International Civil Aviation Organization

Meteorology Panel (METP)

FOURTH MEETING

Montréal, 10 to 14 September 2018

REPORT FOLDER

The material in this report has not been considered by the Air Navigation Commission. The views expressed therein should be taken as advice of a panel of experts to the Air Navigation Commission but not as representing the views of the Organization. After the Air Navigation Commission has reviewed this report, a supplement setting forth the action taken by the Air Navigation Commission thereon will be issued to this report.

METP/4
14/09/18

MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Headquarters, 10 to 14 September 2018

GENERAL

The attached constitutes the general part of the report and should be inserted at the appropriate place in the yellow folder.

FOURTH MEETING OF THE
MEETING OF THE METEOROLOGY PANEL (METP) (2018)

LETTER OF TRANSMITTAL

To: President, Air Navigation Commission

From: Chairman, Meeting of the Meteorology Panel (METP) (2018)

I have the honour to submit the report of the fourth meeting of the Meteorology Panel (METP) which was held in Montréal, from 10 to 14 September 2018.

Mr. Peter Lechner
Chairman

Montréal, 14 September 2018

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LIST OF RECOMMENDATIONS

LIST OF DECISIONS

* Recommendations annotated "RSPP" relate to proposals for amendment of Standards, Recommended Practices and Procedures for Air Navigation Services or guidance material in an Annex.

MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Montréal, 10 to 14 September 2018

HISTORY OF THE MEETING

1. DURATION

1.1 The fourth meeting of the Meteorology Panel (METP) was opened by Mr. Jameel Metwalli, the Vice-President of the Air Navigation Commission in Montréal, at 09:30 hours on 10 September 2018. The meeting ended at 16:00 hours on 14 September 2018.

2. ATTENDANCE

2.1 The meeting was attended by members and observers nominated by 13 Contracting States and 6 International Organizations, as well as by advisers and others as shown in the list below:

Members	Advisers	Nominated By
RIBERO, Claudia		Argentina
O'ROURKE, Sue	BERECHREE, Michael	Australia
MAYNARD, Bill	GRECHUK, Brian RATTE, Gilles TRICHTCHENKO, Larisa	Canada
ZHANG, Zhongfeng	HUANG, Yi LAU, Sharon ZHANG, Xiaoxin ZOU, Juan	People's Republic of China
MASSON, Fabien	DESBIOS, Stéphanie	France
STURM, Klaus	MEISE, Gabriel Christine	Germany

Members	Advisors	Nominated by
RYUZAKI, Jun	ISHIL, Mamoru KUNITSUGU, Masashi	Japan
LECHNER, Peter	ACETHORP, Paula HENRY, Norm	New Zealand
NARYSHKINA, Yuliya	BORODIN, Rusian IVANOVA, Anna MORYAKOV, Dmitry NIKITINA, Larisa VARELDZHIAN, Gamalak	Russian Federation
YAP, Chui Wah		Singapore
MOLOTO, Albert		South Africa
HORD, Colin	DUTTON, Jon	United Kingdom
MURPHY, Michael Patrick	ENTWISTLE, C. Bruce BURCH, Larry HELMS Jr., Thomas J.	United States
MOCTAR, Mahfoudh		ASECNA
HART, Dennis	LAPSLEY, Rosalind Jean	EUORCONTROL
GROUT, Jean-François		IATA
SIEVERS, Klaus		IFALPA
TUCKER, Matthew		IFATCA
BROCK, Greg	LISK, Ian	WMO

3. OFFICERS AND SECRETARIAT

3.1 Mr. Peter Lechner (New Zealand) and Mr. Bill Maynard (Canada) as Chair and Vice-Chair of the panel respectively conducted the meetings. Mr. Raul Romero, Technical Officer Meteorology acted as Secretary for the meeting, with the assistance of Mr. Luis Sánchez, Regional Officer, Aeronautical Meteorology and Environment.

4. AGENDA OF THE MEETING

4.1 The agenda for the meeting shown hereunder was approved by the Air Navigation Commission.

Agenda Item 1: Opening of the meeting

Agenda Item 2: Working arrangements

Agenda Item 3: Meteorological requirements and integration
- 3.1 Meteorology requirements to support trajectory-based operations (TBO) *(Ref: Job card ATMRPP.009.01)*
- 3.2 ASBU-MET development (*Ref*: *Job card METP.002.01*)
- 3.3 PANS-MET development (*Ref: Job card METP.005.01*)

Agenda Item 4: Meteorological information service development
- 4.1 International Airways Volcano Watch (IAVW) (Job card *METP.003.01)*
- 4.2 Release of radioactive material in the atmosphere (*Ref: Job card METP.006.01)*
- 4.3 Regional hazardous weather advisories (*Ref: Job card METP.007.01)*
- 4.4 Space weather advisory information service (*Ref: Job card METP.009.01*
- 4.5 World area forecast system (*Ref: Job card METP.010.01*)
- 4.6 Sulphur dioxide from volcanic eruptions in the atmosphere *(Ref: Job card METP.012.01)*

Agenda Item 5: Meteorological information exchange *(Ref: Job card METP.004.01)*

Agenda Item 6: Meteorological operations group
- 6.1 Operation of the International Airways Volcano Watch (IAVW) (*Ref: Job card METP.003.01)*
- 6.2 Operation of the World Area Forecast System (*Ref: Job card METP.010.01)*
- 6.3 Secure Aviation Data Information Service (*Ref: Job card METP.008.01)*

Agenda Item 7: Cost recovery guidance and governance *(Ref: Job card METP.011.01)*

Agenda Item 8: Annex 3 amendment proposals from other sources

Agenda Item 9: Panel structure

Agenda Item 10: Future meetings

Agenda Item 11: Any other business

WORKING ARRANGEMENTS

4.2 The panel met as a single body, with ad hoc drafting groups as required. Discussions were conducted in English. Working papers were presented in English only. The report was issued in English.

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MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Headquarters, 10 to 14 September 2018

AGENDA ITEM 1

The attached constitutes the report on Agenda Item 1 and should be inserted at the appropriate place in the yellow folder.

1. Agenda Item 1: Opening of the meeting

1.1 Mr Jameel Metwalli (Vice-President of the Air Navigation Commission (ANC) provided some opening remarks. He welcomed the Panel on behalf of the ANC. He noted that the ANC was very appreciative of the fact that the Panel Members have come to Montreal for two meetings during the current year and also appreciative for the effort that this means for participant States and International Organizations in supporting their attendance. He expressed the ANC's appreciation for the hard work since the Second Meeting. He noted with satisfaction that the Panel was going to deal with 43 working papers and 30 information papers, related to the eleven job cards assigned to the METP, and that the ANC has great confidence in the vision, knowledge and competence of the METP so, it would very much appreciate the technical observations and recommendations, emanating from these documents that would help them with their work. He highlighted the role of Panel Members, which like AN Commissioners, act independently in their technical expert capacity, and not representing their State or International Organization. Finally, he noted that the ANC was very interested in hearing from the Panel as to what challenges the Panel are facing in its work, and especially any suggestions for improvement with which the ANC can help the Panel.

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MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Montréal, 10 to 14 September 2018

AGENDA ITEM 2

The attached constitutes the report on Agenda Item 2 and should be inserted at the appropriate place in the yellow folder.

Agenda Item 2: Working arrangements

2.1 The MET work programme was addressed under agenda items 3 to 8.

2.2 Specific working arrangements for the meeting were addressed under History of the meeting. In this regard, Mr. Peter Lechner confirmed his intention to continue as Chairman of the METP to until at least 31 May 2019, after which his availability through to METP/5 (2020) was contingent on access to necessary resources.

2.3 It was agreed that in the event that Mr. Lechner could not continue after 31 May 2019, Mr. William Maynard would assume responsibilities of Chairman and Mrs. Sue O'Rourke would become Vice Chairperson.

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MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Headquarters, 10 to 14 September 2018

AGENDA ITEM 3

The attached constitutes the report on Agenda Item 3 and should be inserted at the appropriate place in the yellow folder.

Agenda Item 3: Meteorological requirements and integration

3.1 Meteorology requirements to support trajectory-based operations (TBO) *(Ref: Job card ATMRPP.009.01)*

3.1.1 The Panel reviewed **WP 1001** which presented WG-MRI's efforts on the task of defining "new MET requirements". In this regard the Panel noted that there have been issues encountered which have limited the effectiveness of progress so far. One of the main issues refers to the coordination with other Panels on aeronautical meteorological information, to support ATM operations from gate to gate, which had proved to be very challenging. The Panel was of the opinion that other panels of relevance to the work of the METP do not necessarily have relevant (MET) expertise to be able to judge what new MET information services would be of benefit to their operations, nor the insight into what MET information could be available to them in the future.

3.1.2 Therefore the Panel discussed the need for a more pragmatic approach to produce robust user requirements involving a collaborative exercise between MET experts and users. A concept demonstrating a tailored MET solution could then be presented to a user community to evaluate, comment on, and refine in partnership with WG-MRI. As an example, the Panel note the recent consultation process with the Navigation Systems Panel (NSP) on the draft Standards and Recommended Practices (SARPs) for space weather. It was also noted that any new MET requirement needed to be useful to users, rather than a potentially expensive "nice-to-have" feature and that a positive impact for any new MET information service should demonstrate how operators would use the service, and what new or different procedures they will adopt because of this new MET information service.

3.1.3 In consideration of the above the Panel agreed on a reorientation of activities of the WG-MRI to meet the stated ATMRPP.009.01 job card objectives, and concluded on the need to:

a) Suspend the development of MET requirements based on the current methodology, but to reconsider this again, after publication of the GANP 2019; and

b) Develop further, the working relationship with Panels based on earlier identified dependencies.

3.1.4 As an alternative, and not to miss opportunities related to known (new) needs, the Panel agreed with the identification of three areas of information service development (long-haul flight operations, aircraft ground de-icing operations and new aerodrome observations.

3.1.5 The Panel, taking into account material included in WP/6203 agreed to include a task related to terminal area forecasts the MRI's scope of work.

3.1.6 These themes were raised by users, which were deemed appropriate to focus upon as a means to demonstrate a workable process for requirement gathering. Additionally it was noted that these themes could then be linked at a later date to ASBU if required.

3.1.7 Concluding this discussion the Panel agreed on the new approach and formulated the following recommendation:

Recommendation 3/1 — New approach for the definition of new MET requirements

That the WG-MRI Rapporteur be tasked to prepare a working paper for the upcoming ATMRPP meeting, on behalf of METP, to ask approval for the proposed new approach consisting in the identification of three areas of information service development (long-haul flight operations, aircraft ground de-icing operations and aerodrome observations).

Note: If deemed necessary, this WP may include consequential changes to the job card of the ATMRPP.009.001.

3.1.8 The Panel reviewed **WP/6203 -** *Defining User Requirements for IWXXM* presented by Jean-Francois Grout (IATA). The IWXXM form of operational meteorological (OPMET) information will be able to support the enhanced information required by operators and ATM to improve capacity and operate safely and efficiently in an increasingly congested airspace, however these products were developed based on criteria largely from the 20th century. A significant use of this enhanced information within the SWIM environment will be the capability to expand the use of collaborative decision-making (CDM) with air traffic control (ATC), MET and airports. This may be in the airport space (i.e. through airport collaborative decision making (A-CDM)) or en-route (through flight and flow information for a collaborative environment (FF-ICE)). It was agreed that a group of experts be formed to gather user requirements for new information services. The group would be composed of users and members from WG-MRI and WG-MIE to assess, scope, articulate and translate information services user requirements with an initial focus on forecast parameters/elements, and their specific characteristics, in the terminal area. The Panel formulated the following recommendation:

Recommendation 3/2 — Operational meteorological information

That an Ad Hoc group composed of members from WG-MRI and WG-MIE, be established to assess, scope, articulate and translate into information services user requirements (operator and ATM) for using meteorological information in a SWIM environment, commencing with forecast elements in the terminal area

3.2 ASBU-MET development (*Ref: Job card METP.002.01)*

3.2.1 The Panel noted **IP/1201(and its Attachment)** related to the work undertaken by the Aviation System Block Upgrade Panel Project Team regarding meteorological information for the 2019 edition of the Global Air Navigation Plan. In this regard, the Panel noted that ICAO established two expert groups to update the GANP, i.e. the Global Multidisciplinary Vision Team (GMVT) which focussed on the Global Strategic Level of the GANP and the ASBU Panel Project Team (ASBU PPT) which was in charge of reviewing the ASBU framework, within the Global Technical Level of the GANP. The Panel was pleased to note that the ASBU PPT team has undertaken a substantial review of the ASBU framework, aiming for its endorsement during the 40th session of the ICAO Assembly in 2019. The majority of work has been completed; it analysed the maturity of the Aviation System Block Upgrade (ASBU) framework for Blocks 0 through to 4. It was noted that the outcomes of the work have been presented to the ICAO Air Navigation Commission (ANC) in May 2018 and will be discussed during the upcoming thirteenth ICAO Air Navigation Conference (ANConf/13) in October 2018.

3.2.2 The Panel noted that the 2019 GANP will take on a multi-layer approach, i.e. Global Strategic (GANP Vision (aligned with the Global ATM Operational Concept), Conceptual Roadmap, Global Performance Ambitions) >> Global Technical (Basic Building Blocks (BBB), Aviation System Block Upgrades (ASBU), Performance-based Decision-making Method) >> Regional >> National.

3.2.3 The Panel noted the key concepts in developing the draft GANP, which were as follows: ASBU Thread, ASBU Element, ASBU Enabler, ASBU Block and ASBU Module. Moreover, the Panel noted the ASBU time steps. Additionally the Panel was informed about the Operational Threads, Enabler Threads (which includes Meteorology) and the supporting Network/Infrastructure Threads. In this regard Meteorology was an enabler for the majority of the Operational Threads and also the Network/Infrastructure Threads. The Panel noted that the challenge would be to ensure that all the other ASBU modules are able to fully articulate the requirements that they have for MET information in the future.

3.2.4 Concluding the review of IP/1201 and its attachment the Panel congratulated Mrs. Sue O'Rourke and Ms. Stéphanie Desbios for the excellent work done on behalf of METP.

3.3 PANS-MET development (*Ref: Job card METP.005.01)*

3.3.1 The Panel reviewed **WP 1301** presented by the Dennis Hart, Rapporteur of the WG-MRI, regarding an overview of activities by the WG on Job Card METP.005.01, on the development of the future PANS-MET. In this regard, the Panel recalled that the 2014 MET Divisional Meeting identified a need to migrate related provisions from a product-based viewpoint to an information-based viewpoint. This approach would thereby lead to a change of emphasis in Annex 3 and create a clear separation between performance and functional requirements as well as an improved separation between these requirements and technical specifications (i.e. means of compliance).

3.3.2 The Panel noted that the restructuring of Annex 3 and the development of the PANS-MET had followed the phased approach requested by the MET Divisional Meeting 2014 as follows:

a) Phase 1 would comprise the transposition of existing Annex 3 SARPs into a new PANS-MET; and

b) Phase 2 would migrate the provisions in the newly restructured Annex 3 and PANS-MET (phase 1 results) from a product-based viewpoint to an information-based viewpoint enabling meteorological information, supporting aviation operations, to better integrate into the SWIM environment. (This phase will develop a final version of the new Annex 3 and PANS MET, expressed in terms of functional and performance requirements and include any new provisions endorsed by METP/4).

It was noted that a fundamental criterion for this exercise was that the restructuring of the aeronautical meteorological provisions must be consistent with the restructuring already progressing for Annex 15 and PANS-AIM.

3.3.3 The Panel noted that the transposition exercise had proved to be challenging for WG-MRI. During the preliminary work on Phase 1, some concerns were raised related to perceived importance of Annexes over PANS, perceived possible safety concerns and a compromise for an initial conservative first edition of the PANS-MET. It was noted that these concerns had been dismissed at WG-MRI/4 and that, consequently, WG-MRI has developed and agreed to the separation of the existing Annex 3 into PANS-MET, shown in METP-4 IP/1302. The Panel noted the need to educate States about PANS-MET and consider issues related to the access by States to the document. In this regard the Panel noted that at the recent 16th session of the Commission of Aeronautical Meteorology (CAeM-16), WMO had been requested (through Recommendation 5) to explore, in consultation with ICAO,) enabling free access, preferably online, to relevant ICAO regulatory and guidance material by WMO Members and their NMHSs providing meteorological service for international air navigation, given a CAeM-16 recommendation to discontinue WMO Technical Regulations (WMO-No. 49_, Volume II, Meteorological Service for International Air Navigation.

3.3.4 Additionally, the Panel reviewed:

a) **IP/1303**, related to the transition principles that have been created and applied to ensure a consistent and harmonised approach to the separation of 'requirement' and 'means of compliance' across all sections of the existing Annex 3;

b) **IP/1302**, related to the results of Phase 1 (which is based upon Annex 3 (Amendment 77), including updates for Amendment 78); and

c) **IP/1301**, regarding two outline structures developed to demonstrate the chapter headings (including one chapter with specific detailed content for a new information service, to aid illustration).

3.3.5 As an example of the transposition exercise the Panel noted a new set of improved World Area Forecast System (WAFS) MET information services, planned for implementation in 2022, developed by the WG-MOG (IP/1301), which provided the transposition of these new WAFS-MET information services into a concept for Phase 2 for a PANS-MET for 2022. It was also noted that IP/1301 also provided two separate examples of a possible outline, i.e. table of content for the PANS-MET for phase 2. The first option organises the content in an information centric manner, while the second option is organised by type of MET service provider.

3.3.6 Concluding the discussion of "transition principles" which has been used as the foundation for developing PANS-MET, after analysis of pros and cons for each option, the Panel agreed to pursue work on option 1 as described in METP/4-IP/1301 Appendix C. In doing so, and as far as practical, WG-MRI will also make the document "user-friendly" for different intended user groups. Therefore, the Panel formulated the following conclusion:

Recommendation 3/3 — Development of PANS-MET

That

a) the WG-MRI Rapporteur be tasked to continue work on the development of the future PANS-MET based in option 1 (an information centric approach), while taking account as far as possible, the needs of intended users groups to have information structured in as helpful a way as possible, as described in METP/4-IP/1301 Appendix C; and,

b) the WG-MRI report back to the next meeting (METP/5) of delivering the finalized draft proposal for Annex 3 and PANS-MET in view of its issuance by 2022.

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MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Headquarters, 10 to 14 September 2018

AGENDA ITEM 4

The attached constitutes the report on Agenda Item 4 and should be inserted at the appropriate place in the yellow folder.

Agenda Item 4: Meteorological information service development

4.1 International Airways Volcano Watch (IAVW) (*Ref: Job card METP.003.01)*

4.1.1 The Panel reviewed **WP/6204** presented by IATA requesting that a formal review be conducted by the Panel to determine if the current nine regional VAACs continue to be geographically or technically optimal to deliver the volcanic ash hazard service and skill level required by operators in the future. In this regard the Panel noted that Item 3.5 of the Roadmap for IAVW in Support of Aviation did state the requirement for a review within the ASBU Block 0 timeframe (through to 2018) however, action in this direction had not been taken yet. Moreover, ICAO needs to formally agree to conduct this necessary review. The Panel noted that IATA strongly believed that the current nine VAAC systems may not be optimal in terms of delivering a consistent and skilled high-quality service in an increasingly globally interoperable environment.

4.1.2 It noted that IATA was of the view that the future will likely see a reduction in the current weather-only products and an increase in the provision of data for both operator and Air Navigation Service Providers (ANSP). The expected increase and availability in both MET and ATS data will drive this transition and the implementation of System Wide Information Management (SWIM) will enable it.

4.1.3 The Panel also noted that IATA was of the view that the successful implementation of an ICAO led global/regional cost recovery scheme will further strengthen and facilitate the case to streamline and modernise IAVW practices, ensure the optimal system of service providers and provide increasingly consistent, sustainable and equitable cost recovery.

4.1.4 In this regard, the Panel noted the extensive work being undertaking by the WG-MOG IAVW work stream, including the nine VAACs, and the development of suitable KPIs for VAACs operations as part of its oversight responsibilities. It was further noted the collaborative ongoing work on VAAC best practices under the WMO umbrella. The Panel discussed whether there was sufficient rationale to consider the review of the number of VAACs, especially in terms of consistency and sustainability.

4.1.5 The METP acknowledged the necessity to review, including the number of VAACs, the requirements for, and the provision of volcanic ash services to aviation as part of wider effort to harmonize the global delivery of meteorological hazards information, and agreed that an update on progress should be reported back to the METP/5 Meeting in 2020.

4.1.6 Concluding the discussion, the Panel agreed to start work in the direction suggested by IATA and formulated the following recommendation:

Recommendation 4/1 — Holistic review of the IAVW
That,

a) an Ad Hoc working group formed by Pat, Dennis, J. Francois, Greg, Sharon and Colin be tasked to review the provision of volcanic ash services to aviation with the view to harmonize the global delivery of meteorological hazards

b) report back at the next METP meeting.

4.1.7 The Panel noted **IP/2401**, presented by the Michael Murphy, Meteorological Information and Service Development (WG-MISD) Rapporteur, containing a report of the status of the activities of the Volcanic Ash and Sulphur Dioxide (VASD) Work Stream, which is part of the work programme of the METP's WG-MISD. In this regard the Panel agreed to discuss it under Agenda Item 4.6.

4.1.8 In a related issue the Panel noted **IP/6201**, presented by IFALPA, that suggested enhancing the information related to be displayed for briefing and consultation to flight crew members and other flight operations personnel by providing annotated satellite images, in colour. Additionally the IP requested that this user requirement should be considered for insertion in the IAVW Roadmap. In this regard the Panel was of view that the right procedure was to present these proposed requirements to the WG MOG/VA Work Stream.

4.2 Release of radioactive material in the atmosphere *(Ref: Job card METP.006.01)*

4.2.1 The Panel reviewed **WP/2101** presented by Pat Murphy, Rapporteur of WG MISD, concerning a proposal for amendment to Annex 3 concerning radioactive cloud (RDOACT CLD) SIGMET. In this regard it was noted that after the changes, introduced by Amendment 78 to Annex 3 – *Meteorological Service for International Air Navigation* concerning RDOACT CLD SIGMET, it was still necessary, for consistency purposes, to make additional changes to Annex 3. The Panel noted that the proposed changes were consistent with a recommendation from the IACRNE SIGMET Task Group of the International Atomic Energy Agency (IAEA) concerning the definition of the RDOACT CLD SIGMET by a cylinder with a fixed radius that extends to all flight levels and that is not time dependent. In particular the proposals were related to changes to Table A6-1A (Template for SIGMET and AIRMET messages) and to Example A6-4 SIGMET message for radioactive cloud. The Panel agreed that the changes would simplify existing requirements, and formulated the following recommendation:

RSPP

Recommendation 4/2: Draft Amendment 79 to Annex 3 concerning SIGMET changes for Annex 3

That, the proposal to amend Annex 3 – *Meteorological Service for International Air Navigation*, concerning SIGMET information for radioactive cloud (Table A6-1A and Example A6-4), as given at **Appendix A** to this report, be included in Amendment 79 to Annex 3 with intended applicability in November 2020.

4.2.2 In a related issue the Panel reviewed **WP/2102** presented by Pat Murphy, Rapporteur of WG MISD, related to the proposed revision of Job Card METP.006.02. The Panel noted the proposed updates to the job card related to completed tasks and the need to add one work programme element (WPE) related to the Update of the Concept of Operations for information on the release of radioactive material into the atmosphere. Concluding the discussion the Panel agreed to propose the update of Job Card METP.006.02 (included in WP/2102) to the ANC and formulated the following recommendation:

Recommendation 4/3: Proposed Revision of Job Card METP.006.02

That the proposed revision to Job Card METP.006.02 *Further Development of Provisions for Information on the Release of Radioactive Material into the Atmosphere*, as given at **Appendix B** to this report and endorsed by the Panel) be presented to the ANC for its consideration.

4.2.3 The Panel, continuing the discussion of WP/2102, noted that thee fourth meeting of the MISD/RRM Work Stream had agreed that until additional improvements in scientific capability can be implemented operationally, it was premature to consider developing draft provisions. The Panel agreed that it was also premature to recommend that the status of Job Card METP.006.02 be changed to “completed” allowing the resumption of the development of any related draft provisions for inclusion in any future amendment to Annex 3, when scientific capabilities reach an appropriate level of maturity.

4.2.4 Related to this discussion the Panel also noted **WP/6202** presented by Klaus Sievers on behalf of IFALPA, which encouraged further development of the Concept of Operations (ConOps) with regards to Release of Radioactive Material into the Atmosphere. In this regard the Panel was of the view that the consultation process for Amendment 78 of Annex 3 was fully in agreement with established ICAO procedures for Annex 3 amendments. The Panel agreed that, other than updating the Concept of Operations document, the MISD/RRM Work Stream would temporarily cease its activities. Therefore the Panel formulated the following decision:

Decision 4/1: Temporary cessation of further development of Standards and Recommended Practices (SARPs) for future Amendments to Annex 3 by the MISD RRM Work Stream,
That:

a) the MISD/RRM Work Stream complete the development of the ConOps with regard to the release of Radioactive Material into the Atmosphere,

b) the temporary cessation of further development of SARPs for future Amendments to Annex 3 by the MISD RRM Work Stream be applied until further refinement of the user needs and Concept of Operations for such information supporting the development of SARPs; and.

c) in light of any improvements in scientific capability that can be operationally implemented, the WG-MISD advise the Panel of any substantive Job Card update that may be appropriate.

4.3 Regional hazardous weather advisories *(Ref: Job card METP.007.01)*

4.3.1 With regard to this agenda item the Panel reviewed **WP/2201 (and its Attachment)**, presented by Pat Murphy, the Rapporteur of the WG-MISD, related to a high-level concept proposal for the phased development of a globally harmonized, phenomena-based, regional hazardous weather advisory service. The Panel noted that the paper, presented as follow-up of Action agreed MISD 4/11 (emanating from the face-to-face Meeting of the MISD/RHWAC Work Stream took place on 7-8 May 2018, in Washington, DC), proposed a high-level concept proposal for Regional Hazardous Weather Advisory System (RHWAS). Regarding issues related to the proposed system it was noted that once established, the Regional Hazardous Weather Advisory Centres (RHWACs) would provide users with phenomena-based, regional hazardous weather information that is not constrained by Flight Information Region (FIR) boundaries. It was also noted that this approach ensures seamless information between participating service providers, without forecast discontinuities at the boundaries of the service providers' area of responsibilities as a core principle of this concept. As a consequence this harmonization will require coordination and collaboration between participating regional service providers and WAFCs, and between regional service providers and local Meteorological Watch Offices (MWOs).

4.3.2 The Panel noted that the proposed service would use, inter alia, global, regional, and local meteorological observations, now-casts, and forecasts. It would replace the SIGMET for all phenomena except, initially, volcanic ash, tropical cyclone, and radioactive cloud. However, in the future, the service may cover all phenomena. The Panel noted the link of the proposal with Doc. 10039, *Manual on System Wide Information Management (SWIM)*, which describes general SWIM concepts and characteristics, and the MET SWIM Plan, *Plan for Meteorology in System Wide Information Management (SWIM).*

4.3.3 The Panel agreed that to accomplish a smooth transition, it was necessary to develop a RHWAS Roadmap, which would describe the transition plan and associated timelines for implementing RHWAC advisories in SWIM. Therefore the Panel formulated the following decision:

Decision 4/2: Regional Hazardous Weather Advisory Service Concept Proposal

That the METP continue to endorse the concept of a regional hazardous weather advisory service (as shown in **Appendix C** to this report) and the development, by the WG-MISD, of its roadmap.

4.3.4 In a related issue the Panel reviewed **WP/2202**, presented by Pat Murphy, the Rapporteur of the WG-MISD, regarding a proposal for the introduction of SIGMET coordination, as a recommended practice in Annex 3. In this regard the meeting noted that the proposal emanated from the Fourth Meeting of the MISD/RHWAC Work Stream and addressed a long standing significant concern raised by IATA of inconsistent or entirely absent SIGMET information in some parts of the world, and given the progress having been made by the SIGMET coordination activities in some Regions determined that it was a requirement to take immediate action and formulated Action MISD4/16: SIGMET Coordination. The referred Action called for an ad hoc group to develop a draft proposal, for inclusion in Draft Amendment 79, upgrading the existing *Note* to paragraph 3.4.1 in Annex 3 to the status of a Recommended Practice. Concluding the discussion the Panel agreed with the proposal and formulated the following recommendation:

RSPP **Recommendation 4/4: Draft Amendment 79 to Annex 3 concerning SIGMET coordination**

That, the proposal to amend Annex 3 – *Meteorological Service for International Air Navigation*, concerning SIGMET coordination, as given at **Appendix D** to this report, be included in Amendment 79 to Annex 3 with intended applicability in November 2020.

4.3.5 The Panel turned its attention to **WP/2203**, presented by Pat Murphy, the Rapporteur of the WG-MISD, that proposed a revision of Job Card METP.007.02. In this regard the Panel agreed to propose to the ANC updates regarding Work Programme Element (WPE) 1696, delivery dates for WPE 1697, 9839, 9840, and 9841. Therefore the Panel formulated the following recommendation:

Recommendation 4/5: Proposed Revision of Job Card METP.007.02

That the proposed revision of Job Card METP.007.02 *Development of Provisions Phenomena-based, Globally-consistent, Regional Advisory System for Select En-route Hazardous Meteorological Conditions*, as given at **Appendix E** to this report and endorsed by the Panel, be presented to the ANC for its consideration.

4.3.6 The Panel noted **IP/2201** related to proposed revision to SIGMET examples in Doc. 8896, *Manual on Aeronautical Meteorological Practices* however this paper was not considered mature and was referred to the WG-MISD for further consideration. The meeting noted that the proposed update should go through further review by the WG-MISD and, given that this updated information is useful for States to initiate necessary actions to coordinate with neighbouring MWOs for the harmonized provision of SIGMET, the finalized draft will be sent to the secretariat and reviewed by the Panel Chair for consideration and processing during the inter-session period.

4.4 Space weather advisory information service *(Ref: Job card METP.009.01)*

4.4.1 With regard to space weather advisory information the Panel reviewed **WP/2301** presented by Pat Murphy, the Rapporteur of the WG-MISD, concerning minor updates to the provisions of space weather information for inclusion in Amendment 79 to Annex 3.

4.4.2 In this regard the Panel noted that the addition of satellite communication (SATCOM) to the SARPs, introduced by the Air Navigation Commission during the final review of Amendment 78, required some minor changes to Table A2-3 – Template for advisory message for space weather information. The proposed changes were related to the need to add a new Note 2 to allow that more than one effect with the same intensity be combined, all or some of the space weather effects (i.e., GNSS, RADIATION, SATCOM and HF COM) be combined in one space weather advisory when the conditions are expected to exist. Additionally the Panel noted that it was necessary to make minor changes to the current Note 2 as the new Note 3, to allow that all space weather effects be described using latitude bands.

4.4.3 The Panel also noted that in accordance with Attachment E to Annex 3, the range for the flight levels for the space weather advisory is from FL250 to FL600, with a resolution of 30 (i.e., 3,000 feet). Taking into account that a vertical resolution of 10 (i.e., 1,000 feet) can be determined for space weather events and thus provide users with improved information, the Panel agreed to change the current resolution of 30 (i.e., 3,000 feet) to 10 (i.e., 1,000 feet).

The Panel formulated the following recommendation:

RSPP **Recommendation 4/6 — Proposed changes for Amendment 79 to Annex 3 - *Meteorological Service for International Air Navigation* concerning space weather advisory information**

That, the proposal to amend Annex 3 provisions related to space weather, as given in **Appendix F** of this report**,** be included as part of draft Amendment 79 to Annex 3 — *Meteorological Service for International Air Navigation* with intended applicability in November 2020.

4.4.4 In a related issue, the Panel reviewed **WP/2302**, presented by Colin Hord and Pat Murphy, the Rapporteurs of the WG-MOG and WG-MISD respectively, regarding the development of a Space Weather Operations oversight capability under the METP. The Panel noted that during the fourth MISD meeting, it had been assumed that the production and dissemination of the Space Weather Advisory product by the two global space weather centres to be designated will be subject to ICAO oversight similar to the IAVW and WAFS under relevant work streams of the WG-MOG. The Panel noted that there could be some differences between the Space Weather operations and the operation of the VAACs and WAFCs which may influence how the Panel may develop acceptable oversight.

4.4.5 The Panel noted **IP/6203** Presented by Larisa Trichtchenko on coordination and collaboration procedures for the future Space Weather Centres. The Panel noted the content related to a draft version of a concept of Collaborative Decision Analysis and Forecasting (CDAF) model adjusted to serve the needs of Space Weather Centres on the issuance of space weather advisories. Therefore it formulated the following recommendation:

Recommendation 4/7: Initial coordination and governance of the space weather information service

That the Panel expeditiously establish:

a) A coordination group, comprised of, at a minimum, representatives of the ICAO-designated global and regional space weather centres and experts of the METP WG-MISD, to facilitate the coordination between the centres necessary to ensure the provision of consistent space weather information coincident with initiation of the ICAO space weather information service; and,

b) An appropriate group, working as part of the METP WG-MOG and comprised of METP Members and Advisors with expertise in space weather and representatives from the ICAO-designated space weather centres, to develop the initial governance necessary to provide oversight of the space weather information service.

4.4.6 The Panel turned its attention to **WP/2303**, presented Pat Murphy,the Rapporteur of the WG-MISD, concerning an update on the development of the future *Manual on Space Weather in Support of International Air Navigation*, Doc 10100. The Panel noted that Job card METP.009.01 tasked the METP to develop “considerations on the use of space weather information and the various impacts space weather events could have on international air navigation.” The Panel noted the draft manual presented as Appendix A to WP/2303 and noted the process of development of the referred manual since a WG-MISD Space Weather Work Stream virtual meeting on 26 April 2017. In this regard, it was noted that the work was progressed through 7 virtual meetings and one face to face meeting (METP WG-MISD/4, 7 May 2018). The progress included five draft versions of the manual, which were released to the WG-MISD Space Weather Work Stream for review and comments. A sixth draft version of the manual was presented at the METP WG-MISD/4 meeting. The consultation process comprised approximately 600 comments, which were processed, from approximately 20 individuals and associated partner groups and organizations. The Panel was pleased with the process and endorsed the content of the draft manual. Therefore it formulated the following decision:

Decision 4/3: Manual on Space Weather Information in Support of International Air Navigation

That Version 1.0 of the *Manual on Space Weather information in Support of International Air Navigation,* as contained in **Appendix G** to this report and endorsed by the Panel, be expeditiously published by ICAO to support the implementation of Amendment 78 to Annex 3 applicable in November 2018.

4.4.7 The Panel reviewed **WP/2304**, presented Pat Murphy as the Rapporteur of the WG-MISD, concerning a revision of Job Card METP.009.03 Development of Provisions for Information on Space Weather to International Air Navigation. In this regard the Panel noted that the WG-MISD Space Weather Work Stream made significant progress over the past 12 months in developing the Annex 3 amendment proposal and actions described in the Job Card METP.009.03. However, additional work remains to be done and the Job Card requires revision to reflect this work. In this regard the Panel noted that the proposed updates were related to the status of Work Programme Element (WPE) 9843; the need to take out references to an “associated roadmap”; update regarding Annex 3 amendments and the need to assign a new WPE concerning the update of Doc 10100. The Panel agreed with the suggested updates and formulated the following recommendation:

Recommendation 4/8: Proposed Revision of Job Card METP.009.03

That the proposed revision of Job Card METP.009.03 *Development of Provisions for Information on Space Weather to International Air Navigation,* as given in **Appendix H** to this report and endorsed by the Panel, be presented to the ANC for its consideration.

4.5 World Area Forecast System (WAFS) (*Ref: Job card METP.010.01)*

4.5.1 No papers presented under this Agenda Item.

4.6 Sulphur dioxide from volcanic eruptions in the atmosphere (*Ref: Job card METP.012.01)*

4.6.1 The Panel noted **IP/2401**, presented by the WG-MISD Rapporteur, containing a report of the status of the activities of the Volcanic Ash and Sulphur Dioxide (VASD) Work Stream. In this regard the Panel appreciated the ongoing work on additional study and tests to recommend a threshold level of sulphur dioxide in the aircraft cabin while in flight that poses a health threat to aircraft occupants. It was also noted that the Job Card for Sulphur Dioxide is being reviewed together with the updated work plan for sulphur dioxide.

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APPENDIX A

Draft Amendment to Annex 3 concerning SIGMET information for radioactive cloud (Table A6-1A and Example A6-4)

Table A6-1A. Template for SIGMET and AIRMET messages

…

…	…	…	…
Location (C)[20, 30]	Location (referring to latitude and longitude (in degrees and minutes))	… *or*[29] WI nnKM (or nnNM) OF Nnn[nn] or Snn[nn] Wnnn[nn] or Ennn[nn]	… WI 30KM OF N6030 E02550~~‡~~
…	…	…	…
Movement or expected movement (C)[20, 24, 31]	Movement *or* expected movement (direction and speed) with reference to one of the sixteen points of compass, *or* stationary	… *or* STNR	… STNR
…	…	…	…
Forecast position (C)[20, 24, 25, 30]	Forecast position of phenomenon at the end of the validity period of the SIGMET message	… *or*[29] WI nnKM (or nnNM) OF Nnn[nn] or Snn[nn] Wnnn[nn] or Ennn[nn]	… WI 30KM OF N6030 E02550~~‡~~
…	…	…	…

~~‡ Applicable 7 November 2019.~~

Notes.—

…

29. Only for SIGMET messages for radioactive cloud. ~~When detailed information on the release is not available, a~~ Use a radius of up to 30 kilometres (or 16 nautical miles) from the source ~~may be applied;~~ and a vertical extent from surface (SFC) to the upper limit of the flight information region/upper flight information region (FIR/UIR) or control area (CTA)~~ is to be applied. *[Applicable 7 November 2019]*~~.
30. For SIGMET messages for radioactive cloud, only within (WI) is to be used for the elements “location” and “forecast position”.
31. For SIGMET messages for radioactive cloud, only stationary (STNR) is to be used for the element “movement or expected movement”.

Example A6-4. SIGMET message for radioactive cloud

YUCC SIGMET 2 VALID 201200/201600 YUDO –
YUCC AMSWELL FIR RDOACT CLD OBS AT 1155Z WI 30KM OF N6030 E02550 SFC/FL550 STNR ~~S5000 W14000 – S5000 W13800 – S5200 W13800 – S5200 W14000 – S5000 W14000 SFC/FL100 WKN FCST AT 1600Z WI S5200 W14000 – S5200 W13800 – S5300 W13800 – S5300 W14000 – S5200 W14000~~

Meaning:

The second SIGMET message issued for the AMSWELL* flight information region (identified by YUCC Amswell area control centre) by the Donlon/International* meteorological watch office (YUDO) since 0001 UTC; the message is valid from 1200 UTC to 1600 UTC on the 20th of the month; radioactive cloud was observed at 1155 UTC within 30 kilometres of 60 degrees 30 minutes north 25 degrees 50 minutes east between the surface and flight level 550. The radioactive cloud is stationary ~~an area bounded by 50 degrees 0 minutes south 140 degrees 0 minutes west to 50 degrees 0 minutes south 138 degrees 0 minutes west to 52 degrees 0 minutes south 138 degrees 0 minutes west to 52 degrees 0 minutes south 140 degrees 0 minutes west to 50 degrees 0 minutes south 140 degrees 0 minutes west and between the surface and flight level 100; the radioactive cloud is expected to weaken in intensity; at 1600 UTC the radioactive cloud is forecast to be located within an area bounded by 52 degrees 0 minutes south 140 degrees 0 minutes west to 52 degrees 0 minutes south 138 degrees 0 minutes west to 53 degrees 0 minutes south 138 degrees 0 minutes west to 53 degrees 0 minutes south 140 degrees 0 minutes west to 52 degrees 0 minutes south 140 degrees 0 minutes west~~.

* Fictitious location

— — — — — — — —

APPENDIX B

Proposed Revision of Job Card METP.006.02

METP.006.02	Further development of provisions for information on the release of radioactive material into the atmosphere
Source	MET Divisional Meeting 2014 (Recommendation 2/8)
Problem Statement	The release of radioactive materials into the atmosphere could pose a risk to aircraft operations and the health of its occupants, air traffic and aerodromes. Recent events highlighted the need to continue and enhance existing international arrangements and procedures. to keep aircraft operations out of areas affected by the release of radioactive material into the atmosphere
Specific Details	It was recommended by the MET Divisional Meeting 2014 (Recommendation 2/8) that an appropriate ICAO expert group, in close coordination with WMO, further develop provisions for information on the release of radioactive material into the atmosphere. The development of this task should include the main legacy tasks from the International Airways Volcano Watch Operations Group (IAVWOPSG) that relate to radioactive release. It should be taken into account that further development of provisions should be consistent with the evolving Global Air Navigation Plan (Doc 9750), including integration of the information produced into the future system-wide information management (SWIM) environment underpinning the future globally interoperable air traffic management system. This development will be supported by the World Meteorological Organization (WMO) Commission for Basic Systems (CBS) Expert Team on Emergency Response Activities (ET-ERA) and the International Atomic Energy Agency (IAEA) Inter-Agency Committee on Radiological and Nuclear Emergencies. ~~Recognizing that the provision of improved information about the release of radioactive material relevant to aviation operations is a difficult challenge to address, the METP is pursuing two parallel efforts. In Amendment 78 to Annex 3, the METP will propose provisions to allow for the issuance of a cylinder-shaped SIGMET and, in certain instances, allow a cylindrical SIGMET to cross the boundaries of adjacent FIRs. Simultaneously, the METP, in consultation with appropriate expert groups, will develop guidance for the provision of information about airspace potentially affected by the release based on airborne transport dispersion modelling using a default source term.~~
Expected Benefits	To continue and enhance the provision of information on the release of radioactive material into the atmosphere to avoid the risks posed to flight safety by aircraft operations in areas affected by the release. Integrate the information produced into the SWIM environment in line with the GANP.
Reference Documents	Annex 3 — Meteorological Service for International Air Navigation, Global Air Navigation Plan (Doc 9750), Manual of Aeronautical Meteorological Practice (Doc 8896), Part II, Manual on Coordination between Air Traffic Services, Aeronautical Information Services and Aeronautical Meteorological Services (Doc 9377), Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds (Doc 9691), Concept of operations for radioactive material information services in support of international air navigation, 10 December 2012, Draft Version 0.3, Meteorology (MET) Divisional Meeting (2014) Report, Doc 10045.
Primary Expert Group:	Meteorology Panel (METP)

	WPE No.	Document Affected or Actions Needed	Description of Amendment proposal or Action	Supporting Expert Group	Status	Expected dates:		
						Delivery	Effective	Applicability
✓	1695	Annex 3	Proposals for inclusion in Amendment 78 to Annex 3 to meet operational requirements in line with the GANP and to integrate the information on the release of radioactive material into the		~~On-schedule~~ Complete	Q3 2016	Jul 2018	Nov 2018

			atmosphere into the SWIM.					
✓	9584	Electronic Air Navigation Plans (eANP)	Based on Annex 3 provisions, provide draft amendment proposals for eANPs as necessary		~~On-schedule~~ Removed	~~Q3 2017~~	~~Nov 2018~~	~~Nov 2018~~
✓	9585	Manual of Aeronautical Meteorological Practice (Doc 8896)	Updates to support the implementation of Annex 3		~~On-schedule~~ Removed	~~Q3 2017~~	~~Nov 2018~~	~~Nov 2018~~
✓	9586	Manual on Coordination between ATS, AIS and AMS (Doc 9377)	Updates to support the implementation of Annex 3		~~On-schedule~~ Removed	~~Q3 2017~~	~~Nov 2018~~	~~Nov 2018~~
✓	9587	Manual on VARMTCC (Doc 9691)	Updates to support the implementation of Annex 3		~~On-schedule~~ Removed	~~Q3 2017~~	~~Nov 2018~~	~~Nov 2018~~
✓	9834	Annex 3	Proposals for inclusion in Amendment 79 to Annex 3 to meet operational requirements in line with the GANP and to integrate the information on the release of radioactive material into the atmosphere into the SWIM.		~~On-schedule~~ Complete	Q3 2018	Jul 2020	Nov 2020
✓	9835	Manual of Aeronautical Meteorological Practice (Doc 8896)	Updates to support the implementation of Annex 3		On-schedule	Q3 2019	Nov 2020	Nov 2020
✓	9836	Manual on Coordination between ATS, AIS and AMS (Doc 9377)	Updates to support the implementation of Annex 3		On-schedule	Q3 2019	Nov 2020	Nov 2020
✓	9837	Manual on VARMTCC (Doc 9691)	Updates to support the implementation of Annex 3		On-schedule	Q3 2019	Nov 2020	Nov 2020
✓	9838	Electronic Air Navigation Plans (eANP)	Based on Annex 3 provisions, provide draft amendment proposals for eANPs, as necessary.		On-schedule	Q3 2019	Nov 2020	Nov 2020
		Action	Update Concept of Operations Radioactive Material Information Services in Support of International Air Navigation.		On schedule	Q1 2019		

Status:	Priority:	Initial Issue Date:	Date Approved by ANC:	Session / Meeting:
Approved	-	17 June 2015	07 June 2017	205-4

RATIONALE

APPENDIX C

Regional Hazardous Weather Advisory Service Concept
RHWAS Concept
(taken directly from Section 3 of METP/4 WP/2201)

PROPOSAL

The discussions amongst the MISD/RHWAC Work Stream ad hoc group resulted in the following high-level concept proposal for Regional Hazardous Weather Advisory System (RHWAS).

