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ASIA AND PACIFIC (APAC) FIFTEENTH MEETING OF THE METEOROLOGICAL REQUIREMENTS WORKING GROUP (MET/R WG/15)

Bangkok, Thailand, 7 to 10 April 2026

Agenda Item 3: Collaboration between MET and ATM stakeholders

UPDATES OF ASIA/PACIFIC REGIONAL GUIDANCE FOR TAILORED METEOROLOGICAL INFORMATION AND SERVICES TO SUPPORT AIR TRAFFIC MANAGEMENT OPERATIONS

(Presented by MET/R WG Ad Hoc Group – Australia, China, Hong Kong, China, Japan (rapporteur), Republic of Korea, Singapore, Thailand, Vietnam and IATA)

SUMMARY

This paper proposes updates on the *Asia/Pacific Regional Guidance for Tailored Meteorological Information and Services to Support Air Traffic Management Operations* to enhance the contents related to verification and evaluation of impact-based MET information to support air traffic management (ATM) decision making.

1. INTRODUCTION

1.1 The *Asia/Pacific regional guidance for tailored meteorological information and services to support Air Traffic Management operations* is aimed at fostering States' implementation and enhancement of meteorological (MET) information and services for air traffic management (ATM) in the Region. It captures necessary processes from preparatory to operational phases. The stepwise (process-wise) structure of the guidance is expected to allow each State to refer to suitable chapters, sections or subsections depending on its status of implementation of MET information and services to support ATM, including commencement, implementation or improvement. Furthermore, it provides details of operational service practices with some examples and operational scenarios in its Appendices

1.2 This regional guidance is maintained by the Ad-hoc group of the MET/R WG consisting of Australia, China, Hong Kong, China, Japan (rapporteur), Republic of Korea, Singapore, Thailand, Vietnam and IATA, and available on the ICAO APAC eDocuments website (https://www.icao.int/APAC/Pages/eDocs.aspx). The latest update was made in 2023, to expand the Guidance to define a framework to capture post operational analysis on the effect of tailored MET information for ATM decision making, in response to the outcomes of the discussion at the MET/ATM Webinar held in July 2021 **[Decision MET SG/27-05]**.

1.3 States are encouraged to provide their activities on MET services in support of ATM and also share their examples and operational scenarios to enrich the cases within the Appendices. The

maintenance procedures and means of publication of the guidance are provided in "Note for Appendix 1 and 2" in the main part of the Guidance.

2. DISCUSSION

2.1 Based on the analysis for updating the Guidance, the ad hoc group found it was necessary to collect experiences of how the States conduct objective verification and to share the relevant experiences in Appendix 1 of the Guidance (MET/R WG/12 WP/11). Considering the outcome, the meeting invited WG members to share the State's practices and challenges of verification and evaluation of impact-based MET information to support ATM operation to be included in the Guidance **[Decision MET/R WG/12-01, c)]**.

2.2 The ad-hoc group was tasked to analyse provided information and other information in the WG meetings/Seminars and consider appropriate actions, such as including it in the Guidance. **[MET/R WG/14 work plan, Deliverable 3, 3.2]**.

2.3 At the MET/R WG/13, China mentioned their practices of verification besides their proposal of inclusion about the State's example of MET services to support ATM, to the Appendix A to the Guidance (Ref. MET/R WG/13 IP/02). Japan and Singapore provided their relevant experience including challenges in identification of true value of the impact-based MET information (Ref. MET/R WG/13 IP/05 and IP/13).

2.4 At the MET/R WG/14, Hong Kong China shared their development of probabilistic forecast information to support ATM decision making on the runway configurations with the results of verification of the forecast (Ref. MET/R WG/14 IP/07).

2.5 The ad-hoc group analysed the above documents in 2.3 and 2.4 and found out useful information to be shared in the Guidance document to assist States perform objective verification of impact-based MET information to support ATM decision making. The results of the analysis were summarised in the paragraphs under the section 3.7.3 of the draft Guidance, where "verification of impact-based MET information to support ATM operation" is elaborated. The section consists of the following topics.

- Verification methods
- Identification of true value

2.6 The draft of the Guidance (excluding its Appendices) including the above updates with some editorial changes is attached as **Attachment A** to this paper.

