne rerouting due to turbulence

3.2.1 MET information in IWXXM is integrated with flight information in Flight Information Exchange Model (FIXM) in the decision supporting tool to assess the number of flights crossing areas of significant weather phenomena mentioned in SIGMET reports (such as SEV TURB) within a requested time period (Figure 5).

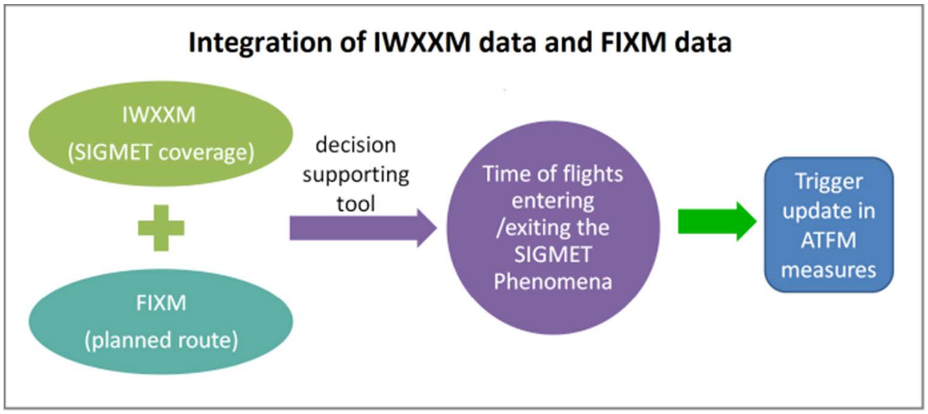

Figure 5: Integration of IWXXM and FIXM Data

3.2.2 ATFMUs or airlines with flight information could subscribe to the SIGMET service via SWIM to access the weather impacts and the need to update the planned routes in FIXM to avoid the affected areas. Meanwhile, MET service provider could also subscribe to the flight information exchange service of relevant ANSP to receive the flight plan published in FIXM and show this information on SWIM-enabled MET-ATM Display for situational awareness.

3.2.3 Figure 6 shows the turbulence reports received from the previous flights crossing the same area. Air Traffic Control (ATC) will relay the pilot report (PIREP) to aviation forecasters at MET office. After aviation forecasters analyze these actual turbulence reports together with the model forecast, forecasters predicted severe turbulence is likely to persist for two more hours over the same region and issued the severe turbulence SIGMET.

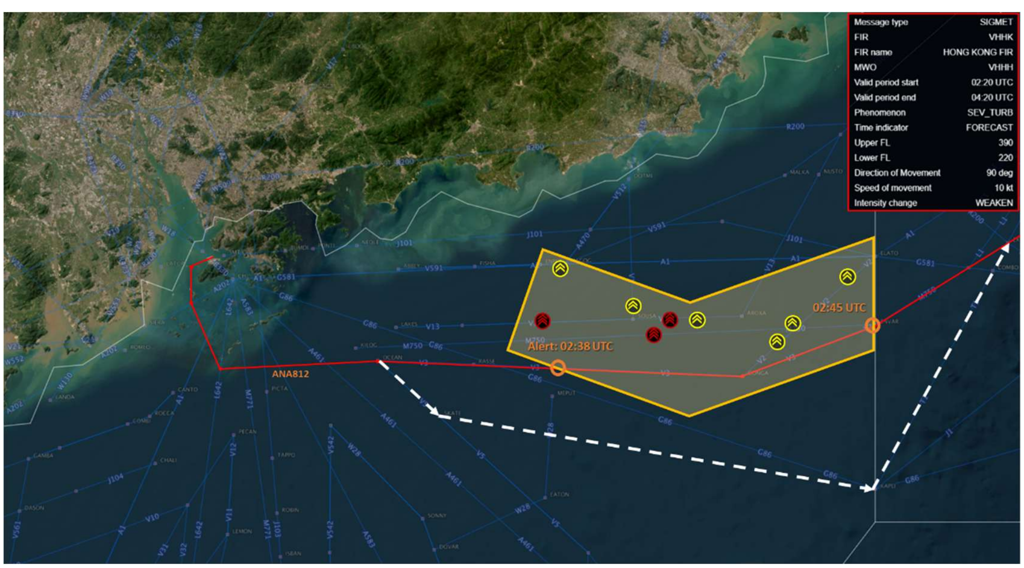

Figure 6: SWIM-enabled MET-ATM Display showing alerts of the estimated timing for a specific flight entering a SIGMET area and the timing for the flight to depart the SIGMET area

3.2.4 With the flight plan and SIGMET exchanged in SWIM-based formats, one of the benefits is that flight and MET information could be integrated together in the automatic decision-supporting tool. The tool could provide flight-specific alerts of the estimated timing for the flight entering the turbulence area and the timing for the flight to depart the turbulence area. Such SWIM-enabled MET application could be used for situational awareness and allow the users to respond faster and better support the timely tactical decision making by the ATC and airlines.