Coverage and coordination
Once established, the RHWACs will provide users with phenomena-based, regional hazardous weather information that is not constrained by Flight Information Region (FIR) boundaries. Figure 1 shows examples of how these advisories may be displayed across FIR boundaries.

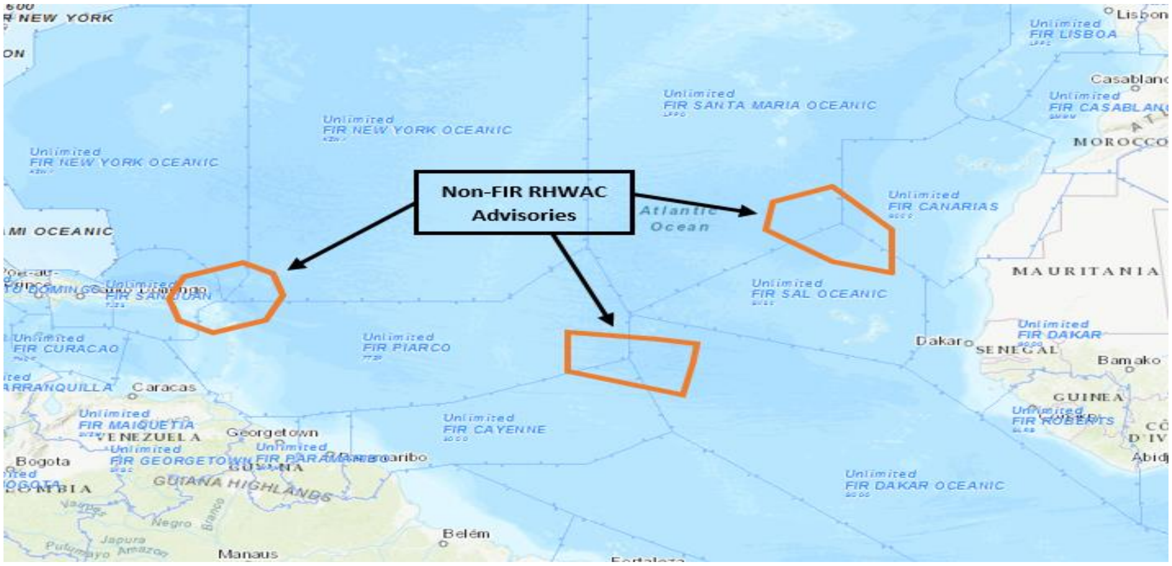

Figure 1. Examples of RHWAC advisories

Once fully implemented, the cross-FIR advisory service will provide global coverage and harmonization. This approach ensures seamless information between participating service providers, with no forecast discontinuities at the boundaries of the service providers' area of responsibilities which is a core principle of this concept. This harmonization will require the establishment of a coordination and collaboration program between participating regional service providers and WAFS, and between regional service providers and local Meteorological Watch Offices (MWOs). An example of coordination flow among participating regional providers to include first guess global numerical weather prediction fields provided by WAFS is shown in

Figure 2, where the regional providers may coordinate with MWOs in the area of responsibility to jointly maintain accurate and timely advisory services.

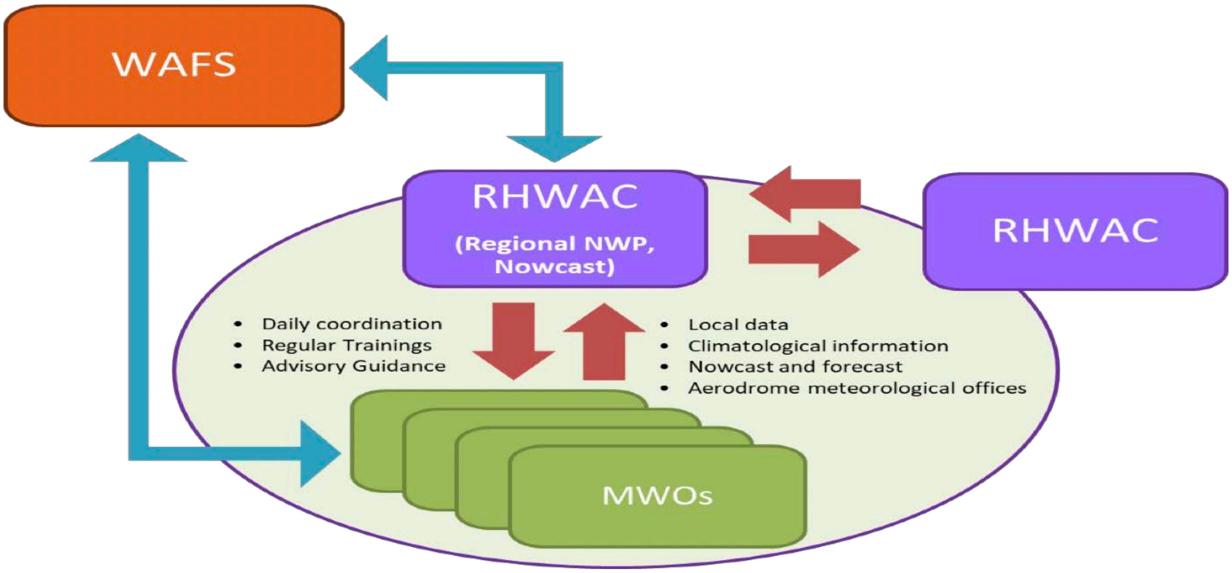

Figure 2. Example of coordination among participating regional providers to include first guess global numerical weather prediction fields provided by WAFS

Format

This new service will use global, regional, and local meteorological observations, nowcasts, and forecasts (e.g. World Area Forecast System, satellite, radar, aircraft data). It will replace the SIGMET for all phenomena except, initially, volcanic ash, tropical cyclone, and radioactive cloud. However, in the future, the service may cover all phenomena and will be of equivalent or higher meteorological standard as the actual SIGMET.

The information will focus on the short-term time scale (as determined by the performance requirements based on user needs). Initially, it will be provided in IWXXM format (yet to be developed) to suit the SWIM environment.

Initially, the information provided will be of sufficient spatial resolution (as determined by the performance requirements) to provide air navigation service providers, operators and flight crews with information on the hazard that is similar in resolution to today's SIGMETs. Eventually, the information provided should have sufficient temporal and spatial resolution (as determined by the performance requirements) to provide the flight crew with a more realistic depiction of the hazard, compared to today's box-shaped SIGMETs.

Roadmap

ICAO Doc. 10039, *Manual on System Wide Information Management (SWIM)*, describes general SWIM concepts and characteristics, and the MET SWIM Plan, *Plan for Meteorology in System Wide Information Management (SWIM)*, provides further detail on the role of aeronautical meteorology in SWIM, including design concepts.

To accomplish a smooth transition, an RHWAS Roadmap will be developed. The RHWAS Roadmap will describe the transition plan and associated timelines for implementing RHWAC advisories in SWIM. The Roadmap will include tables and figures (with descriptive text) to illustrate the transition goals.

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APPENDIX D

Draft Amendment to Annex 3 concerning SIGMET coordination

(Editorial note: New paragraph and consequently renumber the following paragraphs)

3.4.4 ***Recommendation.****— An MWO should~~, whenever necessary,~~ coordinate ~~its~~ SIGMET~~s~~ with ~~its~~ neighbouring MWO(s) especially when the en-route weather phenomenon extends or is expected to extend beyond ~~its FIR~~ the MWO's specified area of responsibility, in order to ~~issue~~ ensure harmonized SIGMET~~s across FIR boundaries~~ provision.*

Note.— Guidance on the bilateral or multilateral coordination between MWOs of Contracting States for the provision of SIGMET can be found in the Manual of Aeronautical Meteorological Practice (Doc 8896).

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APPENDIX E

Proposed Revision of Job Card METP.007.02

METP.007.02	Develop provisions for a phenomena-based, globally-consistent, regional advisory system for select en-route hazardous meteorological conditions
Source	Source MET Divisional Meeting 2014 (Recommendation 2/9 and 4/4) and METP-WG/MISD/2-SN/15
Problem Statement	Long-standing deficiencies in the reporting and forecasting of en-route hazardous meteorological conditions have persisted for many years in some regions with an identified need for the provision of phenomenon-based globally consistent information. In certain areas of the globe, the problem is particularly acute with little or no service at all.
Specific Details	The 2014 MET Divisional Meeting recommended that an appropriate ICAO expert group, in close coordination with WMO, expeditiously develop provisions supporting the implementation of a phenomenon-based regional advisory system for select en-route hazardous meteorological conditions considering users' long-standing requirements for those States where notable SIGMET-related deficiencies persist (Recommendation 2/9). The problem statement provided by the users on the METP, particularly IATA, IFALPA, and IFATCA, reveals that the problem of inconsistent information across FIR boundaries (i.e., lack of phenomena-based coverage), insufficient granularity of forecasts, excessive forecast latencies, and other deficiencies exist over many parts of the world, not just in a few specific regions. Therefore, the users identified a need for phenomena-based, globally-consistent regional advisory system for select en-route hazardous meteorological conditions. The users also recognized the need to develop, in parallel, guidance required for near-term improvement in those areas of the globe with the greatest service deficiencies. Related needs, such as cost recovery mechanisms and governance (Recommendation 4/4), and integration of improved and new services into the SWIM environment, will be undertaken.
Expected Benefits	Increased safety and efficiency of global aviation operations enabling operators to avoid areas of hazardous meteorological conditions.
Reference Documents	Annex 3 — Meteorological Service for International Air Navigation, Global Air Navigation Plan (Doc 9750), Manual of Aeronautical Meteorological Practice (Doc 8896).
Primary Expert Group:	Meteorology Panel (METP)

	WPE No.	Document Affected or Actions Needed	Description of Amendment proposal or Action	Supporting Expert Group	Status	Expected dates:		
						Delivery	Effective	Applicability
✓	1696	Annex 3	Proposals for inclusion in Amendment 78 to Annex 3 to encourage States to cooperate in providing needed services to mitigate current SIGMET deficiencies		~~On-schedule~~ Completed	Q3 2016	Jul 2018	Nov 2018
✓	9588	Manual of Aeronautical Meteorological Practice (Doc 8896)	Update related guidance to support the implementation of amendment 78 to Annex 3		On-schedule	Q3 2017	Nov 2018	Nov 2018
✓	9589	Electronic Air Navigation Plans (eANP)	Based on Annex 3 provisions, provide proposed amendments		On-schedule	Q3 2017	Nov 2018	Nov 2018

			to the eANPs, as necessary.					
		Actions	Develop user needs and short-fall analysis for phenomena-based, globally-consistent en-route hazardous weather information		On-schedule	Q1 2019	N/A	N/A
		Actions	Update Concept of Operations for phenomena-based, globally-consistent en-route hazardous weather information		On-schedule	Q3 2020	N/A	N/A
		Actions	Develop Roadmap for the provision of phenomena-based, globally consistent en route hazardous weather information		On schedule	Q3 2020	N/A	N/A
✓	1697	Actions	Develop guidance for use by ICAO in identifying potential providers of phenomena-based, globally-consistent en-route hazardous weather information		On-schedule	Q3 2021 ~~2019~~	Nov 2022 ~~2020~~	Nov 2022 ~~2020~~
✓	9839	Annex 3	Provisions to enable the establishment of a regional advisory system(s) that will provide phenomenon-based, globally consistent en-route hazardous weather information for select hazardous meteorological conditions.		On-schedule	Q3 2020 ~~2018~~	Jul 2022 ~~2020~~	Nov 2022 ~~2020~~
✓	9840	Manual of Aeronautical Meteorological Practice (Doc 8896)	Update related guidance material to support implementation of Amendment ~~79~~80 to Annex 3		On-schedule	Q3 2021 ~~2019~~	Nov 2022 ~~2020~~	Nov 2022 ~~2020~~
✓	9841	Electronic Air Navigation Plans (eANP)	Based on Annex 3 provisions, provide proposed amendments to the eANPs, as necessary.		On-schedule	Q3 2021 ~~2019~~	Nov 2022 ~~2020~~	Nov 2022 ~~2020~~

Status:	Priority:	Initial Issue Date:	Date Approved by ANC:	Session / Meeting:
Approved	-	17 June 2015	07 June 2017	205-4a
RATIONALE				

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APPENDIX F

Proposed changes to Annex 3 concerning space weather

APPENDIX 2. TECHNICAL SPECIFICATIONS RELATED TO GLOBAL SYSTEMS, SUPPORTING CENTRES AND METEOROLOGICAL OFFICES

…

6. SPACE WEATHER CENTRES

…

Table A2-3. Template for advisory message for space weather information

…

7	Space weather effect and intensity (M)	Effect and intensity ~~of~~ of the space weather phenomena	SWX EFFECT:	HF COM MOD *or* SEV [AND][2] *or* SATCOM MOD *or* SEV [AND][2] *or* GNSS MOD or SEV ~~*or*~~ ~~HF COM MOD *or* SEV AND GNSS MOD *or* SEV~~ [AND][2] *or* RADIATION MOD *or* SEV	SWX EFFECT: SWX EFFECT: SWX EFFECT: ~~SWX EFFECT:~~ ~~SWX EFFECT:~~ SWX EFFECT: SWX EFFECT:	HF COM MOD GNSS SEV HF COM MOD AND SATCOM MOD AND GNSS MOD RADIATION MOD SATCOM SEV
8	Observed or expected extent of space weather phenomena (M)	Time: day, time in UTC; Observed (or forecast if phenomena have yet to occur); horizontal extent [~~2~~3] (latitude bands and longitude in degrees) and/or altitude of space weather phenomena	OBS *or* FCST SWX:	nn/nnnnZ DAYLIGHT SIDE *or* HNH *and/or* MNH *and/or* EQN *and/or* EQS *and/or* MSH *and/or* HSH *and* Wnnn(nn) *or* Ennn(nn) – Wnnn(nn) *or* Ennn(nn) *and/or* ABV FLnnn *or FLnnn–nnn* *or* Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – [Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]] *or* NO SWX EXP	OBS SWX: FCST SWX: OBS SWX:	08/0100Z DAYLIGHT SIDE 08/0100Z HNH HSH W18000 — W09000 ABV FL350 08/0100Z HNH HSH E18000-W18000

…

Notes.—

…

2 One or more effects with the same intensity may be combined.

~~2~~ 3. One or more latitude ranges may ~~should~~ be included in the space weather advisory information ~~for "GNSS" and "RADIATION"~~.

…

ATTACHMENT E. SPATIAL RANGES AND RESOLUTIONS FOR SPACE WEATHER ADVISORY INFORMATION

Note.— The guidance contained in this table relates to Appendix 2, 6.1 Space weather advisory information.

Element		Range	Resolution
Flight Level:		250-600	~~3~~10
Longitudes for advisories:	(degrees) (minutes)	000 – 180 00	15 0
Latitude bands for advisories:	High latitudes northern hemisphere (HNH)	N9000 - N6000	30
	Middle latitudes northern hemisphere (MNH)	N6000 - N3000	
	Equatorial latitudes northern hemisphere (EQN)	N3000 - N0000	
	Equatorial latitudes southern hemisphere (EQS)	S0000 - S3000	
	Middle latitudes southern hemisphere (MSH)	S3000 - S6000	
	High latitudes southern hemisphere (HSH)	S6000 - S9000	

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APPENDIX G

Manual on Space Weather Information in support of International Air Navigation

Doc 10100

Manual on Space Weather Information in Support of International Air Navigation

Approved by the Secretary General and published under his authority

First Edition – 2018

International Civil Aviation Organization

TABLE OF CONTENTS

LIST OF APPENDICES

Chapter 1

INTRODUCTION

1.1 GENERAL

1.1.1 From an operations perspective, space weather events occur when the Sun causes disruptions to aviation communications, navigation and surveillance systems, and elevates radiation dose levels at flight altitudes. Space weather events may occur on short time scales, with the effects occurring from seemingly instantaneous to a few days hence.

1.1.2 From a broader perspective, the World Meteorological Organization (WMO) defines space weather to be, "The physical and phenomenological state of the natural space environment, including the Sun and the interplanetary and planetary environments." This more-comprehensive definition cuts a broader swath across the system, to include the slowly varying Galactic Cosmic Rays (GCR) coming from outside the heliosphere as well as the repetitive high-speed solar wind streams from voids in the solar corona. In short, not all space weather stems from eruptions, but also from variations in the flow of charged particles, photons, and magnetic field.

1.1.3 Space weather forecasts for international air navigation, address particular types of disturbances, i.e. solar radiation storms, geomagnetic storms, ionospheric storms, and solar flares. In addition, predictions of the slowly varying elements; i.e. GCR and high-speed-stream-induced geomagnetic storms, are also produced. These forecasts enable operators the opportunity to be situationally aware and to formulate alternative plans should the impending conditions be of a magnitude and a type that could disrupt normal operations.

1.1.4 The goal of this document is to enable operators to make informed decisions when space weather impacts occur. A proper balance between operationally relevant information and scientific completeness is sought. In many areas, more scientific rigor and detail could be brought forward, but that would not enhance this manual's utility to the aviation community. There is a deeper explanation of the science underpinning the field of space weather science in Appendix 2.

1.2 SPACE WEATHER INDICATORS

1.2.1 The effects of space weather come from processes that are invisible to the human eye. The sole exception are the brilliant auroras, spawned by energetic electrons and ions. Energized auroras indicate the deposition of energy into the upper atmosphere, and may herald the degradation of communications, navigation, and surveillance on aircraft in the vicinity.

1.2.2 For space weather events, the signs of their occurrence and system impacts are very subtle in real time. Given that, the prime value of space weather information is to enhance situational awareness of the proper function of aircraft systems. Anticipating and planning for degraded performance of communications and navigations systems add to the margins of safety. Often degraded performance is unavoidable, but being ready to respond to it with a pre-conceived plan is most desirable.

1.2.3 On the occasions when the effects are apparent, the signs of system impacts may include:

a) Erratic, degraded, or unavailable high frequency (HF) voice communications that worsen very quickly, especially when the aircraft is in the sunlit hemisphere or operating in high latitudes and polar regions;

b) Data and voice dropouts on satellite communications (SATCOM) links, especially for frequencies less than 2 GHz;

c) a variance in positioning between the Actual Navigation Performance (ANP) and the Global Navigation Satellite System (GNSS)-based performance;

d) reduced availability of GNSS augmentation systems; and

e) reboot of on board electronics or display of indications of non-standard performance.

1.2.4 It is not realistic to expect an aircrew to be aware of the slowly occurring variations of space weather, so-called "space climate", in real-time. Nevertheless, indicators such as the change in GCR flux allow an awareness of the variability. The change in GCR flux over an 11-year solar activity cycle (see Appendix 2, Section 3, for explanation of the 11-year solar cycle) is opposite of the conventional solar cycle – GCR is highest when sunspots are lowest – and may be as much as a factor of two at altitudes where commercial aircraft fly.

1.2.5 Some indicators of this slow GCR flux change may include:

a) more than normal avionics (computer) inconsistencies and reboots; and

b) more than normal interruptions of SATCOM for all frequency bands as satellite-borne electronics experience radiation-induced upsets.

1.3 THE HAZARDS

1.3.1 Space weather impacts occur to communications, navigation, surveillance, radiation-sensitive electronics, and human exposure. Beyond the more generic indicators described in section 1.2, the system impacts may include:

a) unexpected loss of communications;

— HF voice and HF data link, i.e. Controller Pilot Data Link Communications (CPDLC), on routes where HF is employed;

— poor or unusable performance of L-band SATCOM;

b) degraded performance of navigation and surveillance that rely on GNSS;

— Automatic Dependent Surveillance – Broadcast (ADS-B) and/or Automatic Dependent Surveillance – Contract (ADS-C) anomalies;

— sporadic loss-of-lock of GNSS, especially near the equator, post-sunset;

c) unanticipated non-standard performance of on-board electronics, resulting in reboots and anomalies; and

d) issues related to radiation exposure by aircrew and passengers.

1.3.2 Over the longer term, the slowly varying component of GCR incrementally adds to effective dose over the lifetime of the passengers and aircrew. The radiation can also cause single event upsets to on board electronic systems. An awareness of the changing GCR flux allows post-facto troubleshooting of operational system issues, as well as serving to educate and inform the passengers and aircrew.

1.4 SPACE WEATHER MITIGATION ASPECTS

1.4.1 Space weather events affecting aviation can be sudden and, at times, unpredictable. For example, dayside HF radio blackouts often come with no warning. Solar radiation storms offer some opportunity for prediction, but at times, radio blackouts, are very fast to impact systems and humans.

1.4.2 Geomagnetic storms, by their nature, are the response of Earth's magnetic field to enhanced energy from the Sun, and are the slowest to eventuate. From the fastest of about 18 hours from the solar eruption, to more commonly a few days from the Coronal Mass Ejection (CME) launch, these events offer forecasters the longest lead time. Even longer lead times are possible with the prediction of recurring high-speed solar wind streams that also cause typically less intense geomagnetic storms. These events may be accurately predicted weeks in advance.

1.4.3 The timely availability of reliable and consistent space weather information (observations and forecasts) is essential to mitigate the safety risk of aircraft losing key in-flight functionality. The designated Space Weather Centres (SWXC) have at their disposal information from satellite and ground-based sensors enabling both prompt event detection as well as providing input for predictive models. Physics-based models are now available to operations centres to predict the trajectory of CMEs and there now exists an ability to predict the onset of a geomagnetic storm to about +/- eight hours. Ionospheric storms, to first order, can be predicted in a similar way.

1.5 COORDINATING THE RESPONSE TO A SPACE WEATHER EVENT

1.5.1 There are many contributors to the overall space weather risk mitigation system such as Air Navigation Service Providers (ANSP) including Aeronautical Information Services (AIS), Air Traffic Flow Management (AFTM) units, surveillance and communication providers, operators, States, Civil Aviation Authorities (CAA), and SWXCs. Their cooperation in assessing, coordinating and providing information relevant for pre-flight and in-flight decision making is essential for effective mitigation of any potential impacts from a space weather event.

1.5.2 Information on the procedures of these units in respect to operations in areas forecast to be affected by space weather is available in International Civil Aviation Organization (ICAO) documents including:

a) Annex 3 – *Meteorological Service for International Air Navigation*

b) Annex 10 - *Aeronautical Telecommunications*

c) Annex 15 – *Aeronautical Information Services*

d) Doc 9377 - *Manual on Coordination between Air Traffic Services, Aeronautical Information Services, and Aeronautical Meteorological Services*

e) Doc 8896 - *Manual of Aeronautical Meteorological Practice*

f) Doc 9849 – *Global Navigation Satellite System (GNSS) Manual*.

1.5.3 This manual, in providing advice to States on addressing the role of the aircraft operator and of the corresponding CAA, is complementary to the documents listed above.

Chapter 2

SPACE WEATHER PHENOMENA AND AVIATION OPERATIONS

2.1 GENERAL

2.1.1 Various types of eruptive space weather disturbances whose occurrence vary over the eleven-year solar cycle, can directly impact critical systems used in aviation. In addition, long-term variability in GCR can also enhance the radiation environment in which these systems function. A prudent approach to formulating actions is to understand what types of conditions may occur, and what systems are most likely to be affected during storm times.

2.1.2 In the design and implementation of aviation systems and procedures, space weather impacts are known and appreciated. It behooves aircrew and operations personnel to understand the full extent of these impacts when the environment is highly disturbed and systems are stressed.

2.2 GEOMAGNETIC STORMS

2.2.1 Geomagnetic storms are strong disturbances in the Earth’s (geo) magnetic field. These are the response to a heightened energy flux carried by the solar wind. The solar wind is the continuous outflow from the Sun of magnetic field and charged particles. Its speed and composition varies dramatically from the normal ambient state to greatly enhanced levels that fuel geomagnetic storms. This energy may come from a CME, an explosive solar event, or the more-gentle sweep of a high speed solar wind stream as it rotates past Earth.

2.2.2 The strongest geomagnetic storms are caused by CMEs; high-speed solar wind streams are typically less intense. The duration of storms varies from a few hours to as long as a few days.

2.2.3 High latitudes and the polar regions bear the strongest impacts, as evidenced by the brilliant auroras seen in the auroral zone that accompany the storms. Lower latitudes experience auroral surges during very intense activity, but typically are less affected. Equatorial regions see but minor impacts. Communication and navigation system impacts from storms are, however, global in longitude.

2.2.4 The frequency of geomagnetic storms, in general, mimics the 11-year solar activity, or sunspot, cycle. A closer inspection of the historical record shows a bi-modal distribution. The strongest storms cluster near solar maximum, as they are usually caused by CMEs, whereas a second peak in activity happens during the declining phase of the solar activity cycle, due to the stable solar coronal holes emanating high-speed solar wind streams.

2.2.5 The strongest storms occur at the rate of approximately four per 11-year cycle. Lesser-sized but significant storms have been observed to occur approximately 200 times per cycle. It should be noted, though, that geomagnetic storms can occur at any time. Even in the quiet of solar minimum, isolated CMEs do occur and can perturb the Earth’s magnetic field.

2.3 IONOSPHERIC STORMS

2.3.1 Ionospheric storms are the result of adding energy to the weakly ionized plasma that is the ionosphere, which extends upward from about 60 km. In most cases, due to the close coupling between the ionosphere and the magnetosphere, they occur in tandem with geomagnetic storms. The intertwined physical relationship between the ionosphere and the magnetosphere causes difficulties when distinguishing which system is affected by a disturbance. For aviation, the physical perturbation in the ionosphere is the primary driver for impacts to HF and GNSS. The boundary of the auroral zone that moves during geomagnetic storms, is significant for radiation effects.

2.3.2 The symptoms of an ionospheric storm are: enhanced electrical currents, magneto hydrodynamic turbulence and wave activity of the plasma. The electrodynamics lead to a non-homogeneous distribution of plasma, particularly in the region about 350 km in altitude. Neutral winds also contribute to the irregular distribution of free electrons and ions.

2.3.3 GNSS signals, originating at the satellite orbiting at about 20,000 km in altitude, pass through this disturbed region and retain their unique characteristics so as to be identified and processed by the GNSS receiver on an aircraft in flight. During ionospheric storms, GNSS amplitude and phase may each be affected making the signals of one or more satellites in view impossible to track. This loss-of-lock may result in reduced positioning accuracy or, at worst case, a denial of GNSS service. In addition, variability in the free electrons along the path of a GNSS signal, so called Total Electron Content (TEC) results in increased range errors, and hence, errors in aircraft positioning. However, it is the gradient of the TEC that may pose the greatest challenges for aviation receivers.

2.3.4 HF propagation is adversely affected, typically during the late phases of ionospheric storms, with the unavailability of the higher end of the HF band. Long distance HF communication is enabled by reflection from the ionosphere. The maximum usable frequency (MUF) for a given communication path is the highest HF radio frequency that can be used for communication via reflection. A depression of the MUF prohibits aircraft from accessing the highest frequencies normally available.

2.3.5 Ionospheric monitoring for HF communication is achieved by monitoring the MUF over a vertical path. MUF depression for a given time of day is defined as the percentage decrease in MUF compared to a 30-day median MUF (for the same local time) in order to account for diurnal, seasonal, and solar cycle variations in ionospheric support of HF.

2.3.6 Given the physically connected relationship between geomagnetic and ionospheric storms, the durations are similar. Some incidents last for days.

2.3.7 The frequency of occurrence of ionospheric storms is also similar to geomagnetic storms with one important exception. The near-equatorial ionosphere – a band extending roughly +/- 20 degrees in latitude on either side of the magnetic (not the geographic) equator – can be very disturbed in the post-sunset hours, even in the absence of a geomagnetic storm. Processes internal to the Earth's system cause a fountain of electrons that rise from nearer the equator and fall on the higher latitude edges. Large depletions in ionospheric electron density may form post-sunset, producing strong spatial gradients in ionospheric distribution. The associated instabilities cause GNSS signals to fluctuate rapidly in amplitude and phase.

2.3.8 Amplitude scintillation can have a serious impact on aircraft using GNSS for Required Navigation Performance (RNP)-based flight navigation. Aircraft lose lock on one or multiple GNSS signals and find GNSS unavailable for short periods.

2.3.9 The strongest ionospheric storms occur at the rate of about four per 11-year cycle (from the geomagnetic storm data). Less impactful storms have been observed to occur approximately 200 times during the same interval. Post-sunset equatorial scintillations interrupting GNSS occur at rates somewhere in the 200 times per cycle range.

2.3.10 Aircraft communications, particularly HF, are degraded or unavailable during geomagnetic storms. Surprisingly, some paths can actually be improved during these times, although those occurrences seem somewhat random and very difficult to foresee. Very high frequency (VHF) and ultra high frequency (UHF) links may also suffer lesser levels of degradation.

2.3.11 SATCOM may be affected during ionospheric storms, but the impacts are minimized the higher the frequency employed. For example, L-band systems may suffer losses similar to GNSS systems, whereas S, C, Ku, and Ka-band systems will rarely be impacted at all by space weather.

2.3.12 Air traffic management in future years plans to make a more extensive use of ADS-B, ADS-C, and SATCOM S, C, Ku and Ka data links. Fundamental to the method, GNSS navigation will enable appropriate positioning for phase of flight, and SATCOM will enable transmission of the information to/from aircraft. In that GNSS is L-band, it will be affected by adverse ionospheric conditions as has been described here. However, for communication frequencies above 2 GHz, impacts will be minimized. And since some L-band SATCOM satellites are in low-earth orbit (LEO), vs. GNSS at medium earth orbit (MEO), the signal will experience less r^{-2} attenuation; furthermore, many communication satellites have higher power transmitters than GNSS.

2.4 SOLAR FLARE RADIO BLACKOUTS

2.4.1 Solar flare radio blackouts are strictly a dayside impact. Solar flares are rapid releases of energy stored in strong, localized magnetic fields on the Sun. When an instability occurs, the speed-of-light flash of X-rays and extreme ultraviolet (EUV) bathe the sunlit side within minutes. The effect is the most acute at the sub-solar point, i.e. local noon near the equator.

2.4.2 These solar flare blackouts can eliminate or degrade HF, both voice and data link, for periods ranging from a few minutes to a few hours. The duration of the impact is much shorter than it is during geomagnetic storms. The affected range of HF frequencies is also quite different. During solar flare radio blackouts, the lower frequencies are lost, similar to the early to mid-phase of a geomagnetic storm. During the latter stages of geomagnetic storms, it is the upper range of HF frequencies that is most affected or completely lost.

2.4.3 Solar flare radio blackouts are most frequent during solar maximum years, and rare during solar minimum years. But during maximum years, there can be as many as 10-20 episodes of solar flare radio blackout on a given, active day.

2.4.4 The worst solar flare radio blackouts occur at a rate of 1 to 2 per 11-year cycle. Less impactful events occur approximately 175 times per 11-year cycle. It should be noted that even low levels of blackout intensity – happening about 2,000 times per cycle – still impede dayside HF communications for a few minutes at a time.

2.4.5 On rare occasions, L-band radio bursts during solar flares are strong enough with the proper polarization to affect GNSS receivers, right hand circularly polarized (RHCP), to overwhelm the reception of GNSS signals for short periods of time (5-10 minutes). This is strictly a dayside impact and primarily seen by non-aviation-type GNSS receivers employing high-precision techniques. The most notable example of this interference occurred in December 2006.

2.4.6 Since aircraft employ a more-robust application of GNSS for navigation, it is highly unlikely this impact would ever be seen in aviation. It has also been noted that dayside HF and UHF radars can be adversely affected by strong solar radio bursts. In 2015 secondary surveillance radars were impacted by solar radio noise.

2.5 SOLAR RADIATION STORMS

2.5.1 Solar radiation storms occur when charged particles, primarily protons, are energized and accelerated in processes occurring near the Sun or beyond. These particles are guided by the interplanetary magnetic field and, under the right conditions, engulf the Earth with additional radiation.

2.5.2 High altitude aircraft flights are susceptible to the ill effects of the added radiation dose, but are protected due to the Earth's atmosphere and magnetic field. Protection increases with lower altitudes (where the atmosphere is more dense) and lower latitudes (where the magnetic field is more horizontal). If an aircraft responds by flying lower in latitude and/or altitude, only events with abnormally high energy (greater than 500 MeV) protons elevate the radiation dose experienced in flight.

2.5.3 Polar and near-polar flights are the most exposed during solar radiation storms. There the geomagnetic field topology allows easy access for the radiation to penetrate through the atmosphere, from the poles to about 60 degrees geomagnetic latitudes. In lower latitudes, the dipole-like magnetic field configuration inhibits the transit through the atmosphere.

2.5.4 Degraded HF during smaller, more commonplace radiation storms, termed Polar Cap Absorption (PCA) can be present for many days at high latitudes., This impact results from energetic proton precipitation into the D-region ionosphere below approximately 100 km.

2.5.5 Solar radiation storms can be long-lived, persisting up to a week, resulting in degraded HF communications at high latitudes for a similar period. Geomagnetic storms also drive the normal boundary (approximately 60 degrees geomagnetic) for increased radiation further equatorward by perhaps an additional 10 degrees in both hemispheres.

2.5.6 Solar radiation storms occur in cadence with the solar cycle with peak occurrence near solar maximum. However, they can occur at any time in the cycle, even very intense ones. The worst solar radiation storms occur roughly just 1-2 times per cycle. Events significantly impacting polar aviation operations may happen 10-15 times.

2.5.7 Solar radiation storms, particularly those with an abundance of high-energy protons, pose concerns for radiation exposure for aircrew and passengers. Aircrews are designated as radiation workers. The United States National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP) have established 45-year exposure limits in NCRP Publication 160, Section 7, and ICRP Publication 132, Section 2.4, respectively.

2.5.8 Semi-conductors in avionics can malfunction during these events in a seemingly random manner. Single event upsets may cause a reset to a computer system. Over the long term, radiation damage may hasten failure of the chip.

2.5.9 Solar radiation storms add to the ever-present GCR-induced radiation dose that, to varying degrees, affects every place on Earth. GCR is addressed in the last section of this chapter. The sum of the two components is the radiation background. It changes with time, place, and level of activity.

2.6 ATTRIBUTES OF ERUPTIVE SPACE WEATHER

2.6.1 Figure 2-1 is a summary of the individual elements described in this chapter. It shows the various types of solar and interplanetary phenomenology, the varying times of propagation to Earth, the domains near the Earth that are affected, and at the far right, potential impacts.

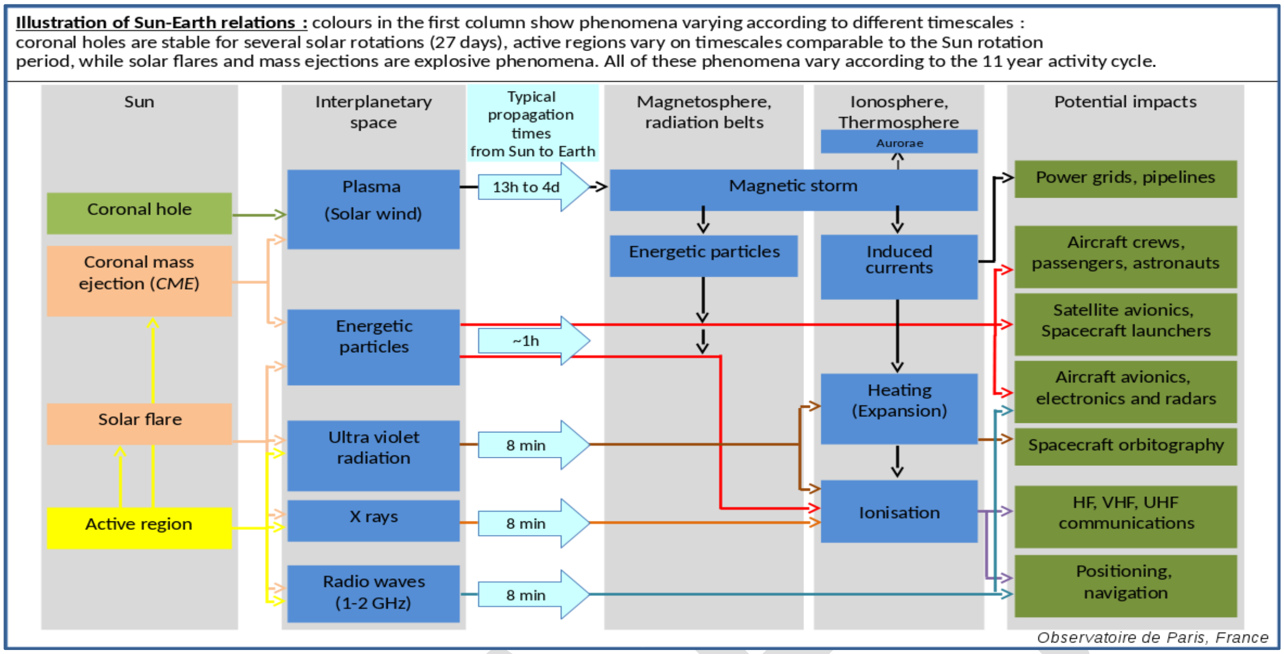

Figure 2-1. Schematic diagram of space weather from Sun to Earth

Note. —All the above phenomena maximize in occurrence and potential impacts to airline operations in the solar maximum epoch.

2.6.2 The sole exception to the focus of activity near solar maximum relationship is GCR. In the following section, properties of GCR are given and an explanation of why it is they are the strongest when the Sun is at its weakest.

2.7 GALACTIC COSMIC RAYS

2.7.1 GCR are the slowest changing element in the suite of variables. Originating in distant supernovae, they are kept to a minimum near the Earth when the Sun is eruptive and producing flares and CMEs, due to the turbulence that activity spawns in the inner heliosphere. As a result, the magnitude of the GCR is inversely correlated (Figure 2-2) with the solar activity cycle.

2.7.2 GCR flux changes over the solar cycle, with its maximum occurring at solar minimum. This variability is a function of energy, location, and altitude of the detector. For typical commercial flight altitudes, the variation is about a factor of two; i.e. the flux is double during solar minimum from solar maximum. However, there are conditions during which the background GCR can quickly abate, due to large-scale shocks, for a few hours at a time. These depletions of GCR are known as "Forbush Decreases."

2.7.3 Higher GCR cause elevated radiation to be measured on polar and high-latitude flights. GCR rates also increase with altitude, until it maximizes at around 18 000- 19 500 metres (60-65,000 feet), the so-called "Pfotzer Maximum." Similar to solar radiation storms, the impacts are focused on health-related issues for the aircrew and passengers, as well as proper functionality of avionics.

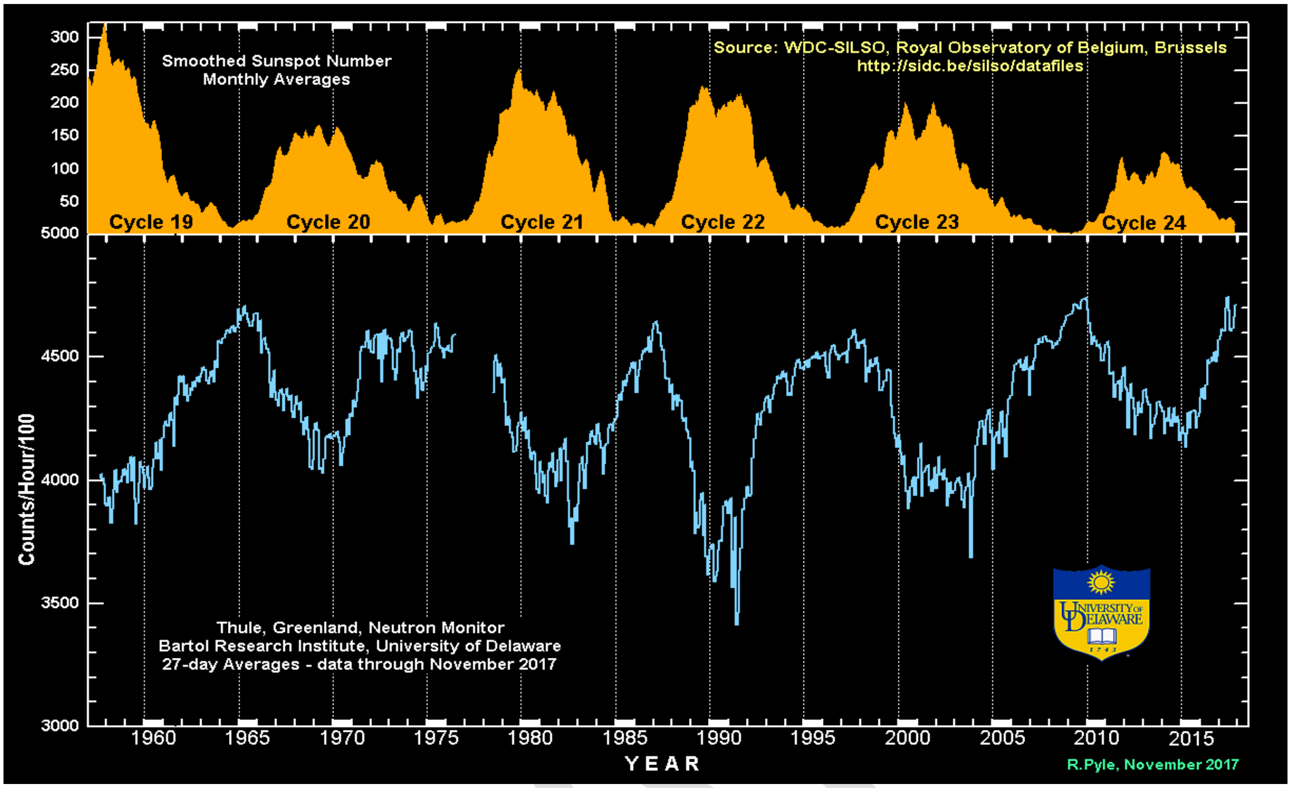

Figure 2-2. Relationship between solar cycles, depicted by sunspots (top panel) and neutrons measured at sea level from GCR (bottom panel); note the anti-correlation between the two quantities.

2.7.4 The goal of this document is to strike a balance between operationally relevant information and scientific completeness. In this chapter, more detail could have been brought forward, but it is considered that it would not have enhanced its utility to the aviation community. Additional details on the sources of space weather are nevertheless provided in Appendix 2.

Chapter 3

PROVISION OF SPACE WEATHER ADVISORY INFORMATION

3.1 GENERAL

The information and services required for safe and efficient aircraft operations will be provided by two designated global centres, assisted by as many as four regional centres passing relevant information to the global centres for dissemination. The working principle for the centres is to provide space weather advisory information that users can employ for decision-making.

3.2 SPACE WEATHER CENTRES (SWXC)

3.2.1 There are basic requirements for the centres, not limited to, but including, reliability, sustainability, and connectivity, to both the users of the services as well as the inflowing data and observations necessary for the products defined by the ICAO Standards and Recommended Practices (SARPs).

3.2.2 Currently, the SWXCs support a broad user base. These users typically include electric power entities, satellite operators, emergency managers, and a myriad of other interested parties. Aviation products must have a high priority in the formulation and distribution of the required space weather advisory information due to the prompt effects on aircraft navigation and communication systems as well as radiation impacts to passengers and aircrew.

3.2.3 The SWXCs are responsible for providing all necessary services in view of issuing space weather advisory information in a timely manner. Specifically, the data and model output must include:

a) ionospheric scintillation (amplitude and phase), and TEC for GNSS;

b) effective dose for radiation; and

c) Kp, PCA, Solar X-ray flux (or equivalent), and MUF for HF.

3.2.4 In some cases, physics-based models are envisioned to support the requirements stipulated by SARPs, in particular, for radiation. The SWXCs must have access to the model and be able to provide output from the model as quickly as possible. It is recognized that input data will have some latency, and performance requirements will evolve to the cadence of the model-based information being disbursed.

3.2.5 The SWXCs must be staffed 24 hours a day/ 7 days a week. Operations personnel are required to keep abreast of the current conditions and disseminate for short-term forecasts as defined in the SARPs.

3.2.6 All SWXCs must develop coordination protocols and procedures to enable clear and unambiguous information disseminated to the aviation industry.

3.3 SPACE WEATHER ADVISORY INFORMATION

3.3.1 Amendment 78 to Annex 3 introduced a requirement to issue space weather advisory information when necessitated by space weather events. The space weather advisory message is similar in structure to advisory messages issued for tropical cyclones and volcanic ash clouds, issued by the tropical cyclone and volcanic ash advisory centres concerned.

3.3.2 SWXCs issue the space weather advisory when impacts to HF communications, communications via satellite, GNSS-based navigation and surveillance systems, or heightened radiation occurs.

3.3.3 The advisory message informs the user of:

a) the type of impact;

b) the expected onset, or that the event is already in progress;

c) the duration of the event;

d) a generalized description of the spatial extent affected for the next 24 hours; and

e) a description of the severity of the impact in moderate (MOD) or severe (SEV) categories.

3.3.4 The space weather advisory uses the spatial ranges and resolutions as shown in Attachment E to Annex 3.

3.4 COMBINATIONS AND USE OF THE COVERAGE DESCRIPTIONS

3.4.1 GEOMAGNETIC STORMS

3.4.1.1 Geomagnetic storms perturb the ionosphere to affect HF communications and GNSS navigation in the high latitude (HNH and HSH) regions and sometimes include middle latitude (MNH and MSH) regions. Equatorial regions (EQN and EQS) may be affected during the worst of storms.

3.4.1.2 If an event were strong enough to produce moderate degradation in the equatorial regions, it would likely be severe in the middle and high regions. In this case, there would be two advisories issued, one for the severe event affecting the high and middle latitudes (HNH, HSH, MNH and MSH), and a second advisory for the moderate event affecting the equatorial latitudes (EQN and EQS).

3.4.1.3 Combinations of latitude bands include:

a) HNH and HSH

b) HNH, HSH, MNH and MSH

c) EQN and EQS

d) MNH, MSH, EQN and EQS

Note.1. — A single band (e.g. HNH) would not be used for geomagnetic storms since both poles are affected.