2.7 The ad hoc group also discussed inclusion of examples of thresholds utilized for deciding category of impact-based MET information or decision making on operational capacity management to a new Appendix of the Guidance. Such practices were presented at MET/ATM Seminar 2025 (Ref. SP/04 and SP/07), and it could help States to plan enhancing utilization of MET information to support ATM decision making. Appropriate action by the WG on this matter could be further discussed in the MET/R WG/15.

2.8 In addition, outcomes of the MET/R WG/15 and the joint plenary session with ATFM & A-CDM SG could also be considered for further update to the Guidance. Similar activity can be continued in future WG meetings.

2.9 In view of the discussion above, the meeting is invited to consider formulating following Decision regarding the update of the regional Guidance for possible adoption at MET SG/30;

Decision MET/R WG/15/x: ***Update on Regional Guidance for Tailored Meteorological Information and Services to Support ATM Operations***

a) The MET/R WG members review the draft Guidance attached to MET/R WG/15 WP/xx and provide comments to the ICAO RO MET no later than 1 June 2026;

b) The ad-hoc group, consisting of Australia, China, Hong Kong, China, Japan (rapporteur), Republic of Korea, Singapore, Thailand, Vietnam and IATA consider the outcomes of a) with the results of discussion during MET/R WG/15 and joint plenary session, and finalizes the draft Guidance for approval at the MET SG/30.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper;

b) consider formulating the Decision in 2.9;

c) consider inclusion of continuous update of the Guidance based on the outcomes of future MET/R WG meetings, as necessary; and

d) discuss 2.7 and any other relevant matters as appropriate.

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ATTCHMENT A

Draft main body of the Regional Guidance for Tailored Meteorological Information and Services to Support Air Traffic Management Operations

Text to be deleted is shown with ~~a line through it~~, and new text to be inserted is highlighted with grey shading.

Attachment A

INTERNATIONAL CIVIL AVIATION ORGANIZATION

ASIA/PACIFIC REGIONAL GUIDANCE FOR TAILORED METEOROLOGICAL INFORMATION AND SERVICES TO SUPPORT AIR TRAFFIC MANAGEMENT OPERATIONS

~~Fourth~~ Fifth Edition, XXX 20xx

[Adopted by MET SG/xx, Decision MET SG/xx/xx: *Update to Regional Guidance for Tailored Meteorological Information and Services to Support ATM Operations*]

RECORD OF AMENDMENTS AND CORRIGENDA

Amendments			
No.	Date of issue	Date entered	Entered by

Corrigenda			
No.	Date of issue	Date entered	Entered by

TABLE OF CONTENTS

1. INTRODUCTION

1.1. Purpose and overview of the guidance

1.1.1. This guidance aims to foster States' implementation and enhancement of meteorological (MET) information and services for air traffic management (ATM)[1] within Asia/Pacific (APAC) region.

1.1.2. The guidance captures most of the necessary processes from preparatory to operational phases. Furthermore, it provides detailed operational services, with specific examples and an operational scenario on ATM-tailored MET information and services. Information in this guidance can also be used to facilitate further improvement by the States who have already implemented ATM-tailored MET services.

1.1.3. A stepwise (process-wise) structure of the guidance is expected to allow each State to refer to chapters, sections or subsections useful for the commencement, implementation or improvement of its MET information and services to support effective ATM.

1.1.4. This Guidance is intended to be referred by the MET and ATM communities to ensure common understanding for the implementation and/or enhancement of ATM-tailored MET services.

1.2. Development of the regional implementation guidance

1.2.1. ICAO APAC Meteorological Requirements Task Force (MET/R TF) 4th meeting, held in July 2015 in Tokyo, noted that so-called 'ATM-tailored' MET information, when provided to support international air navigation, is still required to comply with the Annex 3 - Meteorological Service for International Air Navigation, 'General Provisions'. However, the detailed technical specifications for the information have not yet been specified in Annex 3. The meeting also noted that specific regional guidance material is necessary to assist States in developing and implementing tailored meteorological information and services to support effective ATM; and agreed to develop the regional guidance material.

1.2.2. An ad-hoc group consisting of Australia, China, Hong Kong, China, Japan (rapporteur), New Zealand, Republic of Korea, Singapore, Thailand and Vietnam was tasked to develop a regional guidance material for tailored meteorological information to support ATM operations.

1.2.3. Detailed historical background of efforts for implementation and enhancement of MET information and services for ATM in APAC Region is described in section 1.4.