USE CASE 3: Volcanic ash avoidance based on digital Volcanic Ash Advisory and Volcanic Ash SIGMET

3.3.1 This scenario explores gate-to-gate flight operations and where SWIM enabled ANSPs, airlines and MET Service Providers can enhance ATM System performance through timely sharing of interruptions and trajectory and flow updates. This provides downstream Area Control Centres (ACCs) and other ATM Stakeholders with SWIM capabilities, advance situational awareness of an incoming flight, which can then be used to support common situational awareness across stakeholders, create more accurate demand predictions and improve operational planning and predictability. For this scenario, a flight is planned from Bangkok (VTBS) to Sydney (YSSY).

3.3.2 One hour into the flight, a Volcano Observatory Notice for Aviation (VONA) is issued by the Observatories advising of an eruption of Mt Agung on Bali with ash cloud detected to FL400 moving swiftly and primarily to the west-north-west. A Volcanic Ash Advisory (VAA) was issued by Darwin Volcanic Ash Advisory Centre (VAAC) based on VONA, and subsequently a Volcanic Ash SIGMET was issued in IWXXM by the MET service provider based on the VAA. The IWXXM SIGMET is received by Brisbane and Melbourne Air Traffic Service Centres (BN ATSC and ML ATSC, respectively) and the airline.

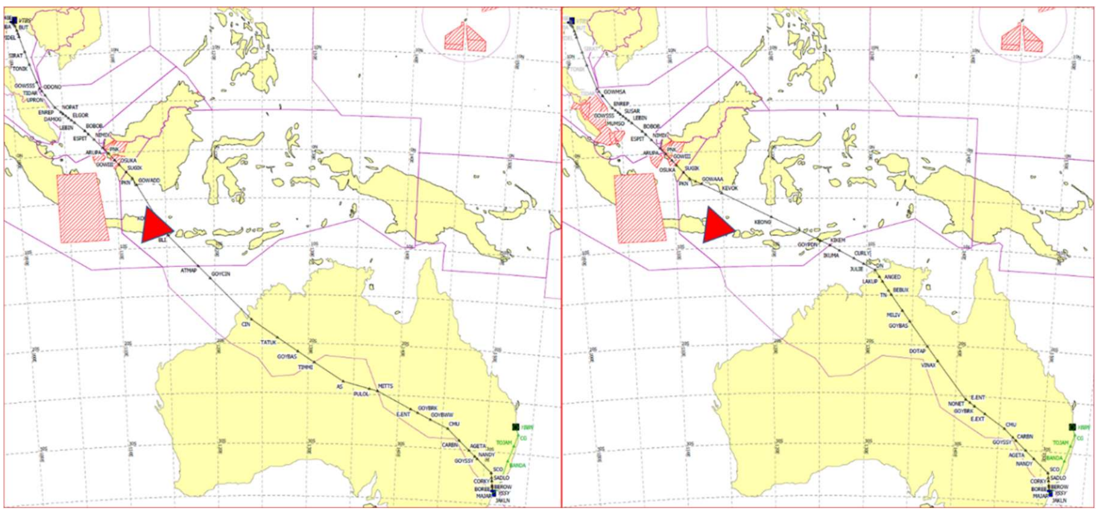

Figure 7: Route diversion for volcanic ash avoidance

3.3.3 The airline decide that the flight should track via a diversion route east of the ash cloud and that the diversion will preferably commence from a waypoint in WSSS airspace and follow a new track east of Bali to avoid the cloud. This will now take the flight directly into Brisbane FIR (YBBB FIR) and not entering into Melbourne FIR (YMMM FIR).

3.3.4 The airline submits a proposed CHG to FPL in FIXM format via SWIM to all affected ANSPs. The pilot requests the amended tracking and is cleared by VTBB ATC. The flight re-cleared via new flight plan track. The Flight Management Computer (FMC) gets updated to send the airline's operation centre a new set of trajectory estimates, which are shared with BN ATSC in FIXM format via SWIM.