Note.2. — Altitudes (e.g. ABV FLnnn) are not used.

3.4.1.4 When using the latitude bands, the latitudes are used to indicate the horizontal extent. Normally the entire latitude band is affected, thus E18000 – W18000 was chosen for the example in Annex 3. Thus, E18000 – W18000 will normally follow the pairing of latitude bands.

3.4.2 IONOSPHERIC STORMS

3.4.2.1 Ionospheric disruptions, caused by scintillation, primarily affect the equatorial and high latitude regions but can also extend into the middle latitudes. In any case they may affect GNSS navigation. These perturbations can be more localized than the other space weather events and thus may be best-described using latitude and longitude coordinates. They can also be described using longitude lines and one or more of the latitude bands.

3.4.2.2 Altitudes (e.g., ABV FLnnn) are not used. Combinations include:

a) a four-sided polygon using four latitude and longitude coordinates;

b) one or more latitude bands coupled with two lines of longitude, e.g.:

— EQN Wnnn(nn) or Ennn(nn) – Wnnn(nn) or Ennn(nn)EQS Wnnn(nn) or Ennn(nn) – Wnnn(nn) or Ennn(nn)

— EQN EQS Wnnn(nn) or Ennn(nn) – Wnnn(nn) or Ennn(nn)

— MNH EQN Wnnn(nn) or Ennn(nn) – Wnnn(nn) or Ennn(nn)

— MSH EQS Wnnn(nn) or Ennn(nn) – Wnnn(nn) or Ennn(nn)

3.4.3 SOLAR FLARE RADIO BLACKOUTS

3.4.3.1 Solar flare radio blackouts degrade communications, and on rare occasions GNSS navigation, and are a “daylight side” impact only. These events may last from a few minutes to a few hours and are a much shorter duration than geomagnetic storm impacts. For the forecast portions of the advisory, the remarks section may include the statement that “periodic disruption possible on the daylight side”. Also a note that these events typically are most acute on the lower end of the HF band. When possible include a forecast of the duration of the blackout.

3.4.3.2 Solar flares are usually very impulsive. Advisories denoting the MOD and SEV, if attained, thresholds are likely to be issued in rapid succession.

3.4.4 SOLAR RADIATION STORMS

3.4.4.1 The impacts of solar radiation storms are most intense at high latitudes and are usually confined to the HNH and HSH latitude bands. On rare occasions they could extend into the MNH and MSH. Solar radiation may be severe above a certain altitude, i.e. Flight Level (FL), and moderate below. For example SEV ABV FL340, MOD FL250-340, which will require two advisories.

3.4.4.2 When two advisories are issued for the same area, it is important that the number of the other advisory and the intensity be stated in the remarks section. For example, an advisory for MOD radiation from FL250-340 would include in the remarks “SEE SWX ADVISORY NR 2018/7 FOR SEV RADIATION ABV FL340”.

3.4.4.3 Radiation storms are the only events that will use altitudes, i.e. ABV FLnnn. Combinations include:

a) HNH and HSH E18000 – W18000 ABV FLnnn

b) MNH and MSH E18000 – W18000 ABV FLnnn

c) EQN and EQS E18000 – W18000 ABV FLnnn

d) HNH, HSH, MNH and MSH E18000 – W18000 ABV FLnnn

e) HNH, HSH, MNH, MSH, EQN and EQS E18000 – W18000 ABV FLnnn

f) HNH and HSH E18000 – W18000 FLnnn–nnn

g) MNH and MSH E18000 – W18000 FLnnn–nnn

h) EQN and EQS E18000 – W18000 FLnnn–nnn

i) HNH, HSH, MNH and MSH E18000 – W18000 FLnnn–nnn

j) HNH, HSH, MNH, MSH, EQN and EQS E18000 – W18000 FLnnn–nnn

3.4.4.4 In accordance with Attachment E to Annex 3, the range for the flight levels is from FL250 to FL600, with a resolution of 30, i.e. 3,000 feet. Usable flight levels for the advisory are: FL250, FL280, FL310, FL340, FL370, FL400, FL430, FL460, FL490, FL520, FL550, and FL580.

3.5 GEOMAGNETIC VS. GEOGRAPHIC LATITUDE

3.5.1 It must be emphasized that with the exception of the “dayside” HF impact which are due to photons, all locations listed in this document are referenced to geographic – not geomagnetic – latitude. It is the Earth’s magnetic field that guides and modulates the charged particles that come from the Sun. The reality of this influence is some regions are exposed (the poles) while other regions are shielded (the equator).

3.5.2 The difference between the two coordinate systems is most pronounced in the American sector, where the magnetic field sags down over North America (Fig 3-1). As an example, Oslo (59.9^{o} N) and Minneapolis (45.0^{o} N) geographic, are at nearly the same magnetic latitude, 56.0^{o} geomagnetic. The net effect of this dipole tilt (maximized near 90^{o} W longitude) is many space weather impacts are most acute over North America. The analog in the Southern Hemisphere is southwest of Australia over the Indian Ocean, a remote sector for airline operations.

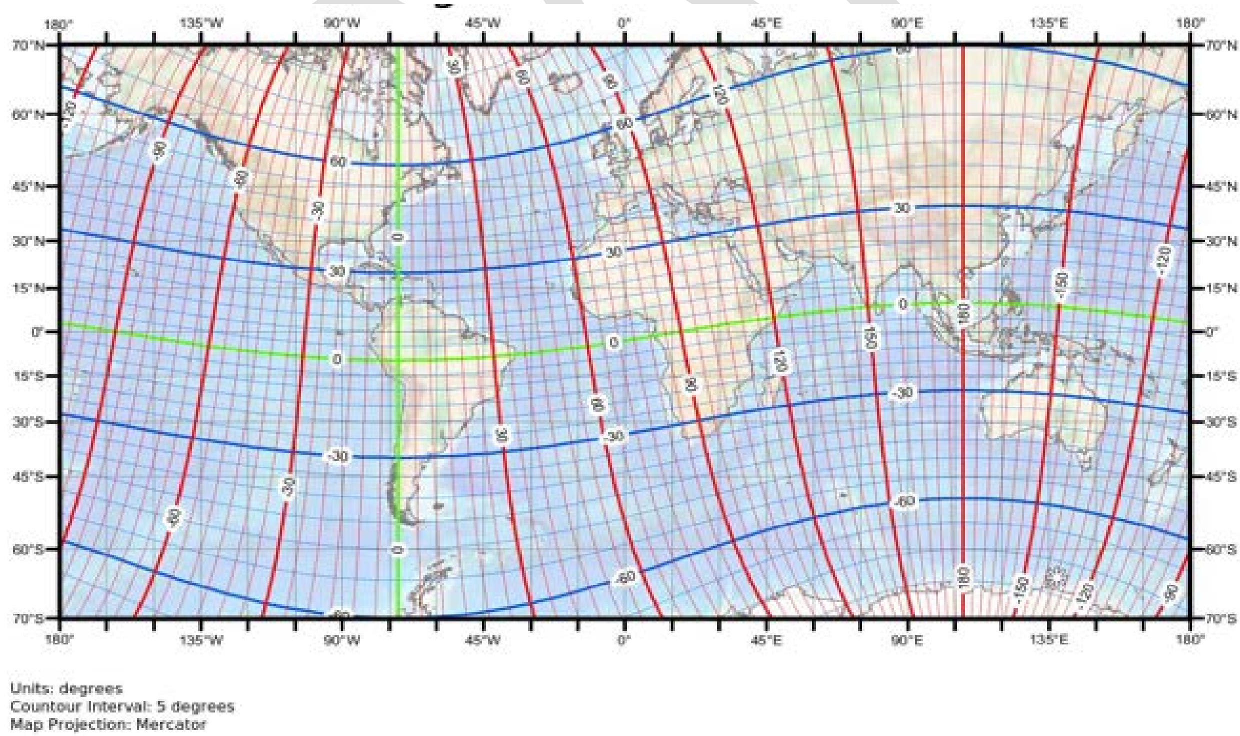

Figure 3-1. US/UK World Magnetic Chart – Epoch 2010 Geomagnetic Coordinates

3.5.3 This offset has practical consequences for aircraft operators. On polar flights between North America and Asia, the aircraft spends an appreciably longer time in the high geomagnetic latitudes where impacts to HF and GNSS are most likely. More critically, the radiation “zone,” i.e. area above 60^{o} N, is stretched southward, meaning longer travel times – and more exposure – through that region.

3.6 ADVISORY THRESHOLDS

3.6.1 Annex 3 refers to thresholds of space weather activity that trigger an advisory. As much as possible, the principle used to define these thresholds is based on impacts to systems rather than phenomenological severity. Unfortunately, the data does not exist for a 1-1 correspondence between system degradation and space weather intensity; therefore estimates are necessary in some cases. This approach makes it necessary for periodic updates to this document, as improvements to the technologies that support critical systems occur.

3.6.2 Table 3-2 is a list of thresholds for the various types of space weather events affecting aviation. Categories are listed as Moderate or Severe, as referenced in the Space Weather Advisory Message in Annex 3.

Table 3-2. Thresholds for space weather advisory

		Moderate	Severe
GNSS			
	Amplitude Scintillation (S4)(dimensionless)	0.5	0.8
	Phase Scintillation (Sigma-Phi)(radians)	0.4	0.7
	Vertical TEC (TEC Units)	125	175
RADIATION			
	Effective Dose (micro-Sieverts/hour)*	30	80
HF			
	Auroral Absorption (Kp)	8	9
	PCA (dB from 30MHz Riometer data)	2	5
	Solar X-rays (0.1 - 0.8 nm)($W\text{-}m^{-2}$)	$1X10^{-4}$ (X1)	$1X10^{-3}$ (X10)
	Post-Storm Depression (MUF)**	30%	50%

** MOD advisories will only be issued when the MOD threshold is reached at FL460 and below. SEV advisories will be issued when the SEV threshold is reached at any flight level.*
*** As compared to a 30-day running median of the critical frequency of the F2 layer (foF2).*

Note. — A more detailed description of how these values were determined can be found in Appendix 1 to this manual.

3.7 EXAMPLES OF SPACE WEATHER ADVISORY MESSAGES

3.7.1 Examples of space weather advisory messages are provided in Annex 3, Appendix 2. Examples A2-3, A2-4 and A2-5 relate to GNSS and HF COM effects; RADIATION effects; and HF COM effects, respectively.

3.7.2 Space weather advisory messages may include multiple categories, e.g. GNSS and HF, HF and RADIATION.

3.8 ACCURACY GOALS FOR SPACE WEATHER ADVISORY INFORMATION

3.8.1 Like all forecasts, space weather advisory information is assessed on its accuracy. Similar to terrestrial weather predictions, forecasts of the extreme events draw the most attention. A key difference between terrestrial and space weather forecasts is the vast volume of space and the sparse data that space weather forecasters are faced with.

3.8.2 Accurate predictions of onset time, duration, and magnitude are of great importance for safety and efficiency to aircraft operators. False alarms and missed events factor into the cost/loss matrices of operators as they try to make the most prudent – yet most economical – operating decisions during an event.

3.8.3 There is a challenge between providing longer lead-time and, at the same time, predicting correct intensity for space weather forecasters. The system that comprises space weather is vast, and data collection is sparse. Improvements in forecast skill do occur, but often depend on new science missions that are infrequent and costly.

3.8.4 Various metrics are used in the validation and verification of space weather advisory information, similar to those used in conventional meteorology. Reliability diagrams, contingency tables, and traditional metrics such as Probability of Detection (POD), False Alarm Rate (FAR), etc., are used.

Chapter 4

USE OF SPACE WEATHER ADVISORY INFORMATION

4.1 GENERAL

Space weather advisory messages must be issued in accordance with the provisions in Annex 3. Some advisories will allow time for a well-considered response plan and no change to an already planned flight. The other extreme will be at the last minute, or enroute, necessitating a recalculation of a preordained flight plan. In many ways, these advisories will be similar to conventional, more familiar products and services documented in Annex 3. But due to the insidious impacts to systems and radiation levels, flight crews and ANSPs may be suddenly faced with situations requiring prompt action.

4.2 PRINCIPLES GUIDING BEST PRACTICES

4.2.1 Solar radiation storms are one type of space weather event that may necessitate a fast response due to the immediacy of its impacts. The lead time for the radiation advisory may be only a few minutes at most at times. In avoidance of radiation, considerations of time, distance and shielding enable decisive actions for mitigation of the threat. Solar radiation storms are the sole space weather type that can be mitigated by shielding.

4.2.2 Shielding from radiation consists of protection by (assuming that the skin of the aircraft provides negligible shielding):

a) the overhead atmosphere. That is, the lower the altitude, the greater protection by the air overhead; and

b) the geomagnetic field. When the field vector is more horizontal than vertical, charged particles are diverted away. The Earth's magnetic field is vertical at the poles and horizontal at the equator, so flying at lower latitudes increases the shielding.

4.2.3 Making use of time and distance flexibility may lessen impacts from other space weather scenarios.

4.3 RESPONDING TO A SPACE WEATHER EVENT

4.3.1 FLIGHT CREW

4.3.1.1 Advisories of imminent or on-going disruptions to HF, GNSS, and occurrence of radiation effects enable alternate route planning, or delayed use of polar routes. Options may include:

a) time – delayed entry into regions specified in the advisory. Radiation and some HF advisories typically have very short (minutes) lead times, whereas the majority of the HF and GNSS advisories may have hours before the threshold is reached;

b) distance – not only avoiding specified regions, but in the case of radiation, flying at a non-optimal but lower altitude for more shielding by the atmosphere. A roughly 2 100-metre (7,000-foot) decrease in altitude decreases the radiation dose by approximately 50%. Polar flights may consider planning lower latitude routes where practicable (the geomagnetic latitude where Earth's magnetic field provides an appreciable boost of shielding is about 60^{o}).

4.3.1.2 GNSS and HF degradations do not offer many mitigation options:

a) time – wait for the disturbance to abate;

b) distance – an element of the disruption is due to the movement overhead of structures in the ionosphere. If those trajectories can be known, then potentially a mitigation strategy could be a change in course. Changing altitude has no effect;

c) other – HF can sometimes improve by using higher frequencies during HF absorption events (solar flares, solar radiation storms) or employing lower frequencies during HF depressions (ionospheric storms). Guidance is found in the remarks section of the space weather advisory.

4.3.2 OPERATOR

4.3.2.1 Operators should develop operational procedures for managing flights in areas impacted by space weather events. Procedures should include the use of risk assessment techniques to determine informed actions based on the provision of space weather advisory information. This includes flight planning tracks using forecasts and tactical nowcasts for inflight situational awareness and re-planning. The best situation is to be able to plan12-24 hours ahead, making allowances for flight reroutes, fuel, and crew schedules. Long-haul flights may be the most problematic as options are constrained by fuel, particularly if the airplane is en route when an unpredicted event occurs.

4.3.2.2 As with ANSPs, situational awareness is very important for safe and efficient flight management. Operators should work with SWXCs to familiarize themselves with the products and services provided, as well as to develop a strong working relationship.

4.3.3 AIR NAVIGATION SERVICE PROVIDERS

4.3.3.1 Situational awareness, in the broader context of managing multiple (numerous) flights, is vital in maintaining safe and efficient operations. The insidious nature of space weather impacts to critical systems necessitates a well-designed advisory that proves useful. Unlike convective weather, there is no visual clue for space weather impacts.

4.3.3.2 ANSPs are well aware of HF issues and have many years of experience working around those. GNSS uncertainties may require greater spacing among aircraft, as a function of phase of flight.

4.3.4 CIVIL AVIATION AUTHORITY

As the statuary authority regulating and overseeing all aspects of civil aviation in each country, the CAA is responsible for properly integrating space weather into the existing docket of aviation considerations. Prescribed actions, centre requirements, and other functional necessities need to be in place to address the deleterious impacts to aviation in the State's purview.

Appendix 1

MODERATE/SEVERE CATEGORY DEFINITIONS

1. GENERAL

As much as possible, these thresholds were based on established system impacts. In some areas, i.e. GNSS, there was more data to make the link between system impacts to space weather activity. In other cases, such as radiation impacts, those data were less available. Additionally, it was much more straightforward to relate GNSS signal fades to receiver loss-of-lock, as opposed to radiation dose to the risk for travellers and flight crew.

2. SPACE WEATHER AFFECTING HF COMMUNICATIONS

2.1 Aircraft cannot avoid the impacts of solar flares as the photons travel at the speed of light and the dayside ionosphere is quickly affected. There is no advance warning for operations on the sunlit side of the earth. The value of the advisory is to alert when they occur, the duration of the impact, and post-facto troubleshooting for equipment performance questions. In regards to HF degradation, MODERATE can be thought of "weak HF communications," whereas SEVERE to be ""radio blackout or scarcely perceptible HF communications." Use R3 (X1) (175/cycle) for MOD; R4 (X10) (8/cycle) for SEV.

2.2 Radio blackouts that result during geomagnetic storms also affect HF. Typically these occur at the latter phases of a storm, and depress the HF band, making the high end of the band unusable. Use a depression of MUF against a 30 day baseline, of 50% (SEV) and 30% (MOD).

2.3 The third type of HF radio blackout is the PCA (see next section).

3. SOLAR RADIATION STORMS

3.1 Solar radiation storms can be predicted with some skill. These inhibit HF at high latitudes (PCA), and also enhance radiation on polar and high latitude flights. To predict the intensity and spatial extent of a PCA, an internationally accepted model should be used. PCA criteria, using data from a typical 30 MHz riometer, are 2.0 dB (MOD) and 5.0 dB (SEV).

3.2 Riometers give the best local measurement of the ionosphere and HF conditions. Threshold levels are defined as; MOD, 2.0 dB; and SEV, 5.0 dB. An additional requirement is that these thresholds must be attained for 15 successive minutes. Additionally, consideration by the global centre, is if a solar radiation storm is in progress, should be taken into account in the analysis of occasionally noisy one-minute riometer data. The 15-minute interval is included so as to avoid noise spikes or momentary disruptions triggering unwanted advisories.

3.3 For the health-related impacts of solar radiation storms, the best way to monitor that environment is to measure effective dose rate. Ideally, sensors with known time and position is the optimal situation. Short of that, a modelled output, from an internationally accepted model, is sufficient. Input to the model should include neutron monitor data, magnetic field data and satellite-based proton data. The output of the model will be the sum of the GCR and solar radiation components.

3.4 The thresholds for radiation are the result of consultations with both space and health scientists. SEV is an effective dose rate of 80 micro-Sievert/hour. MOD is an effective dose rate of 30 micro-Sievert/hour. The dose rates and the location and time will be the output of an accepted radiation model. In that this manual is focused on users in commercial aviation, it follows that the altitudes at which the dose rate is computed be FL460 and below.

4. GEOMAGNETIC STORMS

4.1 Geomagnetic storms allow for the longest lead time predictions, usually on the order of a few days ahead. Impacts from geomagnetic storms are: HF – and to a lesser degree, VHF – at high latitudes; GNSS applications, primarily at high latitudes, although can occur nearer the equator. Rarely are impacts seen at middle latitudes, but do occur occasionally, e.g. Halloween Storms, 2003.

4.2 A secondary effect from geomagnetic storms is the polar cap expands, extending to lower-than-normal latitudes (lower latitude auroras attest to this). That extends the area (volume) affected by enhanced radiation. Generally speaking, where the typical boundary for heightened radiation may be 60^o geomagnetic latitude, during a geomagnetic storm that may drop down to 50^o. Airplanes on polar routes will have longer intervals aloft in areas where heightened radiation exposure occurs.

4.3 MOD threshold is Kp = 8 (100 per cycle). SEV threshold is Kp = 9 (4 per cycle).

5. IONOSPHERIC STORMS

5.1 The normal sequence of events that leads to an ionospheric storm begins with a solar eruption that brings additional enormous energy to the Earth's space environment. Usually it is a CME that causes the ionospheric storm, but not always. At times the shower of energetic protons at high latitudes during a solar radiation storm triggers the ionospheric storm near the poles. And paradoxically, equatorial ionospheric disturbances can occur without any stimulus from the Sun; these disturbances come from instabilities within the domain of the magnetosphere/ionosphere.

5.2 There are a number of ways to measure ionospheric disturbances; signal amplitude scintillation, signal phase scintillation, and TEC in a column extending through the overhead ionosphere can be measured by ground-based GNSS receivers and ionosondes can measure the depressions in MUFs. Scintillations cause signal fades and receivers lose lock on signal if the scintillations are sufficiently strong. A 20 dB fade will typically cause loss of lock by the receiver.

5.3 Amplitude scintillations are measured by specialized GNSS receivers and are given by the index S4, the normalized standard deviation in the signal strength. Phase scintillations, also from specialized receivers, are categorized by the parameter sigma-phi. It is the standard deviation in phase. Typically, S4 and sigma-phi are measured over one minute intervals.

5.4 TEC varies over the globe, the highest values typically near the geomagnetic equator. Values vary by season, time of the solar cycle, and can be heightened or diminished by eruptive solar activity. High TEC results in greater range error for single frequency users. TEC of approximately 200 TEC units occurred over the south-eastern United States during the Halloween Storms in 2003. Commercial airplanes use single frequency L1 receivers. It is often the TEC gradients that challenge and inhibit the proper function of receivers on aircraft.

5.5 Large TEC gradients and scintillations can adversely affect SATCOM at times, especially for frequencies less than 2 GHz. Similar to GNSS, some providers use L-band and, as such, are affected with data losses when the ionosphere is disturbed at thresholds defined in table 3.2 for GNSS. For systems using C, Ku, and/or Ka bands (all well above 2 GHz), space weather is not a troublesome issue. Even for L-band SATCOM systems, when compared to GNSS, the signal is much stronger and the satellites are closer to earth (LEO vs. MEO), so the susceptibility to faults is diminished by design.

5.6 Ground-based ionosondes measure characteristics of the ionosphere that impact HF. Their data allow operators to derive estimates of MUFs and identify periods during which those frequencies are depressed. Typically ionospheric depressions occur during the latter phase of a geomagnetic storm, making the high end of the HF frequency band unusable.

5.7 GNSS thresholds are:

a) S4; MOD, 0.5; SEV, 0.8 (dimensionless units);

b) Sigma-phi; MOD, 0.4; SEV, 0.7 (radians); and

c) TEC; MOD, 125 TEC units; SEV, 175 TEC units (1 TEC unit = 10^{16} electrons/m2).

5.8 MUF depressions against a 30-day median of 30% (MOD) and 50% (SEV) drive the issuance of a Space Weather Advisory.

Appendix 2

SPACE WEATHER SCIENTIFIC BACKGROUND INFORMATION

1. THE SUN – PRIME SOURCE OF SPACE WEATHER

1.1 The Sun is the primary source of the conditions commonly described as space weather. The expression "space weather" is used to designate processes occurring on the Sun, in Earth's magnetosphere, ionosphere and thermosphere, which have the potential to affect the near-Earth environment. Its emissions are continuous in nature; i.e. solar luminescence, solar wind, but also can be eruptive. The eruptive aspects consist of CME, and streams of charged particles. In addition, the periodic fast solar wind streams from coronal holes contribute, especially in the declining phase of the solar cycle. The sudden eruptions cause radio blackouts, magnetic storms, ionospheric storms, and radiation storms at Earth.

1.2 Akin to the activity that originates at the Sun, GCR – the charged particles that originate in more distant supernovae – add another ingredient to the space weather mix. Essentially, these charged particles comprise a steady drizzle of radiation at Earth. On top of this background, the Sun increases the radiation levels during radiation storms, with the sum of the two components being the full extent of the potential radiation dose received. The size of the GCR levels varies inversely with the sunspot cycle. That is, when the interplanetary environment near the Earth is laminar and steady – conditions seen near sunspot minimum – the GCR component is large due to its easier access to the near-Earth environment. At sunspot maximum, the turbulence and energetics associated with solar eruptions reduces GCR access to the vicinity of the Earth.

2. THE SUN'S ENERGY OUTPUT AND VARIABILITY

2.1 The Sun is a variable star. What that means is the aggregate of the continuous emissions and the eruptive emissions changes with time. One metric that is commonly used to track this variability is the occurrence of sunspots. Observers have been recording sunspot observations continuously for hundreds, maybe even thousands, of years. There are mentions of Chinese sunspot observations from many centuries ago and, more recently, European observations for the past 400 years. Though the underlying physics is still not well understood, it is established that sunspots come and go, on average, on an 11-year period. The magnitude and duration of individual cycles varies, but typically more eruptive events occur near the height of the cycle – solar maximum – while few are observed near solar minimum. All solar electromagnetic emissions, from radio to X-rays are also stronger during solar maximum and less intense near solar minimum.

2.2 Satellite observations garnered since the 1960s have added more measurements to describe the Sun's variability over the course of the solar cycle. X-ray emissions increase by a factor of 10; EUV by a factor of 4-5; and the solar constant – the sum of all the electromagnetic energy radiated by the Sun – increases by approximately 0.1% as the Sun evolves from its quiet to its active phases.

3. SUNSPOTS AND THE SOLAR CYCLE

3.1 The sunspot cycle and solar activity cycle are loosely synonymous, with sunspots often used as a proxy index for changing space weather conditions. This is because sunspots, by their very nature, exist due to strong local solar magnetic fields, and when these fields erupt, severe space weather can occur. While sunspots are easily seen on the Sun, other factors, such as GCR, CMEs, and increased solar wind associated with coronal holes, actually cause space weather, but in most cases are more difficult to observe from the ground and cannot be described by long historical records of observation as are sunspots.

3.2 The modern record of sunspot observations extends back roughly 400 years. Galileo and other astronomers in Europe noted these "blemishes" on the surface of the Sun, and speculated as to their origin. Over time, sunspots became the standard used to track the solar variability. Figure A2-1 shows a close up of a mature sunspot group.

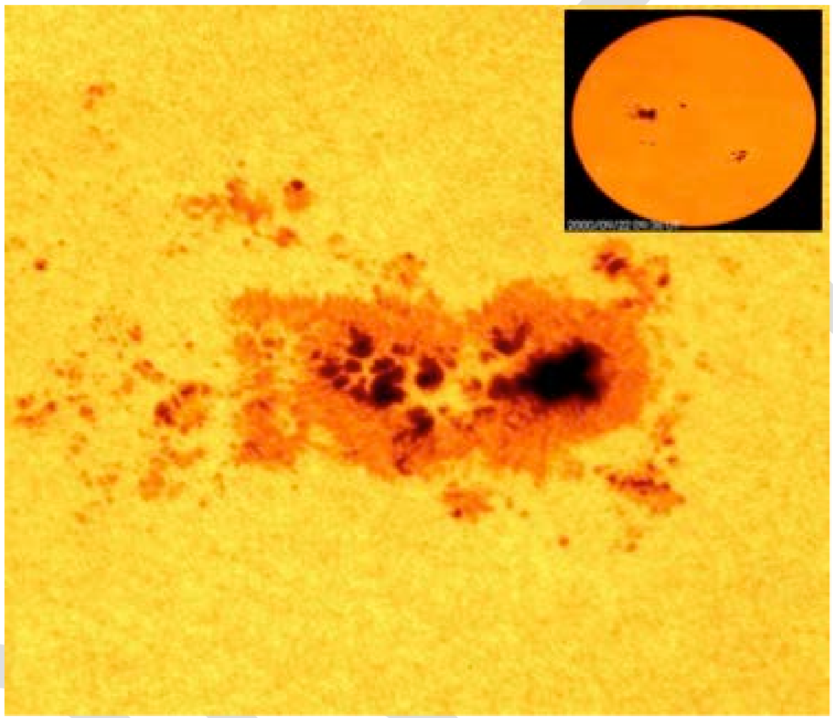

Figure A2-1. A mature sunspot group (inset: the solar disk with this sunspot group center left)

3.3 The solar activity cycle is of consequence to the aviation community as the events that affect communications, navigation, and radiation dose, vary over the 11-year solar cycle (Figure A2-2). In short, explosive solar events that affect aviation are more likely to occur, and be more severe, in the epoch near solar maximum.

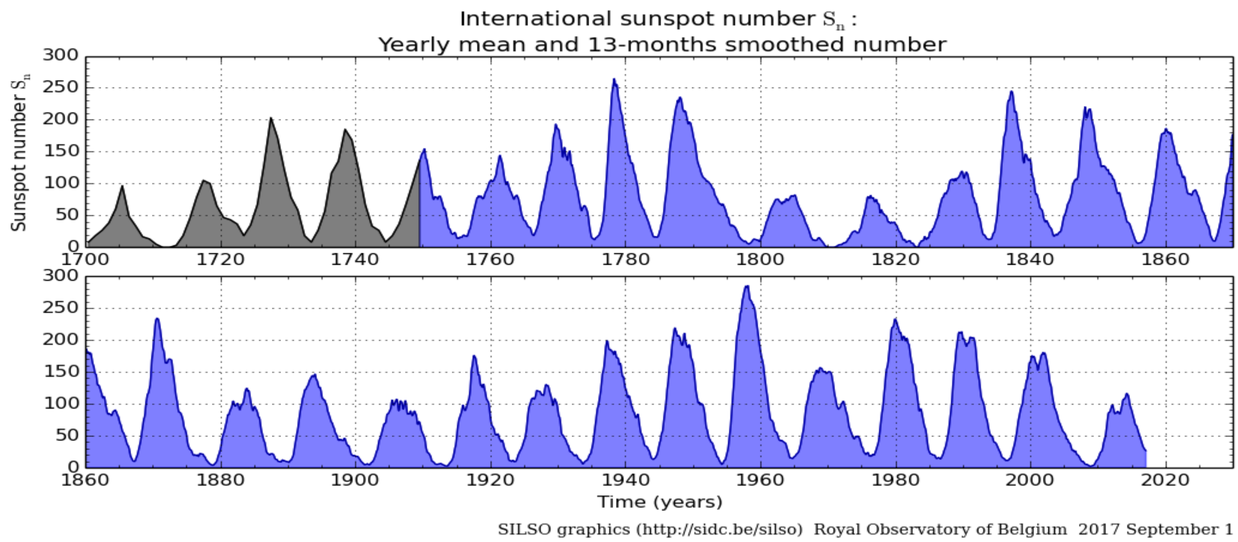

Figure A2-2. Approximately 11 year quasi-periodic variation in the sunspot number

Note. — The polarity pattern of the magnetic field reverses with each cycle. An increase of solar activity, such as solar flares and CMEs, occurs typically during the maximum sunspot period. Cycle 24 is most recent (lower right). Data with greatest uncertainty upper left (gray).

4. SOLAR WIND

4.1 The solar wind is the continuous flow away from the Sun of charged particles and magnetic field, called plasma. It is a consequence of the very high temperature of the solar corona and the resultant expansion of the plasma into space. Electrons and protons with energies of about 1 keV are the dominant constituents.

4.2 The solar wind existence was predicted by Eugene N. Parker in the 1950s who coined the term “solar wind”. This hypothesis was verified by the Soviet satellite Luna 1 in January 1959.

4.3 The solar wind carries the energy from most solar eruptions that affect the near-Earth environment. The sole exception, solar flare photons – light and X-rays– carry the energy released in solar flares. Even in the absence of an eruption, the constant flow of plasma fuels Earth’s magnetic – geomagnetic – field.

4.4 The solar wind may be fast and energetic if an eruption occurs, or can gradually increase due to a coronal hole structure, which allows unimpeded high-speed solar wind to escape from the corona. As seen from the Earth, the Sun rotates on approximately a 27-day period, so well-established coronal hole structures that persist for several months will swing by Earth on schedule, roughly every 27 days when they exist.

4.5 Clearly, knowledge of the conditions existing in the solar wind, (e.g. its speed, density, temperature, magnetic field) is necessary to specify and predict space weather. Understanding normal values for solar wind properties enables realization of typical or atypical conditions.

4.6 Typical values for density are 5 cm-3, and magnetic field, 7 nT. The average speed of the solar wind is approximately 450 km/s, roughly one million miles per hour. In round numbers, that means it takes about four days for a parcel of plasma to travel from the Sun to Earth, a distance of 93 million miles. For severe space weather events, the solar wind speed may be three, four, even five times faster. The latter was observed during the series of extreme space weather events that occurred in October of 2003. The very fast energetic solar wind causes the geomagnetic field to be extremely disturbed.

5. SOLAR ERUPTIVE ACTIVITY

5.1 Most solar eruptions originate in areas that have strong magnetic fields. Almost always with sunspots, these areas are commonly called active regions. Uniquely, the National Oceanic and Atmospheric Administration (NOAA) SWPC in the United States designates, i.e. numbers, active regions for common reference by the space weather community.

5.2 Active regions are numerous and common during solar maximum and scarce during solar minimum. Forecasters scrutinize each active region to discern its potential for eruption. The factors analysed are: the size of the region, its recent dynamic or static nature, the strength and orientation of its magnetic fields, and its recent eruptive activity history.

5.3 Flares and CMEs are two of the major types of solar eruptions. They may occur independently or at the same time. Solar flares have been recognized for more than 100 years, as they can be seen emitting in white light from the ground on rare occasions. Hydrogen-Alpha (656.3 nm wavelength) filter-equipped ground-based telescopes have been used to easily observe flares in recent years.

5.4 Flares are characterized by a very bright flash-phase, which may last for a few minutes, followed by a period of 30-60 minute decay. Flares can emit at all frequencies across the electromagnetic emission spectrum, from gamma rays to radio.

5.5 CMEs, in contrast to solar flares, are difficult to detect, not particularly bright, and may take hours to fully leave the Sun. CMEs literally are an eruption of a large volume of the solar outer atmosphere, the corona, and prior to the satellite era, they were very difficult to observe.

5.6 The energy released in a large solar flare is on par with that released in a CME, but CMEs are far more effective in perturbing the Earth’s magnetic field and are known to cause the strongest magnetic storms, due to the strong magnetic fields encapsulated in CMEs.

5.7 A typical travel time for a CME from the Sun to Earth may range from less than one day, to more than four days. The travel time of the electromagnetic emission produced during flares, by comparison travels at the speed of light – eight minutes Sun to Earth – instantaneously affecting the dayside of Earth. Forewarning of its arrival depends on predicting when a flare will occur.

5.8 The frequency of solar flares and CMEs tracks with the solar cycle. Flare rates on the order of 25/day may occur during the maximum phase of the solar cycle, while at solar minimum it may take six months or more for 25 flares to occur. CME frequency varies from about 5/day near solar maximum, to one per week or longer, at solar minimum. However, many CMEs observed lifting off the Sun are not Earth-directed and are therefore of no consequence to near-Earth technology.

6. MAGNETOSPHERE

6.1 Earth’s magnetic field, the volume of space that surrounds Earth, extends away from it as a dipole, and forms a cocoon for the planet in the flow of the solar wind. The structure – the cocoon – is called the magnetosphere. If Earth did not have a magnetic field, the solar wind would blow past unimpeded and only be affected by the mass of Earth and its atmosphere, as it adjusted downstream to the impediment it just experienced.

6.2 The magnetosphere typically extends towards the Sun about 10 Earth radii on the dayside and stretches away from the Sun many times more than that on the night side. The shape is similar to a comet tail, it being extended during strong solar wind conditions and less so during more quiet times. On its flanks the magnetosphere extends outwards roughly 20 Earth radii in the dawn and dusk sectors.

6.3 The magnetosphere deflects most of the energy carried by the solar wind while making a fraction of it available to be absorbed by the near-Earth system. When the Sun is active and CMEs interact with Earth, the additional energy disrupts the magnetosphere resulting in a magnetic storm. Then, over time the magnetosphere adjusts, through various processes, and once more returns to normal.

6.4 The most visible manifestation of the energy being absorbed from the solar wind is the aurora, both in the Northern and Southern Hemispheres. Although the auroral glow originates from the ionosphere (see next section), it is a product of the close coupling that exists between the magnetosphere and the ionosphere. Simply put, the more energy in the solar wind, the brighter and more widespread the aurora glow becomes.

7. IONOSPHERE

7.1 Nearer Earth is another region called the ionosphere. The ionosphere is a shell of weakly ionized plasma, where electrons and ions exist embedded in the neutral atmosphere. The ionosphere begins at roughly 60 km in altitude, and extends to many Earth radii at the topside. Figure A2-3 depicts ionospheric electron density distributions at sunspot maximum for day and night times.

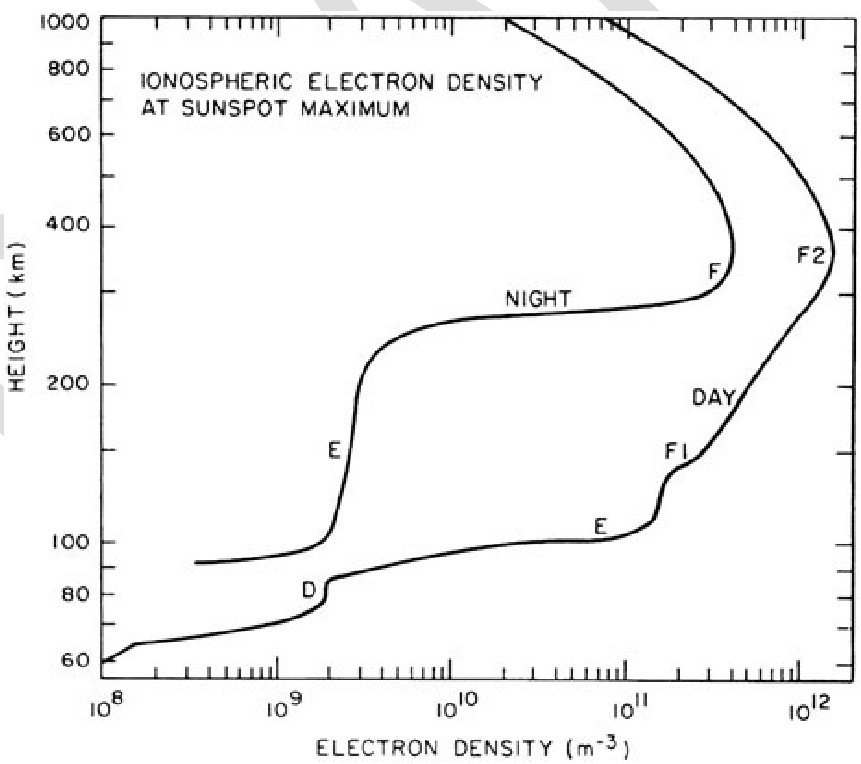

Figure A2-3. Day and night electron density distributions, from 60 to 1,000 km.

7.2 EUV solar emissions create the ionosphere by ionizing the neutral atmosphere. The electrons and ions created by this process then engage in chemical reactions that progress faster in the lower ionosphere, such as the D-Region, than higher up, in the F-Region, the most important ionospheric region. The ionosphere changes significantly from day to night, because when the Sun sets, the slower F-Region chemical processes together with other dynamic processes allows some of the ionization to remain until the new day brings the solar EUV once again. The F-Region of the ionosphere is important because it reflects short-wave radio around the curvature of Earth.

7.3 Below about 90 km some radio energy is lost through the interaction of free electrons and the atmosphere at that height. The amount of energy lost or absorbed increases as the radio wave frequency decreases. Thus the higher the HF radio frequency used, the less it is absorbed.

7.4 It is noted that ionospheric behaviour differs by latitude. At high latitudes, magnetospheric effects are dominant, while neutral atmosphere dynamics dominate low latitudes.

7.5 The ionosphere poses problems for trans-ionospheric propagation, i.e. GNSS, satellite communications, because its waves and density irregularities can distort and damage the information content of transmissions through it. However, the ionosphere is necessary for HF propagation. Therefore, it may be an obstacle or an aid, depending on the application.

7.6 The important point is that the energy that comes from the Sun in the solar wind makes its way to the ionosphere where it alters the ambient conditions either abruptly (storms) or gradually (diurnal variability). This variability may impact HF and GNSS-based activities.

8. GALACTIC COSMIC RADIATION

8.1 Galactic Cosmic Radiation, more commonly known as GCR, is a consequence of distant supernovae raining charged particles – heavy ions, protons, and electrons – onto the inner heliosphere, where the GCR have access to Earth. The abundance of GCR is a function of the solar cycle. When the solar wind flow is turbulent and strong, around solar maximum, the GCR flux is inhibited and therefore low. At solar minimum, the GCR flux increases as a function of energy.

8.2 GCRs are atomic nuclei from which all electrons have been stripped. The energy spectrum goes up to very high energies, i.e. 3 $X10^{20}$ eV. The spectrum includes the relevant energy that impacts commercial aviation altitudes. That flux is roughly twice at solar minimum what it is at solar maximum.

8.3 When high energy GCR enter Earth's atmosphere, they create a cascade of interactions resulting in a range of secondary particles – including neutrons – that make their way to Earth's surface. The neutrons are detected by ground-based neutron monitors and are indicative of high-energy particles at high altitudes. These neutrons reflect the changing radiation environment experienced at airline altitudes, and thus are a space weather issue for aviation.

Appendix 3

GLOSSARY AND EXPLANATION OF TERMS

1. GLOSSARY

A

ABV	Above
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-C	Automatic Dependent Surveillance – Contract
ATFM	Air Traffic Flow Management
AIS	Aeronautical Information Service
Annex 3	Meteorological Service for International Air Navigation
ANP	Actual Navigation Performance
ANSP	Air Navigation Service Provider

C

C-band	4-8 GHz frequency range of radio spectrum
CAA	Civil Aviation Authority
CME	Coronal Mass Ejection
CPDLC	Controller-Pilot Data Link Communications

E

EQN	Equatorial Latitudes Northern Hemisphere
EQS	Equatorial Latitudes Southern Hemisphere
EUV	Extreme Ultraviolet

F

FAR	False Alarm Rate
FL	Flight Level

G

GCR	Galactic Cosmic Rays
GNSS	Global Navigation Satellite System
GPS	Global Positioning System (United States)

H

HF	High Frequency (3-30 MHz)
HNH	High Latitudes Northern Hemisphere
HSH	High Latitudes Southern Hemisphere

I

ICAO	International Civil Aviation Organization
ICRP	International Commission on Radiological Protection

K

Ka-band	26.5 – 40.0 GHz frequency range of the radio spectrum
Kp	A 3 hourly planetary index of geomagnetic activity
Ku-band	12 – 18 GHz frequency range of the radio spectrum

L

L1	GPS frequency at 1575 MHz
L-band	1-2 GHz frequency range of radio spectrum
LEO	Low Earth Orbit

M

MEO	Medium Earth Orbit
MNH	Middle Latitudes Northern Hemisphere
MOD	Moderate
MSH	Middle Latitudes Southern Hemisphere
MUF	Maximum Usable Frequency

N

NCRP	National Council on Radiation Protection and Measurements (United States)
NOAA	National Oceanic and Atmospheric Administration (United States)
nT	nanoTesla – Unit of magnetic field measurement

P

PCA	Polar Cap Absorption
POD	Probability of Detection

R

RHCP	Right Hand Circular Polarization
RNP	Required Navigation Performance

S

S-band	2-4 GHz frequency range of radio spectrum
SARP	Standards and Recommended Practices
SATCOM	Satellite Communication
SEV	Severe
SWPC	Space Weather Prediction Center (United States)
SWXC	Space Weather Centres

T

TEC	Total Electron Content

U

UHF	Ultra High Frequency (300 – 3000 MHz)

V

VHF	Very High Frequency (30 – 300 MHz)

W

WMO	World Meteorological Organization

2. EXPLANATION OF TERMS

***Effective dose*.** A quantity defined by the ICRP that accounts for the type of incoming radiation as well as the nature of the material or organ being irradiated.

Ionosphere*.* The region of the Earth's upper atmosphere containing free electrons and ions, extending from about 60 to 1,000 km above Earth's surface.

Magnetic latitude. A coordinate system linked to the location of the magnetic poles rather than the geographic poles. It is most relevant for space weather effects as charged particles are modulated by magnetic fields and are insensitive to geographic locations.

***Magnetosphere*.** The volume of space near the Earth, influenced by the interaction between Earth's magnetic field and the solar wind.

***Scintillations*.** In the context of this document, scintillations refer to the variations in amplitude and phase of a GNSS signal located in L-band (1-2 GHz) of the radio spectrum, due to effects from diffraction and refraction.

***Solar maximum*.** A few year period, centered around the point of the 11-year solar cycle, during which solar eruptive activity is at its peak.

Thermosphere. The region of the Earth's upper atmosphere with air density so low that it is commonly referred to as outer space. It extends from roughly 90 to between 500 and 1,000 km.