1.3. Importance of ATM-tailored MET information and services

1.3.1. With unprecedented growth in air traffic movements in the Asia/Pacific Region, ATM is paramount for the continued assurance of safe, efficient and timely aircraft operations. Recognizing the importance, various States have continued to evolve their ATM systems and

[1] ATM is defined in PANS-ATM (Doc 4444) as follows: The dynamic, integrated management of air traffic and airspace including air traffic services, airspace management and air traffic flow management – safely, economically and efficiently – through the provision of facilities and seamless services in collaboration with all parties and involving airborne and ground-based functions.

procedures to meet the growing demand and to maintain safety, as the priority. Additionally, neighbouring States are increasingly collaborating on activities such as Air Traffic Flow Management (ATFM[2]), which are enhanced by the incorporation of dedicated support from MET services.

1.3.2. Information sharing and collaborative decision-making (CDM) by relevant stakeholders are indispensable for the successful provision of effective and efficient ATM. Aircraft operations are influenced by atmospheric conditions and meteorological phenomena, in particular adverse conditions can have significant impacts on ATFM planning and provision.

1.3.3. In the APAC Region, diverse weather conditions are experienced on a daily basis, as the region is influenced by climate varying from tropic to sub-polar and is further complicated by geography including both broad land masses and wide oceanic areas. It is therefore, critical that the region's ATM, and particularly ATFM operations are supported by tailored MET information and services to ensure safe, efficient and orderly aircraft operations.

1.4. Historical background

1.4.1. Since ICAO endorsed the Global Air Traffic Management Operational Concept (GATMOC, Doc 9854) in 1996, States have worked on the enhancement of ATM. In the APAC Region, since the late 1990s, ATM (and ATFM) has evolved significantly in many States. Subsequently, tailored MET information and services has been recognised as critical information for the effective provision of ATM and subsequently has been incorporated as part of the strategic and tactical ATM operations in those States. For example, in Japan, the Air Traffic Meteorology Center (ATMetC) of the Japan Meteorological Agency (JMA) was established in February 2006, as a specialized MET service provider for the Air Traffic Management Center (ATMC) of the Japan Civil Aviation Bureau (JCAB).

1.4.2. In 2001, the ICAO APANPIRG Communications/Navigation/Surveillance and Meteorology Sub-Group (CNS/MET SG) formed the MET/ATM Task Force (TF) to facilitate regional implementation of meteorological services in support of ATM. The first Regional MET/ATM Seminar was held at the ICAO Regional Office in Bangkok, Thailand, in February 2006. In order to enhance regional implementation, in 2009, APANPIRG agreed to call for the 1st meeting of the MET/ATM TF[3] to plan the 2nd Regional MET/ATM Seminar and TF Meeting in the 2010 timeframe. In February 2011, the Seminar and the 2nd meeting of the TF were held in Fukuoka, Japan, where experts from MET, ATM and other international organizations in the APAC region gathered to discuss their plans and best practices on the development and implementation of meteorological services in support of ATM. The meeting also included a technical tour to the ATMetC to provide an example of the collaborative work undertaken between MET and ATM organisations. Subsequent TF meetings, and later the MET/R Working Group, successor to the MET/ATM TF, continued the important work of developing regional guidance to assist Asia/Pacific States with implementation or improvement of MET information and services to support ATM.

[2] ATFM is defined in PANS-ATM (Doc 4444) as follows: A service established with the objective of contributing to a safe, orderly and expeditious flow of air traffic by ensuring that ATC capacity is utilized to the maximum extent possible, and that the traffic volume is compatible with the capacities declared by the appropriate ATS authority.

[3] Meteorology/Air Traffic Management Task Force

2. IMPLEMENTATION PROCEDURES

2.1. Preparatory phase (processes towards implementation)

Communication channel establishment

2.1.1. The most important step in the implementation of ATM-tailored MET information and services is to establish a good communication channel for mutual collaboration between MET and ATM organizations through periodic meetings, sharing ideas, familiarisation visits such as to operational centres, etc.. To develop and facilitate an implementation plan, it is recommended to exchange views and information and build mutual understanding of each other's services, through regular consultations and meetings with clear objectives.

2.1.2. In addition, consultation with collaborative decision-making (CDM) stakeholders from the initial stage will be desirable for smoother and better planning. This will further assist in the implementation process, given that CDM is an essential element in the ATM operational concept. Furthermore, it is encouraged to include any other directly affected parties including airspace users[4], such as major airlines, in the CDM process.