3.3.5 Because of the SWIM connectivity, the flight became aware of the volcanic event two FIRs prior to the disrupted airspace. The airline was able to identify an alternate route within the flight's fuel capability that would still enable it to reach its original destination. Furthermore, this provided additional benefit to all SWIM-enabled stakeholders, as a new clearance time was issued much in advance assisting in making early and informed decisions.

USE CASE 4: Flight diversion due to fog

3.4.1 For the same flight planned from VTBS to YSSY mentioned in Use Case 3 above, when the flight is approaching Lombok on the ash avoidance route, an Amended TAF for YSSY is published via SWIM, forecasting heavy fog starting prior to the flight's ETA and to last late into the morning with associated significant delays. The airline considers the new expected holding requirement coupled with the additional fuel used for the ash avoidance and decides at that time to divert the flight to YBBN (Brisbane).

3.4.2 The airline sends a FF-ICE Revision Request in FIXM format via SWIM to Australia, proposing a trajectory change after TN to land at YBBN, including updated trajectory estimates for the new route. Due to other aircraft also diverting to YBBN, the updated trajectory is agreed, however a proposed long-range ATFM time constraint of 10 minutes is proposed for the YBBN arrival fix due to other aircraft also considering the same diversion. The airline considers this delay is acceptable and advises the flight crew they can expect the updated clearance with Brisbane ATC. On initial contact with Brisbane ATC, the flight crew is provided with the amended clearance in accordance with the new agreed trajectory and the associated long-range ATFM time constraint is issued to the pilot to allow the aircraft to absorb the delay prior to the arrival phase.

3.4.3 The pilot loads and executes the clearance as issued by Brisbane ATC including the advised ATFM time constraint.

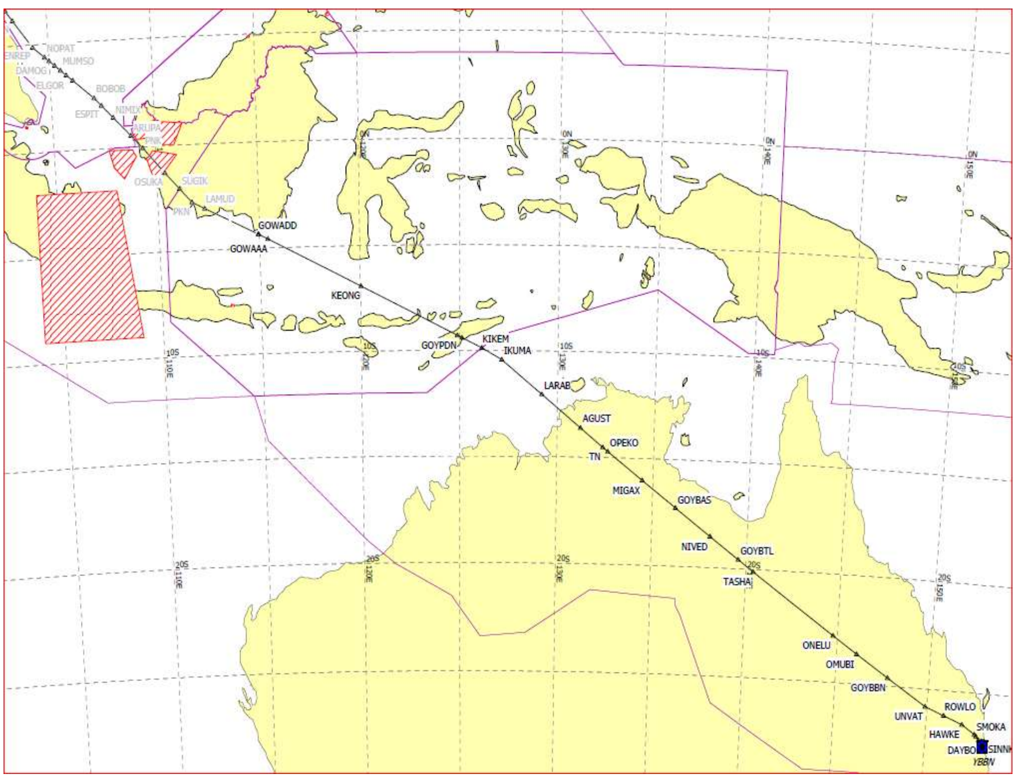

Figure 8: Early flight diversion from YSSY to Brisbane due to fog

3.4.4 BN ATSC analyses the new route of this flight due to the forecast fog in YSSY and modifies their long-range ATFM program for the morning to allocate a slot at Brisbane for this flight. The flight is allocated a gate time Calculated Time Over (CTO) for an arrival fix that requires 10 minutes delay from current estimate and this CTO is shared with the airline. The airline's operation centre communicates with the flight proposing that they make a request to ATC for commencing a fuel-efficient speed reduction from their present position to absorb the delay as much as possible. Finally, BN ATSC applies a short set of vectors on descent for sequencing but no holding is incurred.