Proposed Revision of Job Card METP.009.03

METP.009.03	Development of provisions for information on space weather to international air navigation
Source	MET Divisional Meeting 2014 (Recommendation 2/7)
Problem Statement	Space weather events such as solar radiation storms, solar flares, geomagnetic storms and ionospheric disturbances that impact earth pose a risk to flight safety, impacting communication, navigation systems, on board avionics and also posing a risk to the health of aircraft occupants.
Specific Details	In accordance with the MET Divisional Meeting (Recommendation 2/7), an ICAO expert group, in close coordination with WMO, shall develop provisions for information on space weather to international air navigation. The development should specifically address: a) requirements for space weather information services consistent with the concept of operations for space weather information services; b) selection criteria and associated capability for the designation of global, and regional space weather centres, including the optimum number thereof; and c) considerations on the use of space weather information and the various impacts space weather events could have on international air navigation. It should be taken into account that development of provisions should be consistent with the evolving Global Air Navigation Plan (Doc 9750), including integration of the information produced into the future system-wide information management (SWIM) environment underpinning the future globally interoperable are traffic management system. This development will be supported by the World Meteorological Organization (WMO) Inter-Programme Coordination Team on Space Weather.
Expected Benefits	To provide information on space weather and to avoid the risks posed to flight safety regarding communications, Satellite-base navigation surveillance, and avionics, as well the risk to the health of aircraft occupants (i.e. flight crew and passengers) due to radiation exposure. Integrate the information produced into the SWIM environment in line with the GANP.
Reference Documents	Annex 3 — Meteorological Service for International Air Navigation, Global Air Navigation Plan (Doc 9750), Manual of Aeronautical Meteorological Practice (Doc 8896), Manual on Coordination between Air Traffic Services, Aeronautical Information Services and Aeronautical Meteorological Services (Doc 9377), Concept of operations for space weather information in support of international air navigation, 6 December 2013, Draft version 3.0, Meteorology (MET) Divisional Meeting (2014) Report, Doc 10045.
Primary Expert Group:	Meteorology Panel (METP)

	WPE No.	Document Affected or Actions Needed	Description of Amendment proposal or Action	Supporting Expert Group	Status	Expected dates:		
						Delivery	Effective	Applicability
✓	9843	Actions	Review the WMO audit reports, indicate the optimal number of space weather information providers, and provide a summarized list giving the strengths and weaknesses of all the candidate provider States based on evaluation of the space weather information selection criteria		~~On-schedule~~ Completed	Q2 2018	Jun 2018	Jun 2018

✓	9842	Actions	Develop the new Manual to support the implementation of Annex 3 provisions related to the space weather information, including details and guidance how space weather information would be used by various aviation users, such as Airline operators, pilots, air navigation service providers (ANSP) and etc.	FLTOPSP ATMOPSP SMP NSP WMO	~~On-schedule~~Completed	Q3 2018	Sep 2018	Sep 2018
✓	9592	Manual of Aeronautical Meteorological Practice (Doc 8896)	Update related guidance to support implementation of Annex 3	NSP WMO	On-schedule	Q3 2017	Nov 2018	Nov 2018
✓	9593	Manual on Coordination between ATS, AIS and AMS (Doc 9377)	Update related guidance to support implementation of Annex 3	NSP WMO	On-schedule	Q3 2017	Nov 2018	Nov 2018
✓	1699	Actions	Finalize the concept of operations ~~and associated roadmap~~		On-schedule	Q3 ~~2017~~ 2020	~~Jul 2018~~	~~Nov 2018~~
✓	1698	Annex 3	Initial proposals for inclusion in Amendment 79 to Annex 3 additional SARPs to meet operational requirements related to the Space Weather Advisory Information Service in line with the GANP and to integrate space weather information into the SWIM.	NSP	On-schedule	Q3 2018	Jul 2020	Nov 2020
✓	9590	Electronic Air Navigation Plans (eANP)	Based on Annex 3 provisions, provide draft amendment proposals for eANPs as necessary		On-schedule	Q3 2019	Nov 2020	Nov 2020
✓	9844	Annex 3	Initial proposals for inclusion in Amendment ~~79~~ 80 to Annex 3 additional SARPS to meet operational requirements related to the Space Weather Advisory Information Service in line with the GANP and to integrate space weather information into the SWIM.		On-schedule	Q3 2020	Jul 2022	Nov 2022
		Manual on Space Weather Information in support of International Air Navigation, Doc. 10100 ~~Actions~~	Develop version 2.0 of the Manual to support the implementation of Annex 3 provisions related to the space weather information, including details and guidance how space weather information would be used by various aviation users, such as Airline operators, pilots, air navigation service providers (ANSP) and etc.	FLTOPSP ATMOPSP ~~SMP~~ NSP WMO	On schedule	Q3 2020	Jul 2022	Nov 2022

Status:	Priority:	Initial Issue Date:	Date Approved by ANC:	Session / Meeting:
Approved	-	17 June 2015	05 October 2017	206-5
RATIONALE				
Changes based on AN-MIN/206-5				

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MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Headquarters, 10 to 14 September 2018

AGENDA ITEM 5

The attached constitutes the report on Agenda Item 5 and should be inserted at the appropriate place in the yellow folder.

(12 pages)

Agenda Item 5: Meteorological information exchange *(Ref: Job Card METP. 004.01)*

5.1 METEOROLOGICAL INFORMATION EXCHANGE

5.1.1 The Working Group on Meteorological Information Exchange (WG-MIE) Rapporteur, Sue O'Rourke, informed the Panel that 13 working papers (WP) and three (3) information papers (IP) were delivered to the meeting under this agenda item pertaining to the work completed or in progress by the four work streams under WG-MIE.

5.1.2 The four (4) work streams and their coordinators are:

a) Work Stream 1 – IWXXM Requirements coordinated by Patrick Simon and Pat Murphy;
b) Work Stream 2 – MET-SWIM Plan coordinated by Aaron Braeckel;
c) Work Stream 3 – IWXXM Documentation coordinated by Tim Hailes; and
d) Work Stream 4 – Support and Coordination coordinated by Bill Maynard.

5.1.3 The WG-MIE has held two face-to-face meetings and monthly virtual meetings during the intersessional period (since METP/2). Reports from the face-to-face meetings and minutes from the virtual meetings are available on the METP secure web site.

5.1.4 Sue thanked Bill Maynard (as vice-rapporteur) and the work stream coordinators and experts for their accomplishments, noting the complex and significant nature of their work in defining future MET information exchange.

5.2 IWXXM REQUIREMENTS

5.2.1 The Panel reviewed **WP/3101** - *Missing Parameters in METAR* presented by Sue O'Rourke as Rapporteur of the WG-MIE. There is an identified need to ensure that the ICAO Information Meteorological Exchange Model (IWXXM) schema can appropriately handle missing/incorrect mandatory parameters in METAR in the traditional alphanumeric code (TAC) form so that it doesn't fail validation once translated from TAC into IWXXM. In this regard, the paper proposed updates to Annex 3 *Meteorological Service for International Air Navigation*, Doc 8896 *Manual on Aeronautical Meteorological Practice*, Doc 9328 *Manual of Runway Visual Range Observing and Reporting Practices* and Doc 9377 *Manual on Coordination between Air Traffic Services, Aeronautical Information Services and Aeronautical Meteorological Services* to indicate missing parameters with a solidi ("/").

5.2.2 It was noted that the IWXXM experts, within the WG-MIE and the World Meteorological Organization (WMO) Task Team on Aviation XML (TT-AvXML), have been considering this and looking for the most efficient option for several years. WMO manages the code form of the METAR and solidi are currently not allowed for specific elements of the FM15 code as provided by WMO No.306 *Manual on Codes* (and duplicated in Annex 3, Table A3-2). However WMO-No.386 *Manual on the Global Telecommunication System*, paragraph 2.3.3.2.8 and 2.3.3.2.9 states that:

2.3.3.2.8 The solidus (/) shall be used to indicate missing figures or letters in the text of meteorological bulletins. The solidus is represented in International Telegraph Alphabet No. 2 by the figure case position of Signal No. 24, and in International Alphabet No. 5 by Signal 2/15.

2.3.3.2.9 The procedures given above which refer to bulletins containing meteorological reports shall also apply to bulletins containing other coded information (such as TAF, CLIMAT) from specified locations.

5.2.3 The question of to whether identification of missing parameters by the use of solidi should also apply to the local routine and special report was also considered. However these reports are not yet required in IWXXM and the evolution of aerodrome observations in digital form will be investigated by the Working Group on Meteorological Requirements and Integration (WG-MRI).

5.2.4 There were concerns regarding changing the METAR template in Annex 3 given the decision at METP/2 to freeze the TAC form (refer METP/2 Recommendation 8/1) "unless a strong safety case is presented" and that it may lead to the practice of indicating a missing element when it was mandatory to report that element. It was noted that Annex 3 would still indicate which elements of the METAR were mandatory and States would need to ensure that they comply with this by implementing back-up automated and/or manual observations as is currently required.

5.2.5 The Panel further discussed the possible cost to industry to implement the use of solidi in observation systems, adaptation of receiving systems and training. It was noted that many States already use solidi for missing parameters but that it should be recognised that the change would incur a cost when the use of solidi for missing elements is introduced as a global requirement. However, there is also a cost to not receive a METAR or committing additional resources in each State to overcome the translation issues. Moreover, the meeting was mindful of the principles expressed at METP/2 regarding the TAC freeze, but the majority of the meeting indicated that solidi should be used for missing parameters in order to minimise valid METAR being rejected during the translation to IWXXM – meaning METAR will be available in IWXXM form as required from 2020. It was also noted that this is seen as essential in the transition to IWXXM and system-wide information management (SWIM). The Panel, therefore, formulated the following recommendation:

RSPP **Recommendation 5/1: Draft Amendment 79 to Annex 3 concerning missing parameters in METAR**

That, the proposal to amend Annex 3 – *Meteorological Service for International Air Navigation*, concerning the ability to indicate parameters that are missing in a METAR product with solidi ("/") as given at **Appendix A** to this report, be included in Amendment 79 to Annex 3 with intended applicability in November 2020.

Recommendation 5/2: Guidance Material about Missing Parameters in METAR

That the guidance material regarding the ability to indicate parameters which are missing in a METAR product with solidi ("/"), as provided in Appendix A to this report, be included in Doc 8896 *Manual on Aeronautical Meteorological*

Practice and Doc 9328 *Manual of Runway Visual Range Observing and Reporting Practices*.
Note: The WMO *Manual on Codes* (WMO-No. 306) would require modification for consistency.

5.2.6 The Panel reviewed **WP/3102 -** *TAC Cessation* presented by Sue O'Rourke as Rapporteur of the WG-MIE. The paper highlighted the need for IWXXM to be the primary meteorological data format, as opposed to TAC. All parameters/elements currently required in Annex 3 would remain available within IWXXM providing benefits in terms of extended content and improved data quality. It is envisaged that the human-readable products (text and graphic) would then be created from the IWXXM data. The absence of a specific date for the cessation of TAC within Annex 3 was identified as a major factor that could lead to significant IWXXM adoption issues. This may result in delays in the operational use of IWXXM data and in the introduction of internet technology as an early step towards SWIM. Thus it will be beneficial to provide multi-year advance notice for TAC to be removed as a standard in Annex 3, thus allowing States and other aviation stakeholders to procure or build alternatives and identify processes to be considered as precursors for the cessation of TAC.

5.2.7 The Panel discussed the proposed timeline emanating from the WG-MIE as follows:

a) 2024: TAC data exchange to change from a Standard to a Recommended Practice in amendment 80 to Annex 3 (2022) with applicability in 2024.
b) 2026: TAC data exchange to be removed from Annex 3.

There was discussion within the Panel to bring the date for changing to a Recommended Practice forward to 2022, however it was felt that this would not give adequate time to get the provisions into Amendment 79 to Annex 3 (2020) for applicability in 2022. While the Panel unequivocally agreed to the removal of TAC from Annex 3 not later than 2026 and the requirement to provide industry ample warning of the change (downgrading), it was felt that further investigation was required regarding the change of TAC from a standard to a recommended practice in 2024 and whether this was a necessary step. Given the above discussion the Panel formulated the following recommendations:

Recommendation 5/3: Roadmap for IWXXM and TAC

That the MET Panel:

a) Agree to propose a change to Annex 3 – *Meteorological Service for International Air Navigation* provisions to remove traditional alphanumeric code (TAC) forms from the Annex not later than 2026, ensuring adequate lead-time of this change.
b) Create a Roadmap document outlining the different steps to be considered so that the current legacy TAC products are no longer required to be distributed internationally after 2026.
c) Determine mechanisms to ensure TAC is secondary information and promote the use of ICAO Information Meteorological Exchange Model (IWXXM) data, particularly leading up to full system-wide information management (SWIM) implementation.

5.2.8 It was noted that human-readable visualisation/representation of meteorological information (text and graphic products) derived from IWXXM may still be necessary for users for human factors reasons. In this regard it was observed that ICAO and WMO could still manage these through specified means of compliance in the *Procedures for Air Navigation Services – Meteorology* (PANS-MET). However, in the first instance, the Panel agreed that resources would be better utilized in looking at developing generalized elements (as per the meteorological parameters in Annex 3) for IWXXM (i.e. build the IWXXM from the meteorological parameters rather than on existing legacy TAC products). Human-readable products/visualization can then be derived from the IWXXM. The Panel, therefore, formulated the following decision:

Decision 5/1: MET information visualisation/representation

That, in light of METP/4 Recommendation 5/3, the MET Panel consider what level of visualization/representation of meteorological information should be managed in a system-wide information management (SWIM) environment by ICAO and the World Meteorological Organization (WMO) when traditional alphanumeric code (TAC) is removed from Annex 3 – *Meteorological Service for International Air Navigation*.

5.2.9 The Panel reviewed **WP/3103 -** *Proposed Changes to TCA and TC SIGMET* presented by Sue O'Rourke, Rapporteur of the WG-MIE. The paper identified several inconsistencies, deficiencies and areas requiring further clarification in Annex 3 and associated guidance relating to the format of Tropical Cyclone Advisories (TCA) and SIGMET messages to prevent user misinterpretation, with associated safety implications. Without addressing these issues, translating TAC into IWXXM may result in IWXXM errors. The following changes to the SIGMET were proposed:

a) The addition of OBS AT and FCST AT for each location/position;
b) The removal of reference to the forecast time being the end of the SIGMET validity (already agreed at METP/2);
c) The removal of extra "or" and "00" from the example;
d) The addition of "CB" to the element "TC Forecast position";
e) The addition of “WI nnnKM (or nnnNM) OF TC CENTRE” to the element “forecast position”;
f) The separation of Note 20 into two notes so that the different requirements for WC and WV SIGMET can be distinguished; and
g) The change of Note 27 to refer to the CB rather than the TC centre.

5.2.10 The Panel noted that WP/3103 also recommended a number of changes required for the TCA to reduce inconsistencies between SIGMETs and TCAs, including:

a) The addition of a new element for “Changes in intensity” of the TC; and
b) The update of ICAO Annex 3, Section 3.7 to include new elements "Observed CB Cloud" and "Changes in intensity".

5.2.11 The Panel noted **IP/6202** – *Concerns with WP/3103* **-** *Proposed Changes to TCA and TC SIGMET* presented by Pat Murphy which raised some additional questions for clarity that may lead to future changes being required. It was therefore agreed that the "Observed CB cloud" element should be changed from conditional to optional. Given the above discussion the Panel formulated the following recommendation:

RSPP **Recommendation 5/4: Draft Amendment 79 to Annex 3 concerning Tropical Cyclone Advisory and SIGMET messages**

That, the proposal to amend Annex 3 – *Meteorological Service for International Air Navigation*, concerning the provisions related to SIGMET for tropical cyclone and tropical cyclone advisories, as given in **Appendix B** to this report, be included in Amendment 79 to Annex 3 with intended applicability in November 2020.

5.2.12 **WP/3103** also noted that confusion can often occur when there are two products trying to convey the same information. Users have previously requested that a single product representing the details of the hazardous phenomenon (such as tropical cyclones or volcanic ash) is preferred. The Panel agreed that it would be a better use of time and resources to concentrate on developing the tropical cyclone information in IWXXM form and then look at a human-readable representation of the meteorological information that can be derived from this.

5.2.13 The Panel reviewed **WP/3104 -** *ATM Information Reference Model (AIRM) Alignment* presented by Pat Murphy. In this regard the Panel noted that the Information Management Panel (IMP) was developing the ATM Information Reference Model (AIRM) to support the ICAO Global Interoperability Framework (IGIF) and to enable unambiguous information exchange using SWIM, in particular between the Aeronautical Information Exchange Model (AIXM), the Flight Information Exchange Model (FIXM), and IWXXM. A comparative analysis, sponsored by the United States' Federal Aviation Administration (FAA) in support of the IMP, mapped the elements within the AIRM to the three exchange models (XMs). Based on this mapping, recommendations were formulated to update the XMs to align them with the reference model and identify potential gaps in the XMs based on their defined scope. The Panel agreed to:

a) Align with Annex 3 in supporting legacy data capture, as referenced in the AIRM, while continuing to support modern, higher-resolution data capture;
b) Align IWXXM element names and definitions with Annex 3;
c) Define all relationship roles in IWXXM; and
d) Ensure current and future IWXXM and Annex 3 concepts and terminology align with the AIRM, by adding new concepts and products.

Therefore the Panel formulated the following decision:

Decision 5/2: ATM Information Reference Model (AIRM) alignment

That the MET Panel affirms its commitment to the *ATM Information Reference Model (AIRM)* alignment and interoperability and include this activity in the work plan for the Working Group on Meteorological Information Exchange (WG-MIE).

5.3 MET-SWIM PLAN

5.3.1 The Panel reviewed **WP/3201** - *MET-SWIM Plan and Roadmap* presented by Sue O'Rourke, Rapporteur of the WG-MIE. The paper presents the concepts, technologies, and relationships of MET-SWIM with other components of SWIM and a roadmap for implementation of meteorology (MET) in SWIM. Doc 10039 *Manual on System Wide Information Management* describes the overall

SWIM concept and Doc 10003 *Manual on the Digital Exchange of Aeronautical Meteorological Information* provides implementation guidance on aeronautical meteorological data exchange models and XML/GML. The *MET-SWIM Plan* and *MET-SWIM Roadmap* supplement these manuals with further detail on the exchange of aeronautical meteorology information within SWIM. The *MET-SWIM Plan* and *MET-SWIM Roadmap* are aimed at assisting the ICAO Planning and Implementation Regional Groups (PIRGs) and States plan for the implementation for SWIM. It was noted that, in the latest draft of Doc 10039, the architectural choices had been removed so it was felt that this should also be done in the *MET-SWIM Plan*. The *MET-SWIM Plan* and *MET-SWIM Roadmap* are both "living" documents and consultation with IMP and the Communications Panel (CP) is required. Given the above discussion the Panel formulated the following recommendation:

Recommendation 5/5: MET-SWIM Plan and Roadmap

That the Panel:

a) Endorse the version of the *MET-SWIM Plan* and *MET-SWIM Roadmap* as given in **Appendix C** to this report;
b) Invite the Secretariat to upload the *MET-SWIM Plan* and *MET-SWIM Roadmap* to the ICAO METP website (both public and secure) and to distribute it to the Planning and Implementation Regional Groups (PIRGs); and
c) Seek to further align the *MET-SWIM Plan* and *MET-SWIM Roadmap* with the concepts in Doc 10039 *Manual on System Wide Information Management.*

5.3.2 The Panel reviewed **WP/3202 -** *Distribution Requirements Common to both MET in SWIM and WIS* presented by Bill Maynard. The paper highlighted the need to ensure close cooperation between concerned ICAO Panels, between ICAO and the WMO and among States and user groups regarding globally harmonized implementation of relevant international standards and guidelines related to the access to each of the meteorological component of SWIM and the WMO Information System (WIS). WMO Resolution 40 (Cg-XII), explicitly affirms the WMO commitment to the principle of free and unrestricted exchange of meteorological and related data and products *except for* aeronautical information generated specifically to serve the needs of aviation and controlled under the Convention on International Civil Aviation (Chicago, 1944). The WIS is intended to meet the information exchange requirements of all WMO programmes, in accordance with the requirements on data sharing. Whilst MET in SWIM will have unrestricted access to any information in WIS that is relevant to aviation, there will be aviation specific elements within MET in SWIM that are not intended to be freely distributed (due to aviation cost recovery in many States). These will require anew and appropriate data policy in order to be exchanged via the WIS. The information elements that are unique to aviation, and therefore may be fully cost recoverable from aviation, need an associated data sharing policy to ensure clear and consistent access management. Therefore, the Panel reaffirmed the need for ongoing cooperation and formulated the following decision:

Decision 5/3: MET information in SWIM and WIS

That,

a) Joint members of both the Information Management Panel (IMP) and the METP are considered essential to ensure a common approach going forward; and
b) ICAO, the World Meteorological Organization (WMO) and other relevant stakeholders, must continue to work in close cooperation on the various

interoperability requirements related to ICAO system- wide information management (SWIM) and the WMO Information System (WIS).).

5.4 IWXXM DOCUMENTATION

5.4.1 The Panel reviewed **WP/3301 -** *IWXXM Related Changes to Annex 3* presented by Sue O'Rourke, Rapporteur of the WG-MIE. This paper provides some minor changes to ICAO Annex 3 relating to the exchange of IWXXM, given that IWXXM cannot be exchanged over the aeronautical fixed telecommunication network (AFTN). It was also recommended that the generic term aeronautical fixed service (AFS) be used. The paper also noted that METP/2 had agreed to make IWXXM a Standard from November 2020 for a number of operational meteorological (OPMET) products and this will be implemented in Amendment 78 to Annex 3 as a matter of course. Therefore the Panel formulated the following recommendation:

RSPP **Recommendation 5/6: Draft Amendment 79 to Annex 3 concerning to IWXXM and AFTN and AFS**

That the proposal to amend Annex 3 – *Meteorological Service for International Air Navigation*, concerning the Aeronautical Fixed Telecommunications Network (AFTN) and the Aeronautical Fixed Service (AFS), as given at **Appendix D** to this report, be included in Amendment 79 to Annex 3 with intended applicability in November 2020.

5.4.2 The Panel reviewed **WP/3302 -** *IWXXM Related Changes to Annex 10* presented by Sue O'Rourke, Rapporteur of the WG-MIE. This paper recommended some minor changes to ICAO Annex 10, Volume II, *Communication Procedures* associated with the exchange of IWXXM over the Air Traffic Services (ATS) Message Handling Services (ATSMHS) and that only OPMET information in TAC form can be exchanged via the AFTN. The meeting noted that it may be better to use the term Aeronautical Fixed Service (AFS) instead, but this should be confirmed with the Communications Panel (CP) Secretariat. Therefore the Panel formulated the following recommendation:

RSPP **Recommendation 5/7: Draft Amendment to Annex 10, Volume II concerning to IWXXM and the AFS**

That, the proposal to amend Annex 10 - *Aeronautical Communications, Volume II – Communication Procedures* including those with PANS status concerning the exchange of IWXXM over the Air Traffic Services (ATS) Message Handling Services (ATSMHS), as given at **Appendix D** to this report, be included in Amendment 92 to Annex 10 with intended applicability in November 2020.

5.4.3 The Panel reviewed **WP/3303 -** *IWXXM Related Changes to Doc 8896* presented by Sue O'Rourke, Rapporteur of the WG-MIE. This paper proposed updates to Doc 8896 to introduce

IWXXM elements and to distinguish between TAC and IWXXM versions of OPMET information, where necessary. The updates were agreed to include the following:

a) Align with Amendment 78 of Annex 3;
b) Introduce of IWXXM elements;
c) Distinguish between TAC and IWXXM versions of OPMET information;
d) Replace the reference of “XML/GML” with IWXXM;
e) Replace references to WAFS "digital form" with "gridded form";
f) Expand references AFTN to also reference the ATS Message Handling System (AMHS) to support IWXXM exchange; and
g) Modification refers to Chapters 2, 3, 4, 5, 6 and 9 and Appendices 1 and 9 of Doc 8896.

5.4.4 It was noted that paragraph 6.2.6 in Doc 8896 would require the addition of information regarding the Space Weather Advisory message. Given the above discussion the Panel formulated the following recommendation:

Recommendation 5/8: Changes to Doc 8896 pertaining to IWXXM

That, the proposed changes pertaining to the introduction of IWXXM elements and to distinguish between traditional alphanumeric code (TAC) and the ICAO Meteorological Information Exchange Model (IWXXM) versions of operational meteorological (OPMET) information, as shown in the **Appendix E** to this report, be included in Doc 8896 - *Manual of Aeronautical Meteorological Practice*.

5.4.5 The Panel reviewed **WP/3304** - *IWXXM Related Changes to Doc 10003* presented by Sue O'Rourke, Rapporteur of the WG-MIE. In this regard the Panel noted that Doc 10003 provides a high-level description of the purpose and structure of IWXXM. It was noted that it was necessary to introduce some modifications to ICAO Doc 10003 to align it with Amendment 78 to Annex 3. The proposals in **WP/3304** were related to:

a) Alignment with Amendment 78 to Annex 3
b) Change to the document title
c) Introduction of Space Weather Advisories
d) A range of enhancements to the IWXXM schema, including:

    1) Extended content in IWXXM;
    2) Operational and non-Operational Status Indicators;
    3) Translation Centre Information;
    4) Validation Of IWXXM Messages; and
    5) COLLECT construct to support the generation of the equivalence of TAC bulletins.

5.4.6 With regard to the document title change it was noted that this did not occur in Amendment 78 to Annex 3 so the existing title would remain. Additionally it was noted that a new version of Doc 10003 will likely be required with each version of IWXXM and whenever there are new requirements listed in Annex 3. Concluding the discussion the Panel formulated the following recommendation:

Recommendation 5/9: Changes to Doc 10003 pertaining to IWXXM

That, the proposed changes related to the ICAO Meteorological Information Exchange Model (IWXXM) as shown in the **Appendix F** to this report, be included in Doc 10003 - *Manual on the Digital Exchange of Aeronautical Meteorological Information*.

5.4.7 The Panel reviewed **WP/3305** – concerning a proposal to update the IWXXM Guidelines document presented by Sue O'Rourke, Rapporteur of the WG-MIE. A number of changes to the IWXXM Guidelines document - *Guidelines for the Implementation of OPMET Data Exchange Using IWXXM* were proposed, including:

a) Updates associated with IWXXM becoming an Annex 3 standard;
b) Introduction of Space Weather Advisories in IWXXM form;
c) Guidance for translating TAC to IWXXM, Translation Centre operations and draft contents for a Translation Centre service agreement;
d) Guidelines on the use of Operational and Non-operational Status Indicators in IWXXM Messages;
e) Use of GML.id to ensure unique keys in IWXXM;
f) Data validation and statistics to be gathered by Regional OPMET Centres (ROCs) and Regional OPMET Databanks (RODBs);
g) Acronyms and Terminology; and
h) Appendices covering:

    1) AMHS Profile; and
    2) IWXXM exchange testing.

5.4.8 The Panel also noted that the referred document provides the Planning and Implementation Regional Groups (PIRGs) and systems developers with practical information on the use and encoding of the IWXXM and is a "living document". The Panel agreed that the future role of the ROC/RODB needed clarification and that this should be further investigated and brought to the next METP meeting as a working paper. The Panel also agreed that the WG-MIE, in conjunction with WMO, should ensure that the IWXXM Guidelines are updated as required. Therefore the Panel formulated the following recommendation:

Recommendation 5/10: Update to IWXXM Guidelines

That the Panel:

a) Endorse the revised *Guidelines for the Implementation of OPMET Data Exchange Using IWXXM* as given in **Appendix G** to this report;
b) Invite the Secretariat to upload the *Guidelines for the Implementation of OPMET Data Exchange Using IWXXM* to the ICAO METP website (both public and secure) and distribute it to the Planning and Implementation Regional Groups (PIRGs); and
c) Task the Working Group on Meteorological Information Exchange (WG-MIE) to keep updated the *Guidelines for the Implementation of OPMET Data Exchange Using IWXXM*.

5.5 SUPPORT AND COORDINATION

5.5.1 The Panel reviewed **WP/3401** – *Job Card METP.004* presented by Sue O'Rourke, Rapporteur of the WG-MIE. The paper presented a proposed update to Job Card METP.004.02 relating to the inclusion of aeronautical information in the SWIM-enabled environment and further development of the SWIM concept relating to meteorology. Specifically, the updates relate to updated deliverables (including PANS-MET) and their associated timelines and the inclusion of missing content that was inadvertently omitted from the latest version of the Job Card that was approved by the Air Navigation Commission (ANC) following the METP/2 meeting in 2016. Some minor additional edits were discussed. Therefore the Panel formulated the following recommendation:

Recommendation 5/11: Job Card METP.004.02

That the updated Job Card METP.004.02, as given in **Appendix H** and endorsed by the Panel, be presented to the ANC for its consideration.

5.5.2 The Panel reviewed **WP/3402** – *Job Card CP-DCIWG.008* presented by Sue O'Rourke, Rapporteur of the WG-MIE. The ICAO Communications Panel – Data Communication Infrastructure Working Group (CP-DCIWG) accepted a Job Card (CP-DCIWG.008.01) from the METP to evaluate the feasibility of using the AMHS to carry MET messages. The Job card included the testing of both OPMET and World Area Forecast System (WAFS) data, however it was agreed that WAFS (gridded) forecasts would not be exchanged over AMHS. Instead the existing WAFS (Secure Aviation Data Information Service (SADIS) & WAFS Internet File Service (WIFS)) services would provide gridded data until SWIM services were provisioned. It has been agreed that the global IWXXM exchange over AMHS incorporates compression and, as a result, messages rarely exceed 15 Kb. Despite this, many of the tests performed to validate the use of AMHS have used message sizes up to 1Mb. The AMHS consists of a series or network of circuits which together provide global connectivity. These AMHS circuits are replacing AFTN circuits and will carry existing AFTN traffic and IWXXM and other exchange model data (such as FIXM). The overall carrying capacity of any AMHS connection/circuit will be a direct result of the underling network/connection circuit. These are subject to regular review by the relevant PIRGs and are upgraded as needed in order to ensure continuity of service. Hence the METP can be confident that adequate capacity will be available for the carriage of MET messages. As this capability has been tested and is now in use in some Regions, the Panel concurs with the Communications Panel that Job Card CP-DCIWG.008 can be closed.

5.5.3 The Panel noted **IP/3401** – *WG-MIE Status Report* presented by Sue O'Rourke and Bill Maynard, Rapporteur and Deputy Rapporteur respectively of the WG-MIE. This paper outlined the progress by the WG-MIE, including the decisions and actions from the last face-to-face meeting. It also provided details of membership of the working group and the current work plan. The group is a very effective group, with strong leadership and expertise. It is making great progress on the tasks at hand. The WG-MIE works with the IMP to ensure meteorological developments are consistent with those of the broader aviation industry and in particular those governed by the IMP.

5.5.4 The Panel noted **IP/3402** – *IWXXM Development and Approval Process* presented by Sue O'Rourke, Rapporteur of the WG-MIE. The process to establish the IWXXM provisions, IWXXM schema and the associated guidance material is a joint undertaking by the WMO and ICAO. Therefore changes to IWXXM often involve changes and approvals within both organizations. The paper defined the associated processes in each organization and the required inter-organization processes that rationalise why such changes take quite a while to implement.

APPENDIX A

Draft Amendment to Annex 3 related to METAR

…

*Annex 3, 4.5 "**contents of reports**" be modified by introducing a new paragraph 4.5.4 as follows:*

4.5.4 While all elements shall be provided, an element missing on a temporary basis shall be indicated in accordance with the template shown in Table A3-2.

…

Annex 3, Appendix 3, Table A3-2 be modified as follows:

APPENDIX 3. TECHNICAL SPECIFICATIONS RELATED TO METEOROLOGICAL OBSERVATIONS AND REPORTS

Table A3-2 Template for METAR and SPECI

Key: M = inclusion mandatory, part of every message;
C = inclusion conditional, dependent on meteorological conditions or method of observation;
O = inclusion optional.

Note 1.— The ranges and resolutions for the numerical elements included in METAR and SPECI are shown in Table A3-5 of this appendix.

Note 2.— The explanations for the abbreviations can be found in the PANS-ABC (Doc 8400).

Note3. — A meteorological element, when produced by either an automatic observing system or a human observer, could be reported as missing. This should only occur temporarily since back-up arrangements should be in place.

Element as specified in Chapter 4	*Detailed content*	*Template(s)*	*Examples*
Identification of the type of report (M)	Type of report (M)	METAR, METAR COR, SPECI *or* SPECI COR	METAR METAR COR SPECI
Location indicator (M)	ICAO location indicator (M)	nnnn	YUDO[1]
Time of the observation (M)	Day and actual time of the observation in UTC (M)	nnnnnnZ	221630Z
Identification of an automated or missing report (C)[2]	Automated *or* missing report identifier (C)	AUTO *or* NIL	AUTO NIL
END OF METAR IF THE REPORT IS MISSING.			

Element as specified in Chapter 4	*Detailed content*	*Template(s)*				*Examples*
Surface wind (M)	Wind direction (M)	nnn or ///[12,19]	VRB			24004MPS VRB01MPS ///10MPS (24008KT) (VRB02KT) 240//KT 19006MPS /////KT (19012KT) 00000MPS (00000KT) 140P49MPS (140P99KT)
	Wind speed (M)	[P]nn[n] or //[12,19]				
	Significant speed variations (C)[3]	G[P]nn[n]				12003G09MPS (12006G18KT) 24008G14MPS (24016G28KT)
	Units of measurement (M)	MPS (*or* KT)				
	Significant directional variations (C)[4]	nnnVnnn	—			02005MPS 350V070 (02010KT 350V070)
Visibility (M)	Prevailing *or* minimum visibility (M)[5]	nnnn or ////[12,19]			C A V O K	0350 //// CAVOK 7000 9999 0800
	Minimum visibility and direction of the minimum visibility (C)[6]	nnnn[N] *or* nnnn[NE] *or* nnnn[E] *or* nnnn[SE] *or* nnnn[S] *or* nnnn[SW] *or* nnnn[W] *or* nnnn[NW]				2000 1200NW 6000 2800E 6000 2800
Runway visual range (C)[7]	Name of the element (M)	R				R32/0400 R12R/1700 R10/M0050 R14L/P2000
	Runway (M)	nn[L]/*or* nn[C]/*or* nn[R]/				
	Runway visual range (M)	[P *or* M]nnnn or ////[12,19]				R16L/0650 R16C/0500 R16L///// R10///// R16R/0450 R17L/0450
	Runway visual range past tendency (C)[8]	U, D *or* N				R12/1100U R26/0550N R20/0800D R12/0700
Present weather (C)[2, 9]	Intensity *or* proximity of present weather (C)[10]	– *or* +	—	VC		
	Characteristics and type of present weather (M)[11]	DZ *or* RA *or* SN *or* SG *or* PL *or* DS *or* SS *or* FZDZ *or* FZRA *or* FZUP[12] *or* FC[13] *or* SHGR *or* SHGS *or* SHRA *or* SHSN *or* SHUP[12] *or* TSGR *or* TSGS *or* TSRA *or* TSSN *or* TSUP[12] *or* UP[12]	FG *or* BR *or* SA *or* DU *or* HZ *or* FU *or* VA *or* SQ *or* PO *or* TS *or* BCFG *or* BLDU *or* BLSA *or* BLSN *or* DRDU *or* DRSA *or* DRSN *or* FZFG *or* MIFG *or* PRFG *or* //[12]	FG *or* PO *or* FC *or* DS *or* SS *or* TS *or* SH *or* BLSN *or* BLSA *or* BLDU *or* VA		RA HZ VCFG +TSRA FG VCSH +DZ VA VCTS –SN MIFG VCBLSA +TSRASN –SNRA DZ FG +SHSN BLSN UP FZUP TSUP FZUP //

Element as specified in Chapter 4	*Detailed content*	*Template(s)*				*Examples*
Cloud (M)[14]	Cloud amount and height of cloud base *or* vertical visibility (M)	FEWnnn *or* SCTnnn *or* BKNnnn *or* OVCnnn *or* FEW///[12] *or* SCT///[12] *or* BKN///[12] *or* OVC///[12] *or* ///nnn[12] *or* //////[12,19]	VVnnn *or* VV///[12,19]	NSC *or* NCD[12]		FEW015 VV005 OVC030 VV/// NSC SCT010 OVC020 BKN/// ///015
	Cloud type (C)[2]	CB *or* TCU *or* ///[12]	—			BKN009TCU NCD SCT008 BKN025CB BKN025/// //////CB
Air and dew-point temperature (M)	Air and dew-point temperature (M)	[M]nn/[M]nn or ///[M]nn[12,19] or [M]nn///[12,19] or /////[12,19]				17/10 ///10 17/// ///// 02/M08 M01/M10
Pressure values (M)	Name of the element (M)	Q				Q0995 Q1009 Q1022 Q//// Q0987
	QNH (M)	nnnn or ////[12,19]				
Supplementary information (C)	Recent weather (C)[2, 9]	REFZDZ *or* REFZRA *or* REDZ *or* RE[SH]RA *or* RE[SH]SN *or* RESG *or* RESHGR *or* RESHGS *or* REBLSN *or* RESS *or* REDS *or* RETSRA *or* RETSSN *or* RETSGR *or* RETSGS *or* RETS *or* REFC *or* REVA *or* REPL *or* REUP[12] *or* REFZUP[12] *or* RETSUP[12] *or* RESHUP[12]				REFZRA RETSRA
	Wind shear (C)[2]	WS Rnn[L] *or* WS Rnn[C] *or* WS Rnn[R] *or* WS ALL RWY				WS R03 WS ALL RWY WS R18C
	Sea-surface temperature and state of the sea *or* significant wave height (C)[15]	W[M]nn/Sn *or* W[M]nn/Hn[n][n]				W15/S2 W12/H75

Element as specified in Chapter 4	*Detailed content*		*Template(s)*					*Examples*
	State of the runway (C)[16]	Runway designator (M)	R nn[L]/ *or* Rnn[C]/ *or* Rnn[R]/		R/SNOCLO			R99/421594 R/SNOCLO R14L/CLRD//
		Runway deposits (M)	n *or* /	CLRD//				
		Extent of runway contamination (M)	n *or* /					
		Depth of deposit (M)	nn *or* //					
		Friction coefficient *or* braking action (M)	nn *or* //					
Trend forecast (O)[17]	Change indicator (M)[18]		NOSIG	BECMG *or* TEMPO				NOSIG BECMG FEW020 TEMPO 25018G25MPS (TEMPO 25036G50KT) BECMG FM1030 TL1130 CAVOK BECMG TL1700 0800 FG BECMG AT1800 9000 NSW BECMG FM1900 0500 +SNRA BECMG FM1100 SN TEMPO FM1130 BLSN TEMPO FM0330 TL0430 FZRA TEMPO TL1200 0600 BECMG AT1200 8000 NSW NSC BECMG AT1130 OVC010 TEMPO TL1530 +SHRA BKN012CB
	Period of change (C)[2]			FMnnnn *and/or* TLnnnn *or* ATnnnn				
	Wind (C)[2]			nnn[P]nn[n][G[P]nn[n]]MPS (*or* nnn[P]nn[G[P]nn]KT)				
	Prevailing visibility (C)[2]			nnnn			CAVOK	
	Weather phenomenon: intensity (C)[10]			– *or* +	—	NSW		
	Weather phenomenon: characteristics and type (C)[2, 9, 11]			DZ *or* RA *or* SN *or* SG *or* PL *or* DS *or* SS *or* FZDZ *or* FZRA *or* SHGR *or* SHGS *or* SHRA *or* SHSN *or* TSGR *or* TSGS *or* TSRA *or* TSSN	FG *or* BR *or* SA *or* DU *or* HZ *or* FU *or* VA *or* SQ *or* PO *or* FC *or* TS *or* BCFG *or* BLDU *or* BLSA *or* BLSN *or* DRDU *or* DRSA *or* DRSN *or* FZFG *or* MIFG *or* PRFG			
	Cloud amount and height of cloud base *or* vertical visibility (C)[2, 14]			FEWnnn *or* SCTnnn *or* BKNnnn *or* OVCnnn	VVnnn *or* VV///	NSC		
	Cloud type (C)[2,14]			CB *or* TCU	—			

1. Fictitious location.
2. To be included whenever applicable.
3. To be included in accordance with 4.1.5.2 c).
4. To be included in accordance with 4.1.5.2 b) 1).
5. To be included in accordance with 4.2.4.4 b).
6. To be included in accordance with 4.2.4.4 a).
7. To be included if visibility or runway visual range < 1 500 m; for up to a maximum of four runways in accordance with 4.3.6.5 b).
8. To be included in accordance with 4.3.6.6.
9. One or more, up to a maximum of three groups, in accordance with 4.4.2.9 a), 4.8.1.1 and Appendix 5, 2.2.4.1.
10. To be included whenever applicable; no qualifier for *moderate* intensity in accordance with 4.4.2.8.
11. Precipitation types listed under 4.4.2.3 a) may be combined in accordance with 4.4.2.9 c) and Appendix 5, 2.2.4.1. Only moderate or heavy precipitation to be indicated in trend forecasts in accordance with Appendix 5, 2.2.4.1.
12. For automated reports only.

13. Heavy used to indicate tornado or waterspout; moderate (no qualifier) to indicate funnel cloud not reaching the ground.
14. Up to four cloud layers in accordance with 4.5.4.3 e).
15. To be included in accordance with 4.8.1.5 a).
16. To be included in accordance with 4.8.1.5 b).
17. To be included in accordance with Chapter 6, 6.3.2.
18. Number of change indicators to be kept to a minimum in accordance with Appendix 5, 2.2.1, normally not exceeding three groups.
19. When an element is temporarily missing, or its value considered temporarily as incorrect, it should be replaced by "/" for each digit of the abbreviation of the text message and indicated as missing for its IWXXM version.

Appendix A (continuation)

Proposed update to Doc 8896 related to missing parameters in METAR and SPECI

Changes are proposed to Doc 8896 - *Manual on Aeronautical Meteorological Practice* within Sections 2.3 and 2.4 regarding Routine and Special Reports

…

2.3 ROUTINE REPORTS

…

2.3.8 Surface wind

…

2.3.8.2 Direction (true) from which surface wind is blowing should be indicated in degrees rounded off to the nearest 10°. The unit used for wind speed should be indicated both in local routine reports and METAR. In local routine reports, the term "CALM" is used when a wind speed of less than 0.5 m/s (1 kt) is observed. Wind speed of 50 m/s (100 kt) or more is to be indicated as ABV49MPS or ABV99KT.

Note 1.— Wind direction reported to aircraft for landing or take-off purposes must be converted into degrees magnetic. This conversion is normally carried out by the ATS unit concerned.

Note 2.— For wind speed, either metres per second or knots may be used.

Note 3.— In case of temporary wind sensor failure, a missing value will be indicated by 5 "/ " followed by (KT or MPS) /////KT or /////MPS, either Wind direction or Wind Speed could be present. In such case, the missing element will be represented by the same number of "/" as the number of element digits.

…

2.3.10 Visibility

(VIS 600M RVR RWY 12 TDZ 1000M) — Local

…

2.3.10.1 Visibility may be observed by a human observer or measured by instruments. The following definition for visibility for aeronautical purposes applies.
Visibility for aeronautical purposes is the greater of:

a) the greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognized when observed against a bright background; and

b) the greatest distance at which lights in the vicinity of 1 000 candelas can be seen and identified against an unlit background.

Note 1.— The two distances have different values in air of a given extinction coefficient, and the latter (b) varies with the background illumination. The former (a) is represented by the meteorological optical range.

Note 2.— Guidance on the conversion of instrumented readings into visibility is given in Annex 3, Attachment D.

Note 3.— Transmissometers and/or forward-scatter meters should be used as sensors in instrumented systems for the measurement of visibility.

Note 4.— In case of temporary visibility sensor failure, a missing value will be indicated by //// .

…

2.3.11 RVR

(RVR RWY 12 TDZ 1000M) — Local routine report
(R12/1000U) — METAR

2.3.11.3 The provisions given in 2.3.11.1 also apply to METAR. In these reports, RVR values in metres are reported by four figures preceded by the letter indicator R and the runway designator in two figures (e.g. R12/0500, R26/1200). Additional reporting procedures are given in Table 2-5.

Note 1.— RVR is the best possible assessment of "the range over which the pilot of an aircraft on the centre line of a runway can see the runway surface markings or the lights delineating the runway or identifying its centre line". RVR should be assessed at a height of approximately 2.5 m (7.5 ft) above the runway for instrumented systems or assessed at a height of approximately 5 m (15 ft) above the runway by a human observer. This assessment should therefore be based on readings of transmissometers or forward-scatter meters for CAT I, CAT II and CAT III runways or, for non-precision runways, by an observer counting markers, runway lights or, in some cases, specially installed lights on the side of the runway.

Note 2.— Detailed information on RVR observing and reporting is contained in the Manual of Runway Visual Range Observing and Reporting Practices (Doc 9328).

Note 3.— In case of temporary RVR sensor failure, a missing value will be indicated by RD_RD_R*///// (e.g. R32/////)*

…

2.3.14 Air temperature/dew point temperature
(T17 DP16) — Local routine report
(17/16) — METAR

…

2.3.14.4 Air temperature and dew point temperature values are reported in METAR in two figures separated by “/”, e.g. air temperature of +20.4 and dew point temperature of +8.7 are reported as “20/09”. Temperatures below 0°C are preceded by M (meaning minus). Temperatures in the range of –0.5°C to –0.1°C are reported as “M00”, while temperatures in the range of 0.0° to 0.4°C are reported as “00”.

Note 1.— In case of temporary Temperature sensor failure, a missing value will be indicated by 5 "/" ///// Or TT/// or ////TdTd e.g.: 12/// or ///10.

2.3.15 Atmospheric pressure

(QNH 1018 HPA) — Local routine reports

(Q1018) — METAR

…

2.3.15.2 In local routine reports and METAR, atmospheric pressure is given in hectopascals, rounded down to the nearest lower whole hectopascal and reported in four figures, e.g. QNH 1011.4 is reported as “QNH 1011HPA” in local routine reports and “Q1011” in METAR, and QFE 995.6 is reported as “QFE 0995HPA” or “QFE RWY 18 0995HPA” (where the number of the runway is indicated).

Note 1.— In case of temporary Atmospheric pressure sensor failure, a missing value will be indicated by Q////

…

2.4 SPECIAL REPORTS

…

2.4.2 Aerodrome special meteorological report (SPECI)

3.1.1.1 SPECI are issued in accordance with the following criteria:

…

3.1.1 l) any other criteria based on local aerodrome operating minima, as agreed between the meteorological authority, the appropriate ATS authority and the operators concerned.

Note 1.— Other criteria based on local operating minima are to be considered in parallel with similar criteria for the inclusion of change groups and for the amendment of aerodrome forecasts (TAF).