Service Identification

Understanding ATM and aircraft operations

2.1.3. ATM operations vary in each State depending on its technical capabilities and characteristics of their responsible airspace. Better understanding of the State's ATM system is necessary to determine the scope of MET information and services to support ATM. This aspect will assist in understanding the local ATM requirements and determining the most appropriate process to meet these requirements, including any constraints.

2.1.4. Additionally, procedures for aircraft operations adopted by airlines are also important in defining ATM-tailored MET information and services. The safety and efficiency of aircraft operations are fundamentally dependent on weather conditions. For example, each aircraft has maximum crosswind threshold values for take-off and landing. Adverse weather conditions may force aircraft to fly irregular flight routes and conduct unusual operations, which could result in significant diversion from the normal and planned distribution of air traffic. In this context, understanding aircraft operational procedures is helpful in designing a fit-for-purpose MET information and services**.**

Past Events and Case Studies

2.1.5. Investigation of MET-related impacts on air traffic flow is essential to determine of the types of MET information and services required to effectively support ATM. One practical approach, in cooperation with airlines, is to compare operational records (including causes of delay, where available) with past weather data.

2.1.6. Once ATFM is implemented, focus could be on more direct ways to use the flow management records in the ATFM process in addition to the aircraft operations records for the comparison with past MET data.

[4] Airspace users is defined in Global Air Traffic Management Operational Concept (GATMOC) (Doc 9854) as follows: The term airspace users mainly refer to the organizations operating aircraft, and their pilots.

Service proposal (Proposal from MET organization)

2.1.7. Through the process mentioned in 2.1.3. to 2.1.6., it is expected to obtain better understanding of the ATM processes based on aircraft operational procedures and possible weather impact on air traffic flow. The next step would be to develop a draft plan for MET information and services in support of ATM and to provide a proposal to the ATM organization. The proposed plan could be conceptual process with specific explanation and prototypes of MET information or services.

Service development (Requirements from ATM organization)

2.1.8. With the feedback from the ATM organization described in 2.1.7., the MET and ATM organisations could modify and make necessary changes to the proposed plan. This will ensure that both parties (MET and ATM) are aware of the requirements and limitations and are able to adopt a practical plan for the region. This would be an iterative process, until the proposed plan for MET information and services becomes matured.

Service definition

2.1.9. Once the proposed plan is matured, the provision of MET information and services in support of ATM can be formalized. The plan should also describe how the ATM tailored MET products will be utilised in conjunction with the other MET products. In addition, these products including MET information tailored to the specific ATM service provider could be made available to the airspace users, to ensure all stakeholders are in possession of the same information in a timely fashion at the same time when making decisions through CDM process.

System development

2.1.10. The next step is to develop a system and associated software applications necessary to provide ATM-tailored information and services defined in section 2.1.9.

Trial run of the system and service

2.1.11. It is essential to conduct a trial of the system and procedures to test secure delivery of the defined MET information and services. If any issues are identified through the trial, they should be resolved through close consultation with the stakeholders concerned (mainly the ATM organizations), before the service becomes operational. In addition, the trial process will assist in determining the system reliability. The outcomes of the trial and lessons learned should be well documented to assist with future requirements.

Service provision agreement

2.1.12. In parallel with the system development, to ensure that continuous provision of the defined MET information and services is maintained, it is important to formalize a written agreement (or to amend an existing agreement, if applicable) between the MET and ATM organizations. The Agreement should include the MET and ATM capabilities, and outlining the operational processes, working relationship and the communication channels. When such an agreement is later implemented with airlines or other stakeholders, existing agreements should also be amended accordingly.

2.2. Operational phase (processes for continuous improvement)

Operational trial

2.2.1. Before MET information and services are provided operationally, an operational trial should be conducted so that forecasters and ATM officers can familiarize themselves with the provision and usage of the new information and services. The trial period should be set based on agreement between the parties concerned. A post implementation of the operational trial should be conducted to ensure lessons learned from the process are documented and improvements are made prior to implementation.

Provision of MET information and services

2.2.2. MET information and services should be developed in accordance with the process described in 2.1, and with the service provision agreement between the MET and ATM organizations.