3.4.5 Overall, early notice of the amended TAF published via SWIM and associated delays permitted the airline to identify the need for a diversion to alternate destination and to share and receive that amended clearance prior to entering Australian airspace so that any small track efficiencies could be realised (no fuel wasted continuing towards MEL and then diverting later).

USE CASE 5: Use of Quantitative Volcanic Ash Concentration Information in Trajectory-based Operation

3.5.1 Quantitative volcanic ash (QVA) concentration information is proposed for inclusion in the 82nd amendment to ICAO Annex 3. The information will be issued in gridded-data and IWXXM format to provide level of concentration and probabilities exceeding certain concentration thresholds.

3.5.2 Use of this information was included in a scenario developed by multilateral States to demonstrate trajectory-based operations. In the scenario, a flight departs from Narita International Airport (RJAA) for Changi International Airport (WSSS), under trajectory-based operations interacted by ANSPs and an aircraft operator.

3.5.3 The aircraft cruising southwest Japan is informed that Mt. Suwanosejima's eruption. The volcano is located in the area where the flight plans passing over around one hour later. A PIREP issued by an aircraft near the volcano reports existence of ash plume. The ash cloud may cause a risk to the planned flight.

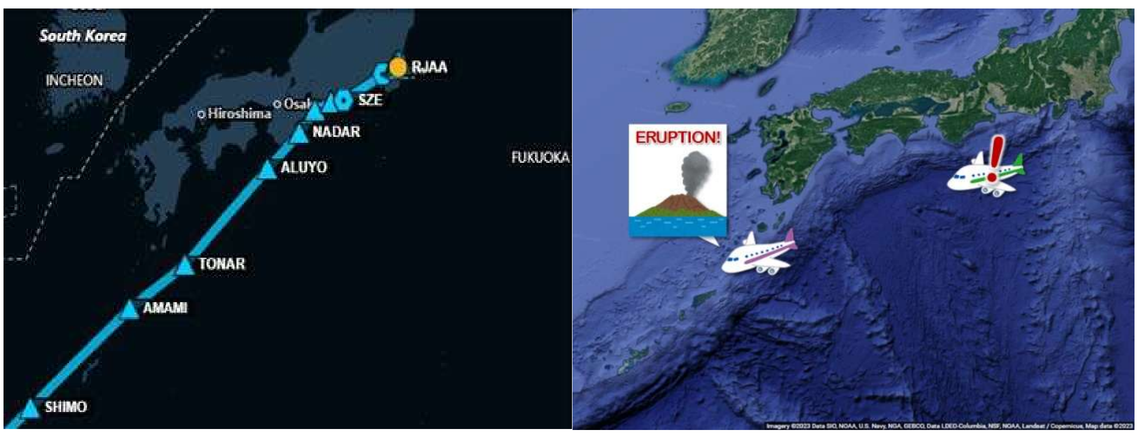

Figure 9: Planned flight path and the illustration of PIREP issuance

3.5.4 The VAAC Tokyo then issues QVA concentration information. The information promptly becomes available on the crew's Electric Flight Bag (EFB). The crew starts interacting with their flight dispatcher via the EFB. Based on this chat message exchange, they conclude that only a low-concentration area would affect the planned flight path, so engine exposure to volcanic ash would be below the acceptable limit and therefore, detour wouldn't be required.