Note 2. — Coding of temporarily missing parameters values are the same than those defined for METAR. (refer 2.3).

Appendix A (continuation)

Proposed update to Doc 9328 related to METAR

The missing parameters could be indicated in Chapter 11 Transmission and Reporting Practices of Doc 9328 - *Manual of Runway Visual Range Observing and Reporting Practices* by adding examples in Table 11-2 (as given below)

…

11.1 METHODS OF TRANSMISSION AND DISPLAY OF RVR.

Table 11-2. Detailed structure of RVR information included in METAR/SPECI[1]

Detailed content	*Template*	*Examples*
Name of the element	R	R10/M0050; R14L/P2000;
Runway	nn[n]/	R32/0400; R16L/0650 R16C/0500 R16R/0450; R17L/0450;
RVR	[P *or* M] nnnn	R26/0550N R20/0800D; R32///// (no RVR can be produced for RWY 32, due to temporary failure)

— — — — — — — —

APPENDIX B

Amendment to Annex 3 concerning Tropical Cyclone Advisory and SIGMET messages

…

Table A6-1A. Template for SIGMET and AIRMET messages

Element	*Detailed content*	*SIGMET template*	*AIRMET template*	*SIGMET message examples*	*AIRMET message examples*
…					
Observed or forecast phenomenon (M)[20, 21]	Indication whether the information is observed and expected to continue, *or* forecast	OBS [AT nnnnZ] *or* FCST [AT nnnnZ]		OBS OBS AT 1210Z FCST FCST AT 1815Z	

Element	*Detailed content*	*SIGMET template*	*AIRMET template*	*SIGMET message examples*	*AIRMET message examples*
Location (C)[20, 21]	Location (referring to latitude and longitude (in degrees and minutes))	Nnn[nn] Wnnn[nn] *or* Nnn[nn] Ennn[nn] *or* Snn[nn] Wnnn[nn] *or* Snn[nn] Ennn[nn] *or* N OF Nnn[nn] *or* S OF Nnn[nn] *or* N OF Snn[nn] *or* S OF Snn[nn] [AND] W OF Wnnn[nn] *or* E OF Wnnn[nn] *or* W OF Ennn[nn] *or* E OF Ennn[nn] *or* N OF Nnn[nn] *or* N OF Snn[nn] AND S OF Nnn[nn] *or* S OF Snn[nn] *or* W OF Wnnn[nn] *or* W OF Ennn[nn] AND E OF Wnnn[nn] *or* E OF Ennn[nn] *or* N OF LINE[~~21~~22] *or* NE OF LINE[~~21~~22] *or* E OF LINE[~~21~~22] *or* SE OF LINE[~~21~~22] *or* S OF LINE[~~21~~22] *or* SW OF LINE[~~21~~22] *or* W OF LINE[~~21~~22] *or* NW OF LINE[~~21~~22] Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] [– Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]] [– Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]] [AND N OF LINE[~~21~~22] *or* NE OF LINE[~~21~~22] *or* E OF LINE[~~21~~22] *or* SE OF LINE[~~21~~22] *or* S OF LINE[~~21~~22] *or* SW OF LINE[~~21~~22] *or* W OF LINE[~~21~~22] *or* NW OF LINE[~~21~~] Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] [– Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]] [– Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]]] *or* WI[~~21~~22, ~~22~~23] Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – [Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]] *or* APRX nnKM WID LINE[~~21~~22] BTN (*or* nnNM WID LINE[~~21~~22] BTN) Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] [– Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]] [– Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]] or ENTIRE UIR *or* ENTIRE FIR *or* ENTIRE FIR/UIR *or* ENTIRE CTA *or*[~~23~~24] WI nnnKM (*or* nnnNM) OF TC CENTRE *or*[~~24~~25] WI nnKM (*or* nnNM) OF Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]		N2020 W07005 N48 E010 S60 W160 S0530 E16530 N OF N50 S OF N5430 N OF S10 S OF S4530 W OF W155 E OF W45 W OF E15540 E OF E09015 N OF N1515 AND W OF E13530 S OF N45 AND N OF N40 N OF LINE S2520 W11510 – S2520 W12010 SW OF LINE N50 W005 – N60 W020 SW OF LINE N50 W020 – N45 E010 AND NE OF LINE N45 W020 – N40 E010 WI N6030 E02550 – N6055 E02500 – N6050 E02630 – N6030 E02550 APRX 50KM WID LINE BTN N64 W017 – N60 W010 – N57 E010 ENTIRE FIR ENTIRE UIR ENTIRE FIR/UIR ENTIRE CTA WI 400KM OF TC CENTRE WI 250NM OF TC CENTRE WI 30KM OF N6030 E02550[†]	

Element	*Detailed content*	*SIGMET template*	*AIRMET template*	*SIGMET message examples*	*AIRMET message examples*
Level (C)[20, 21, ~~24~~]	Flight level *or* altitude	[SFC/]FLnnn *or* [SFC/]nnnnM (*or* [SFC/][n]nnnnFT) *or* FLnnn/nnn *or* TOP FLnnn *or* [TOP] ABV FLnnn (*or* [TOP] ABV [n]nnnnFT) [nnnn/]nnnnM (*or* [[n]nnnn/][n]nnnnFT) *or* [nnnnM/]FLnnn (*or* [[n]nnnnFT/]FLnnn) *or* [2324] TOP [ABV *or* BLW] FLnnn		FL180 SFC/FL070 SFC/3000M SFC/10000FT FL050/080 TOP FL390 ABV FL250 TOP ABV FL100 ABV 7000FT TOP ABV 9000FT TOP ABV 10000FT 3000M 2000/3000M 8000FT 6000/12000FT 2000M/FL150 10000FT/FL250 TOP FL500 TOP ABV FL500 TOP BLW FL450	
Movement or expected movement (C)[20, ~~25~~26]	Movement *or* expected movement (direction and speed) with reference to one of the sixteen points of compass, *or* stationary	MOV N [nnKMH] *or* MOV NNE [nnKMH] *or* MOV NE [nnKMH] *or* MOV ENE [nnKMH] *or* MOV E [nnKMH] *or* MOV ESE [nnKMH] *or* MOV SE [nnKMH] *or* MOV SSE [nnKMH] *or* MOV S [nnKMH] *or* MOV SSW [nnKMH] *or* MOV SW [nnKMH] *or* MOV WSW [nnKMH] *or* MOV W [nnKMH] *or* MOV WNW [nnKMH] *or* MOV NW [nnKMH] *or* MOV NNW [nnKMH] (*or* MOV N [nnKT] *or* MOV NNE [nnKT] *or* MOV NE [nnKT] *or* MOV ENE [nnKT] *or* MOV E [nnKT] *or* MOV ESE [nnKT] *or* MOV SE [nnKT] *or* MOV SSE [nnKT] *or* MOV S [nnKT] *or* MOV SSW [nnKT] *or* MOV SW [nnKT] *or* MOV WSW [nnKT] *or* MOV W [nnKT] *or* MOV WNW [nnKT] *or* MOV NW [nnKT] *or* MOV NNW [nnKT]) *or* STNR		MOV SE MOV NNW MOV E 40KMH MOV E 20KT MOV WSW 20KT STNR	
Changes in intensity (C)[20]	Expected changes in intensity	INTSF *or* WKN *or* NC		INTSF WKN NC	
Forecast time (C)[20, 21, ~~25~~, 26]	Indication of the forecast time of phenomenon	FCST AT nnnnZ	—	FCST AT 2200Z	—
TC forecast position (C)[~~23~~24]	Forecast position of TC centre ~~at the end of the validity period of the SIGMET message~~	TC CENTRE PSN Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] CB[31]	—	TC CENTRE PSN N1030 ~~TC CENTRE PSN~~ E1600015 CB	—

Element	*Detailed content*	*SIGMET template*	*AIRMET template*	*SIGMET message examples*	*AIRMET message examples*
Forecast position (C)[20, 21, ~~25~~, 26, 27]	Forecast position of phenomenon at the end of the validity period of the SIGMET message	Nnn[nn] Wnnn[nn] *or* Nnn[nn] Ennn[nn] *or* Snn[nn] Wnnn[nn] *or* Snn[nn] Ennn[nn] *or* N OF Nnn[nn] *or* S OF Nnn[nn] *or* N OF Snn[nn] *or* S OF Snn[nn] [AND] W OF Wnnn[nn] *or* E OF Wnnn[nn] *or* W OF Ennn[nn] *or* E OF Ennn[nn] *or* N OF Nnn[nn] *or* N OF Snn[nn] AND S OF Nnn[nn] *or* S OF Snn[nn] *or* W OF Wnnn[nn] *or* W OF Ennn[nn] AND E OF Wnnn[nn] *or* E OF Ennn[nn] *or* N OF LINE[~~21~~22] *or* NE OF LINE[~~21~~22] *or* E OF LINE[~~21~~22] *or* SE OF LINE[~~21~~22] *or* S OF LINE[~~21~~22] *or* SW OF LINE[~~21~~22] *or* W OF LINE[~~21~~22] *or* NW OF LINE[~~21~~22] Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] [– Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]] [AND N OF LINE[~~21~~22] *or* NE OF LINE[~~21~~22] *or* E OF LINE[~~21~~22] *or* SE OF LINE[~~21~~22] *or* S OF LINE[~~21~~22] *or* SW OF LINE[~~21~~22] *or* W OF LINE[~~21~~22] *or* NW OF LINE[~~21~~22] Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] [– Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]]]	—	N30 W170 N OF N30 S OF S50 AND W OF E170 S OF N46 AND N OF N39 NE OF LINE N35 W020 – N45 W040 SW OF LINE N48 W020 – N43 E010 AND NE OF LINE N43 W020 – N38 E010 WI N20 W090 – N05 W090 – N10 W100 – N20 W100 – N20 W090 APRX 50KM WID LINE BTN N64 W017 – N57 W005 – N55 E010 – N55 E030 ENTIRE FIR ENTIRE UIR ENTIRE FIR/UIR ENTIRE CTA NO VA EXP WI 30KM OF N6030 E02550[†] WI 150NM OF TC CENTRE	—

Element	*Detailed content*	*SIGMET template*	*AIRMET template*	*SIGMET message examples*	*AIRMET message examples*
		or WI[~~21~~, 22, 23] Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] *or* APRX nnKM WID LINE[~~21~~22] BTN (nnNM WID LINE[~~21~~22] BTN) Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] [– Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]] [– Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]] *or* ENTIRE FIR *or* ENTIRE UIR *or* ENTIRE FIR/UIR *or* ENTIRE CTA *or*[~~27~~28] NO VA EXP *or*[~~24~~25] WI nnKM (*or* nnNM) OF Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] *or*[24] WI nnnKM (nnnNM) OF TC CENTRE			
Repetition of elements (C)[28]	Repetition of elements included in a SIGMET message for volcanic ash cloud or tropical cyclone	[AND][~~28~~29]	—	AND	—

OR

Cancellation of SIGMET/ AIRMET (C)[~~29~~30]	Cancellation of SIGMET/AIRMET referring to its identification	CNL SIGMET [n][n]n nnnnnn/nnnnnn *or*[~~27~~28] CNL SIGMET [n][n]n nnnnnn/nnnnnn VA MOV TO nnnn FIR	CNL AIRMET [n][n]n nnnnnn/nnnnnn	CNL SIGMET 2 101200/101600 CNL SIGMET A13 251030/251430 VA MOV TO YUDO FIR[2]	CNL AIRMET 05 151520/151800

Notes.—

1. See 4.1.
2. Fictitious location.
3. In accordance with 1.1.3 and 2.1.2.
4. See 2.1.3.
5. Used only when the message issued to indicate that a test or an exercise is taking place. When the word “TEST” or the abbreviation “EXER” is included, the message may contain information that should not be used operationally or will otherwise end immediately after the word "TEST". *[Applicable 7 November 2019]*
6. In accordance with 1.1.4 and 2.1.4.
7. In accordance with 4.2.1 a).
8. In accordance with 4.2.4.
9. In accordance with 4.2.1 b).
10. In accordance with 4.2.2.
11. In accordance with 4.2.3.
12. Used for unnamed tropical cyclones.
13. In accordance with 4.2.5 and 4.2.6.
14. In accordance with 4.2.7.
15. In accordance with 4.2.8.
16. In accordance with 2.1.4.
17. In accordance with 4.2.1 c).
18 In accordance with 4.2.1 d).
19. The use of cumulonimbus (CB) and towering cumulus (TCU) is restricted to AIRMETs in accordance with 2.1.4.
20. In the case of volcanic ash cloud ~~or cumulonimbus clouds associated with a tropical cyclone~~ covering more than one area within the FIR, these elements can be repeated, as necessary. Each location and forecast position must be preceded by an observed or forecast time.
21. In the case of cumulonimbus clouds associated with a tropical cyclone covering more than one area within the FIR, these elements can be repeated as necessary. Each location and forecast position must be preceded by an observed or forecast time.

~~21~~22. A straight line is to be used between two points drawn on a map in the Mercator projection or between two points which crosses lines of longitude at a constant angle.

~~22~~23. The number of coordinates should be kept to a minimum and should not normally exceed seven.

~~23~~24. Only for SIGMET messages for tropical cyclones.

~~24~~25. Only for SIGMET messages for radioactive cloud. When detailed information on the release is not available, a radius of up to 30 kilometres (or 16 nautical miles) from the source may be applied; and a vertical extent from surface (SFC) to the upper limit of the flight information region/upper flight information region (FIR/UIR) or control area (CTA) is to be applied. *[Applicable 7 November 2019]*

~~25~~26. The elements “forecast time” and “forecast position” are not to be used in conjunction with the element “movement or expected movement”.

~~26~~27. The levels of the phenomena remain fixed throughout the forecast period.

~~27~~28. Only for SIGMET messages for volcanic ash.

~~28~~29. To be used for two volcanic ash clouds or ~~two centres of tropical cyclones~~ cumulonimbus clouds associated with a tropical cyclone simultaneously affecting the FIR concerned.~~.~~

~~29~~30. End of the message (as the SIGMET/AIRMET message is being cancelled).

31. The term CB is to be used when the forecast position for the cumulonimbus cloud is included.

Appendix B

Amendment to Annex 3 concerning Tropical Cyclone Advisory and SIGMET messages (continuation)

…

Table A2-2. Template for advisory message for tropical cyclones

Element		*Detailed content*	*Template(s)*		*Examples*	
1	Identification of the type of message (M)	Type of message	TC ADVISORY		TC ADVISORY	
2	Status indicator (C)[1]	Indicator of test *or* exercise	STATUS:	TEST *or* EXER	STATUS:	TEST EXER
3	Time of origin (M)	Year, month, day and time in UTC of issue	DTG:	nnnnnnnn/nnnnZ	DTG:	20040925/1900Z
4	Name of TCAC (M)	Name of TCAC (location indicator *or* full name)	TCAC:	nnnn *or* nnnnnnnnnn	TCAC:	YUFO[2] MIAMI
5	Name of tropical cyclone (M)	Name of tropical cyclone *or* "NN" for unnamed tropical cyclone	TC:	nnnnnnnnnnnn *or* NN	TC:	GLORIA
6	Advisory number (M)	Year in full and message number (separate sequence for each cyclone)	ADVISORY NR:	nnnn/[n][n][n]n	ADVISORY NR:	2004/13
7	Observed position of the centre (M)	Day and time in UTCand position of the centre of the tropical cyclone (in degrees and minutes)	OBS PSN:	nn/nnnnZ Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]	OBS PSN:	25/1800Z N2706 W07306
8	Observed CB cloud[3] (~~C~~O)	Location of CB cloud (referring to latitude and longitude (in degrees and minutes)) *and* vertical extent (flight level)	CB:	WI nnnKM (*or* nnnNM) OF TC CENTRE *or* WI[4] Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – [Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]] *and* TOP [ABV *or* BLW] FLnnn	CB:	WI 250NM OF TC CENTRE TOP FL500
9	Direction and speed of movement (M)	Direction and speed of movement given in sixteen compass points and km/h (*or* kt), respectively, *or* stationary (< 2 km/h (1 kt))	MOV:	N nnKMH (*or* KT) *or* NNE nnKMH (*or* KT) *or* NE nnKMH (*or* KT) *or* ENE nnKMH (*or* KT) *or* E nnKMH (*or* KT) *or* ESE nnKMH (*or* KT) *or* SE nnKMH (*or* KT) *or* SSE nnKMH (*or* KT) *or* S nnKMH (*or* KT) *or* SSW nnKMH (*or* KT) *or* SW nnKMH (*or* KT) *or* WSW nnKMH (*or* KT) *or* W nnKMH (*or* KT) *or* WNW nnKMH (*or* KT) *or* NW nnKMH (*or* KT) *or* NNW nnKMH (*or* KT) *or* STNR	MOV:	NW 20KMH
10	Changes in intensity	Expected changes in intensity	INTENSITY CHANGE:	INTSF or WKN or NC	INTENSITY CHANGE:	INTSF

~~10~~ 11	Central pressure (M)	Central pressure (in hPa)	C:	nnnHPA	C:	965HPA
~~11~~ 12	Maximum surface wind (M)	Maximum surface wind near the centre (mean over 10 minutes, in m/s (*or* kt))	MAX WIND:	nn[n]MPS (*or* nn[n]KT)	MAX WIND:	22MPS
~~12~~ 13	Forecast of centre position (+6 HR) (M)	Day and time (in UTC) (6 hours from the "DTG" given in Item 3); Forecast position (in degrees and minutes) of the centre of the tropical cyclone	FCST PSN +6 HR:	nn/nnnnZ Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]	FCST PSN +6 HR:	25/2200Z N2748 W07350
~~13~~ 14	Forecast of maximum surface wind (+6 HR) (M)	Forecast of maximum surface wind (6 hours after the "DTG" given in Item 3)	FCST MAX WIND +6 HR:	nn[n]MPS (*or* nn[n]KT)	FCST MAX WIND +6 HR:	22MPS

~~14~~ 15	Forecast of centre position (+12 HR) (M)	Day and time (in UTC) (12 hours from the "DTG" given in Item 3); Forecast position (in degrees and minutes) of the centre of the tropical cyclone	FCST PSN +12 HR:	nn/nnnnZ Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]	FCST PSN +12 HR:	26/0400Z N2830 W07430
~~15~~ 16	Forecast of maximum surface wind (+12 HR) (M)	Forecast of maximum surface wind (12 hours after the "DTG" given in Item 3)	FCST MAX WIND +12 HR:	nn[n]MPS (*or* nn[n]KT)	FCST MAX WIND +12 HR:	22MPS
~~16~~ 17	Forecast of centre position (+18 HR) (M)	Day and time (in UTC) (18 hours from the "DTG" given in Item 3); Forecast position (in degrees and minutes) of the centre of the tropical cyclone	FCST PSN +18 HR:	nn/nnnnZ Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]	FCST PSN +18 HR:	26/1000Z N2852 W07500
~~17~~ 18	Forecast of maximum surface wind (+18 HR) (M)	Forecast of maximum surface wind (18 hours after the "DTG" given in Item 3)	FCST MAX WIND +18 HR:	nn[n]MPS (*or* nn[n]KT)	FCST MAX WIND +18 HR:	21MPS
~~18~~ 19	Forecast of centre position (+24 HR) (M)	Day and time (in UTC) (24 hours from the "DTG" given in Item 3); Forecast position (in degrees and minutes) of the centre of the tropical cyclone	FCST PSN +24 HR:	nn/nnnnZ Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]	FCST PSN +24 HR:	26/1600Z N2912 W07530
~~19~~ 20	Forecast of maximum surface wind (+24 HR) (M)	Forecast of maximum surface wind (24 hours after the "DTG" given in Item 3)	FCST MAX WIND +24 HR:	nn[n]MPS (*or* nn[n]KT)	FCST MAX WIND +24 HR:	20MPS
~~20~~ 21	Remarks (M)	Remarks, as necessary	RMK:	*Free text up to 256 characters* *or* NIL	RMK:	NIL
~~21~~ 22	Expected time of issuance of next advisory (M)	Expected year, month, day and time (in UTC) of issuance of next advisory	NXT MSG:	[BFR] nnnnnnnn/nnnnZ *or* NO MSG EXP	NXT MSG:	20040925/2000Z

Notes. —

1. Used only when the message issued to indicate that a test or an exercise is taking place. When the word "TEST" or the abbreviation "EXER" is included, the message may contain information that should not be used operationally or will otherwise end immediately after the word "TEST". *[Applicable 7 November 2019]*
2. Fictitious location.
3. In the case of CB clouds associated with a tropical cyclone covering more than one area within the area of responsibility, this element can be repeated, as necessary.
4. The number of coordinates should be kept to a minimum and should not normally exceed seven.

Example A2-2. Advisory message for tropical cyclones

TC ADVISORY

DTG:	20040925/1900Z
TCAC:	YUFO*
TC:	GLORIA
ADVISORY NR:	2004/13
OBS PSN:	25/1800Z N2706 W07306
CB:	WI 250NM OF TC CENTRE TOP FL500
MOV:	NW 20KMH
INTENSITY CHANGE:	INTSF
C:	965HPA
MAX WIND:	22MPS
FCST PSN +6 HR:	25/2200Z N2748 W07350
FCST MAX WIND +6 HR:	22MPS
FCST PSN +12 HR:	26/0400Z N2830 W07430
FCST MAX WIND +12 HR:	22MPS
FCST PSN +18 HR:	26/1000Z N2852 W07500
FCST MAX WIND +18 HR:	21MPS
FCST PSN +24 HR:	26/1600Z N2912 W07530
FCST MAX WIND +24 HR:	20MPS
RMK:	NIL
NXT MSG:	20040925/2000Z

*Ficticious location

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APPENDIX C

MET-SWIM Plan and Roadmap

Plan for Meteorology in System Wide Information Management (SWIM)

First Edition — October 2018

International Civil Aviation Organization

RECORD OF REVISIONS

REVISIONS		
No.	Date	Description

FOREWORD

This first edition of the *Plan for Meteorology in System Wide Information Management (SWIM)* is published to complement the introduction of the *Manual on System Wide Information Management* (Doc 10039). This plan describes the role of meteorological information in a SWIM environment, and the relationship of MET SWIM to other components of the overall system.

As of November 2016, many aeronautical meteorology products from ICAO Annex 3 – *Meteorological Service for International Air Navigation* are recommended for exchange in ICAO Meteorological Information Exchange Model (IWXXM) form by States. This exchange will initially take place outside of a SWIM environment of Service Oriented Architecture (SOA) and web services, but as SWIM implementation takes place these exchanges will be transitioned to a SWIM environment.

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LIST OF ABBREVIATIONS AND ACRONYMS

AIM	Aeronautical information management
AIXM	Aeronautical information exchange model
AMQP	Advanced message queuing protocol
Annex 3	Annex 3 – *Meteorological Service for International Air Navigation*
ASBU	Aviation system block upgrade
ASP	ATM service provider
ATM	Air traffic management
CRS	Coordinate reference system
FIXM	Flight information exchange model
FL	Flight Level
GANP	ICAO Doc 9750 – *Global Air Navigation Plan*
GML	Geography markup language
GRIB	Gridded binary format
HTTP	Hypertext transfer protocol
ICAO	International Civil Aviation Organization
ISO	International Organization for Standardization
IWXXM	ICAO meteorological information exchange model
MET	Meteorology or Meteorological
METAR	Aerodrome routine meteorological report (in meteorological code)
NetCDF	Network common data form
OGC	Open Geospatial Consortium
OPMET	Operational meteorology, usually operationally-used aeronautical meteorology data products
SOA	Service-oriented architecture
SOAP	Simple object access protocol
SWIM	System-wide information management
TAC	Traditional alphanumeric codes
TCP/IP	Transmission control protocol / internet protocol
WCS	Web coverage service
WFS	Web feature service
WMS	Web map service
XML	Extensible markup language

GLOSSARY OF TERMS

When the subsequent terms are used in this manual, they have the following meanings:

Authorization. Permission to engage in a specific activity. A SWIM-enabled application is authorized if it has permission to engage in a specific activity, such as subscribing to a publication service.
Consumer. See *Information consumer*.
Core Services. Functional capabilities of the SWIM Infrastructure such as interface management, request-reply and publish-subscribe messaging, service security, and enterprise service management.
Discoverable. An information service that may be discovered by a potential user is discoverable.
Discovery. See *Service Discovery.*
Information Dissemination. The act of distributing information to one or more recipients.
Domain. A set of business activities that: (a) have a common mission or purpose; (b) share common operational and functional requirements and capabilities; and (c) needs to be considered separately from other activities, while maintaining the relevant relationships with them. For example, the MET and AIM information domains
Enterprise. See *SWIM Enterprise.*
Enterprise Service Management (ESM). The SWIM core service addressing the management of SWIM-enabled services, including performance and availability. ESM provides the ability to monitor, manage, and scale services within the enterprise to ensure the capability offerings are available, responsive and scalable to the operational environment supported.
Expose. To make a service interface discoverable. In SWIM, information services are exposed via one or more SWIM Service Registries.
Information Consumer. The person, application or system consuming an information service. Also called *consumer*.
Information Domain. Focused on identifying, defining, and satisfying the information needs of the set of business activities associated with a specific domain.
Information Exchange Model. An Information Exchange Model is designed to enable the management and distribution of information services data in digital format. Normally this is defined for a specific domain such as aeronautical information.
Information Model. An information model is a representation of concepts and the relationships, constraints, rules, and operations to specify data semantics for a chosen domain.
Information Producer. The person, application or system producing an information service. Also called producer.
Information Provider. Information service provider. Also called provider.
Information Service. An information service is a web service which provides information consumers access to one or more applications or systems by means of the SWIM core services. It encapsulates a distinct set of operations logic within a well-defined functional boundary.
Infrastructure. The logical and physical (i.e., hardware and software) elements that together provide (SWIM) functionality.
Message**.** A structured information exchange package consisting of a header and payload.
Messaging. The SWIM core service that provides delivery of data and notifications between applications and systems.
Notification. An indication presented to a user regarding the status of a system or an element in a system. In a publish-subscribe system, a publication may consist of notifications about data rather than the data itself.
Operational Pattern. An operational pattern describes the essential flow of a SWIM-enabled service. It is based on the term pattern, which describes the essential features of a common solution to a common problem in software development.
Publication. An information service based on the publish-subscribe operational pattern.

Publisher. An information service provider utilizing the publish-subscribe operational pattern.

Publish-subscribe. A one-to-many operational pattern in which an information provider called a *publisher* makes its services available (i.e. publishes) on a subscription basis. An information consumer in this paradigm called a *subscriber* requests access to the publication service via a subscription request. Based on the nature of their subscriptions, subscribers will continue to receive updates from the publisher until they request the termination of their subscription.

Reliable Delivery. A characteristic of information transfer in which the transfer is either successful or the sender of the information is notified of the failure of the transfer.

Request/Reply. The operational pattern distinguished by a two-way interaction between a requesting entity and a responding entity. This pattern is also called request/response.

REST. A REpresentational State Transfer (REST) architecture is an alternative to SOAP for implementing web services over HTTP.

Security. The SWIM core service responsible for the protection of information, operation, assets and participants from unauthorized access or attack.

Service. Attention is drawn to the dual meaning of "service" in an ICAO context. In the context of SWIM and this document, "service" refers to a web service (also see *Information Service*) rather than an ICAO service which is provided by States or other ICAO organizations.

Service Discovery. The act of locating and accessing the metadata (such as a web address) for a specific information service. Also referred to as *discovery*.

Service-Oriented Architecture (SOA). An approach to integrate applications running on heterogeneous platforms using industry-wide acceptable standards. Each application is exposed as one or more web services where each information service provides a particular function. Information services (applications) communicate with each other in a coordinated sequence that is defined by a business process.

Service Provider. An organization or entity providing a service. Refers (in this document) to ASPs or vendors that provide network or other value-added services; distinct from an information provider.

Service Registration. The act of creating an entry in the SWIM Service Registry.

Service Registry. SWIM web service registry.

SOAP. A SOAP architecture is an alternative to REST for implementing web services over HTTP.

State. An ICAO Member State.

Subscriber. A consumer of a publication service.

Subscription. The process of becoming a subscriber to a publication service. Subscription consists of subscription administration and subscription activation.

Subscription Administration. The act of administering a subscription, including authorization, access list and other database updates, etc.

System-Wide Information Management (SWIM). SWIM consists of standards, infrastructure and governance enabling the management of ATM related information and its exchange between qualified parties via interoperable services.

SWIM Access Point. A SWIM access point is a logical entity which bundles a number of technical capabilities (e.g. messaging, security, logging, interface management, etc.).

SWIM core services. The fundamental SWIM mechanisms that enable information sharing: Interface Management, Messaging, Enterprise Service Management (ESM) and Security. These services are solution-agnostic (not limited to a single process or solution environment) and have a high degree of autonomy so that they support reuse. Also referred to as "core services".

SWIM core services infrastructure. Hardware and software elements that provide the SWIM core services. Also referred to as "core services infrastructure".

SWIM-enabled application. A SWIM enabled application consumes or provides SWIM information services using SWIM standards. Also referred to as "application".

SWIM-enabled service. An information service that may be accessed via SWIM.

SWIM Enterprise. A SWIM enterprise can be an ATM service provider (ASP), a group of ASPs, or an Airspace User, or an ATM support industry that has full control of the implementation planning and execution within the enterprise.

***SWIM Region*.** A collection of SWIM enterprises that have agreed upon common regional governance and internal standards. A region will be delineated by the area of influence of a given governance structure that defines the standards, policies, etc. that are applicable to all the participants within the region.

SWIM Registry. A registry or directory containing entries with the information necessary to discover and access services. The Registry utilizes a formal registration process to store, catalog and manage metadata relevant to the services, thereby enabling the search, identification and understanding of resources. Also referred to as “Service Registry” or “Registry”.

SWIM User. Depending on context, a person, organization or application authorized to provide and/or consume services via SWIM.

Web Service. A software system which provides request/reply support to consumers for querying data or generating results. Web services commonly communicate using HTTP and often work with and return XML, JSON, and binary data.

Chapter 1

INTRODUCTION

1.1 BACKGROUND

1.1.1 ICAO Doc 10039 - *Manual on System Wide Information Management (SWIM) Concept,* describes general SWIM concepts and characteristics. This document provides further detail on the role of aeronautical meteorology in SWIM, such as the relationship between meteorology and other SWIM domains (such as aeronautical information management (AIM)) in the system.

1.2 SCOPE

1.2.1 The scope of the plan is limited to the following:

a) identifying required infrastructure (IP network, security capabilities, etc.);
b) identifying interfaces and relationships with the other SWIM Air Traffic Management (ATM) information domains, such as AIM;
c) identifying technologies and required high-level capabilities (web services, XML, and messaging) required for MET SWIM information exchange;
d) describing information flows and high-level data types; and
e) describing the roles and responsibilities of aeronautical meteorological system stakeholders, such as regional centers and member states.

1.2.2 The scope of the plan excludes the detailed description of specific products. It is anticipated that data products will be able to be modified over time without substantial changes to the concepts and infrastructure described in this plan.

1.3 PURPOSE/OBJECTIVE

1.3.1 This document, the *Plan for Meteorology in System Wide Information Management (SWIM)*, describes the role of aeronautical meteorology (MET) in SWIM. In particular, approaches and concepts for the exchange of meteorological information (such as web services), high-level concepts regarding aeronautical meteorological information exchange models and XML/GML are discussed. This document supplements the broader SWIM concept described in the *Manual on System Wide Information Management (SWIM) Concept* (Doc 10039) with approaches and technologies specifically relevant to the exchange of meteorological information in SWIM.

1.4 TARGET AUDIENCE

1.4.1 This plan has been developed for ICAO States seeking information on integrating their MET SWIM information management within a global SWIM construct. The plan does not specifically address any individual member of the ATM community with interested parties to be found in all of the following communities:

a) ICAO;
b) regulatory authorities; and
c) States.

1.5 ORGANIZATION OF THE PLAN

1.5.1 The plan is organized as follows:

a) Chapter 1 gives the background and the purpose and scope of the document;
b) Chapter 2 considers the MET SWIM global interoperability framework and its details, including interoperability and governance at the information exchange services, the information exchange models and at the SWIM infrastructure level. The functions and representative standards are provided;
c) Chapter 3 considers the transition to MET SWIM and operations in a mixed environment; and
d) The appendices provide supporting material.

1.6 RELATIONSHIP TO OTHER DOCUMENTS

1.6.1 The *Global Air Traffic Management (ATM) Operational Concept* (Doc 9854) describes a future concept in which information is managed system-wide. Based upon this concept, the *Manual on Air Traffic Management System Requirements* (Doc 9882) explicitly identifies the implementation of SWIM as a requirement for the future ATM System.

1.6.2 The *Manual on Flight and Flow Information for a Collaborative Environment* (FF-ICE) (Doc 9965) provides a vision specifically for flight information that relies on SWIM as a mechanism for exchange of flight information while managing the consistency and timeliness of the information. The *Manual on Collaborative Air Traffic Flow Management* (Doc 9971) describes the importance of information exchange in establishing a collaborative environment.

1.6.3 There are two aviation system block upgrade (ASBU) modules within the *Global Air Navigation Plan* (GANP) (Doc 9750) that focus on SWIM development: B1-SWIM and B2-SWIM. The ASBU module B1-SWIM is termed ‘Performance Improvement through the application of SWIM’ and applies to the “implementation of SWIM services (applications and infrastructure) creating the aviation intranet based on standard data models, and internet-based protocols to maximize interoperability”. The ASBU module B2-SWIM is termed ‘Enabling Airborne Participation in collaborative ATM through SWIM’ and applies to the “connection of the aircraft as an information node in SWIM enabling participation in collaborative ATM processes with access to rich voluminous dynamic data including meteorology”.

1.6.4 The *Manual on System Wide Information Management (SWIM) Concept* (Doc 10039) describes the overall SWIM concept, along with key goals and characteristics of the system. This plan provides further detail on this general concept, and how aeronautical meteorological information is exchanged and used within the broader system.

1.6.5 The *Manual on the Digital Exchange of Aeronautical Meteorological Information* (Doc 10003) provides implementation guidance on aeronautical meteorological information exchange models and XML/GML. This plan addresses the long-term concept of the MET SWIM system beyond implementation of the information exchange models and beyond initial implementation of XML/GML and digital exchange.

Chapter 2

THE MET SWIM CONCEPT

2.1 MET SWIM CONCEPTS

2.1.1 Meteorological information exchange takes place in SWIM utilizing the core concepts described in Doc 10039. MET SWIM exchanges are enabled by the following more specialized concepts:

Information: The aeronautical meteorology contents being utilized and exchanged in SWIM. In the MET SWIM system there are three types of information: gridded data, non-gridded data, and imagery data. Information is exchanged using a data exchange format, of which one type is an Information Exchange Model. Further detail on the full range of MET information is provided in Section 2.3. Data exchange formats are typically returned from information exchange services (request/reply) or sent as a portion of publish/subscribe messages. The primary information exchange model in MET SWIM is the IWXXM.

Information Exchange Services: An information service which is used to exchange MET information. An information exchange service enables interoperability by following well-defined standards and governance specifications agreed upon by stakeholders and implemented via commonly agreed means. In the MET SWIM system, information exchange services are used to distribute, filter, and transform MET information for use in SWIM.

2.2 SWIM INTERFACES

2.2.1 MET SWIM is a portion of the larger SWIM system and will interface with other SWIM components. There are two primary relationships: a MET SWIM utilization and reliance upon SWIM infrastructure (such as reliable messaging); and MET SWIM use of AIM SWIM information services and data. MET SWIM utilizes the common SWIM infrastructure for TCP/IP network communications, publish/subscribe messaging, request/reply communications, security, registry and metadata, and other facilities.

2.2.2 MET SWIM may interface with AIM SWIM for the following:

a) meteorological observing station metadata at aerodromes (such as location);
b) aerodrome reference points;
c) aerodrome runways;
d) flight information region (FIR) data and locations; and
e) links to further metadata regarding aeronautical service providers such as: meteorological watch offices, air traffic service units, world area forecast centres volcanic ash advisory centres and tropical cyclone advisory centres.

2.3 INFORMATION AND DATA EXCHANGES

2.3.1 Traditional OPMET exchanges have relied on textual data formats, also known as Traditional Alphanumeric Codes (TAC). TAC data exchanges are being replaced by IWXXM XML exchanges in MET SWIM, and new data forms will be exchanged.

2.3.2 INFORMATION EXCHANGE MODELS (NON-GRIDDED DATA)

2.3.2.1 MET SWIM will utilize IWXXM for information exchanges, one of several existing XML/GML exchange models intended for use in the aeronautical domain. As MET SWIM implementation proceeds, current data products in IWXXM will migrate away from the restrictions of traditional alphanumeric code (TAC) towards the exchange of observations, forecasts and warnings with broader utility. One example of such a change is the reporting of the raw observed meteorological values coming from the sensor instead of "binned" data values, such as is reported today with METAR ceiling values. These types of improvements allow for multiple uses of MET SWIM data products, including different visualizations, ready ingest into weather forecast models and direct utilization by both information exchange web services and potentially higher-level decision support web services.

2.3.3 GRIDDED DATA

2.3.3.1 While many data products are adequately specified with non-gridded exchange models, MET SWIM stakeholders will also need to exchange gridded data. Gridded data (also known as raster data) is often, but not always, a regularly spaced set of values such as a satellite image or a set of temperature values over a large geographic area. While gridded data values may also be represented in exchange models in XML format, gridded data is generally too voluminous to be transported efficiently in XML.

2.3.3.2 A graphic showing gridded data with nearby map location information (such as highways) is shown in Figure 1. The individual grid cells are visible, as is the regular spacing of each data value. Gridded data is geo-located on a CRS, such as the world geodetic system (WGS-84) geographic CRS (latitude/longitude) or a Mercator projection CRS.

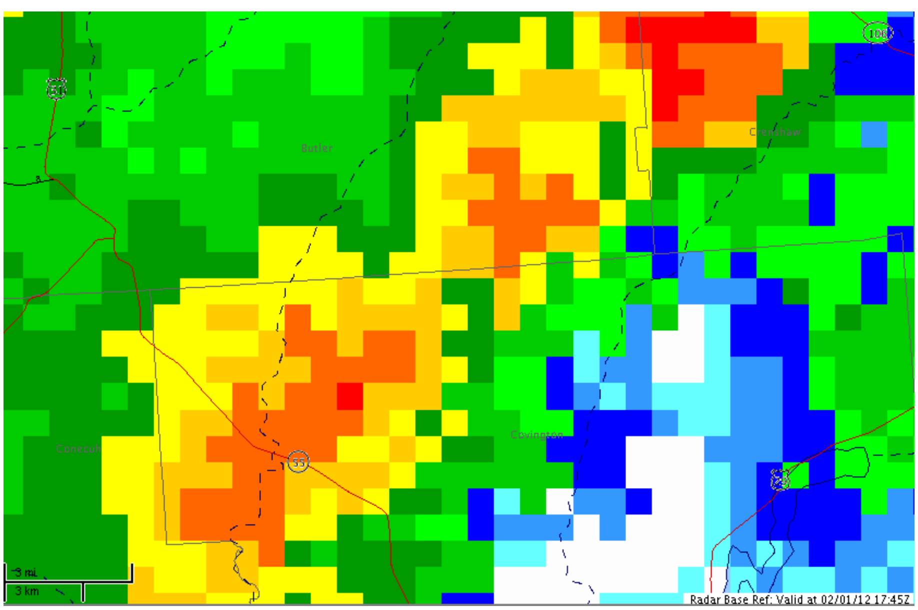

Figure 1 – Rendered geographic map with gridded data cells

2.3.3.3 Gridded data is an efficient representation of raw data values (i.e., not rendered values such as the colored pixels seen in imagery) representing data values from data types such as satellite, radar and numerical weather models, including fields such as wind speed and air temperature.

2.3.3.4 In aeronautical meteorology, gridded data is often exchanged in either the GRIB or netCDF file formats. While other formats are used, few of these are as broadly utilized. Gridded data in the meteorological domain is usually updated over time and is comprised of either two or three spatial dimensions (2-D or 3-D) depending upon whether there is a vertical component.

2.3.4 IMAGE DATA

2.3.4.1 While most of the MET SWIM requirements are met with the raw data values exchanged within gridded and non-gridded data, some MET SWIM products may be disseminated as rendered, geo-located images. Examples of image data formats include JPEG, PNG, and SVG files, such as those seen embedded in web mapping tools and other web sites. Image data may be useful in cases where data consumers need an authoritative and/or globally consistent visualization of raw data.

2.3.4.2 Image data can be used to visualize both gridded and non-gridded data. An example of both types of data can be seen in Figure 1, which shows the rendered gridded radar values overlain with non-gridded road and political boundaries. Due to the simple representation of images it can easily be combined with other images (layered) with little effort or much knowledge of the details of the data being represented.

2.4 REGISTRIES AND METADATA

2.4.1 Doc 10039 describes the need for a registry for use in SWIM. The fundamental purpose of the SWIM registry (also known as a catalog) is to provide a repository of information about who are the available data service providers, what data services they each provide and what data sets they each provide. MET SWIM will utilize many of the resources identified for the SWIM registry, including:

a) web service instances (list of services available in SWIM from the various SWIM information service providers);
b) web service description documents;
c) reference models (common models for the implementation of services and information structures, i.e., the Aeronautical information reference model - AIRM);
d) information exchange standards (e.g., AIXM, IWXXM, FIXM);
e) policies (constraints to be respected in SWIM for security or other purposes);
f) compliance (describe levels of conformity e.g., SWIM compliance); and
g) participants (e.g., information service providers).

2.4.2 In addition, MET SWIM will store and access aeronautical meteorology-specific metadata in the SWIM registry for the following:

a) meteorological data products (e.g., update rate, data quality characteristics, data lineage, detailed data structure descriptions, list of included data fields);
b) static publish/subscribe messaging topics and/or queues available from providers;
c) sensor metadata (e.g., location, quality characteristics); and
d) semantic metadata relating to web services and data products available in the MET SWIM system.

2.5 INFORMATION EXCHANGE SERVICES (WEB SERVICES)

2.5.1 There are two main mechanisms by which data will flow from producers to consumers: data which may be requested through web services as needed, and on-going real-time feeds of messages (notifications or actual data). The former describes the request/reply message exchange pattern described in this section, and the latter the publish/subscribe or messaging exchange pattern discussed in the next section. Both mechanisms will be utilized in MET SWIM.

2.5.2 MET SWIM information exchange services will be utilized to exchange and filter data. MET SWIM information exchanges can be quite voluminous and information exchange services can be utilized to trim down exchanged data to the exact needs of consumers. Due to the different nature of data being exchanged (gridded, imagery, and non-gridded) a specialized information exchange service is required for each. MET SWIM will utilize the OGC Web Feature Service (WFS) for non-gridded data, the OGC Web Coverage Service (WCS) for gridded data, and the OGC Web Map Service (WMS) for image data.

2.5.3 For all information exchange web services (gridded, non-gridded, and imagery web services) the following capabilities are supported:

- Requesting the set of data product(s) offered by the web service;
- Requesting the high-level capabilities of the web service;
- Requesting the detailed structure and content of the offered data products, such as geographic region of the data and the structure of offered data (such as the XML schema that describes offered non-gridded data);
- Requesting metadata regarding the data provider, such as contact information and organization name; and
- Requesting metadata regarding the operational status of the web service and/or data product, such as metadata indicating experimental products.

2.5.4 For non-gridded information exchange using the Web Feature Service, the following capabilities are supported in addition to the common capabilities identified above:

- Requesting data filtered by a geographic bounding box;
- Requesting data within a time range or at a time instant;
- Requesting data within a fixed distance from a route of flight; and
- Requesting data that matches free-form queries, such as all aircraft observations where altitude is greater than FL400 and where the aircraft type is ‘Boeing 747’.

2.5.5 For gridded information exchange using the Web Coverage Service, the following capabilities are supported in addition to the common capabilities identified above:

- Requesting data filtered by a geographic bounding box;
- Requesting data within a time range or at a time instant;
- Requesting data which was generated at a specific forecast run time (for forecast model run data);
- Requesting data within a fixed distance from a route of flight (i.e., returning a vertical cross section, 4-D corridor, or horizontal slice); and
- Requesting data that is re-sampled to a new grid spacing.

2.5.6 For imagery information exchange using the Web Map Service, the following capabilities are supported in addition to the common capabilities identified above:

- Requesting data filtered by a geographic bounding box;

- Requesting data within a time range or at a time instant;
- Requesting data which was generated at a specific forecast run time (for gridded forecast model run data);
- Requesting imagery that is at a different image resolution than the original data;
- Requesting data with custom rendering options such as color ranges, transparency, and symbology; and
- Requesting data in different image formats, such as SVG, JPEG, and PNG.

2.5.7 While the information exchange services as described above address the basic needs for the data exchange requirements of MET SWIM, other more specialized web services are also possible in a MET SWIM environment. These web services can be built to utilize data from the information exchange web services to address more specialized requirements. Because these web services are built atop of the data made available from the information exchange services, information exchange web services may be considered the first tier (Tier 1) and a necessary building block for a second tier (Tier 2) of specialized web services.

2.5.8 An example of one such “Tier 2” web service is a warning service which would enable customized warnings to be pushed (over publish/subscribe communications) to consumers. The warning web service would allow consumers to receive crucial information for decision-making without needing access to large amounts of raw aeronautical meteorology information. As MET SWIM information is updated, thresholds and geographic areas would be checked and warnings pushed to consumers as appropriate. Consumers could submit the following to the warning web service:

- any number of data variable names (such as composite reflectivity or observed wind speed);
- geographic area(s) of interest (bounding box, flight path and distance, or polygon area);
- time period(s) of interest; and
- rules describing when warnings are issued, such as the relationships between data variables, upper and lower data variable thresholds, geographic areas, and time periods.