Verification and evaluation

2.2.3. After the implementation of ATM-tailored MET information and services, it is required to regularly verify and evaluate its quality to ensure that it practically supports ATM requirements. Also, when a meteorological condition has a significant impact on ATM, it is recommended that stakeholders conduct a post-event analysis to identify any opportunities to improve the process..

Continuous improvement

2.2.4. Regular evaluation meetings between relevant parties such as airspace users, ATM and MET organizations are one of the basic approaches to continuously improve the provision of information and services. These meetings should draw from the results of verification and evaluation as well as lessons learned from significant events, to identify challenges and opportunities to continually improve MET information and services.

3. MET INFORMATION AND SERVICES IN SUPPORT OF ATM

3.1. Introduction

3.1.1. In this chapter, some examples of MET information and services that are effective for supporting ATM operations are discussed. As it will require budget, resources, technology, and time to introduce relevant MET information and services, some of which may not be defined in ICAO Annex 3, it is recommended to consider implementing them in a stepwise manner, depending on the situation in each State.

3.1.2. Examples of MET information and services for ATM in some States are described in Appendix 1. In addition, operational scenarios of MET/ATM collaboration, such as how MET information and services are provided to ATM officers, are described in Appendix 2.

3.2. Participation of MET organizations in CDM

3.2.1. CDM is an approach where relevant stakeholders share necessary information in order to make decisions collaboratively to enable enhanced ATM operations. This process involves a collaboration of stakeholders to generate products suitable for better pre-tactical traffic

management strategies and optimised use of available capacity. The expected role of a MET organization in CDM is for aviation forecasters with an understanding of the effects of meteorology on ATM to provide necessary meteorological information at and around relevant aerodromes and air routes in a timely manner.

3.2.2. To achieve effective CDM, aviation forecasters should have a basic understanding of ATM and Air Traffic Control (ATC) procedures, such as, inter alia, runway weather minima and aircraft operating criteria so that they would be able to foresee meteorological factors affecting aviation operations and provide appropriate briefings to ATM and ATC in a timely manner.

3.2.3. Where an event or phenomena has a significant impact on normal air traffic flows (e.g.: mass deviation of aircraft), it is vital to ensure that common situational awareness is maintained at all times among affected stakeholders. Rapid identification of the possible cause of such a situation (e.g. adverse meteorological conditions, runway closure) allows both ATM and MET organizations to take effective and immediate action(s) in a collaborative manner, to mitigate any impacts.

3.3. Weather briefing in support of ATM

3.3.1. Direct weather briefings for ATM officers are an effective method to share current and expected weather assessments in and around major aerodromes and air routes, including any expected impacts on aircraft operation and air traffic flow.

3.3.2. Regular weather briefings in support of ATM may be provided several times per day. Depending on rostered shift arrangements in ATC centres, MET briefings may be scheduled for groups of controllers just prior to commencing their operational duty.

3.3.3. Where unexpected weather phenomena may affect aircraft operation and/or air traffic flow (or the actual weather deviates significantly from what is being forecast), a special briefing should be provided by aviation forecasters. Special briefings can be either proposed by aviation forecasters or requested by ATM officers.

3.4. ATM-tailored meteorological information

Impact-based weather information

3.4.1. Tailored MET information that shows possible impact on air traffic flow (e.g. when and where the weather phenomenon affects air traffic flow) can be useful to support the management of air traffic capacity in each ATC sector and execution of air traffic flow controls.

3.4.2. Information that is relevant to the impact to air traffic flow will be extremely valuable; for example, a probabilistic forecast of impact to ATFM may provide a quantitative estimate of reduction in air traffic capacity. To develop such impact-based information, consensus among stakeholders has to be developed regarding relationships between specific meteorological conditions and their possible impacts on air traffic flow.

Information for common situational awareness

3.4.3. It would be helpful for ATM representatives and other relevant stakeholders to understand the background of relevant meteorological conditions (e.g. occurrence process and characteristics), as well as the associated forecast confidence, which would facilitate risk

assessment to enable more effective and efficient ATM operations. It is desirable to provide relevant graphical information which can explain meteorological conditions effectively, such as pressure distribution charts, weather radar and satellite imagery, and/or weather advisories with simple associated descriptions.