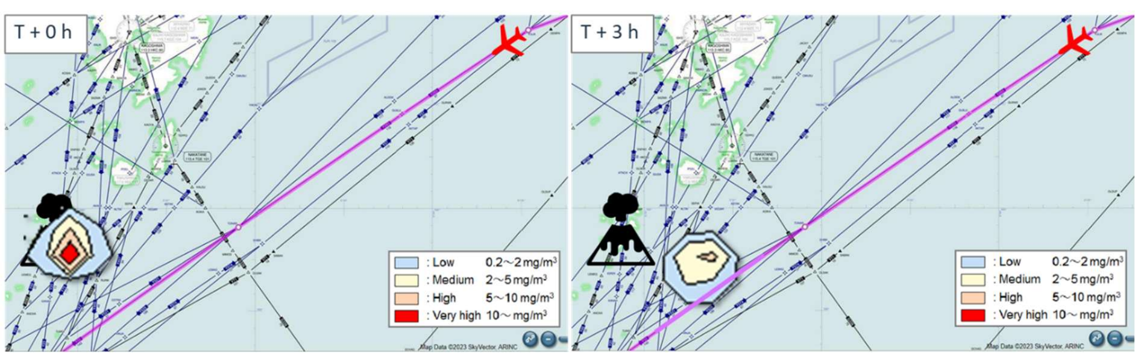

Figure 10: QVA concentration information for the Suwanosejima eruption

3.5.5 Figure 11 illustrates that how much options advanced MET information such as QVA concentration information with 4-D quantitative/probabilistic forecast can provide. It would lead to more efficient aircraft operations as well as time savings, reduced fuel consumption and lower greenhouse gas emissions.

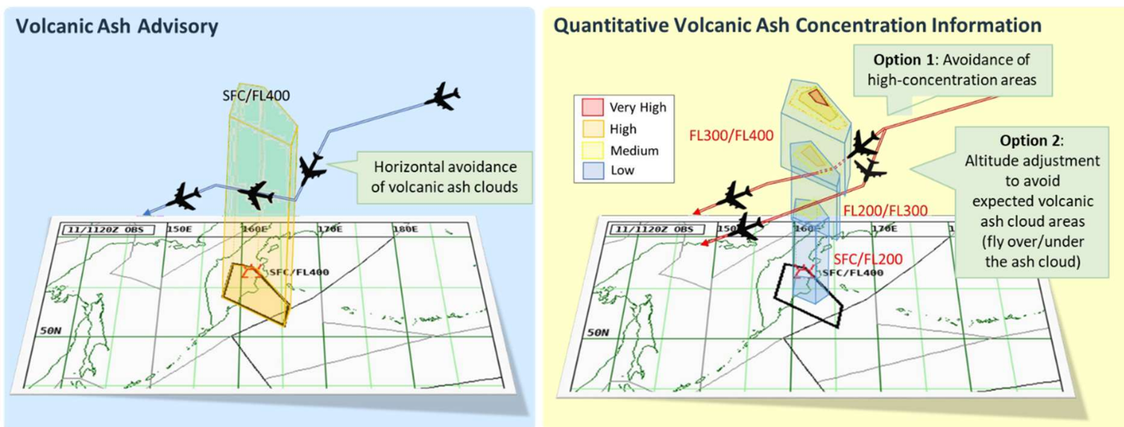

Figure 11: How 4-D quantitative / probabilistic forecast could support trajectory-based operations

3.5.6 The MET information service of the above QVA concentration information is expected to also benefit pre-flight planning scenario via the following operational workflow:

1) During the flight planning stage, volcanic ash advisory indicates that there is discernable ash with coverage intersecting with the direct route. An indirect route with horizontal avoidance of volcanic ash clouds needs to be considered.
2) After some while, subscribed users are notified that QVA concentration information becomes available.
3) Flight dispatch office of the airline obtains the QVA concentration information (grids and/or polygons) which shows its low concentration areas, so the office clears the flight to fly the more direct and fuel efficient route.

3.5.7 SWIM is one of the key enablers of the trajectory-based operation. To make the best use of such 4-D quantitative/probabilistic meteorological information, all related information including aeronautical and trajectory information should be digitalized, updated as necessary and shared among the stakeholders in real-time basis in SWIM environment. Digitalized trajectory and QVA concentration information shared via SWIM would allow the stakeholders to assess how much exposure would be expected for a specific flight.

3.5.8 Establishing convenience communication mechanism among the stakeholders is also essential. Operational systems/procedures/rules to allow such information sharing (including communication) and flexible in-flight trajectory changes are also important.

USE CASE 6: Weather impact assessment based on actual air traffic volume over Standard Terminal Arrival Routes (STARs)

3.6.1 MET service providers routinely share weather forecast and warnings with ANSPs that predicts timing of weather phenomena affecting airspace, including terminal control area where there is a relatively high volume of air traffic.

3.6.2 If a local ANSP could share surveillance data and/or FIXM data with a local MET service provider via SWIM, more advanced MET information service would become possible. In this case MET service providers could provide services for the targeted busy routes or airspace only. For example, the more advanced MET information service could provide ANSPs with the estimated time of approach of severe thunderstorms to specific Standard Terminal Arrival Routes (STARs) or the associated critical airspace (Figure 12).