2.5.9 Another example of a “Tier 2” web service would enable authoritative conversion from XML to TAC for transition purposes and human display. This would remove potential ambiguities in the conversion process, and assist with a smooth transition away from TAC having the role of an data exchange format towards TAC having the role of a display format (potentially among many).

2.5.10 Tier 2 web services can be used to address global needs for complex decision-making, authoritative and consistent decisions, and/or a synthesis of multiple sources of SWIM data including data from outside the MET domain, such as AIM. Due to their dependence upon Tier 1 information exchange services for basic data access, implementation of Tier 2 web services in the MET SWIM system will follow the deployment of Tier 1 web services. Given the unique and aviation-specific nature of these web services, they may not fit well into existing standardized web service protocols such as WCS, WFS, and WMS, but will be implemented using web services and fit into the general SWIM architecture.

2.6 MESSAGING AND PUBLISH/SUBSCRIBE

2.6.1 While information exchange services provide advanced capabilities for accessing MET data, they are insufficient to address all MET SWIM scenarios of real-time information exchange. The *Manual on System Wide Information Management* (Doc 10039) describes common messaging capabilities (the publish/subscribe messaging pattern) to be used throughout SWIM and MET SWIM will utilize this capability to reliably distribute data, notifications, and status updates. Messaging is particularly useful with data that is issued at an unpredictable rate, data that must be delivered as quickly as possible, or data that represents a series of frequent and small updates. Publish/subscribe messaging technology is generally not well suited to distributing large data files/messages directly, and as such will be utilized in MET SWIM for:

- notifying data consumers that data is available for access through a web service such as when a new gridded forecast is available for retrieval;
- pushing relatively small data files directly to consumers as they become available on the provider, such as non-gridded data like aerodrome observations; and
- mission-critical service updates to data consumers, such as notifications of a web service outage, data outage, service/maintenance windows, or degraded provider capabilities.

2.6.2 There are many messaging broker implementations, such as ActiveMQ and RabbitMQ, but relatively few open and standard messaging protocols. As a programming application program interface (API), the Java Message Service (JMS) does not provide network level interoperability between implementations, merely a convenient way for software written in the Java programming language to be written to operate against different messaging broker implementations.

2.6.3 While messaging capabilities are considered a cross-cutting SWIM capability, States and other SWIM participants will communicate directly with other participants. No central messaging brokers will be utilized, and similarly to other SWIM components will be built upon standards that support heterogeneous information exchanges between multiple broker and/or client implementations. Of the messaging protocol standards, the Advanced Message Queueing Protocol (AMQP) is the most general-purpose and well suited to support MET SWIM requirements, and is supported by many existing messaging broker implementations. MET SWIM publish/subscribe messaging will utilize AMQP directly between SWIM participants, which allows stakeholders to choose their message broker and client software as appropriate for their requirements but allow for broad system-wide interoperability.

2.6.4 Publish/subscribe messaging can be utilized to publish information in either a static or dynamic fashion. Static publish/subscribe configurations may be considered a design-time configuration regarding what information is published to predefined topics and/or queues. In the case of static configurations, SWIM providers publish to a fixed set of topics and/or queues which do not change while the system is running. With a dynamic publish/subscribe configuration, the set of published data and the destination topics and/or queues can be modified as the SWIM system is running. For example, a filtered meteorological observation within a specific geographic area could be delivered to a small group of interested Consumers as needed. Dynamic configuration requires an additional request/reply web service on each SWIM Provider to allow modifications to published information at runtime such as described in the OASIS WS-Notification and OGC Publish/Subscribe Interface standards. There are currently no identified requirements for dynamic subscription capabilities, and as such all publish/subscribe messaging will be published in a static, pre-defined manner.

2.7 TESTING AND VALIDATION

2.7.1 As advanced capabilities (and particularly web services) are implemented in SWIM, they introduce the possibility of new types of interoperability problems when implemented incompletely or incorrectly. Therefore, as States and Regional OPMET Centres (ROCs) implement MET SWIM capabilities testing software will be available for evaluating the correct functioning of both web services and data products.

2.7.2 Testing and validation will occur on all components of the system, including web services, messaging capabilities, real-time data flow, and data products. The specific techniques to evaluate the correct functioning of MET SWIM services are beyond the scope of this document, but will be developed and described in a subsequent document.

Appendix A

MET SWIM Standards

This appendix describes the MET SWIM standards which should be implemented by MET States and Regions.

A.1 Standards

Capability	Standard
Request/reply network connectivity	Transmission Control Protocol version 4 (IETF RFC 793) Internet Protocol version 6 (IETF RFC 2460) and Internet Protocol version 4 (IETF RFC 791) Hypertext Transfer Protocol -- HTTP/1.1 (IETF RFC 2616)
Publish/subscribe network connectivity	Advanced Message Queuing Protocol (AMQP) 1.0
Gridded information exchange	OGC Web Coverage Service Interface Standard – Core v2.0.1 OGC Web Coverage Service Interface Standard – Range Subsetting Extension v1.0.0 OGC Web Coverage Service Interface Standard – Scaling Extension v1.0.0 OGC Web Coverage Service Interface Standard – CRS Extension v1.0.0 OGC Web Coverage Service Interface Standard – Interpoation Extension v1.0.0 OGC Web Coverage Service Interface Standard – XML/SOAP Protocol Binding Extension v1.0.0 OGC Web Coverage Service Interface Standard – Key Value Pair (KVP) Protocol Binding Extension v1.0.1
Non-gridded information exchange	OGC Web Feature Service Interface Standard v2.0.0 (also ISO 19142)
Imagery information exchange	OGC Web Map Service Implementation Specification v1.3.0 OGC Styled Layer Descriptor (SLD) Profile of the Web Map Service Specification v1.1.0 OGC Symbology Encoding Implementation Specification v1.1.0

— END —

Appendix C

MET-SWIM Plan and Roadmap (continuation)

Roadmap for Meteorology in System Wide Information Management (SWIM)

2 October 2018

Version 1.3

International Civil Aviation Organization

RECORD OF REVISIONS

Revisions		
No.	Date	Description
1.0	6 September 2016	Initial version developed by the ICAO Meteorological Information Exchange (MIE) Working Group
1.1	6 April 2018	WG-MIE updated based on GANP changes and discussions with the Communications and Information Management Panels
1.2	19 June 2018	Updated based on the outcomes of WG-MIE/4. Additional detail added on timelines and implementation plans
1.3	2 October	Updated based on METP/4 feedback

TABLE OF CONTENTS

LIST OF ABBREVIATIONS AND ACRONYMS

AFTN	Aeronautical Fixed Telecommunication Network
AMHS	Aeronautical Message Handling System
AMQP	Advanced message queuing protocol
ASBU	Aviation system block upgrade
FTBP	File Transfer Body Part
GANP	Global Air Navigation Plan (Doc 9750)
HTTP	Hypertext transfer protocol
IP	Internet protocol
IROG	International Regional OPMET Gateway
IWXXM	ICAO meteorological information exchange model
MET	Meteorology or Meteorological
MWO	Meteorological Watch Office
NOC	National OPMET Centre
RHWAC	Regional Hazardous Weather Advisory Centre
ROC	Regional OPMET Centre
RODB	Regional OPMET Data Bank
RQM	Request/reply query for meteorological databank data in TAC format
SWXC	Space Weather Centre
SWIM	System-wide Information Management
TAC	Traditional Alphanumeric Code
TCAC	Tropical Cyclone Advisory Centre
VAAC	Volcanic Ash Advisory Centre
WAFC	World Area Forecast Centre
WCS	Web Coverage Service
WFS	Web Feature Service
WMS	Web Map Service

Chapter 1 – MET SWIM Roadmap

1.1 INTRODUCTION

1.1.1 The System Wide Information Management (SWIM) will complement human-to-human communications with machine-to-machine communications and improve data distribution and accessibility. However, the flexibility inherent in human communication is not intrinsically included in Information Technology (IT) systems and must be specified and included in the system design. To enable the desired flexibility, IT systems will increasingly need to "ask for / discover" operationally relevant facts, depending on the circumstances, rather than remain "being informed" by pre- agreed messages. Increased machine-to-machine capabilities will enable many new software applications while continuing to support existing human usages.

1.1.2 ICAO Doc 10039 - *Manual on System Wide Information Management (SWIM),* describes general SWIM concepts and characteristics. The MET SWIM Plan – *Plan for Meteorology in System Wide Information Management (SWIM)* - provides further detail on the role of aeronautical meteorology in SWIM, such as the relationship between meteorology and other SWIM domains (such as aeronautical information management (AIM)) in the system, along with design concepts.

1.1.3 This document, the MET SWIM Roadmap, describes the transition plan and associated timelines for implementing MET in SWIM, including the necessary timelines and strategies for implementing necessary non-MET components such as IP networking and HTTP support.

1.1.4 Transition to MET SWIM can be summarized as the following phases:

a) Provision of meteorological products in ICAO Meteorological Exchange Model (IWXXM) format;
b) Provision of meteorological via MET SWIM information exchange services, including Web Feature Service (WFS), Web Coverage Service (WCS), and Web Map Service (WMS), over HTTP;
c) Additional data types beyond IWXXM (non-gridded), including gridded data and imagery;
d) Replacement of AFTN and AMHS "message push" communications with AMQP; and
e) Additional data products beyond those currently distributed in IWXXM.

1.2 TRANSITION PLAN

1.2.1 MET SWIM implementation and transition will proceed based upon the Global Air Navigation Plan (GANP) Block upgrade schedule. IWXXM messages will also become a standard practice in 2020.

1.2.2 There are several components of the MET SWIM transition: physical network connectivity, communications protocols (AFTN, AMHS, AMQP, HTTP), information exchange services (WCS, WFS, WMS), and data types exchanged (gridded, non-gridded, and imagery). The following table summarizes the MET SWIM implementation timeline, this is expanded upon in sections below.

Table 1 - MET SWIM Timeline

	Block 0	Block 1	Block 2	Block 3
Communication protocols (AFTN, AMHS, AMQP)	AFTN (legacy) AMHS FTBP (transitional) AMQP/HTTP (optional)	AFTN (legacy) AMHS FTBP (transitional) AMQP/HTTP (optional)	AFTN (legacy) AMHS (legacy) AMQP/HTTP	AMQP/HTTP
Request/Reply at Regional OPMET Data Banks (RODBs)	AFTN/AMHS request/reply	AFTN request/reply (legacy) WFS, WCS, WMS (optional) AMHS request/reply	AMHS request/reply (legacy) WFS, WCS, WMS	WFS, WCS, WMS
Data Types	Non-gridded	Non-gridded Gridded (optional) Imagery (optional)	Non-gridded Gridded Imagery	Non-gridded Gridded Imagery
Data Addressing	NOC, ROC, RODB, IROG	NOC, ROC, RODB, IROG	IP and SWIM Registry	IP and SWIM Registry

1.2.3 In addition to the technology changes, a transition to MET SWIM will also result in modifications to the organizational roles involved in aeronautical meteorological exchanges. The most significant changes are:

a) IP communications and the SWIM Registry will greatly reduce the need for data aggregation; and
b) More organizations (especially States) will offer web services and data directly to data consumers.

Table 2 - MET SWIM Roles

Function/Role	Block 0	Block 1	Block 2
Data Producer	MWO, VAAC, TCAC, WAFC	MWO, VAAC, TCAC, WAFC, SWXC, RHWAC	MWO, VAAC, TCAC, WAFC, SWXC, RHWAC
Data Aggregator and Validator	NOC, ROC, RODB, IROG	NOC, ROC, RODB, IROG	NOC, ROC, RODB
Data Repository	WAFC, RODB	WAFC, RODB	WAFC, RODB, and State/NOC

Block 0: Current System

1.2.4 The current, mixed system of AFTN and AMHS communications will continue through the end of Block 0. States, ROCs, RODBs, and IROGs in a position to implement AMQP communications in addition to AMHS File Transfer Body Part (FTBP) may do so for IWXXM dissemination. AMHS is considered a transitional communications technique and AMQP implementation plans should be prioritized.

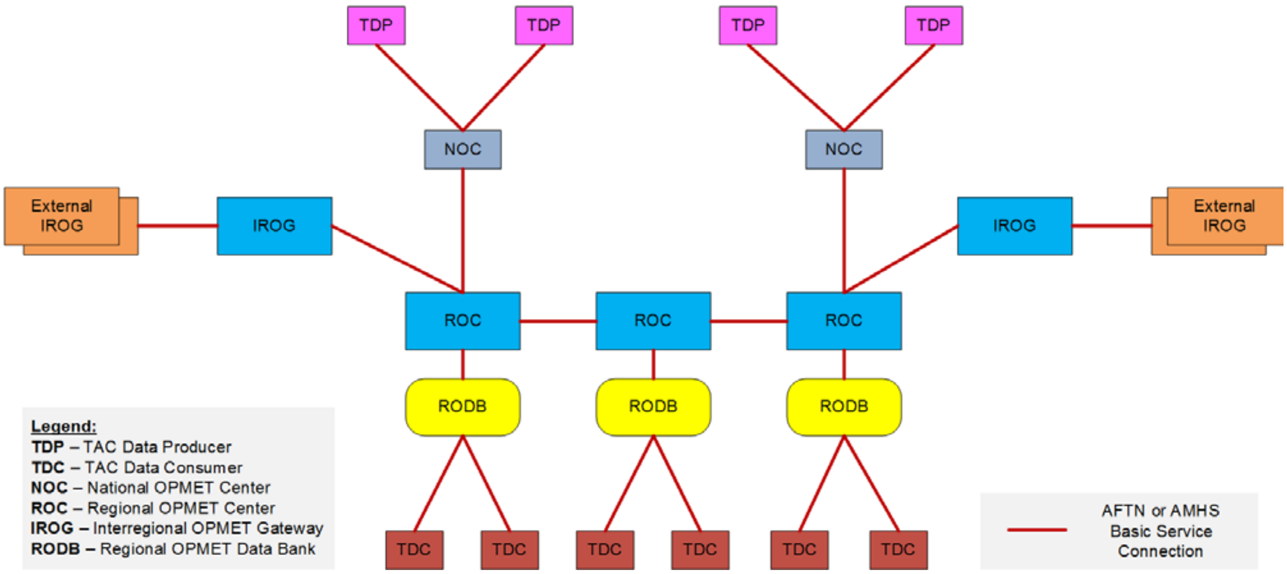

Figure 1 - MET SWIM Block 0

1.2.5 RODBs will utilize the existing RQM method for providing request/reply access to data, and States/RODBs may also offer information exchange services. Most States should be exchanging non-gridded IWXXM and TAC messages and some States may have commenced gridded and imagery information services.

Block 1 and 2: Transition to MET SWIM

1.2.6 States, ROCs, RODBs, and others may commence SWIM technology adoption in Block 1. As a transition Block, both legacy and SWIM communications technologies, data formats, and technology will co-exist for the duration. States, ROCs, RODBs, and others should commence and complete SWIM technology adoption in Block 2. Due to the transition being undertaken in both of these Blocks, the technology will be a mixture of traditional and SWIM-based approaches throughout both Blocks.

1.2.7 States shall implement IWXXM message production as of 2020, but TAC message production will continue throughout Block 1. States, ROCs, and RODBs in a position to do so will introduce gridded and imagery product dissemination on a regional basis.

1.2.8 For those RODBs and States in a position to do so, adoption of AMQP and HTTP (SWIM) communications should be adopted with a preference over AMHS-related communications for publish/subscribe messages and request/reply communications in Block 1. Specifically, ROCs and IROGs should prioritize the adoption of AMQP communications to facilitate State SWIM progress, RODBs should utilize Web Feature Services for request/reply access as an alternative to the AFTN and AMHS FTBP request response interface, and IWWXM data consumers should use the Web Feature Service to consume messages from RODBs and implement AMQP message consumption.

1.2.9 By the end of Block 2, adoption of AMQP and HTTP (SWIM) communications will be complete. ROC and IROG adoption of AMQP communications will be complete, RODBs will utilize Web Feature Services for request/reply access, and IWWXM data consumers will use the Web Feature Service to consume messages from RODBs and implement AMQP message consumption.

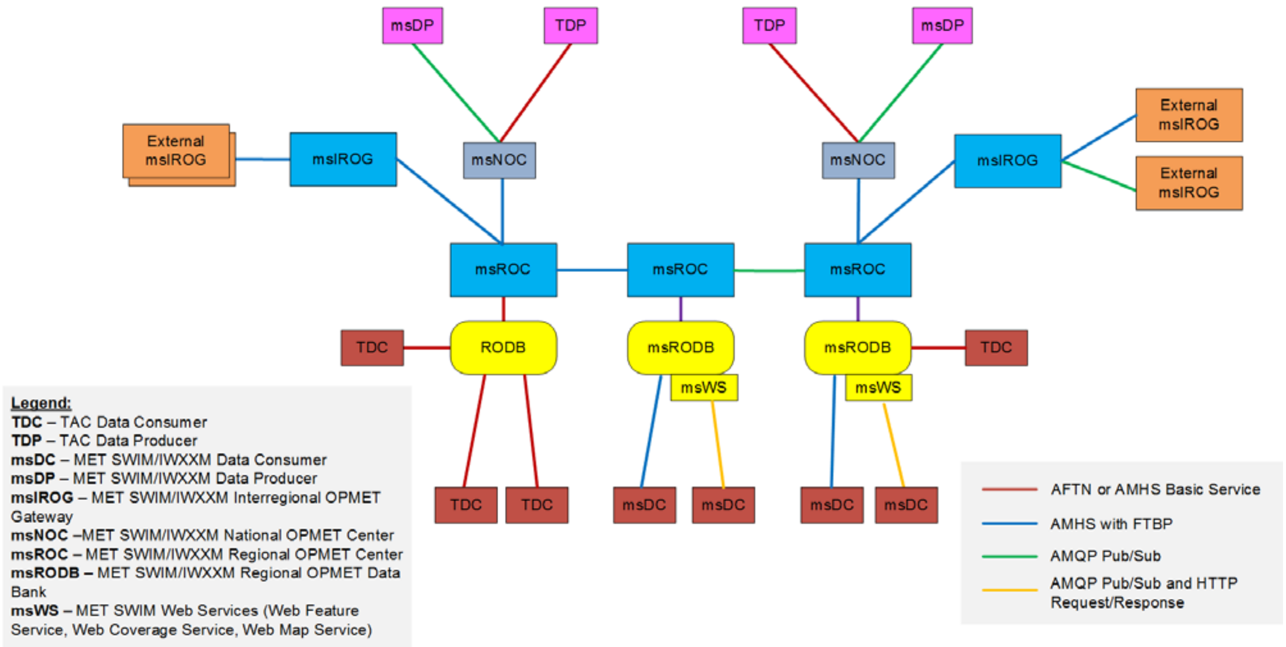

Figure 2 - MET SWIM Block 1 and 2

Block 3: MET SWIM Implementation

1.2.10 In Block 2 the protocol and data exchange transitions are completed and both IWXXM messages and gridded/image data notifications are distributed with AMQP. Gridded and image data consumers retrieve data using HTTP request/response to MET SWIM information exchange services.

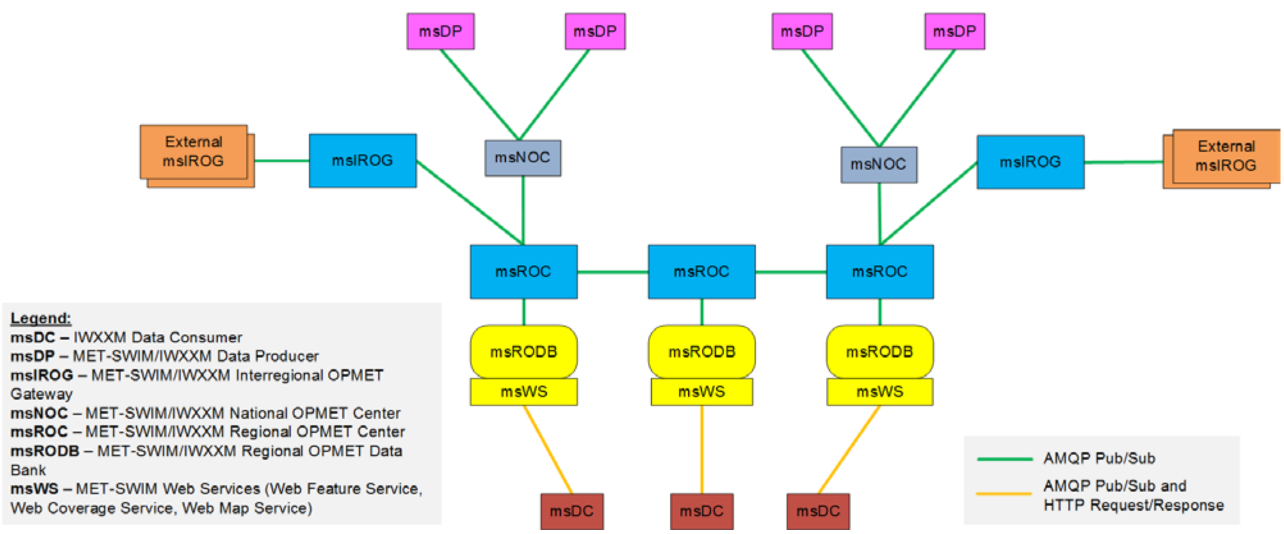

Figure 3 - MET SWIM Block 3

1.3 TIMELINES

1.3.1 As part of the SWIM activity and as part of the Global Air Navigation Plan, MET SWIM implementation will proceed in accordance with the GANP and ASBU schedule. The current ASBU timelines are as follows:

ASBU Block 0 – 2013 to 2018
ASBU Block 1 – 2019 to 2024: B1-SWIM and B1-AMET
ASBU Block 2 – 2025 to 2030: B2-SWIM and B2-AMET
ASBU Block 3 – 2031 and beyond

1.3.2 All MET SWIM pre-requisite interfaces are included in ASBU Module B1-SWIM and therefore MET SWIM Phase 1 can proceed concurrently with ASBU Module B1-SWIM.

Table 3 - MET SWIM Implementation Timelines

	ASBU Module	Implementation Start	Implementation End
SWIM Registry	**B1-SWIM**	2019	2024
Service security	**B1-SWIM**	2019	2024
MET SWIM Block 1 (Early Adoption/Transition)	**B1-AMET**	2019	2024
MET SWIM Block 2 (Transition)	**B2-AMET**	2025	2030
MET SWIM Phase 3 (Operation)	**B3-AMET**	2031	-

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Appendix D

Proposed Amendment to Annex 3 concerning to IWXXM and AFTN and AFS

…

APPENDIX 10. TECHNICAL SPECIFICATIONS RELATED TO REQUIREMENTS FOR AND USE OF COMMUNICATIONS

…

1.1 Required transit times of meteorological information

~~AFTN m~~Messages and bulletins containing operational meteorological information shall achieve transit times of less than 5 minutes, unless otherwise determined to be lower by regional air navigation agreement.

…

2.1.4 ~~Structure~~ Exchange of OPMET bulletins

Meteorological bulletins containing operational meteorological information ~~to~~ shall be transmitted via the ~~AFTN~~ AFS ~~shall be encapsulated in the text part of the AFTN message format~~.

Appendix D (continuation)

Proposed amendment to Annex 10, Volume II concerning to IWXXM and the AFS

…

CHAPTER 4. AERONAUTICAL FIXED SERVICE (AFS)

…

4.3 METEOROLOGICAL OPERATIONAL CHANNELS AND METEOROLOGICAL OPERATIONAL TELECOMMUNICATION NETWORKS

Meteorological operational channel procedures and meteorological operational communication network procedures shall be compatible with aeronautical fixed telecommunication network (AFTN) or ATS (air traffic services) message handling services (ATSMHS) procedures.

Note.— "Compatible" is to be interpreted as a mode of operation ensuring that the information exchanged over the meteorological operational channels also can be exchanged over the ~~*aeronautical fixed telecommunication network*~~ AFTN or ATSMHS *without harmful effect on the operation of the* ~~*aeronautical fixed elecommunication network*~~ AFTN or ATSMHS *and vice versa.*

4.4 AERONAUTICAL FIXED TELECOMMUNICATION NETWORK (AFTN)

4.4.1 General

4.4.1.1 *Categories of messages.* Subject to the provisions of 3.3, the following categories of message shall be handled by the aeronautical fixed telecommunication network:

a) distress messages;

b) urgency messages;

c) flight safety messages;

d) meteorological messages in text format;

…

————————

Appendix E

Changes to Doc 8896 pertaining to IWXXM

…

Chapter 2

METEOROLOGICAL OBSERVATIONS AND REPORTS

…

2.3 ROUTINE REPORTS

2.3.1 Paragraphs 2.3.4 to 2.3.16 deal with the content and format of routine reports in text format; both those in abbreviated plain language disseminated locally (local routine reports or MET REPORTs) and those disseminated beyond the aerodrome of origin (METAR). Local special reports (SPECIALs) and special reports disseminated beyond the aerodrome of their origin (SPECI) are dealt with in paragraph 2.4. Paragraphs 2.4.1.2 to 2.4.2.3 deal with the content and format of special reports in text format. Practices relating to the transmission of local reports by local ATS units to aircraft taking off and landing are given in Doc 9377.

2.3.2 The METAR and SPECI code forms were developed by the World Meteorological Organization (WMO) on the basis of aeronautical requirements established by ICAO. These code forms and local reports use the approved ICAO abbreviations contained in the *Procedures for Air Navigation Services — ICAO Abbreviations and Codes* (PANS-ABC, Doc 8400). In view of this, METAR and SPECI in text format are ~~easily~~ human-readable while their ICAO Meteorological Informational Exchange (IWXXM) version is machine-readable.

Note 1.— All details relating to the METAR and SPECI code forms in text format are contained in the Manual on Codes — International Codes (*WMO-No. 306)*, *Volume I.1, Part A* — Alphanumeric Codes. *Details related to the XML coding are contained in Volume I.3, Part D* — Representations derived from data models.

…

2.3.3 Additionally, METAR and SPECI should be disseminated in ~~a digital~~ IWXXM GML form ~~that must conform with a globally interoperable information exchange model and use extensible markup language (XML)/geography markup language (GML), as well as be accompanied by the appropriate metadata~~.

Note.— Guidance on the IWXXM GML form ~~information exchange model, XML/GML and the metadata profile~~ is contained in the Manual on the Digital Exchange of Aeronautical Meteorological Information *(Doc 10003).*

…

Chapter 3

FORECASTS

…

Table 3-2. Formats of forecasts, including SIGMET and AIRMET information,

warnings, volcanic ash advisories and tropical cyclone advisories

Type of forecast	Abbreviated plain language	Alpha-numeric code form	Binary code form1	IWXXM GML ~~Digital~~ form2	Graphical format

…

1. BUFR and GRIB code forms for WAFS forecasts.
2. ~~Using XML/GML~~ IWXXM form.
3. Part of the METAR code form.
4. Chart form for area forecasts for low-level flights.
5. See Chapter 4.
6. Portable network graphic (PNG) format.
7. Format not specified in Annex 3.

…

3.4 AERODROME FORECASTS (TAF)

3.4.1 TAF follow the general form of an aerodrome routine meteorological report (METAR), consisting of a concise statement of the expected meteorological conditions at an aerodrome for a specified period. Paragraphs 3.4.4 to 3.4.7 deal with the content and format of TAF in text format. They include surface wind, visibility, weather phenomena and cloud, and relevant significant changes thereto (see Example 3-1). Forecasts of weather phenomena are for the area at the aerodrome, i.e. the area within a radius of approximately 8 km of the aerodrome reference point. The word “approximately” is used to cater for aerodromes that have perimeters which are not precisely a radius of 8 km from the aerodrome reference point. Forecasts of cloud are for the aerodrome and its vicinity, i.e. the area within a radius of approximately 16 km of the aerodrome reference point. Forecasts of maximum and minimum temperatures are included in accordance with regional air navigation (RAN) agreement. Detailed technical specifications for TAF can be found in Annex 3, Appendix 5, Table A5-1, which also includes an extensive set of examples of TAF in text format relating to individual portions of the forecast. TAF valid for less than 12 hours are issued every 3 hours and those valid for 12 hours or more are issued at 6-hour intervals. The validity period of TAF is determined for each region in accordance with regional air navigation agreement but must be between 6 and 30 hours inclusive. When issuing TAF, aerodrome meteorological offices must ensure that only one TAF is valid at an aerodrome at any given time. TAF must be issued at a specified time not earlier than one hour prior to the beginning of its validity period.

…

Example 3-1. TAF in text format

…

3.4.8 The TAF code form was developed by the World Meteorological Organization (WMO) on the basis of aeronautical requirements established by ICAO. This code uses the approved ICAO abbreviations contained in the *Procedures for Air Navigation Services — ICAO Abbreviations and Codes* (PANS-ABC, Doc 8400). In view of this, TAF in text format are easily readable while their IWXXM version is machine readable.

Note.— All details relating to the TAF code forms in text format are contained in the Manual on Codes — International Codes *(WMO-No. 306)*, *Volume I.1, Part A* — Alphanumeric Codes. *Details related to the XML coding are contained in Volume I.3, Part D —* Representations derived from data models.

3.4.9 Additionally, TAF should be disseminated in IWXXM GML form ~~in a digital form that must conform with a globally interoperable information exchange model and use extensible markup language (XML)/geography markup language (GML), as well as be accompanied by the appropriate metadata~~.

Note.— Guidance on the IWXXM GML form *~~information exchange model, XML/GML and the metadata profile~~ is contained in the* Manual on the Digital Exchange of Aeronautical Meteorological Information *(Doc 10003).*

Example 3-2. Cancellation of TAF in Text Format

…

3.5 TREND FORECASTS

3.5.1 In most ICAO regions, landing forecasts are supplied. They are prepared in the form of trend forecasts which consist of a concise statement indicating any significant changes expected to occur during the next two hours in one or more of the following meteorological elements: surface wind, visibility, weather phenomena and cloud (see Example 3-3). Paragraphs 3.5.2 to 3.5.3 deal with the content and format of trend forecast in text format. The trend forecast is always appended in text format to a local routine report or a local special report, or METAR or SPECI. Forecasts of weather phenomena are for the area at the aerodrome, i.e. the area within a radius of approximately 8 km of the aerodrome reference point. The word "approximately" is used to cater for aerodromes that have perimeters which are not precisely a radius of 8 km from the aerodrome reference point. Forecasts of cloud are for the aerodrome and its vicinity, i.e. the area within a radius of approximately 16 km of the aerodrome reference point. Detailed technical specifications concerning trend forecasts can be found in Annex 3, Appendix 3, Tables A3-1 and A3-2.

Note.— The aerodromes for which trend forecasts are to be prepared are indicated in the relevant eANP~~, Volume II~~.

…

Example 3-3. Trend forecasts appended to a local routine and special report and to METAR and SPECI in text format

…

3.7 FORECASTS OF EN-ROUTE CONDITIONS

…

3.7.2 WAFS upper-air forecasts

3.7.2.1 Upper-air forecasts are received from WAFCs in ~~digital~~ gridded form and supplied to users in ~~digital~~ gridded or chart form. Wind and temperature data selected from the global forecasts should be depicted on the upper wind and upper-air temperature charts in a sufficiently dense latitude/longitude grid. On the charts, the wind direction is shown by arrows with a number of feathers or shaded pennants to indicate the wind speed, and temperatures are given in degrees Celsius as thus:

…

3.7.2.4 In addition, forecasts of cumulonimbus (CB) clouds, icing, and clear air and in-cloud turbulence are prepared in ~~digital~~ gridded form four times daily by WAFCs and are valid for 6, 9, 12, 15, 18, 21, 24, 27, 30, 33 and 36 hours after the time (0000, 0600, 1200 and 1800 UTC) of the synoptic data on which they are based.

…

3.7.2.6 The WAFS forecasts are provided by the WAFCs in the form of upper-air gridded global datasets for use in flight planning. These datasets include wind, temperature, humidity, CB clouds, icing and turbulence. These data are provided in ~~digital~~ gridded format (i.e. WMO GRIB 2 code form) and are intended to be integrated directly into automatic flight planning systems. The operator may use these data in their flight planning decisions, in accordance with their own business model and safety management systems. It is important to note that the WAFCs do not provide visualizations of upper-air gridded global forecasts in support of flight documentation requirements included in Annex 3, Chapter 9.

…

Chapter 4

SIGMET INFORMATION, TROPICAL CYCLONE AND VOLCANIC ASH ADVISORY INFORMATION, AIRMET INFORMATION, AERODROME WARNINGS AND WIND SHEAR WARNINGS AND ALERTS

…

4.2 SIGMET INFORMATION

4.2.1 The purpose of SIGMET information is to advise pilots of the occurrence or expected occurrence of en-route weather and other phenomena in the atmosphere which may affect the safety of aircraft operations. The weather phenomena (and their code in text format) listed below, when occurring at cruising levels (irrespective of altitude), call for the issuance of SIGMET:

…

4.2.4 SIGMET messages are issued by MWOs and their text form disseminated to aircraft in flight through associated air traffic services (ATS) units. Aircraft in flight should be given, on the initiative of flight information centres (FICs), SIGMET information affecting their routes to a distance equivalent to two hours' flying time ahead of the position of the aircraft.

…

4.2.11 SIGMET messages in text format (see Example 4-1) are issued in abbreviated plain language using approved ICAO abbreviations. In order to facilitate computer processing of the information, strict adherence to the relevant specifications concerning SIGMET messages is essential. To describe weather phenomena, no additional descriptive material is therefore permitted. Detailed technical specifications for SIGMETs in text format are contained in Annex 3, Appendix 6, Table A6-1A.

…

Note 2.— For further details on the preparation and dissemination of SIGMET messages, see the regional SIGMET guides prepared by the ICAO regional offices for use in their respective regions. Information on the required exchanges of SIGMET messages between meteorological offices/stations is contained in the relevant air navigation plan (eANP), Volume II, Part V, Table MET II-1. Additional useful information including arrangements for the distribution of SIGMET messages at aerodromes and to FICs, etc., can be obtained from the Manual on Coordination between Air Traffic Services, Aeronautical Information Services and Aeronautical Meteorological *Services (Doc 9377).*

…

4.2.13 SIGMETs in alphanumeric format should be supplemented by the issuance of these SIGMETs in ~~digital~~ IWXXM GML form by the MWOs. ~~The digital form used must conform with a globally interoperable information exchange model and use extensible markup language (XML)/geography markup language (GML), as well as be accompanied by the appropriate metadata~~.

Note.— Guidance on the IWXXM GML form~~*, XML/GML and the metadata profile*~~ *is contained in the* Manual on the Digital Exchange of Aeronautical Meteorological Information *(Doc 10003).*

Example 4-1. SIGMET messages in text format

…

4.3 TROPICAL CYCLONE AND VOLCANIC ASH ADVISORY INFORMATION

…

4.3.3 The detailed content and format in text format of volcanic ash and tropical cyclone advisory information are in Annex 3, Appendix 2, Tables A2-1 and A2-2, respectively. The advisories in text format are issued in abbreviated plain language using approved ICAO abbreviations. The order of information presented in both advisories is to be strictly adhered to. Examples 4-2 a) and b) in text format show a tropical cyclone advisory message and a volcanic ash advisory message. The advisories should also be issued in IWXXM GML form ~~a digital form and formatted in accordance with a globally interoperable information exchange model, using extensible markup language (XML)/geography markup language (GML). Graphical advisories in a digital form must be accompanied by the appropriate metadata~~. The advisories may also be issued in graphical format in accordance with the models in Annex 3, Appendix 1.

Note.— Guidance on the IWXXM GML form ~~*information exchange model, XML/GML and metadata profile*~~ *is contained in the* Manual on the Digital Exchange of Aeronautical Meteorological Information *(Doc 10003)*.

…

4.3.4.4 The ICAO aeronautical fixed telecommunication network (AFTN) cannot accommodate graphical advisories. ~~Therefore,~~ TCACs and VAACs are expected to make their graphical advisories available through their public Internet websites. The following URL addresses can be used to access tropical cyclone advisories:

…

Example 4-2. Advisory messages for tropical cyclones and volcanic ash in text format

…

4.4 AIRMET INFORMATION

4.4.1 The purpose of AIRMET information is to advise pilots of the occurrence or expected occurrence of specified en-route weather phenomena which may affect the safety of low-level aircraft operations and which were not already included in the forecast issued for low-level flights (see 3.7.5) in the FIR concerned or sub-area thereof. An MWO whose area of responsibility encompasses more than one FIR and/or CTA issues separate AIRMET messages for each FIR and/or CTA within its area of responsibility. The weather phenomena (and their code in text format) listed below, when occurring at cruising levels below FL 100 (or below FL 150 or higher, where necessary in mountainous areas) call for the issuance of AIRMET:

…

4.4.4 AIRMET information is issued by MWOs in accordance with regional air navigation agreement, such agreement taking into account the density of air traffic operating below FL 100 (or FL 150 in mountainous areas). AIRMET messages in text format are disseminated to aircraft in flight through associated ATS units. Low-level flight operations should normally be provided, by FICs, with AIRMET information affecting their routes.

…

4.4.7 AIRMET messages in text format (see Example 4-3) are issued in abbreviated plain language using approved ICAO abbreviations. In order to facilitate computer processing of the information, strict adherence to the relevant specifications concerning AIRMET messages is essential. To describe weather phenomena, no additional descriptive material is therefore permitted. Detailed technical specifications for AIRMET messages in text format are contained in Annex 3, Appendix 6, Table A6-1A.

…

4.4.8 AIRMETs in alphanumeric format should also be supplemented by the issuance of these AIRMETs in ~~digital form~~ IWXXM GML form by the MWOs. ~~The digital form used must conform with a globally interoperable information exchange model and use extensible markup language (XML)/geography markup language (GML), as well as be accompanied by the appropriate metadata~~.

Note.— Guidance on the IWXXM GML form *~~information exchange model, XML/GML and the metadata profile~~ is contained in the* Manual on the Digital Exchange of Aeronautical Meteorological Information *(Doc 10003).*

Example 4-3. AIRMET message in text format

…

Chapter 5

METEOROLOGICAL SERVICE FOR OPERATORS AND FLIGHT CREW MEMBERS

…

Note 1.— The provision of operational meteorological (OPMET) information to aircraft in flight is normally the responsibility of air traffic services (ATS) units. OPMET information supplied by meteorological offices/stations to ATS units in text format is outlined in the Manual on Coordination between Air Traffic Services, Aeronautical Information Services and Aeronautical Meteorological Services *(Doc 9377).*

Note 2.— Details on the use of OPMET information in computer and manual flight planning by operators and flight crew members are given in Appendix 6.
…

5.1.4 Meteorological information is supplied to operators and flight crew members by one or more of the following means, as agreed between the meteorological authority and the operator concerned (the order shown does not imply priority):

a) written or printed material, including specified charts and forms;
b) data in ~~digital~~ GRIB, BUFR and/or IWXXM forms;

c) briefing;
d) consultation;
e) display; or
f) in lieu of a) to e) above, by means of automated pre-flight information systems providing self-briefing
g) and flight documentation facilities while retaining access by operators and flight crew members to
h) consultation, as necessary, with the aerodrome meteorological office.

…

5.1.7 Forecasts listed under 5.1.6 a) 1) to 10) are to be generated from the ~~digital~~ forecasts provided by WAFCs in the GRIB and BUFR code forms whenever these forecasts cover the intended flight path in respect of time, altitude and geographical extent ~~This implies that the meteorological authority has the obligation to make available world area forecast system (WAFS) forecasts for any operator that requires them. Forecasts issued by WAFCs should be received through the aeronautical fixed service (AFS) Internet-based services which disseminate such forecasts to authorized users. If arrangements have been made between the meteorological authority and operators, the operators may obtain these forecasts directly from the WAFC concerned through the AFS Internet-based services (i.e. SADIS FTP and WIFS)~~, unless otherwise agreed between the meteorological authority and the operator concerned.

Note.— Since no forecasts of SIGWX phenomena for the layer from ground to FL 100 are issued by WAFCs, such forecasts, where required for flight planning, briefing, consultation or display, would have to be prepared by the meteorological offices concerned.

5.1.8 When forecasts are identified as being originated by WAFCs, the meteorological authority must ensure that no modifications are made to their meteorological content. Furthermore, charts generated from the ~~digital~~ forecasts provided by WAFCs, in BUFR and GRIB code forms, are to be made available for fixed areas of coverage as shown in Annex 3, Appendix 8 whenever required by operators.

…

Table 5-1. Format of flight documentation

Type of operation / *Product*	*Medium- or high-level flight (above FL 100)*		*Low-level flights (up to FL 100)*	
	Chart form	*Abbreviated plain language*	*Chart form*	*Abbreviated plain language*
Forecasts of upper wind and upper-air temperature	WAFS chart(s)		National/regional charts for the following altitudes: 600, 1 500 and 3 000 m (2 000, 5 000 and 10 000 ft)	GAMET area forecast
Forecasts of SIGWX	WAFS chart(s)		National/regional low-level charts	GAMET area forecast
Aerodrome reports	METAR/SPECI	METAR/SPECI	METAR/SPECI	METAR/SPECI
Aerodrome forecasts	TAF	TAF	TAF	TAF
En-route warnings	SIGMET	SIGMET	SIGMET, AIRMET	SIGMET, AIRMET
En-route advisories	Volcanic ash and tropical cyclone advisories	Volcanic ash and tropical cyclone advisories	Volcanic ash and tropical cyclone advisories	Volcanic ash and tropical cyclone advisories

…

5.3.3 Forecasts of en-route conditions

5.3.3.1 Charts displaying the forecast en-route meteorological conditions to be included in flight documentation are to be generated from the ~~digital~~ forecasts provided by WAFCs *in BUFR and GRIB code forms* whenever these forecasts cover the intended flight path in respect of time, altitude and geographical extent. This implies that meteorological authorities have the obligation to ensure that WAFS forecasts be provided as flight documentation for any operator that requires them. Additionally, to meet the requirements of long-haul flights, route-specific concatenated upper wind and upper-air temperature forecasts should be provided when agreed between the meteorological authority and the operator concerned (see 3.7.4).

…

5.3.3.5 Flight documentation for low-level flights can be provided either in chart form (i.e. a combination of a low-level SIGWX forecast, and an upper wind and upper-air temperature forecast) or in abbreviated plain language (i.e. GAMET), as indicated in Table 5-1. Irrespective of the presentation, the forecasts of upper wind and upper-air temperature are to be provided for points separated no more than 500 km (300 NM) and for at least the following altitudes: 600, 1 500 and 3 000 m (2 000, 5 000 and 10 000 ft) and 4 500 m (15 000 ft) in mountainous areas. When a route to be flown involves the use of both GAMET and a combination of low-level SIGWX forecast and an upper wind and upper-air temperature forecast, the users' attention should be drawn to the differences in the information content in these forecasts. They are listed in Table 5-3.

Note 1.— SIGMET messages in text format are to be included in flight documentation in both cases.

…

Chapter 6

DISSEMINATION OF OPMET INFORMATION AND WAFS FORECASTS

…

6.1.2 For the dissemination of OPMET information beyond the aerodrome, the aeronautical fixed telecommunication network (AFTN), air-traffic services (ATS) message handling system (AMHS) and the aeronautical fixed service (AFS) Internet-based services (see 6.2 and 6.3, respectively) are the primary communication means. ~~Both are~~ These form part of the AFS, which embraces all telecommunication systems used for international air navigation, except ground-to-air transmissions.

6.1.3 In addition, the Internet may be used for the exchange of non-time-critical OPMET information (see 6.3). ICAO international OPMET databanks, which can be accessed through the AFTN or AMHS support inter-regional and regional exchanges and dissemination of OPMET information. **...**

…

6.2 DISSEMINATION OF OPMET INFORMATION ON THE AFTN AND AMHS

6.2.1 OPMET information is transmitted on the AFS, where already implemented on AMHS and if not already, on the AFTN.

6.2.~~1~~2 OPMET information in ~~alphanumeric~~ text format is transmitted on the AFTN (and on most other networks including the public Internet) in the form of "bulletins", each bulletin containing one or more METAR, TAF or other types of information (but always only one type per bulletin) and the appropriate bulletin heading. The heading is essential to permit recognition by users and data handlers, including computers, of type, time and origin of the data contained in the bulletin. It should not be confused with the "AFTN message heading" which determines priority, routing and other telecommunication aspects of the message. All meteorological bulletins transmitted via the AFTN have to be "encapsulated" into the text part of the AFTN message format.

6.2.3 OPMET information in IWXXM GML form will be collated into bulletins, compressed and then transmitted on an AMHS connection with File Transfer Body Part (FTBP) enabled. Each bulletin will contain one or more METAR, TAF or other types of information (but always only one type per bulletin) and the appropriate "bulletin" heading tags. The heading is essential to permit recognition by users and data handlers, including computers, of type, time and origin of the data contained in the bulletin.

Note.— Details concerning the AFTN message format and AMHS protocol are given in Annex 10 — Aeronautical Telecommunications, *Volume II —* Communication Procedures including those with PANS status. *Other details on IWXXM format is available on regional documentation about* "Guidelines on the Implementation of OPMET Data Exchange Using IWXXM Data", *where available, and on WMO website*.

6.2.4 The meteorological "bulletin" abbreviated heading depends on its format, either text or IWXXM.

6.2.~~2~~5 In text format, ~~T~~the meteorological bulletin abbreviated heading consists of a single line, precedes the OPMET information contained in the bulletin, and normally comprises three groups as follows:

...