3.5. Information and products developed for other use

3.5.1. Existing meteorological information may also be useful to support ATM. Some examples are listed below:

- Operational meteorological (OPMET) information such as Aerodrome Weather Reports (METAR/SPECI), Aerodrome Forecast (TAF), etc.
- Volcanic Ash Advisory (VAA) and Tropical Cyclone Advisory (TCA)
- World Area Forecast System (WAFS) products, i.e., Wind and Temperature (WINTEM) chart, Significant Weather (SIGWX) chart, and gridded global forecast of wind, temperature, cumulonimbus clouds, icing and turbulence
- Real-time observational data at congested aerodromes
- Weather radar imagery
- Specific phenomena based information, such as thunderstorm and lightning information
- Satellite imagery and derived products
- "Nowcasting" products
- Numerical weather prediction data and/or derived products
- Earthquake and tsunami information
- Space weather information

3.6. Means of provision

Dedicated information sharing system

3.6.1. To facilitate CDM, information sharing among all relevant stakeholders in MET and ATM is necessary, to ensure common situational awareness is maintained. In order to support ATM operations, a system should be acquired or developed which enables ATM officers to utilize MET information at any time. Similarly, aviation forecasters need an environment through which they can look at ATM-related information to provide appropriate MET information. Therefore, it is desirable to establish dedicated system(s) for information sharing between MET and ATM organizations, to ensure ATC officers and aviation forecasters can effectively and efficiently exchange operational information.

Means of communication

3.6.2. Listed below are some examples of how ATM stakeholders can communicate and share necessary information:

- The aeronautical fixed service, such as Aeronautical Fixed Telecommunication Network (AFTN) and Aeronautical Message Handling System (AMHS).
- Hotline (direct phone line)
- Web-chatting system
- Telephone or video conference system
- Use of common CDM software/application
- Joint use of an operation room
- Information sharing web-portal

3.7. Continuous improvement of MET information and services

ICAO Annex 3 notes that State shall ensure that the designated meteorological authority establishes and implements a properly organized quality system comprising procedures, processes and resources necessary to provide for the quality management of the meteorological information to be supplied to the users. It is also recommended that the quality system should conform to ISO 9000 family. Continuous improvement is a key point of ISO 9001.

In order to conduct continuous improvement of MET information and services, as mentioned in chapter 2, it is required to verify regularly and evaluate the MET information and services to ensure that it practically supports ATM. Close coordination between MET and ATM is important not only in daily operations but also in post-operational analysis and continuous improvement of MET information and services in support of ATM operations. Joint post-operational analysis conducted by MET and ATM, as well as input from other stakeholder, is beneficial to improve the effectiveness of MET information and services in support of ATM operations.

3.7.1 Records of operations

3.7.1.1 It is important that each MET and ATM keeps daily records of its operations to enable case reviews. The records should be shared as necessary for joint post-operational analysis. The following are examples of the types of record that could form the basis of the case review:

- MET
  - Daily logs
    (e.g. Contents of briefings and ATFM measures)
  - Impact on air traffic flow and ATFM measures taken, as feedback from ATM (e.g. ATC capacity value and deviation with their time and location)
  - All products provided for ATM
- ATM
  - Daily logs
    - Impact on air traffic flow
      (e.g. appropriate capacity value and divert situations)
    - Significant weather affecting ATC capacity
  - Control and coordination logs for ATFM
  - All products provided by MET

3.7.2 Joint post-operational analysis between MET and ATM

3.7.2.1 Post-operational analysis can be conducted on a regular basis (e.g. yearly, monthly, etc.) and/or as required as post-event analysis following any significant impact to air traffic flow due to a weather event. Specifically, effectiveness of MET information and services to ATM operations can be reviewed and evaluated in the meeting attended by MET and ATM. The meeting with all stakeholders including airspace users (airlines) is also beneficial to collect user input such as the impact on the aircraft operations. The results of the analysis can be summarised as the joint investigation reports.

3.7.2.2 The following are examples of content that can be included in the joint investigation reports or focused at the post-event analysis meetings;

- ✈ Overview and necessary details of weather assessment impacting air traffic flow

  (e.g. METAR/SPECI, radar, surface wind, lidar, air-reports, lightning detection system, rain, snow depth)
- ✈ Air traffic flow management status
  - ✧ Details of air traffic flow (e.g. capacity values adopted, spacing time)
  - ✧ Details of flow controls (e.g. time, measures, etc.)
- ✈ MET information and services provided
  - ✧ Contents of weather briefings (e.g. timing, phenomena, expected scenario)
  - ✧ Contents of products, such as impact-based MET information
- ✈ Evaluation of the effectiveness of MET information and services for the ATM decision making
- ✈ Identify any challenges and opportunities and discuss any relevant matters.