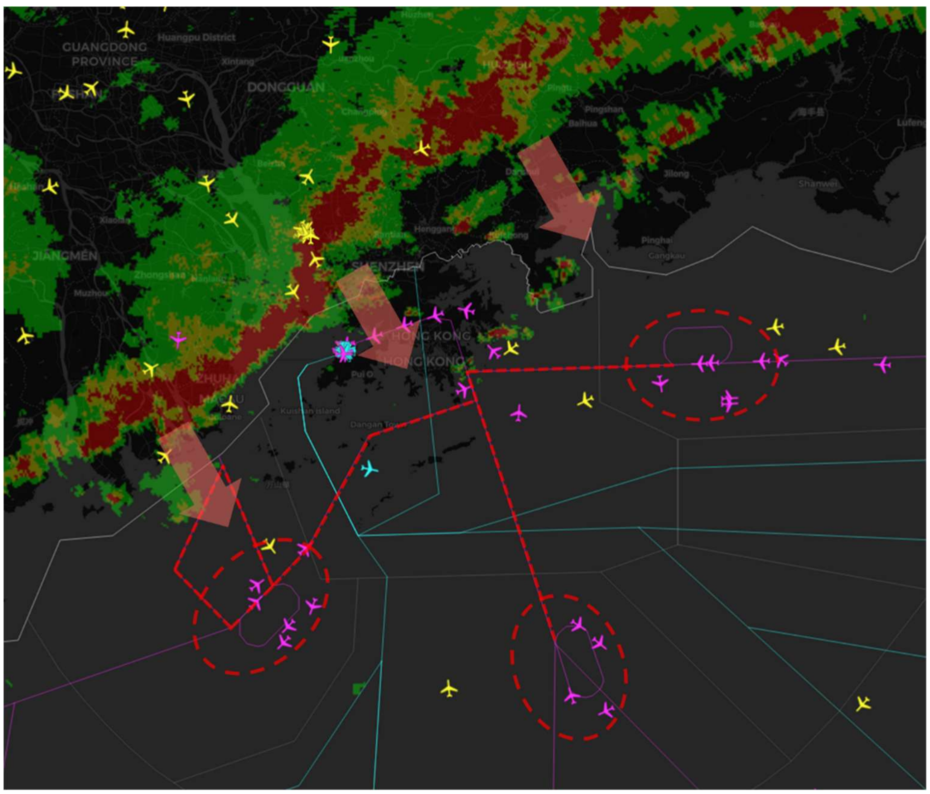

Figure 12: Illustration of severe thunderstorms approaching and posing potential impact on Standard Terminal Arrival Routes (dotted lines) and associated critical airspace (dotted ellipses) with high air traffic volume

3.6.3 When real-time surveillance data are shared in SWIM and integrated into the MET information services, new products such as weather impact related risk matrix for air traffic could be developed (Figure 13) for determining the level of impact on aviation traffic based on the air traffic volume over the STARs or the associated critical airspace. For example, if the timing of severe thunderstorm matches with the timing with higher air traffic volume over STARs, the operational risk level on arrival would be higher, and vice versa. Such enhanced MET application would better support ATFM in the monitoring and assessment of the weather impact on the actual air traffic for ensuring the aviation safety and operational efficiency.