6.2.6 In IWXXM format, the meteorological "bulletin" header first two letters are as follows:

LA	METAR including trend forecasts, if provided
LP	SPECI including trend forecasts, if provided
LT	TAF valid for 12 hours or more
LC	TAF valid for less than 12 hours
LW	AIRMET information
LS	SIGMET information
LY	SIGMET information for tropical cyclones
LV	SIGMET information for volcanic ash
LK	Tropical cyclone advisory information
LU	Volcanic ash advisory information
LN	Space weather advisory information

Note: Other elements related to the IWXXM GML form can be found WMO-No.306, Volume I.3, Part D — Representations derived from data models.

6.2.~~3~~7 Bulletins containing OPMET information and disseminated on the AFTN and AMHS are given priorities depending on their urgency; warnings (SIGMET information), amendments to forecasts, and other meteorological information of immediate concern to aircraft in flight or about to depart are given a relatively high priority; next are METAR, TAF, and other messages exchanged between aerodrome meteorological offices.

Note.— Details concerning message priorities on the AFTN and AMHS are given in Annex 10, Volume II and in the Manual on Detailed Technical Specifications for the Aeronautical Telecommunication Network (ATN) using ISO/OSI Standards and Protocols *(Doc 9880), Part II.*

6.2.4~~8~~ Messages containing OPMET information should be filed promptly for transmission on the AF~~TN~~S in good time. METAR and SPECI are normally filed within five minutes of the time of the observation, and TAF not earlier than one hour prior to the beginning of their validity period.

6.2.~~5~~9 The time interval between the time of filing and the time of receipt of a message is called the "transit" time. Messages containing OPMET information transmitted on the AF~~TN~~S should ~~normally~~ have transit times of less than five minutes~~, except for METAR, SPECI and TAF exchanged over distances exceeding 900 km which may have transit times of up to ten minutes~~.

6.2.~~6~~10 In some regions, special collection and dissemination systems have been designed for the more efficient handling of OPMET information exchanged on ~~AFTN circuits~~ AFS such as ROBEX in the ICAO ASIA/PAC and MID Regions, ~~and~~ the Africa-Indian Ocean Meteorological Bulletin Exchange (AMBEX) in the ICAO AFI Region and the RODEX in the ICAO EUR Region.

...

6.3.1 A global set of OPMET information and world area forecast system (WAFS) forecasts are made available through the AFS Internet-based services (SADIS FTP and WIFS operated by WAFC London and WAFC Washington, respectively) to meteorological offices. Where the necessary arrangements have been made, the service may also be available to other users, such as ATS units and operators. The AFS forecasts available through the AFS Internet-based services are in the ~~form of digital data in the~~ GRIB code form, comprising forecasts of upper wind and upper-air temperature, humidity, tropopause heights and temperatures, maximum winds, CB clouds, icing, in-cloud and clear air turbulence and geopotential altitude data, as well as SIGWX forecasts in the BUFR code form.

...

6.4 INTERROGATION PROCEDURES FOR INTERNATIONAL OPMET DATABANKS

...

6.4.2 In order to be accepted by the databank, the interrogation must be in agreement with the following principles:

a) it must contain the proper AFTN address used for interrogation to get data in text format and the proper AMHS address used for interrogation to get data in IWXXM GML form ~~(e.g. SBBRYZYX for Brasilia, EBBRYZYX for Brussels, LOWMYZYX for Vienna, KWBCYMYZ for Washington)~~; and

b) only one line of interrogation (69 characters of text) is allowed to get data in text format.

6.4.3 The standard interrogation for one message must include the elements listed below in the following order:

a) "RQM/" indicating the start of a data request line for a text data and "RQX/" indicating the start of a data request line for an IWXXM data;

b) data-type identifier;

c) four-letter ICAO location indicator; and

d) equal sign (=) indicating the end of the interrogation line, e.g. RQM/SAKMIA=.

…

6.4.5 The following special interrogation procedures are available if more than one message is needed:

a) the same data type may be requested for a number of meteorological offices/stations without repeating the data-type identifier. The location indicators have to be separated by commas (,) which indicate the continuation of the request for the same type of data, e.g. for text data RQM/SAEHAM,EHRD= ;

b) various data types may be interrogated in the same message using the oblique (/) as a separator, e.g. for IWXXM data RQ~~M~~X/~~S~~LAKMIA/~~F~~LTKMIA=.

…

Chapter 9

RELEVANT DOCUMENTS

…

Regional guides

Most ICAO regional offices prepare and make available regional guides on various subjects including: regional SIGMET guides; the AMBEX system; the ROBEX system; the RODEX system; catalogue of information available in international OPMET databanks, Guidelines for the Implementation of OPMET Data Exchange Using IWXXM etc. For details, regional offices should be approached directly.

…

Appendix 1
INFORMATION ON THE WORLD AREA FORECAST SYSTEM (WAFS)

(See 1.5)

1. GENERAL DESCRIPTION

…

1.2 The objective of the system is to provide meteorological offices, meteorological authorities and other users (e.g. pilots and operators) with global aeronautical meteorological en-route forecasts ~~in digital form~~. This objective is achieved through a comprehensive, integrated, worldwide, uniform and cost-effective system which takes full advantage of evolving technologies. Currently, two world area forecast centres (WAFCs), i.e. WAFC London and WAFC Washington, issue global upper-air forecasts in the WMO GRIB Edition 2 code form and medium- and high-level SIGWX forecasts in the BUFR code form. In addition, the WAFCs issue, as a back-up, SIGWX forecasts in the PNG chart form which can also be used by States unable to generate charts from the BUFR data.

…

2. GUIDELINES FOR AUTHORIZED ACCESS TO THE WAFS INTERNET-BASED SERVICES

…

2.1.2 The aeronautical information made available by the WAFS Internet-based services includes primarily OPMET information and WAFS upper wind and upper-air temperature, humidity, tropopause heights and temperatures, maximum winds, cumulonimbus clouds, icing, in-cloud and clear air turbulence and significant weather forecasts in gridded~~digital grid-point~~ and graphical formats, and alphanumeric messages.

…

Appendix 9

GUIDELINES FOR ACCESS TO AERONAUTICAL METEOROLOGICAL INFORMATION

…

1.1 Aeronautical meteorological information consists of operational meteorological (OPMET) information ~~including~~ and the WAFS upper wind, humidity and temperature and significant weather forecasts and alphanumeric messages. The ~~alphanumeric~~ OPMET messages consist of tropical cyclone advisories, volcanic ash advisories, aerodrome routine meteorological reports (METAR), aerodrome special meteorological reports (SPECI), special air-reports (AIREP), aerodrome forecasts (TAF), GAMET area forecasts, ~~route forecasts (ROFOR)1,~~ and SIGMET and AIRMET information.

…

~~[1] Requirements for ROFOR have since been eliminated from Annex 3.~~

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Appendix F

Proposed changes to Doc 10003 pertaining to IWXXM

Doc 10003
AN/503

Manual on the Digital Exchange of Aeronautical Meteorological Information

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AMENDMENTS

Amendments are announced in the supplements to the *Publications Catalogue;* the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
No.	Date	Entered by
1	29/9/17	ICAO
2	XX/XX/18	ICAO

CORRIGENDA		
No.	Date	Entered by

FOREWORD

This first edition of the *Manual on the Digital Exchange of Aeronautical Meteorological Information* was published in response to the introduction of the exchange of aeronautical meteorological information in a digital form as part of Amendment 76 to Annex 3 — *Meteorological Service for International Air Navigation*, applicable 14 November 2013. As of this date, aerodrome routine and special meteorological reports (METAR and SPECI, including trend forecasts (TREND)), aerodrome forecasts (TAF) and SIGMET information may be exchanged in a digital form by States that are in a position to do so.

Amendment No. 1 was issued to reflect Amendment 77 to Annex 3, applicable 10 November 2016, which recommended the issuance of volcanic ash advisory and tropical cyclone advisory information, METAR and SPECI (including TREND), TAF, and SIGMET and AIRMET information in a digital form, in addition to their issuance in abbreviated plain language.

Amendment No. 2 was issued in accordance with the mandatory exchange of the above information from November 2020, in addition to space weather advisory, in IWXXM form as specified in Amendment 78 to Annex 3 which will become applicable from 8 November 2019. The document title was changed to *Manual on the ICAO Meteorological Information Exchange Model*.

Where States exchange space weather advisory, volcanic ash advisory and tropical cyclone advisory information, METAR and SPECI, TAF, and SIGMET and AIRMET information in a digital form, Annex 3 requires that the information:

a) be formatted in accordance with a globally interoperable information exchange model;

b) use extensible markup language (XML)/geography markup language (GML); and

c) be accompanied by the appropriate metadata.

This manual is intended to assist States in each of these three respects.

The availability of aeronautical meteorological information in a globally interoperable digital format is seen as a key enabler for future global air traffic management within a system-wide information management (SWIM) environment. Consequently, the enabling of digital exchange is an important part of the transition of all required aeronautical meteorological information to a digital form and its integration into a SWIM environment. Future amendments to Annex 3 are therefore expected to enhance and expand the digital exchange provisions. This manual will, consequently, be subject to periodic review and amendment to ensure necessary alignment with the evolving Annex 3 provisions in this regard.

The content of the manual was developed primarily by the ICAO Meteorological Aeronautical Requirements and Information Exchange Project Team (MARIE-PT) and subsequently by the Meteorological Panel (METP) Working Group on Meteorological Information Exchange (WG-MIE). Expertise from airline and pilot representative organizations and regional programmes for air transport modernization, and the World Meteorological Organization, was utilized. The first edition of this manual was peer-reviewed by various domain experts.

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LIST OF ABBREVIATIONS AND ACRONYMS

AFS	Aeronautical Fixed Service
AIM	Aeronautical information management
AIRMET*	Information concerning en-route weather phenomena which may affect the safety of low-level aircraft operations
AIXM	Aeronautical information exchange model
ANSP	Air navigation service provider
ATM*	Air traffic management
CDM	Collaborative decision making
FIXM	Flight information exchange model
GML	Geography markup language
ISO	International Organization for Standardization
IWXXM	ICAO meteorological information exchange model
METAR*	Aerodrome routine meteorological report (in meteorological code)
METCE	Modèle pour l'Échange des Informations sur le Temps, le Climat et l'Eau (of the World Meteorological Organization, WMO)
NOP	Network operations plan
OGC	Open Geospatial Consortium
OPM	Observable property model
~~SAF~~	~~Simple aeronautical features~~
SIGMET*	Information concerning en-route weather and other phenomena in the atmosphere that may affect the safety of aircraft operations
SPECI*	Aerodrome special meteorological report (in meteorological code)
SWIM	System-wide information management
TAC	Traditional Alphanumeric Code
TAF*	Aerodrome forecast (in meteorological code)
TREND*	Trend forecast
UML	Unified modelling language
W3C	World Wide Web Consortium
WMO	World Meteorological Organization
~~WXXM~~	~~Weather information exchange model~~
XML	Extensible markup language
XSD	XML schema definitions

* Abbreviations included in the *Procedures for Air Navigation Services — ICAO Abbreviations and Codes* (PANS-ABC, Doc 8400)

Chapter 1

BACKGROUND

1.1 THE EVOLVING GLOBAL AIR TRANSPORT SYSTEM

1.1.1 The *Global Air Traffic Management Operational Concept* (Doc 9854) describes the manner in which the air traffic management (ATM) system will deliver services and benefits to airspace users by 2025-2030 and is in line with the recommendations of the Twelfth Air Navigation Conference (Montreal, 19–30 November 2012). It also details how ATM will act directly on the flight trajectory of a manned or an unmanned vehicle during all phases of flight, and the interaction of that flight trajectory with any hazard. Its scope describes the services that will be required to operate the global ATM system up to and beyond 2028.

1.1.2 This operational concept and the *Global Air Navigation Plan* (Doc 9750) address what is needed to increase user flexibility and maximize operating efficiencies in order to increase system capacity and improve safety levels in the future ATM system.

1.1.3 The guiding principle is that the ATM system is based on the provision of services. The service-based framework described in the operational concept considers all resources (including airspace, aerodromes, aircraft and humans) to be part of the ATM system. The primary functions of the ATM system will enable flight from an aerodrome into airspace and its subsequent landing, safely separated from hazards, within capacity limits, making optimum use of all system resources. The description of the operational concept components is based on realistic expectations of human capabilities and the ATM infrastructure at any particular time in the evolution of the ATM system described by this operational concept. It is independent of reference to any specific technology.

1.1.4 It is evident that the future ATM system will be founded on knowledge-based collaborative decision making (CDM). Effective CDM requires the intelligent use of the characteristics of uncertainty that are associated with the meteorological information provided. This form of risk management will enable decision makers to make executive choices according to their own objectively determined thresholds for action.

1.1.5 The system will be a network-based operation formed by four main components:

a) a robustly networked ATM system which improves information sharing;

b) a sharing of information which will enhance the quality of information and provide shared situational awareness;

c) collaboration and self-synchronization enabled by shared situational awareness; and

d) enhanced sustainability and speed of decision-making.

Collectively these will dramatically increase the efficiency of the ATM system.

1.2 NET-CENTRIC OPERATIONS

1.2.1 The concept of common (collaborative) information sharing has been under development for a decade or more. It was borne from a clear recognition that future ATM will be managed on a “network-centric” (net-centric) basis, with each aerodrome and each aircraft being considered as a node interlinked with all others within the system. Considerable investment is being made to develop the means to implement CDM at aerodromes and from a flow-management perspective, as first steps towards system-wide efficiency. Substantial progress has been made with the individual stakeholders at an aerodrome identified and the information needs and flows mapped. Site-specific trials are yielding positive results and CDM is being progressively rolled-out on a global basis.

1.2.2 Nevertheless, it is clearly recognized that individual (national) airspaces and aerodromes cannot continue to be regarded as singular and isolated components of ATM. Each will serve as a node interlinked with all others within the system. A transition to a service-centric approach within a global business framework is clearly required. ATM must be managed on a net-centric basis, and aerodrome and network CDM and the transition to a “time-ordered” system will be practical representations of this concept.

1.3 CONSEQUENCES FOR METEOROLOGICAL SERVICES

1.3.1 The global ATM system will continue to be subject to the same vagaries of weather phenomena that affect air transport today. The additional and significant volume of air traffic predicted for the coming years will render the system significantly more sensitive to disruption and the consequential increased costs associated with it. Historically, aeronautical meteorological services have mainly addressed safety issues. Now, within the context of the evolving ATM system, the considerable impact of weather on capacity and efficiency and the potential to mitigate some of the environmental impacts of aviation must be given greater consideration while continuing to operate safely.

1.3.2 The importance of timely, accurate and easily available meteorological information for decision support is emphasized in Doc 9854. As such it is recognized that the success of the ATM system will be reliant on effective planning and management to deliver to the airspace user the (near as possible) optimum business trajectory while ensuring flexibility. Flow and capacity management enabled by high-precision time-based metering (e.g. consistently achieving the required time of arrival, four-dimensional (4D)-trajectory management and short/medium-term conflict detection and resolution) will be significant means of ensuring flight punctuality, efficiency and maintaining system throughput. This will be a key component in the effective management of congested airspace and aerodromes.

1.3.3 Furthermore, based on forecast traffic volumes and their orientations, and weather forecasts, air traffic flow management will originate and control the daily plan (e.g. network operations plan (NOP), story book) and will apply any refinements to accommodate real-time events. The need to adapt the original plan may also result from forecast significant weather phenomena that are monitored on a continuous basis.

1.3.4 A key change needed is the evolution of the interfaces between the airlines, flight crews and ATM network in determining the optimum profiles for a flight. The airline operations centres will examine the requirements for a flight and the current and predicted environment in which to operate (e.g. as meteorological conditions, airspace structure, en-route capacity, aerodrome capacity and environmental considerations) so as to select the optimum flight trajectory. Meteorological information will be collated and analysed in order to assess, in conjunction with aircraft performance data and user charges, the cost benefit of modified flight profiles or alternative routes, and aircraft may be re-planned while in flight.

1.3.5 The development of air- and ground-based automated systems, in association with new procedures and working arrangements in ATM (e.g. 4D trajectory management[1]), is required to support future operations. It is expected that these will permit the dynamic management of airspace allowing the tactical routing of aircraft to provide significant operational benefits (safety, economy, flexibility, improved regularity and environmental-impact mitigation) to users.

1.3.6 Certain meteorological conditions (e.g. low visibility, strong winds, thunderstorms) and weather-induced runway contamination (e.g. snow, volcanic ash) can and do restrict aerodrome and airspace capacity. Each aerodrome, and to some extent, each sector of airspace is affected by local meteorological conditions which impact on their individual actual capacity at any moment in time. New equipment to support aircraft operations during hazardous meteorological conditions (e.g. advanced surface movement guidance and control systems, synthetic vision), are becoming increasingly available. Nevertheless, the key to mitigation and minimization of disruption will rely primarily on the intelligent use of increasingly accurate forecasting of meteorological conditions. This will be especially important for large, congested hub aerodromes and their associated airspace.

1.3.7 Improvements are also foreseen in terminal area short-term forecasting (e.g. departure and approach wind profiles) to maximize runway throughput. This will be achieved by the incorporation of such data into algorithms to provide tools for use by controllers to improve aerodrome throughput by delivering time-based separation rather than the inefficient distance-based separation of today, and a reduction of wake-vortex separation when conditions so exist. Furthermore, terminal area short-term forecasting will support continuous descent operations in general.

1.3.8 Figure 1-1 provides a graphical representation of the different stages in the 4D-trajectory evolution linked to the various stages of planning and where the integration of meteorological information could be envisaged.

1.3.9 The key to efficient operation of the ATM system is interoperability within the ATM environment. This will be enabled by advanced communications systems, standard interfaces and by standard information exchange models that support the required seamless, transparent and open digital exchange of meteorological information.

1.3.10 An important consideration in this respect is to ensure global interoperability not only from a meteorological information perspective but also on interlinks with other identified relevant data domains. ATM systems, such as controller decision support tools, will not only use meteorological information but will fuse this information with other relevant information, such as aeronautical information and flight Information, to support knowledge-based decision-making. Figure 1-2 provides a graphical representation of the different identified data domains and user communities.

1. 4D trajectory management is the process that captures the overall traffic situation in the NOP and controls the development of the business or mission trajectories in four dimensions (latitude, longitude, flight level and time). Specifically, 4D trajectory management is the process by which the business trajectory of the aircraft is established, agreed, updated and revised. This is achieved through collaborative decision making processes between the operator, ATM, and other stakeholders where applicable, except in time-critical situations when only the flight crew and controller are involved.

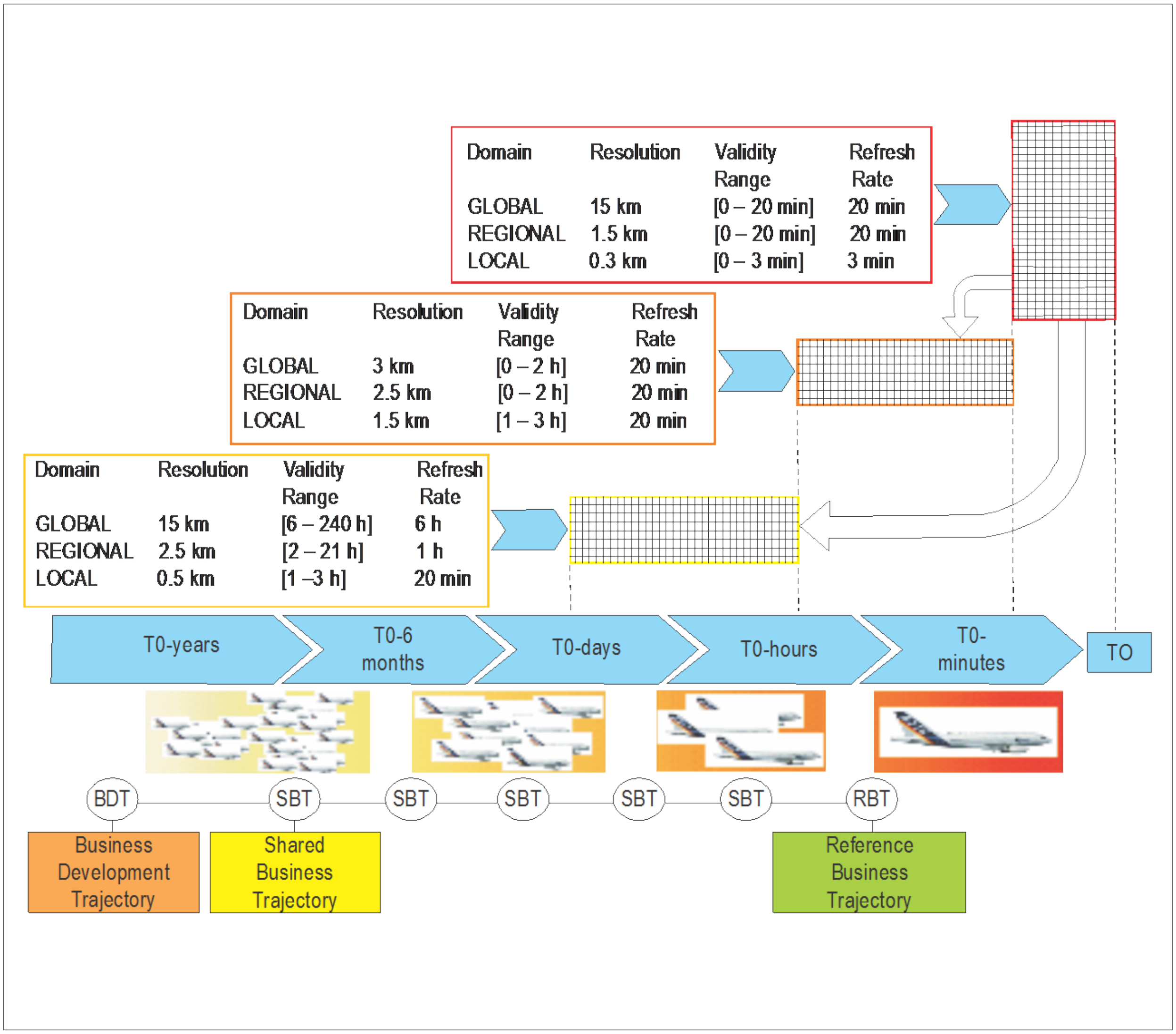


Figure 1-1. MET-ATM perspective

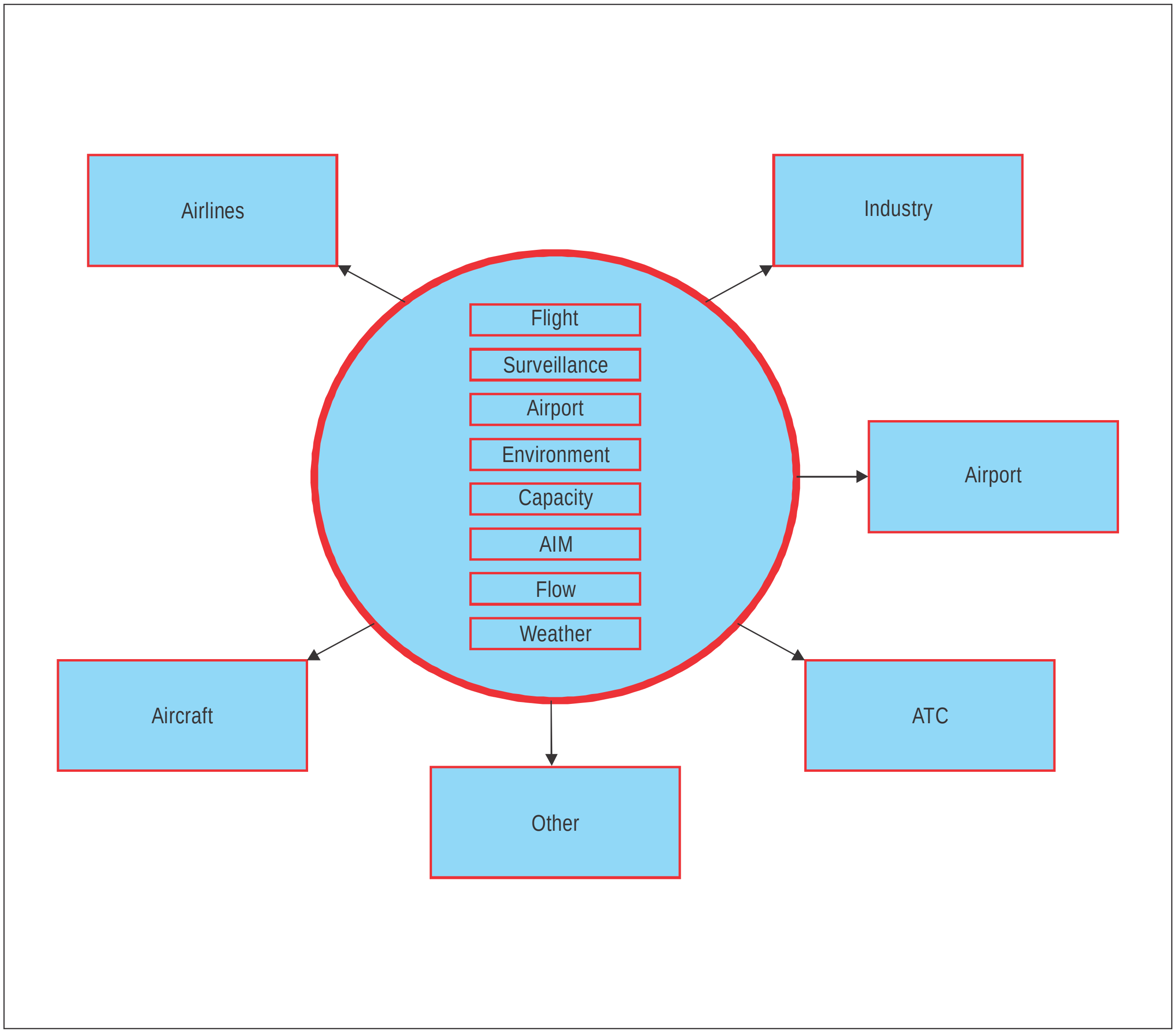


Figure 1-2. ATM information

Chapter 2

DIGITAL INFORMATION EXCHANGE PRINCIPLES

2.1 GLOBAL INTEROPERABILITY

2.1.1 To achieve global interoperability within the ATM system (see 1.3), it is crucial that the exchanged data share the same meaning at both its origin and its destination. This enables systems to combine and process received data from different identified domains and from (multiple) sources. This so-called global semantic interoperability is vital for international air navigation. It is a true strategic air transport industry asset and resource.

2.1.2 A simplified, non-exhaustive overview of the aggregation of the different information components that one could identify only in the wider context of aeronautical meteorological information exchange includes the following:

a) ICAO global aeronautical meteorological constructs (the globally defined aeronautical meteorological information constructs that are uniquely required by the provisions of Annex 3 and to be globally shared);

b) ICAO regional aeronautical meteorological constructs (the regional aeronautical meteorological information constructs that are uniquely required by the provisions of ICAO regional air navigation plans as determined by regional air navigation agreement); and

c) user, State or multi-State specific aeronautical meteorological constructs (the aeronautical meteorological information constructs that are not specifically required by the provisions of Annex 3, or are additions to Annex 3 but identified as important to be shared in a specific user context with a specific user benefit).

2.1.3 These three identified components are a high-level decomposition of aeronautical meteorological information exchange recognizing that this could be decomposed further. From a meteorological information provision perspective, each component includes elements that are not unique to aeronautical meteorology but are common to meteorology in general; or elements could be identified that are not unique to aeronautical meteorology but are common to aviation.

2.1.4 When establishing true global semantic interoperability, the efforts to standardize or specify meteorological information exchange should not be limited to the high-level perspective on aeronautical meteorological information only, but should include establishing the same meaning at both their origin and their destination of these common meteorological and common aeronautical information elements. For example, the notion "runway" in a meteorological information exchange environment cannot have a different meaning than a "runway" used in aeronautical information exchange. Alternatively the meaning of "temperature" could not be modified in an aeronautical context and still be called "temperature".

2.1.5 The decomposition of the broad domain of aeronautical meteorological information exchange in distinct elements such as the global aeronautical meteorological component, generic meteorological element and generic aeronautical element is the prerequisite for a truly data-centric environment to support international air navigation. By this decomposition, information is unbundled to potentially be rebundled and integrated in an information service that contributes to the overall air transport safety and performance targets.

2.1.6 Meteorological information exchange then becomes an integral component of the system-wide information management concept, where information management solutions will be defined at the overall system level, rather than individually at each major subsystem (programme/project/process/function) and interface level, as has happened in the past (Doc 9854 refers).

2.2 SYSTEM-WIDE INFORMATION MANAGEMENT

2.2.1 The scope of global system-wide information management (SWIM) includes all the information exchanged globally between applications and the infrastructure that makes it possible; by using a common methodology for information elements of interest and by the use of appropriate technology and standards. Conceptually, the following five loosely coupled, bidirectional layers are identified (see Figure 2-1):

a) applications of global service providers and service consumers that publish and/or use information;

b) services for information exchange, defined for each ATM information domain following governance specifications, and agreed by SWIM stakeholders;

c) standards for information exchange which provide the subject-specific standards for sharing information for the above information exchange services;

d) SWIM messaging infrastructure which provides the infrastructure and governance for sharing information and sometimes referred to as the “SWIM Infrastructure”; and

e) global information technology infrastructures, providing consolidated telecommunications services, including hardware.

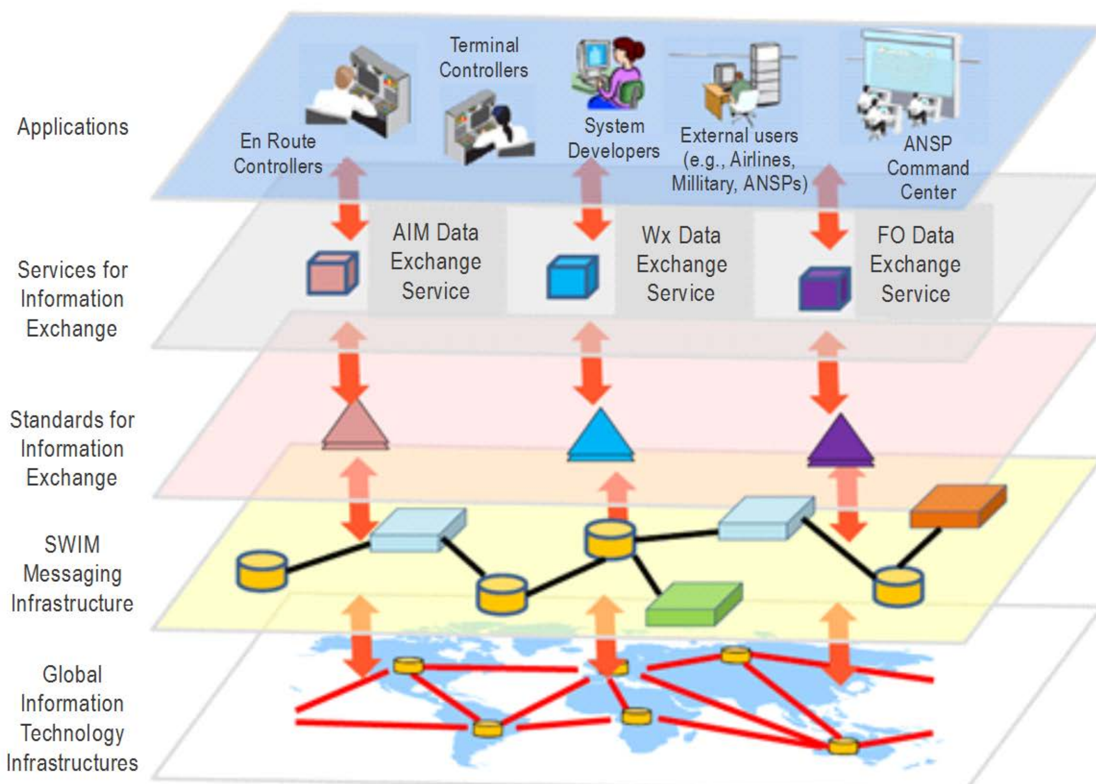
2.2.2 The required provisions and guidance for the digital exchange of aeronautical meteorological information especially operate at levels b) and c) of this layered SWIM approach. The messaging infrastructure and information technology standards (levels d) and e)) are prerequisites for the Annex 3 provisions on digital information exchange and the scope of this guidance. The applications level (level a)) is considered stakeholder-specific so is the concern of the actual provider and consumer and, as such, not included in Annex 3 provisions or in the associated guidance.

2.3 DATA, INFORMATION AND SERVICE MODELLING

2.3.1 One technique to structure the complex and interlinked aspects of global interoperability and the supporting information management framework is by modelling the data, information and services that are required from a systems perspective.

2.3.2 Data and information models are used to represent concepts, relationships, constraints, rules and operations to specify data semantics for a chosen domain of discourse, in this case ATM and its related domain aeronautical meteorology. These data models provide a sharable, stable, and organized structure of information requirements in a domain context and as such provide a key component of the required global (semantic) interoperability. Service models provide a description of (information) services needed to directly support an operational domain and as such build on the data/information captured in these respective models to define the information content of a service.

2.3.3 Different approaches exist in what the required level of abstraction and composition for data, information and services models should be for describing the required level of interoperable information exchange. For the purpose of digital aeronautical meteorological information exchange in support of Annex 3, it is sufficient to specify a so-called foundation and to represent the required models at the logical and



physical level only.

Figure 2-1. SWIM layers

2.3.4 Following iterations of the models to support the digital exchange of aeronautical meteorological information could require a separate conceptual view. This view usually provides a high-level description of the meteorological data concepts and the relationships between those concepts which are currently interwoven with the logical models, since a specific exchange solution was in mind.

2.3.5 The conceptual view should, in the medium to long term, not be described at the level of the data domain but on the level of all global air transport information exchanges required. When required, specific logical and physical representations of the meteorological exchange required could be derived from that. The recommendations of the AN-Conf/12 on a) globally interoperable system-wide information management and b) developing a logical architecture to address the global interoperability issues will drive this approach to derive logical and physical information exchange models from one reference. This will have an impact on the digital exchange of aeronautical meteorological information and the supporting models for iterations to come.

Foundation

2.3.6 Certain elementary steps need to be performed to create data models and the desired (semantic) interoperability to ensure that exchanged data from system component to system component share the same meaning at both their origin and their destination. In this elementary phase of modelling data, choices are made on the fit for use and fit for purpose of existing generic principles and standards with respect to information exchange. This so-called "foundation" of generic standards applicable for aeronautical meteorological information is primarily based on the notion that it is a type of geospatial and time referenced information. Furthermore, when discussing the physical exchange of the information in more detail, this should be based on available generic web technology. Moreover, all should fit in the overall context of ATM information exchange also referred to in the draft ICAO SWIM Concept.

2.3.7 The foundation applied to model aeronautical meteorological information is based on the following, mainly International Organization for Standardization (ISO), standards and specifications:

- ISO 19103 — *Geographic information — Conceptual schema language*
- ISO 19107 — *Geographic information — Spatial schema*
- ISO 19108 — *Geographic information — Temporal schema*
- ISO 19115 — *Geographic information — Metadata*
- ISO 19123 — *Geographic information — Schema for coverage geometry and functions*
- ISO 19136 — *Geographic information — Geography Markup Language (GML)*
- ISO/TS 19139 — *Geographic information — Metadata - XML schema implementation*
- ~~ISO 19156 — *Geographic information — Observations and measurements*~~
- ISO 639-2 — *Codes for the representation of names of languages* (Part 2)
- World Wide Web Consortium (W3C) — *XML Schema Specification.*

Logical data model

2.3.8 The level of abstraction required for a model that represents the aeronautical meteorological data exchange needs varies from system environment to system environment and is strongly related to the level of restrictions imposed by the choice of foundation.

2.3.9 To describe aeronautical meteorological information constructs with the given foundation, the level of abstraction reflected in the ICAO provisions is the logical data model. This model allows analysis of data definition aspect without consideration of implementation specific or product specific issues. Furthermore, the details of an often complex physical exchange of data are hidden in order to facilitate the communication of it to those who are not familiar with the techniques involved.

2.3.10 A commonly used language to provide the semantics and abstract structure of all the information that needs to be made available by meteorological service providers as prescribed by the existing provisions is the unified modelling language (UML)[1]. Such a description in UML includes the intrinsic data requirements and structural business process rules and is a so-called technology independent description not concerned with code form specifications. More detail on UML is provided in Appendix A.

1. Defined by the object management group. The UML is a graphical language designed to visualize, specify, construct and document the artefacts of a software-intensive system. The UML offers a standard way to write a system's blueprints, including conceptual aspects such as business processes and system functions as well as concrete considerations such as programming language statements, database schemas and reusable software components.

2.3.11 The ICAO meteorological information exchange model (IWXXM) provides such a logical data model for aeronautical meteorological information in support of international air navigation.

Physical data model

2.3.12 From a system's architectural perspective, a guiding logical data model for aeronautical meteorological information is sufficient. This is the only prerequisite required to develop physical implementations of systems that exchange meteorological information in the ATM domain.

2.3.13 However, for the purpose of international information exchange and to establish true interoperability, it is beneficial to provide an additional level of structure. Currently, such a structure is provided by Annex 3 and other supporting documents, e.g. World Meteorological Organization Publication No. 306 — *Manual on Codes*.

2.3.14 This structure in the context of the digital exchange of aeronautical meteorological information is provided by a physical data model. Such a model for the physical implementation of aeronautical meteorological information exchange is for instance based on generic standards for the exchange of geospatial and time-referenced information.

Extensibility

2.3.15 As described in previous paragraphs, key to an interoperable data-centric environment satisfying user needs is the application of the common foundation of standards, specifications and modelling practices for all components of ATM information. This includes the possibility of developing an easy and cost-effective extension to the global baseline. Without the possibility of developing an extension, regional and State practices based on Annex 3 and user specific requirements will require the development and maintenance of specific solutions for the information of their concern.

2.3.16 The extensibility of the IWXXM is fundamental to successful and affordable digital meteorological information exchange.

2.4 IDENTIFIED COMPONENTS TO SUPPORT THE DIGITAL EXCHANGE OF AERONAUTICAL METEOROLOGICAL INFORMATION

2.4.1 Based on the notions and principles described in 2.1, 2.2 and 2.3, the following structure of (model) components has been chosen to support the digital exchange of aeronautical meteorological information:

> ***IWXXM logical model.*** The exchange model for aeronautical meteorological information in UML, in the form of an ISO 19109 application schema, which, in its version 3~~2~~, ~~is restricted to~~ describes the exchange of space weather advisory, volcanic ash advisory and tropical cyclone advisory information, METAR and SPECI (including TREND), TAF, and SIGMET and AIRMET only[2];

2. By some architectural frameworks, the current iteration of the IWXXM logical model would not qualify as a data model but as an information service model due to its specific nature of describing the exchange of legacy reports.

IWXXM XML schema. A GML-based[3] implementation of the IWXXM logical model derived programmatically following proven industry standards and best practices; and

~~***Simple aeronautical features (SAF) logical model (deprecated).*** Originally developed and maintained as integral part of the IWXXM to represent the decomposed common aeronautical information constructs, the use of SAF had deprecated starting from IWXXM version 2 as references were made directly to relevant aeronautical information constructs in AIXM;~~

~~***SAF XML schema (deprecated).*** See SAF logical model above; and~~

WMO packages[4] which are either ~~from an IWXXM perspective~~ foundation elements (2.3.6 and 2.3.7 refers) from an IWXXM perspective or a construct for packaging a collection of IWXXM messages expressed as logical models in the form of UML class diagrams and as GML-based implementations (schema):

— Modèle pour l'Échange des Informations sur le Temps, le Climat et l'Eau (WMO METCE) provides conceptual definitions of meteorological phenomena, entities and concepts in order to underpin semantic interoperability in the weather, climate and water domain in the form of an application schema[5]; and

— Observable Property Model (WMO OPM) provides a framework for qualifying or constraining physical properties based on a draft best practice developed by the Open Geospatial Consortium (OGC) Sensor Working Group[6].

— Feature Collection Model (WMO COLLECT) is used to represent a collection of IWXXM messages[7] of the same type. The intent is to allow IWXXM encoded meteorological information to be packaged in a way that emulates the existing data distribution practices used within the Aeronautical Fixed System (AFS).

2.4.2 Figure 2-2 provides an overview of the described structure in the form of a UML package diagram.

3. GML is the XML grammar defined by the OGC to express geographical features. GML serves as a modelling language and an open interchange format for geographic information transactions. The ability to integrate all forms of geographic information is key to the utility of GML.
4. The manual includes guidance on the IWXXM logical model and IWXXM XML schema only. For the WMO components refer to the appropriate WMO guidance material.
5. The relevant schema, in the form of xsd-files, are available at http://schemas.wmo.int/metce/~~1.0/~~
6. The relevant schema, in the form of xsd-files, are available at http://schemas.wmo.int/opm/~~1.0/~~.
7. A collection of meteorological information is often referred to as a bulletin.

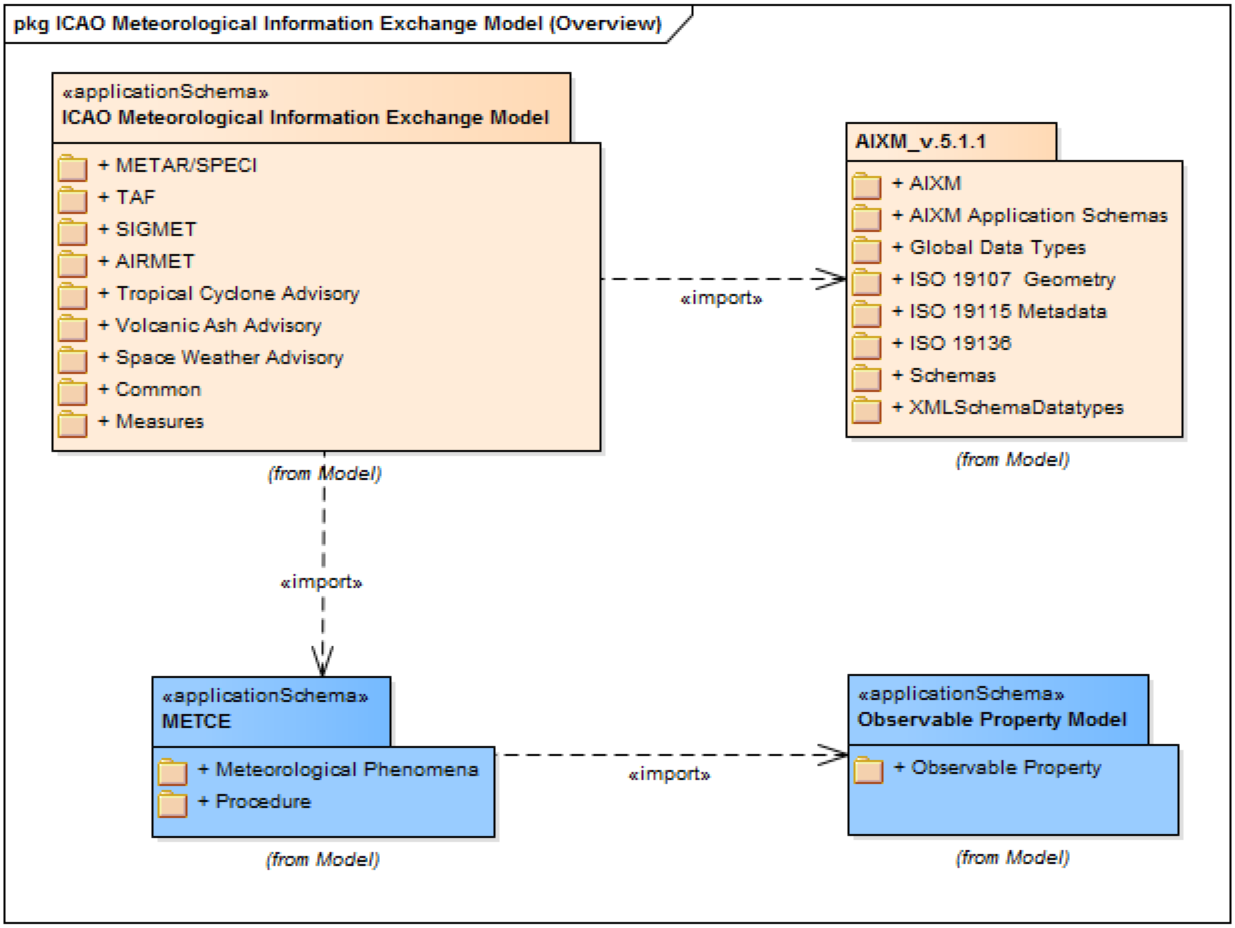


Figure 2-2. UML package diagram

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Chapter 3

IWXXM LOGICAL MODEL

3.1 SCOPE

3.1.1 It is important to consider that the scope of the IWXXM logical model will evolve as aeronautical meteorological information requirements and the digital exchange of this required information will change over time. Additionally, not only evolving meteorological requirements but also emerging developments in other ICAO data domains will have an impact on the scope of the IWXXM.

3.1.2 This requires a modular approach for the logical data model which is provided by a strict adherence of next iterations of the logical data model to the declared foundation (inclusive of the WMO packages). The foundation provides the common ground for this modular approach and thus a flexible IWXXM.

3.1.3 Figure~~s~~ 3-1 ~~and 3-2~~ provides a graphical representation of the~~ potential evolution~~ foundation elements of IWXXM. The IWXXM will over time evolve into the single global baseline for aeronautical meteorological information exchange capturing all the global information exchange requirements with the possibility of creating IWXXM extensions to satisfy user specific needs.