3.7.3 Verification of impact-based MET information to support ATM operation

3.7.3.1 Objective and continuous verification is desirable for the impact-based information, and it would be ideal to develop some index or scheme for verification. In order to perform objective verification, it is necessary to identify the target to be evaluated. These targets need to be agreed by all relevant stakeholders in advance. However, verification for the prediction of meteorological impacts on ATM can be challenging and should be carried out carefully, as it includes multiple ~~following~~ factors to be assessed as follows:

- ✈ Accuracy of the forecast of weather phenomena – to be evaluated by MET
- ✈ Impact to the air traffic flow or ATM operations by the actual meteorological condition – to be evaluated by MET and ATM jointly

The former factor could be conducted in 'steps' manner (e.g. level of accuracy plotted against the lead time of the forecast) in consideration of the nature of weather conditions prediction, that is, the accuracy could be different depending on its lead-time. The latter is sometime still challenging to verify objectively, and it would be supplemented by post-event analysis in coordination with ATM officers.

Verification methods

3.7.3.2 Verification of impact-based MET information can be conducted mainly through the following approaches:

- ✈ Case studies
  - ✧ When a weather event significantly affects air traffic flow management, MET and ATM jointly conduct a post-operational review. The MET service provider may also receive real time feedback from ATM units during the event regarding meteorological impacts on operations. This approach can particularly be valuable in the early stages

of tailored MET service implementation, when the mechanisms through which weather affects ATM operations were not yet fully understood.

- Statistical verification
  - For evaluating forecast performance for meteorological conditions objectively, comparison of forecasted weather categories with those derived from observed conditions, such as aerodrome meteorological observations (i.e. METAR/SPECI reports), radar reflectivity and echo tops, can be done. The metrics including Threat Score (Critical Success Index), Probability of Detection, Bias Score and False Alarm Late, can be utilized to indicate accuracy quantitatively. When the MET information is provided in probabilistic form, it can be verified using reliability diagrams to assess how well forecast probabilities match observed frequencies.
  - For evaluating impact-category forecasts, it can be done by comparison of actual meteorological conditions with actual ATC capacity to assess the suitability of category criteria. For example, in the case that the impact-category forecasts for airspace are derived by coverage of radar echoes meeting certain thresholds within airspace of high traffic volume, the coverage can be compared with actual ATC capacity. Such analysis helps refining impact-category thresholds and improves the performance of impact-based forecasts.

Identification of true value of MET impact on ATM

3.7.3.3 Defining a “true value” that represents the actual meteorological impact on ATM operations remains a challenge, because interdependences by the following factors make identification of meteorological ground truth complex:

- ATC capacity is influenced by non-meteorological factors, such as congestion caused by rerouted aircraft, making it difficult to isolate weather-related impacts.
- Mitigating measures, such as capacity reductions or air traffic flow restrictions, may often involve judgment based on multiple factors including non-meteorological effects, resulting in different impact assessments for similar weather situations.
- Adjustment of ATC capacity may be based on the forecasted meteorological condition other than the actual meteorological situation.

However, although influenced by multiple factors, ATM operational metrics, such as ATC capacity, remain essential indicators for identifying operational impacts in ATM.

3.7.3.4 To improve the reliability of verification, the following approaches can be considered:

- Documenting the reasons for ATC capacity adjustments in ATFM logs, enabling clearer

separation of meteorological and non-meteorological influences.

- ✈ Focusing verification on selected periods, such as high traffic hours, in which impacts are more consistently observable.
- ✈ Evaluating the impact of actual weather conditions on traffic flow and the validity of weather forecasts independently of one another.

3.7.4 Meetings for continuous improvement

3.7.4.1 It is recommended that the key lessons learned from the results of the post-operational analysis be consolidated and reviewed periodically (e.g. in the same season each year) in the study meeting between MET and ATM so that best practices can be integrated into the daily operations of each party. The latest developments in aviation weather services can also be shared and discussed in such meeting to further enhance the MET information and services to effectively support ATM operations.