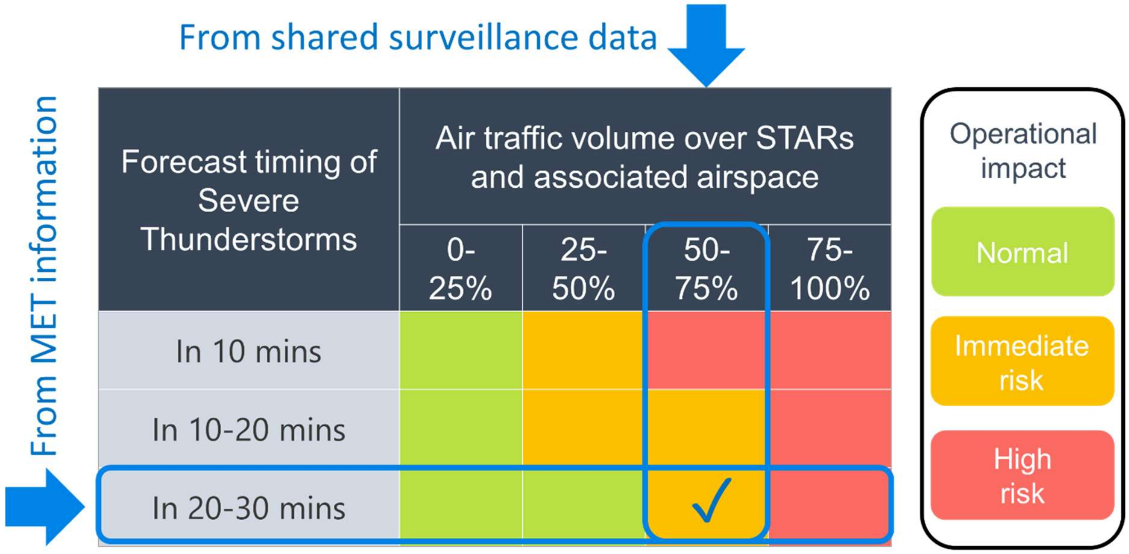

Figure 13: Risk matrix for accessing the operational risk level on a Standard Terminal Arrival Route and the associated critical airspace if surveillance data could be integrated with MET information in SWIM

<u>USE CASE 7 (*potential future use case*): Aircraft spacing management based on MET information and real-time surveillance information shared in SWIM</u>

3.7.1 To avoid aircraft being disrupted by wake turbulence created by preceding aircraft, flights are traditionally separated by certain distances depending on the pair of aircraft types and the wake vortex size created by the preceding aircraft. The stronger the headwind, the slower the ground speed will be and so it would take longer to travel the same distance. With distance-based separation, strong headwinds on approach could significantly reduce arrival rates and cause arrival delays.

3.7.2 Wake vortices generally dissipate faster in strong headwind conditions, so aircrafts could be separated by a shorter time. Also, the effect of wind on the arrival rate could be counteracted if the distance-based separation is replaced by time-based separation.

3.7.3 The benefits of time-based separation could be realised if live Mode-S Downlinked Aircraft Parameters (DAPs) or wind data from an aircraft could be downlinked, incorporated in the surveillance data and shared with MET system through SWIM. This would allow the SWIM-enabled MET system to dynamically generate the best estimation of actual wind profile along the approach path (Figure 14). The wind profile in high spatial and temporal resolution along the approach path could then be provided through the SWIM-based MET information service to ATC tool for determining the optimal safe time-spacing between arriving aircraft, allowing separation distances to be dynamically adjusted.

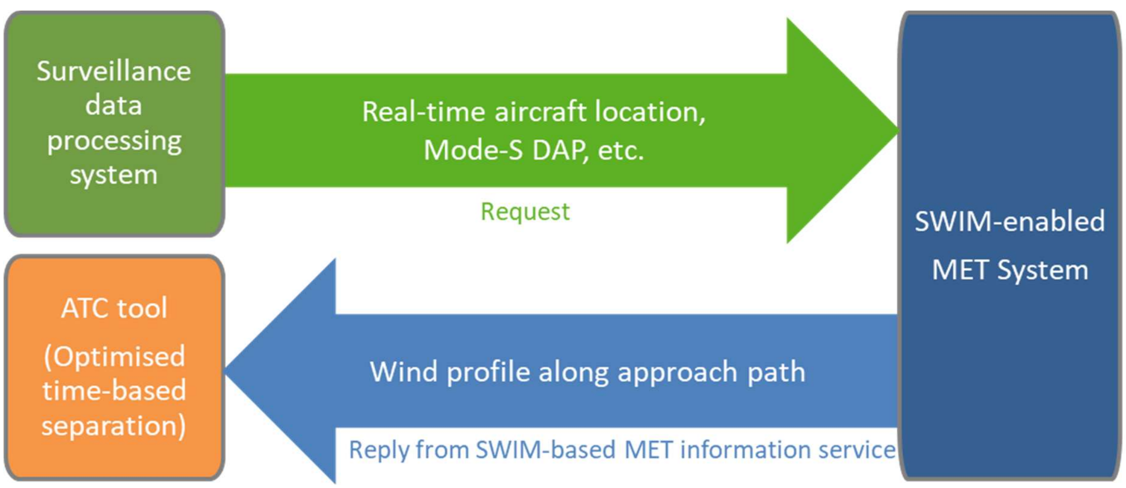

Figure 14: Conceptual data flow diagram showing the provision of SWIM-based MET information services for wake turbulence separation via request/reply

3.7.4 Such wind-dependent optimisation of separation would provide the opportunity to enhance traffic capacity. It could maximise the arrival rate and reduce the chance to activate ATFM measures due to strong headwinds on approach (Figure 15).