4. FUTURE PROGRESS IN MET/ATM SERVICES

4.1. Global Air Navigation Plan (GANP)

4.1.1. In 2014, the 38th Session of the ICAO Assembly amended the Global Air Navigation Plan (GANP) and formulated the Aviation Systems Block Upgrades (ASBUs), the implementation plan of the GANP, as proposed by the twelfth ICAO Air Navigation Conference (AN-Conf/12). The ICAO Meteorology Panel (METP) was established in September 2014 is tasked with providing standard and recommended practices for MET information and services in support of ATM for the terminal area and in line with the aviation system block upgrades (ASBU).

4.1.2. In the future, States in a position to do so would be required to provide ATM-tailored MET services based on globally consistent requirements. Since this global standardization is being welcomed among users such as airlines and pilots, the States in the APAC Region may adapt their systems accordingly when such standards are available.

4.2. Future integration of MET information into ATM decision-making

4.2.1. The ICAO Air Traffic Management Requirements and Performance Panel (ATMRPP), in coordination with the METP and other panels concerned, has discussed future integration of MET information into ATM decision-making system, along with the Global Air Traffic Management Operational Concept (GATMOC) (ICAO Doc 9854). The “Concept for the integration of Meteorological information for ATM” has been developed by the ATMRPP and other bodies concerned. It provides guidance on methods and procedures to interpret MET information as it relates to possible constraints on air traffic flow. It supports estimation of the potential impact of the meteorological condition to ATM and provides ATM officers with possible actions to be taken, e.g. selecting the safest routes while minimising diversions.

4.3. Next generation air transportation system developments

4.3.1. To deal with growing air traffic congestion, some States or Regions have been planning the development of next generation air transportation systems. These include NextGen[5] (United

[5] Next Generation Air Transportation System

States), SESAR[6] (Europe) and CARATS[7] (Japan). It is important for MET organizations to make the best effort to improve their capability in the provision of MET information and services to meet such future requirements and facilitate the development of a new generation air transportation system.

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[6] Single European Sky ATM Research

[7] Collaborative Actions for Renovation of Air Traffic Systems

REFERENCES

- ICAO Annex 3 – *Meteorological Service for International Air Navigation*
- ICAO Doc 9854 – *Global Air Traffic Management Operational Concept*
- ICAO Doc 9377 – *Manual on Coordination between Air Traffic Services, Aeronautical Information Services and Aeronautical Meteorological Services*
- ICAO Doc 4444 – *Procedures for Air Navigation Services, Air Traffic Management*
- ICAO GANP Portal (https://www4.icao.int/ganpportal/)
- ICAO Asia/Pacific Regional Framework for Collaborative ATFM

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NOTES FOR APPENDIX 1 AND APPENDIX 2

a) The example from each State for Appendix 1 should follow the format below:

1) ATM-tailored MET information and services
- MET information and services for ATM, excluding OPMET information.
- One sub-section for each MET information and service, e.g.: Dedicated MET information; Participation in CDM; Briefing for ATM officers; etc.

2) Means of Provision
- Means of MET information provision for ATM officers, such as dedicated information provision system.

3) Other useful information (if any)
- Collaboration with ATM officers for MET information and/or services improvement (e.g. regular meeting, collaborative post event analysis).
- Verification of MET information described in section 1) ATM-tailored MET information and services.
- Implementation history of ATM-tailored MET information and services, including how long it took to implement such information and services.

b) Number of pages in Appendix 1 and Appendix 2

- Each State's example for Appendix 1 should be up to four (4) pages. Five (5) pages are allowed in the cases that the post-operational analysis is included in the contents.
- To avoid increasing the pages, states are encouraged to provide general and/or essential information.
- States may include links to WPs/IPs and/or their public website in their examples to show supplemental or advanced information.
- The operational scenario from each State for Appendix 2 should be up to four (4) pages.

c) Maintenance procedure for Appendix 1 and Appendix 2

- States that wish to add or update their own examples or operational scenarios in Appendix 1 and Appendix 2 should submit detailed proposals (describing the drafts of examples or operational scenarios) in the form of working papers for discussion and adoption by the MET/R WG[8].
- The designated ad hoc group of the MET/R WG will then consolidate the adopted changes and seek the MET SG's[9] endorsement for updating the guidance.

d) Means of publication of Appendix 1 and Appendix 2

- Each example and operational scenario in Appendix 1 and Appendix 2 is published on the ICAO APAC website (APAC eDocuments), in separate PDF files considering the user's accessibility to the information.

[8] Meteorological Requirements Working Group

[9] Meteorology Sub-Group

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