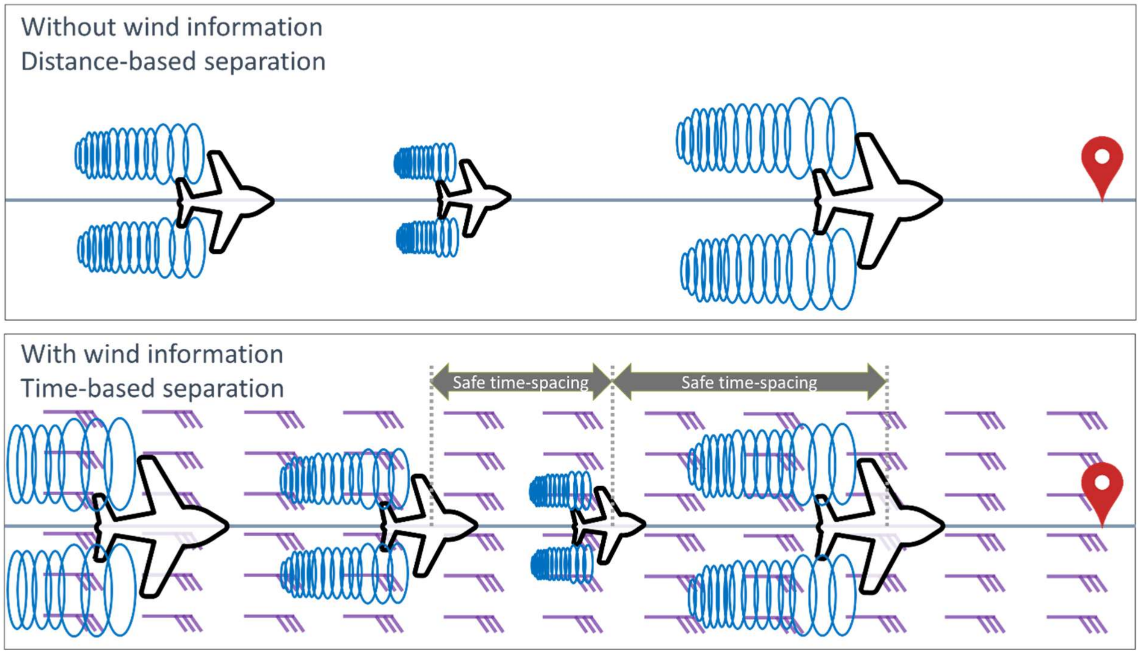

Figure 15: Illustration of the benefits of optimised time-based separation if the provision of high-resolution wind profile along the approach path is made available through SWIM information service

Section 4

MET Data Catalogue and ATFM Data Catalogue for SWIM-based Operation

4.1 The SWIM-based MET Information Exchange Services have the capability to geospatially and/or temporally filter a data set to provide the users' system with only the tailored information required to fulfill the specific users' needs.

4.2 The table below provides MET and ATFM data which could be exchanged using SWIM-based Information Exchange Services. Such data elements identified in the data catalogue could assist the SWIM TF in developing the relevant service catalogue for the APAC region.

MET data catalogue (draft)	ATFM data catalogue (draft)
Aerodrome ● Cloud amount and type ● Lightning/thunderstorm ● QNH ● RVR ● Surface wind and wind gusts ● Temperature and dew point ● Turbulence ● Visibility ● Windshear **Enroute** ● Wind ● Temperature ● Tropopause height ● Volcanic ash ● Tropical cyclone ● Space weather ● Thunderstorm ● Turbulence (including clear air turbulence and in-cloud turbulence) ● Icing ● Mountain waves ● Dust / sand storms ● Radioactive clouds	● Global Unified Flight Identifier (GUFI) ● Departure aerodrome ● Destination aerodrome ● Flight identification ● Planned route/trajectory ● Estimated Off-Block Time (EOBT) ● Estimated Take-Off Time (ETOT) ● Estimated Landing Time (ELDT) ● Estimated Elapsed Time (EET) ● Calculated Take-Off Time (CTOT) ● Calculated Landing Time (CLDT) ● Target Off-Block Time (TOBT) ● Target Start Up Approval Time (TSAT) ● Target Take-Off Time (TTOT) ● Actual Off-Block Time (AOBT) ● Estimated Time Over (ETO) ● Calculated Time Over (CTO) ● Actual Time Over (ATO)

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