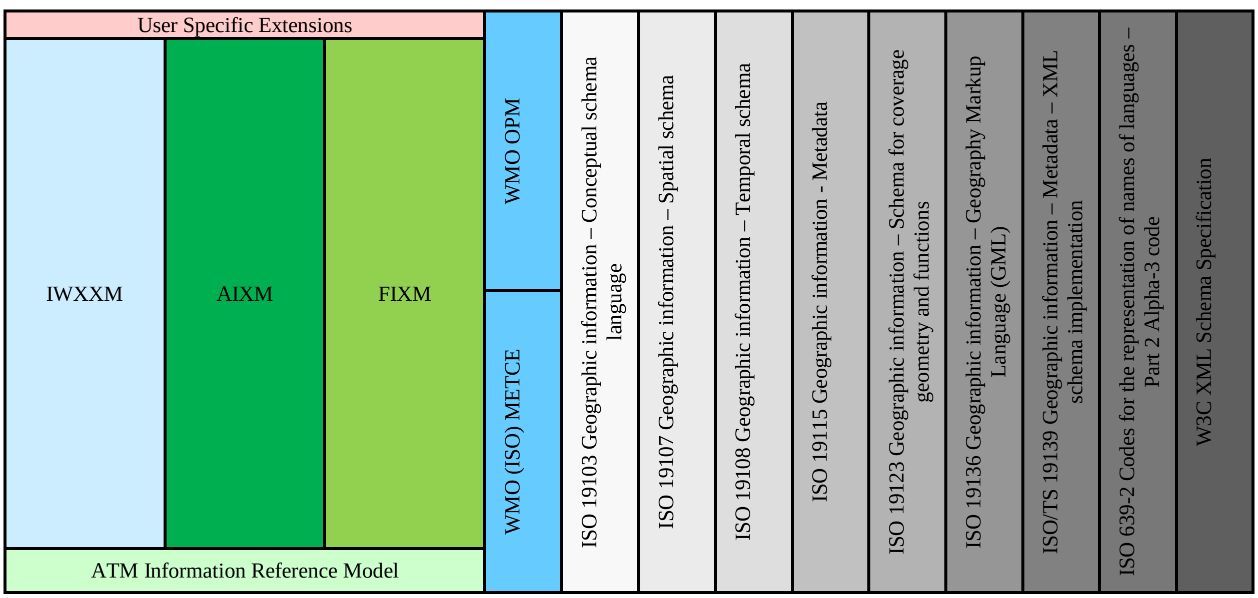

Figure 3-1. IWXXM and its foundation elements ~~positioning 2013~~

~~**Figure 3-2. IWXXM foreseen positioning 2019 onwards**~~

~~3.1.4 The stakeholder requirement to have other aeronautical meteorological information exchange models such as WXXM[1] available to bridge the gap between the current scope of IWXXM and what is desired will then potentially become obsolete from a global information exchange perspective.~~

3.2 BASELINE VERSION

The baseline for the IWXXM includes all information constructs ~~relevant to~~involved in the exchange of meteorological information described in ICAO Annex 3 which includes~~replacing the traditional alphanumeric codes. The traditional alphanumeric code formats involved are~~:

a) METAR (including TREND);

b) SPECI (including TREND);

c) TAF;

d) SIGMET;

e) AIRMET;

f~~e~~) tropical cyclone advisory;

g~~f~~) volcanic ash advisory; and

~~g) AIRMET~~ h) space weather advisory.

3.3 SPECIFICATION

3.3.1 The IWXXM logical model describing the exchange of METAR and SPECI (including TREND), TAF, SIGMET, AIRMET, tropical cyclone advisory, volcanic ash advisory and space weather advisory information ~~AIRMET~~ is specified by a number of interdependent context (class) diagrams (UML). The context (class) diagrams describe the interrelationships between identified features, types and allowed enumerations.

3.3.2 The following context (class) diagrams specify the IWXXM at the logical level:

a) METAR/SPECI:

1) METAR/SPECI;

2) METAR/SPECI observation;

~~1. WXXM is a meteorological information model fully aligned with the foundation as described in 2.3.6 and 2.3.7. Where IWXXM covers the specific information exchange requirements for a selected set of Annex 3 products, WXXM covers a broader scope of aeronautical meteorological information exchange requirements.~~

3) METAR/SPECI trend forecast;

4) METAR/SPECI weather;

5) METAR/SPECI runway state;

b) TAF:

1) TAF

2) TAF forecast

c) SIGMET:

1) SIGMET;

2) SIGMET analysis;

3) SIGMET forecast position;

d~~f~~) AIRMET:

1) AIRMET;

2) AIRMET evolving condition analysis;

e~~d~~) tropical cyclone advisory:

1) tropical cyclone advisory;

2) tropical cyclone observed conditions;

3) tropical cyclone forecast conditions;

f~~e~~) volcanic ash advisory:

1) volcanic ash advisory;

2) volcanic ash conditions;

g) space weather advisory:

1) space weather advisory;

2) space weather conditions;

h~~g~~) common:

1) cloud;

2) surface wind;

3) weather;

4) relational operator; and

i~~h~~) measures:

1) measure.

3.3.3 Figure 3-~~3~~2 provides an example of a context diagram for MeteorologicalAerodromeObservation.

3.3.4 All the IWXXM context (class) diagrams with identified features, types and allowed enumerations are published in World Meteorological Organization Publication No. 306 — *Manual on Codes*, Volume I.3, Part D — *Representations derived from data models*, which is available online at http://www.wmo.int/pages/prog/www/WMOCodes.html.

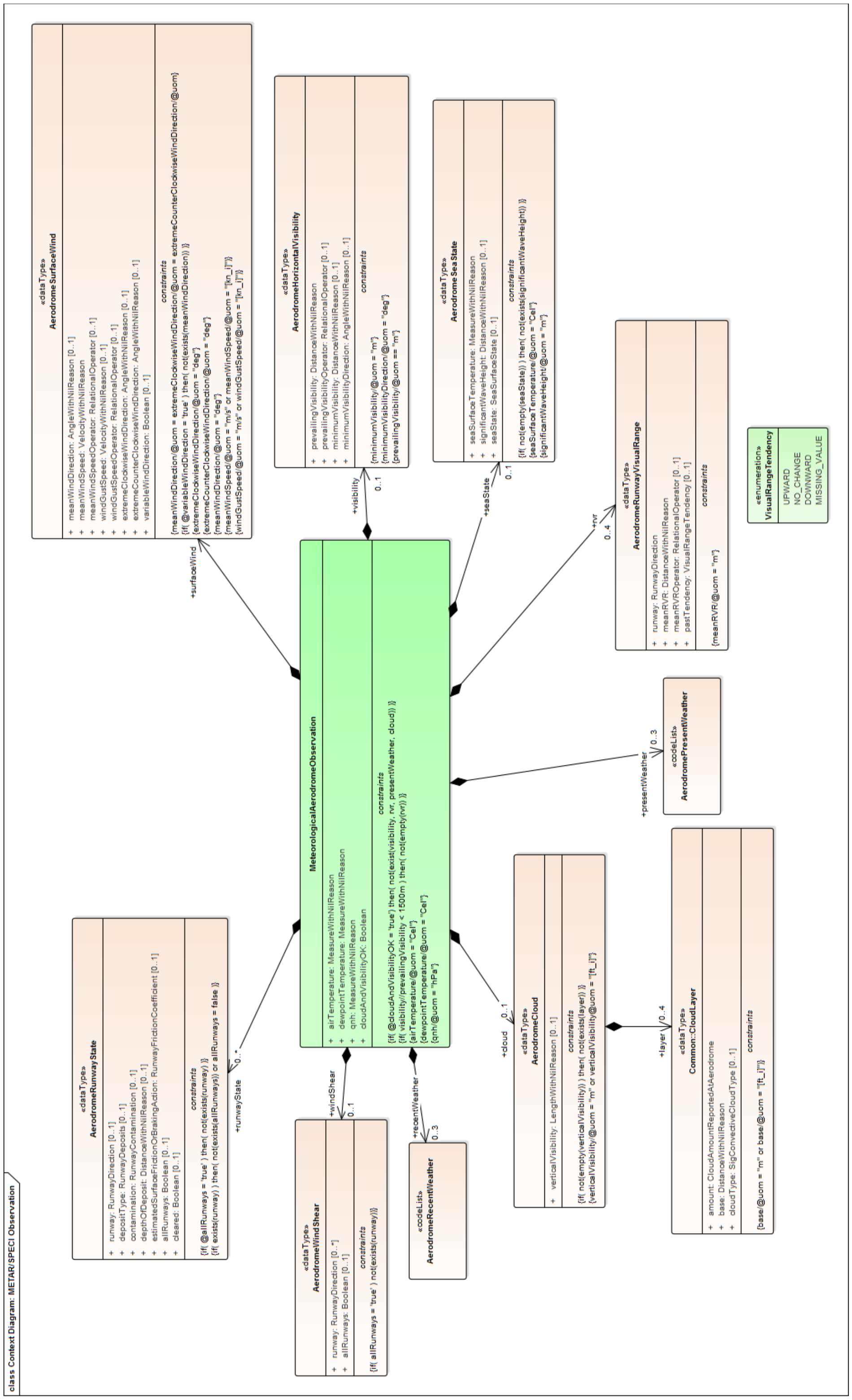

Figure 3-~~3~~2. Example of a context diagram METAR/SPECI Observation

---

Chapter 4

IWXXM XML SCHEMA

4.1 INTRODUCTION

4.1.1 The IWXXM XML schema is a physical data model for aeronautical meteorological information in support of the meteorological service for international air navigation. It is a GML-based application of the logical data model. It uses pre-defined XML/GML elements and is based on industry standards and the available WMO packages; the physical model elements of the so-called foundation.

4.1.2 A physical exchange form based on XML was identified as the most suitable for the digital exchange of aeronautical meteorological information. Moreover, this general consensus extends to the need to migrate towards a specific XML grammar to express geographical features. The specific XML grammar selected to describe meteorological information in function of time, place, coverage, etc. is GML. More detail on XML/GML is provided in Appendix B.

4.1.3 It is worthwhile noting that not every existing or emerging code format to exchange aeronautical meteorological information should necessarily be replaced by a GML-based code format in IWXXM. For example, gridded data can be exchanged in other more efficient manners. Optionally, GML could still be used as the so-called "wrapper" of the information when found necessary.

4.1.4 However, independent of the exchange format, it is essential that all the information constructs, also for the gridded data, are captured at the technology- and format-independent layer of the IWXXM logical data model.

4.2 SPECIFICATION

XML/GML schema for aeronautical meteorological information exchange

4.2.1 The IWXXM XML/GML schema describing the physical exchange of METAR and SPECI (including TREND), TAF, SIGMET, tropical cyclone advisory, volcanic ash advisory and AIRMET in the form of XML is specified by a number of XML schema definitions (XSD).

4.2.2 The following XSD specify the IWXXM at the physical exchange level:

a) iwxxm.xsd;

b) metarSpeci.xsd;

c) taf xsd;

d) sigmet.xsd;

e~~g~~) airmet.xsd;

ef) tropicalCycloneAdvisory.xsd;

g~~f~~) volcanicAshAdvisory.xsd;

h) spaceWeatherAdvisory.xsd;

i~~h~~) common.xsd; and

j~~i~~) measure.xsd.

4.2.3 Table 4-1 provides an example of a fragment of metarSpeci.xsd from the IWXXM.

4.2.4 All the IWXXM XSD are published at http://schemas.wmo.int/iwxxm.
.

Table 4-1. A fragment of metarSpeci.xsd

```
<?xml version="1.0" encoding="UTF-8"?>
<schema elementFormDefault="qualified" targetNamespace="http://icao.int/iwxxm/3.0" version="3.0.0RC1"
xmlns:iwxxm="http://icao.int/iwxxm/3.0" xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns="http://www.w3.org/2001/XMLSchema">
  <include schemaLocation="measures.xsd"></include>
  <include schemaLocation="common.xsd"></include>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"></import>
  <annotation>
    <documentation>METAR and SPECI reporting constructs as defined in ICAO Annex 3 / WMO No. 49-2.

    METAR and SPECI reports include identical information but are issued for different purposes.

    METAR reports are routine observations made at an aerodrome throughout the day.  METAR observations are made (and
distributed) at intervals of one hour or, if so determined by regional air navigation agreement, at intervals of one half-hour.

    SPECI reports are special (i.e., non-routine) observation made at an aerodrome as needed. SPECI observations are made
(and distributed) in accordance with criteria established by the meteorological authority, in consultation with the
appropriate ATS authority, operators and others concerned.

    References to WMO and ICAO Technical Regulations within this XML schema shall have no formal status and are for
information purposes only. Where there are differences between the Technical Regulations and the schema, the Technical
Regulations shall take precedence. Technical Regulations may impose requirements that are not described in this
schema.</documentation>
  </annotation>
  <simpleType name="TrendForecastTimeIndicatorType">
    <annotation>
      <documentation>Time indicators for trend forecast conditions.  These are equivalent to the traditional FM, TL, and AT
codes</documentation>
    </annotation>
    <restriction base="string">
      <enumeration value="AT">
        <annotation>
          <documentation>This trend forecast specifies a time instant at which time conditions occur (AT)</documentation>
        </annotation>
      </enumeration>
      <enumeration value="UNTIL">
        <annotation>
          <documentation>This trend forecast specifies a time period which commences at the beginning of the trend forecast
period and is completed by a specified time (TL)</documentation>
        </annotation>
```

```
      </enumeration>
      <enumeration value="FROM">
        <annotation>
          <documentation>This trend forecast specifies a time period which commences at a specified time and is completed by
the end of the trend forecast period (FM)</documentation>
        </annotation>
      </enumeration>
      <enumeration value="FROM_UNTIL">
        <annotation>
          <documentation>This trend forecast specifies a time period which commences at a specified time and is completed by
another specified time (FM and TL)</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
  <element name="MeteorologicalAerodromeObservationReport"
type="iwxxm:MeteorologicalAerodromeObservationReportType" substitutionGroup="iwxxm:Report" abstract="true">
    <annotation>
      <documentation>A report of observed and trend forecast weather phenomenon from the surface near an aerodrome. This is
a shared superclass for METAR and SPECI reports, which have identical reported information.</documentation>
    </annotation>
  </element>
  <complexType name="MeteorologicalAerodromeObservationReportType" abstract="true">
    <complexContent>
      <extension base="iwxxm:ReportType">
        <sequence>
          <element name="aerodrome" type="iwxxm:AirportHeliportPropertyType">
            <annotation>
              <documentation>The aerodrome location for this report</documentation>
            </annotation>
          </element>
          <element name="issueTime" type="gml:TimeInstantPropertyType">
            <annotation>
              <documentation>The time at which this report was issued</documentation>
            </annotation>
          </element>
          <element name="observationTime" type="gml:TimeInstantPropertyType">
            <annotation>
              <documentation>The time at which phenomena were observed.  This may differ from the times reported for
forecast conditions</documentation>
            </annotation>
          </element>
          <element nillable="true" name="observation" type="iwxxm:MeteorologicalAerodromeObservationPropertyType">
            <annotation>
              <documentation>The observation which resulted in the current meteorological conditions at an
aerodrome</documentation>
            </annotation>
          </element>
          <element nillable="true" name="trendForecast" minOccurs="0" maxOccurs="3">
            <annotation>
              <documentation>The process that results in a trend forecast.  When no change is expected to occur during a
forecast period ("NOSIG") this is indicated by a single missing trend forecast with a nil reason of
noSignificantChange</documentation>
            </annotation>
            <complexType>
              <complexContent>
                <extension base="gml:AbstractMemberType">
                  <sequence>
                    <element ref="iwxxm:MeteorologicalAerodromeTrendForecast"></element>
                  </sequence>
                </extension>
              </complexContent>
            </complexType>
          </element>
        </sequence>
        ,,,
```

Referencing meteorological vocabulary in IWXXM

4.2.5 In IWXXM, meteorological vocabulary has been moved out of the model so that changes to the vocabulary do not require a corresponding change in the data model. A uniform resource identifier (URI) is used in IWXXM messages to describe a meteorological concept or phenomena. For example, drizzle as described in Table 4678 of World Meteorological Organization Publication No. 306 — *Manual on Codes* is written as URI http://codes.wmo.int/306/4678/DZ in an XML document. See Table 4-2 for a fragment of a METAR XML message with drizzle in its present weather.

4.2.6 WMO has published authoritative meteorological terms on the WMO Codes Register (Appendix C refers) at http://codes.wmo.int to facilitate referencing of meteorological vocabulary in IWXXM. Through a browser, one can view not only whether a registry reference is valid, but also the authentic and detailed description of the entry. A local copy of the registry can also be used to validate the content of an IWXXM instance.

Table 4-2. A fragment of an XML METAR message


```xml
<?xml version="1.0" encoding="UTF-8"?>
<!--
  An example of a METAR.  Original METAR from ICAO Annex 3 Example A3-1:

     METAR YUDO 221630Z 24004MPS 0600 R12/1000U DZ FG SCT010 OVC020 17/16 Q1018
     BECMG TL1700 0800 FG BECMG AT1800 9999 NSW
-->
<iwxxm:METAR xmlns:iwxxm="http://icao.int/iwxxm/3.0" xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:gml="http://www.opengis.net/gml/3.2"
  xmlns:aixm="http://www.aixm.aero/schema/5.1.1"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://icao.int/iwxxm/3.0 http://schemas.wmo.int/iwxxm/3.0.0RC1/iwxxm.xsd"
  gml:id="uuid.510df5de-fefb-4406-bafd-faab35333ec0"
  permissibleUsage="OPERATIONAL"
  status="NORMAL"
  automatedStation="false">

  <!-- The aerodrome at which this observation took place -->
  <iwxxm:aerodrome>
    <aixm:AirportHeliport gml:id="uuid.143d63d9-15f5-442e-9bdc-1f3db93fb619">
     <aixm:timeSlice>
      <aixm:AirportHeliportTimeSlice gml:id="uuid.75c3340c-3679-4e31-8aec-efdabe375d49">
        <gml:validTime/>
        <aixm:interpretation>SNAPSHOT</aixm:interpretation>
        <aixm:designator>YUDO</aixm:designator>
        <aixm:name>DONLON/INTERNATIONAL</aixm:name>
        <aixm:locationIndicatorICAO>YUDO</aixm:locationIndicatorICAO>
        <aixm:ARP>
          <aixm:ElevatedPoint gml:id="uuid.dd2c810b-edaa-4ad9-bb65-9ab774d1522e" srsDimension="2"
  srsName="http://www.opengis.net/def/crs/EPSG/0/4326">
            <gml:pos>12.34 -12.34</gml:pos>
          </aixm:ElevatedPoint>
        </aixm:ARP>
      </aixm:AirportHeliportTimeSlice>
     </aixm:timeSlice>
    </aixm:AirportHeliport>
  </iwxxm:aerodrome>

  <!-- the same as observationTime except for corrections/re-issuances -->
  <iwxxm:issueTime>
    <gml:TimeInstant gml:id="uuid.e5460ae4-98a4-48fa-bbfc-21799896f1f2">
      <gml:timePosition>2012-08-22T16:30:00Z</gml:timePosition>
    </gml:TimeInstant>
  </iwxxm:issueTime>
```

```
&lt;!-- time at which the METAR phenomena were observed --&gt;
&lt;iwxxm:observationTime&gt;
   &lt;gml:TimeInstant gml:id="uuid.85802aab-b4e5-4c4b-9303-10a02064e243"&gt;
      &lt;gml:timePosition&gt;2012-08-22T16:30:00Z&lt;/gml:timePosition&gt;
   &lt;/gml:TimeInstant&gt;
&lt;/iwxxm:observationTime&gt;

&lt;iwxxm:observation&gt;
   <iwxxm:MeteorologicalAerodromeObservation gml:id="uuid.dc262f4d-1dc8-428b-91d8-74e10ed3cf69"
cloudAndVisibilityOK="false">
      &lt;iwxxm:airTemperature uom="Cel"&gt;17.0&lt;/iwxxm:airTemperature&gt;
      &lt;iwxxm:dewpointTemperature uom="Cel"&gt;16.0&lt;/iwxxm:dewpointTemperature&gt;
      &lt;iwxxm:qnh uom="hPa"&gt;1018&lt;/iwxxm:qnh&gt;
      &lt;iwxxm:surfaceWind&gt;
         &lt;iwxxm:AerodromeSurfaceWind variableWindDirection="false"&gt;
            &lt;iwxxm:meanWindDirection uom="deg"&gt;240&lt;/iwxxm:meanWindDirection&gt;
            &lt;iwxxm:meanWindSpeed uom="m/s"&gt;4.0&lt;/iwxxm:meanWindSpeed&gt;
         &lt;/iwxxm:AerodromeSurfaceWind&gt;
      &lt;/iwxxm:surfaceWind&gt;
      &lt;iwxxm:visibility&gt;
         &lt;iwxxm:AerodromeHorizontalVisibility&gt;
            &lt;iwxxm:prevailingVisibility uom="m"&gt;600&lt;/iwxxm:prevailingVisibility&gt;
         &lt;/iwxxm:AerodromeHorizontalVisibility&gt;
      &lt;/iwxxm:visibility&gt;
      &lt;iwxxm:rvr&gt;
         &lt;iwxxm:AerodromeRunwayVisualRange pastTendency="UPWARD"&gt;
            &lt;iwxxm:runway&gt;
               &lt;aixm:RunwayDirection gml:id="uuid.f920a641-0eba-4fa3-9411-5c50444a0aa3"&gt;
                  &lt;aixm:timeSlice&gt;
                     &lt;aixm:RunwayDirectionTimeSlice gml:id="uuid.23b637cb-c450-4a24-83dd-ec6b965fe71d"&gt;
                        &lt;gml:validTime/&gt;
                        &lt;aixm:interpretation&gt;SNAPSHOT&lt;/aixm:interpretation&gt;
                        &lt;aixm:designator&gt;12&lt;/aixm:designator&gt;
                     &lt;/aixm:RunwayDirectionTimeSlice&gt;
                  &lt;/aixm:timeSlice&gt;
               &lt;/aixm:RunwayDirection&gt;
            &lt;/iwxxm:runway&gt;
            &lt;iwxxm:meanRVR uom="m"&gt;1000&lt;/iwxxm:meanRVR&gt;
         &lt;/iwxxm:AerodromeRunwayVisualRange&gt;
      &lt;/iwxxm:rvr&gt;
      &lt;iwxxm:presentWeather xlink:href="http://codes.wmo.int/306/4678/DZ"/&gt;
      &lt;iwxxm:presentWeather xlink:href="http://codes.wmo.int/306/4678/FG"/&gt;
      &lt;iwxxm:cloud&gt;
         &lt;iwxxm:AerodromeCloud&gt;
            &lt;iwxxm:layer&gt;
               &lt;iwxxm:CloudLayer&gt;
                  &lt;iwxxm:amount xlink:href="http://codes.wmo.int/bufr4/codeflag/0-20-008/2"/&gt;
                  &lt;iwxxm:base uom="[ft_i]"&gt;1000&lt;/iwxxm:base&gt;
               &lt;/iwxxm:CloudLayer&gt;
            &lt;/iwxxm:layer&gt;
            &lt;iwxxm:layer&gt;
               &lt;iwxxm:CloudLayer&gt;
                  &lt;iwxxm:amount xlink:href="http://codes.wmo.int/bufr4/codeflag/0-20-008/4"/&gt;
                  &lt;iwxxm:base uom="[ft_i]"&gt;2000&lt;/iwxxm:base&gt;
               &lt;/iwxxm:CloudLayer&gt;
            &lt;/iwxxm:layer&gt;
         &lt;/iwxxm:AerodromeCloud&gt;
      &lt;/iwxxm:cloud&gt;
   &lt;/iwxxm:MeteorologicalAerodromeObservation&gt;
&lt;/iwxxm:observation&gt;
…
```

Extended content in IWXXM

4.2.7 Version 1.1 of the IWXXM schemas was a strict implementation of Annex 3 technical specification for products and did not allow for additional content to appear in the resulting XML documents. However, given XML's built-in ability to allow a schema's complex types to be extended, this was not a significant limitation. States could (and did) extend IWXXM 1.1 complex types to support requirements of the Annex 3 products and their nation's unique specifications at the same time. After review of the technique used to extend IWXXM 1.1 schemas, there were concerns, even if using XML built-in capabilities, that this approach was too burdensome for States to implement and the use of XML extensible feature was not applied consistently.

4.2.8 To facilitate consistency in how additional content appears in IWXXM, starting from version 2.1, the IWXXM schemas have an additional element named "extension" in many of its complex type definitions. This solution allows unique and customized content in the resulting XML documents. The optional <extension> elements are of type <anyType>. As such, any simple or complex type defined in IWXXM or other published schemas like AIXM and FIXM or by the State in a separate schema file can be used. Typically, a State would create and define their own complex types specific to their needs in a schema file and make the file widely available. An IWXXM XML product with extended content would also refer to the State's schema file so that XML validation tools can find the definitions and verify correct usage.

4.2.9 To illustrate, suppose a State wishes to include wind shear information, as measured by radar profilers situated at the country's major airports, into their METAR and SPECI report. Table 4-3 shows a fragment of the schema file created containing an XML complex type to encode the profiler information. An IWXXM METAR message with additional wind shear information so encoded may look like the XML document in Table 4-4.

Table 4-3. A fragment of a national extension schema for encoding additional wind shear information

```
<schema elementFormDefault="qualified" targetNamespace="http://weather.gov.ss/iwxxm-ss/1.0" version="1.0"
     xmlns="http://www.w3.org/2001/XMLSchema" xmlns:gml="http://www.opengis.net/gml/3.2"
     xmlns:iwxxm-ss="http://weather.gov.ss/iwxxm-ss/1.0">
 <import namespace="http://www.opengis.net/gml/3.2" schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
 <!--
   This schema file is meant to illustrate the use of IWXXM <extension> elements and how externally defined
   complex types would appear IWXXM XML documents
 -->
 <annotation>
  <documentation>
    Low-level wind shear is one of the major hazards to flight safety. Sudden changes in lift near the ground
    give pilots little time to recover. The deployment of radar profilers at the major, high traffic airports that
    are able to detect low-level wind shears below 500 meters, it is vitally important that information regarding
    the base height and magnitude of the wind shear layer be communicated to airport traffic controllers and
    pilots. The complex type defined below will allow profiler data at the time of the METAR or SPECI measurement
    period be included in the IWXXM XML document.
  </documentation>
 </annotation>
 <element name="windShearAlert" type="iwxxm-ss:WindShearAlertType"/>
 <complexType name='WindShearAlertType'>
   <annotation>
     <documentation>
Complex type to convey wind shear information to air-traffic control and pilots. Wind shears usually occur near
the boundary of the PBL and the free atmosphere. Shear is given in units of 'per time'.
     </documentation>
   </annotation>
   <sequence>
     <element name='windShearBaseHeight' type='gml:MeasureType'/>
     <element name='windShearValue' type='gml:MeasureType'/>
     <element name='windShearMagnitude' type='iwxxm-ss:WindShearSeverityTypes'/>
```

```
    <element name='windSpeedAtBase' type='gml:SpeedType'/>
    <element name='windDirectionAtBase' type='gml:AngleType'/>
   </sequence>
  </complexType>
  <simpleType name="WindShearSeverityTypes">
   <annotation>
    <documentation>
      Simple table to describe the wind shear values (WS) in qualitative terms:
     "Moderate" 0.06 < WS <= 0.12 per second
     "Severe" 0.12 < WS <= 0.17 per second
     "Extreme" WS > 0.17 per second

      For large commercial aircraft, these categories represent lost/gain of relative wind speed over the wing of 10-15, 15-
20, and 20 knots and greater.
    </documentation>
   </annotation>
   <restriction base="string">
    <enumeration value="Moderate"/>
    <enumeration value="Severe"/>
    <enumeration value="Extreme"/>
   </restriction>
  </simpleType>
</schema>
```

Table 4-4. An XML METAR message with extension

```
<METAR xmlns="http://icao.int/iwxxm/3.0" status="NORMAL" permissibleUsage="OPERATIONAL" gml:id="...">
 <observation>
  <iwxxm:aerodrome/>
  <iwxxm:issueTime/>
  <iwxxm:observationTime/>
  <iwxxm:observation>
   <iwxxm:MeteorologicalAerodromeObservation/>
    <iwxxm:airTemperature/>
    <iwxxm:dewpointTemperature/>
    <iwxxm:qnh/>
    <iwxxm:surfaceWind>
    <iwxxm:visibility/>
    <iwxxm:rvr/>
    <iwxxm:presentWeather/>
    <iwxxm:cloud/>
    <windShear>
     <AerodromeWindShear allRunways='true'>
     <extension>
      <windShearAlert xmlns="http://weather.gov.ss/iwxxm-ss/1.0"
        xsi:schemaLocation="http://weather.gov.ss/iwxxm-ss/1.0 http://weather.gov.ss/iwxxm-ss/1.0/IWXXM-SS.xsd">
       <windShearBaseHeight uom="[ft_i]">780</windShearBaseHeight>
       <windShearValue uom="1/s">0.084</windShearValue>
       <windShearMagnitude>Moderate</windShearMagnitude>
       <windSpeedAtBase uom="[kn_i]">32</windSpeedAtBase>
       <windDirectionAtBase uom="deg">145</windDirectionAtBase>
      </windShearAlert>
     </extension>
    </AerodromeWindShear>
   </windShear>
  </MeteorologicalAerodromeObservation>
 </observation>
</METAR>
```

Chapter 5

METADATA FOR AERONAUTICAL METEOROLOGICAL INFORMATION EXCHANGE

5.1 INTRODUCTION

5.1.1 Meteorological bulletins, because of the traditional requirement to be compact and concise due to constraints including communication bandwidths, carry only a minimal amount of information with them. Previously during situations when instances of data in tests or exercises have to be distributed over operational network, the content of the Traditional Alphanumeric Code (TAC) messages involved were modified (and hence deviated from the standard template in ICAO Annex 3) to discriminate them from other operational messages to avoid misuse. While the human readable, modified TAC messages could be recognized by users, it may not be obvious for the machines which decode the messages, especially as the associated modifications are likely to be different in different cases. The situation will be even more complex for non-human readable IWXXM messages as the schemas involved are rigid, making it not possible to create a modified message that could pass XML validation and interpreted by downstream machines for display in a human readable form.

5.1.2 Starting from Version 2.1 of IWXXM, formal and well-known indicators and information have been included as metadata in IWXXM messages to facilitate interpretation of the messages.

5.2 METADATA AS INDICATORS

Operational and Non-Operational Status Indicators

5.2.1 Under certain circumstances, it has been, and will continue to be, necessary to issue IWXXM messages under test or exercise conditions. In particular VAA, TCA and SIGMET messages are issued from time to time for test or exercise purposes. Operational and non-operational Status Indicators have been introduced in IWXXM to let the machines identify these messages from the normal ones so that they could be properly handled, like filtering of operational and non-operational messages on a display.

5.2.2 An operational message is one that is intended to be used as the basis for operational decision making. As such, the content of the message may result in decisions that may affect any or all phases of flight by any authorised and competent stakeholder (i.e. air navigation service providers, airport authorities, pilots, flight dispatchers, etc). Recipients of such messages (either automatic or human) would therefore expect that the information is sourced from a competent entity and that originating equipment (sensors etc) are serviceable and that any human involvement is carried out by qualified, competent personnel.

5.2.3 A non-operational message is one that is not intended to be used for operational decision making, even though it may contain realistic data (particularly during an exercise). Recipients of such messages shall ignore the content of the message with regard to operational decision making. Non-operational messages may be further classified as either being related to test or exercise.

5.2.4 A guideline on the use of operational and non-operational indicator in IWXXM can be found at the WMO website at https://wiswiki.wmo.int/tiki-index.php?page=TT-AvXML&structure=WIS+up

Translation Centre Information

5.2.5 While it is anticipated that IWXXM messages will eventually be prepared at the source, it is inevitably that during the early stage of the implementation of IWXXM some of the States will not be able to provide IWXXM messages and require National OPMET Centre (NOC), Regional OPMET Centre (ROC) or Regional OPMET Data Bank (RODB) to carry out the translation of TAC to IWXXM on behalf of the States. To identify these messages from those generated at the source and to enable translated message traceability, translation centre information have been introduced as metadata in IWXXM.

5.2.6 Further information on the inclusion of Translation Centre Information in IWXXM can be found at WMO website at https://wiswiki.wmo.int/tiki-index.php?page=TT-AvXML&structure=WIS+up

~~IWXXM version 1 has no specific requirements on metadata. In IWXXM version 2, metadata may be introduced to give more specific descriptions for proper handling and use of the information carried by each IWXXM message. Further details on the metadata involved will be included here as appropriate.~~

Chapter 6

ENSURING INFORMATION QUALITY THROUGH XML VALIDATION

6.1 INTRODUCTION

6.1.1 Creating correctly formatted aeronautical meteorological messages is an essential part to ensure the quality of information being exchanged. ICAO Traditional Alphanumeric Code (TAC) information (e.g. METAR, SPECI, TAF, SIGMET, etc.) is currently distributed with many errors in the data streams. These errors come in many different forms: transposed characters due to human error; extra non-standard content; the number ‘0’ instead of the letter ‘O’; incorrect ordering of information elements; missing required information markers; alternative formatting for location information, and many others. As a free text format, TAC data is particularly vulnerable to a variety of data issues. Data quality checks on TAC data have previously been performed by using TAC decoder software to try to read the TAC messages, but this can have results that are specific to a particular implementation of the software. Additionally, decoder software is often complex and may not be broadly available.

6.1.2 The IWXXM XML schema formally describe the expected structure and content of the XML messages. Using software in a process known as XML validation, a specific IWXXM message (e.g. an IWXXM METAR) can be checked against the IWXXM XML schema to ensure it is properly formatted. An XML message is said to have passed validation if it is correctly structured and meets all the requirements specified in the XML schema.

6.2 VALIDATION OF IWXXM MESSAGES

Scope of validation

6.2.1 IWXXM currently includes several validation capabilities. This includes the location and number of information elements; the expected structure and order of the information; checks to ensure the unit of measures on each information is among those allowed in ICAO Annex 3; and more. More validation capabilities would be added in future versions of IWXXM as necessary. Each of these capabilities is intended to allow both producers and consumers of XML information to detect errors, and thereby improve the overall quality of data in the system.

6.2.2 Validation can be used in two ways: as an informative tool or as a method of enforcing compliance. The roles and responsibilities of stakeholders in the creation, distribution and utilization of IWXXM messages is out of scope of this document and references should be made to other ICAO documents as required.

The validation process

6.2.3 The correct formatting of IWXXM messages is comprised of two parts: (1) validation against the IWXXM XML schemas and (2) validation against rules written in ISO Schematron. Schematron is a rule-based validation language for making assertions about the presence of absence of patterns in an XML document. It is capable of expressing constraints in ways that other XML schema languages like XML Schema cannot. The IWXXM XML schema and Schematron rules jointly describe how IWXXM messages should be formatted. XML schema and Schematron are standardized technology, and therefore a number of open source and closed source software packages can be used for validation.

6.2.4 A command line tool CRUX (Command-line Refuter of Unshapely XML) is provided by WMO for authoritative validation purposes. CRUX is a cross-platform Java tool which supports validating IWXXM XML schemas and Schematron rules, and is available at https://github.com/NCAR/crux/releases. For offline and/or local validation purposes, Crux can be used with an XML catalog file to utilize local copies of XML schema and Schematron rules. For convenience, a schema bundle is distributed for use with Crux or other XML validation tools.

6.2.5 To facilitate implementation of IWXXM, an authoritative validation website for WMO and ICAO data models is available at http://wmo-icao-validator.rap.ucar.edu. Based on Crux, schemas which are hosted from schemas.wmo.int can be validated there, including IWXXM, METCE, WMO Collect, and others. The site uses local copies of XML schema and Schematron files. XML files with WMO, ICAO, ISO, and OGC namespaces should validate quickly without any outgoing network connections.

Chapter 7

EXCHANGING IWXXM MESSAGES

7.1 INTRODUCTION

7.1.1 A meteorological bulletin in TAC format is composed of meteorological information preceded by an appropriate heading that typically identifies its type, point of origin and issue time. The meteorological information involved may be a single TAC message or a collection of TAC messages of the same type. The meteorological bulletin is usually distributed by the Aeronautical Fixed Telecommunication Network (AFTN) or Air Traffic Services (ATS) Message Handling System (AMHS) among local, regional and global stakeholders.

7.1.2 In order to emulate the existing information distribution practices, WMO developed the COLLECT-XML construct to represent a collection of GML feature instances of the same type of meteorological information in the same way as a meteorological bulletin in TAC format. In addition to the XML schema, Schematron rules are also in place to validate conformance of aggregated IWXXM messages to COLLECT-XML requirements. The resulting meteorological bulletin in IWXXM format can either be sent directly, or as a compressed file, as attachment via AMHS with File Transfer Body Part enables, often as part of AMHS Extended Services. Table 7-1 is an example of a bulletin of IWXXM METAR messages aggregated with COLLECT-XML and Table 7-2 shows its corresponding TAC bulletin.

Table 7-1. An example of a bulletin of IWXXM METAR messages aggregated with COLLECT-XML

```xml
<?xml version="1.0" encoding="UTF-8"?>
  <collect:MeteorologicalBulletin gml:id="LAHK31VHHH-201511020800">
   <collect:meteorologicalInformation>
      <iwxxm:METAR gml:id="metar-VHHH-201511020800">
         ...
      </iwxxm:METAR>
    </collect:meteorologicalInformation>
    <collect:meteorologicalInformation>
      <iwxxm:METAR gml:id="metar-RCTP-201511020800">
         ...
      </iwxxm:METAR>
    </collect:meteorologicalInformation>
    <collect:meteorologicalInformation>
      <iwxxm:METAR gml:id="metar-RCHK-201511020800">
         ...
      </iwxxm:METAR>
    </collect:meteorologicalInformation>
    <collect:meteorologicalInformation>
      <iwxxm:METAR gml:id="metar-RCSS-201511020800">
         ...
      </iwxxm:METAR>
    </collect:meteorologicalInformation>
      ...
  <collect:bulletinIdentifier>
    A_LAHK31VHHH020800_C_VHHH_201511020800--.xml
```

</collect:bulletinIdentifier>
</collect:MeteorologicalBulletin>

Table 7-2. TAC bulletin corresponding to the IWXXM bulletin in Table 7-1

```
SAHK31 VHHH 020800
METAR VHHH 020800Z 34011KT CAVOK 24/14 Q1018 NOSIG=
METAR RCTP 020800Z 05017KT 5000 BR FEW010 SCT016 BKN025 19/16Q1021 NOSIG RMK A3015=
METAR RCKH 020800Z 34006KT 310V020 9999 FEW016 BKN045 BKN060 27/22Q1016 NOSIG RMK A3001=
METAR RCSS 020800Z 12009KT 4500 BR FEW008 BKN018 OVC035 20/17Q1021 NOSIG RMK A3015=
METAR RCMQ 020800Z 02017G28KT 9999 FEW012 BKN150 20/16 Q1017 NOSIGRMK A3004=
METAR RCNN 020800Z 33010KT 9999 FEW012 SCT025 BKN080 26/20 Q1016NOSIG RMK A3001=
METAR VMMC 020800Z 36014KT 9999 FEW045 23/15 Q1018 NOSIG=
METAR RPLL 020800Z 12008KT 040V170 9999 VCSH FEW023CB SCT025 SCT090BKN300 30/23 Q1010
    NOSIG RMK A2983 CB NW PCPN DSTN W-N=
METAR RPVM 020800Z 04005KT 9999 FEW020 BKN100 29/24 Q1010 A2984 CBDSPTD=
METAR RPMD 020800Z NIL=
METAR RPLB 020800Z 06005KT 9999 FEW020 BKN080 29/22 Q1010 A2983NOSIG=
METAR RPLI 020800Z 34002KT 9999 FEW019 32/23 Q1009 NOSIG RMK A2980=
METAR RPMZ 020800Z NIL=
NNNN
```

Appendix A

UML

1. UML is a widely used modelling methodology, developed primarily for "object oriented" software engineering. In the context of this manual, only UML "class diagrams" are considered with the following elements:

UML class. The abstraction of a concept in the application domain. A class is shown in a class diagram as a rectangle giving its name (e.g. aircraft).

Properties. Properties represent structural features of a class. Properties are a single concept but they appear in two quite distinct notations: attributes and associations. Although they look quite different on a diagram, they are really the same thing.

Note.— Attributes are represented as a line of text in the second compartment of the class symbol.

2. Figure A-1 shows an example of a UML class (of data type) representing the trend forecast of wind at an aerodrome with the following attributes:

a) meanWindDirection (data of angle type);

b) meanWindSpeed (attribute of velocity type); and

c) windGustSpeed (attribute of velocity type).

3. From a modelling perspective, you can conclude from the example provided in Figure A-1 that the forecast of wind will be provided with the mean direction, and speed of wind, and the speed of gusts. For information, each attribute may define its type (in this case, angle or velocity, but could also be, for example, CharacterString, Real or DateTime).

«Data Type» AerodromeSurfaceWindTrendForecast
+ meanWindDirection :Angle [0..1]
+ meanWindSpeed :Velocity
+ windGustSpeed :Velocity [0..1]

Figure A-1. Example of UML class

4. Associations express the relationship between classes. UML represents an association between two classes by drawing a line between their symbols. The role on the association end describes how the related class is used. Figure A-2 provides an example of an association and can be explained as follows:

a) the “runway” has the property of being associated with an AirportHeliport. This is the role of “aerodrome” in the association; and

b) such a diagram could also explicitly indicate that an aerodrome has (at least) one runway.

5. It is sometimes necessary to have unidirectional navigability. This is indicated by adding an arrow at the destination end of the association. This means that the association is easily navigated in the direction indicated by the arrow. This does not mean that the associations cannot be navigated in the other direction but the directionality is a hint that implementations should make the navigation in the primary direction convenient and efficient. One class knows about the existence of the other in the direction of navigation but the reverse is not necessarily true.

6. The multiplicity of a property is an indication of how many values are allowed for that property. Multiplicity of [0..1] means that the attribute is optional (i.e. it can appear once or not at all); for example, a runway is associated to maximum one aerodrome.

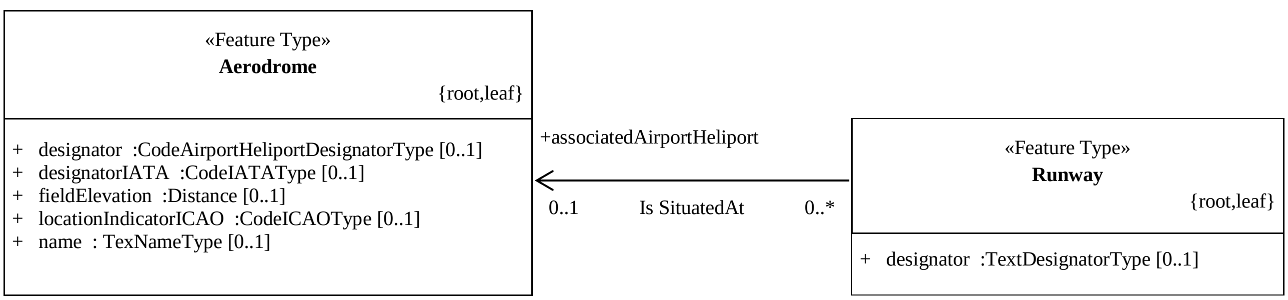

Figure A-2. Example of UML association

Appendix B

XML/GML

1. The geography markup language (GML) is an XML encoding in compliance with ISO 19118 for the transport and storage of geographic information modelled according to the conceptual modelling framework used in the ISO 19100–series and including both the spatial and non-spatial properties of geographic features. This specification defines the XML Schema syntax, mechanisms, and conventions that:

a) provide an open, vendor-neutral framework for the definition of geospatial application schemas and objects;

b) allow profiles that support proper subsets of GML framework descriptive capabilities;

c) support the description of geospatial application schemas for specialized domains and information communities;

d) enable the creation and maintenance of linked geographic application schemas and datasets;

e) support the storage and transport of application schemas and data sets; and

f) increase the ability of organizations to share geographic application schemas and the information they describe.

2. GML serves in daily life as a modelling language for systems as well as an open interchange format for geographic transactions on the Internet. The concept of feature in GML is a very general one and includes not only conventional "vector" or discrete objects, but also coverage. The ability to integrate all forms of geographic information is key to the utility of GML.

3. GML contains a rich set of primitives which are used to build application specific schemas or application languages. These primitives include:

a) feature;

b) geometry;

c) coordinate reference system;

d) topology;

e) time;

f) dynamic feature;

g) coverage (including geographic images);

h) unit of measure;
i) directions; and

j) observations.

4. Application schemas such as IWXXM are XML vocabularies defined using GML and which reside in an application-defined target namespace. In the case of IWXXM, the application schema resides in the icao.int/iwxxm namespace. Application schemas themselves can be built on the full GML schema set or use specific GML profiles.

5. GML profiles are logical restrictions to GML, and may be expressed by a document, an XML schema or both. These profiles are intended to simplify adoption of GML, to facilitate rapid adoption of the standard. In contrast with application schema, GML profiles are part of the GML namespaces (open GIS GML).

Appendix C

WMO CODES REGISTRY

1. The WMO Codes Registry is the mechanism through which the authoritative terms required in IWXXM messages are published as web-accessible resources, enabling the controlled vocabulary for IWXXM to be managed outside the data model. The definitive source of terms is World Meteorological Organization Publication No. 306 — *Manual on Codes* and other WMO Technical Regulations. Current coverage of WMO No. 306 is sparse, but it will be expanded with further development of digital exchange formats.

2. Overview of registry concepts:

Register. A single controlled collection (e.g. a list) maintained on behalf of some owner organization which provides the authority and governance regime for the collection.

Entity. A member of the controlled collection, the entity type is completely open but may be constrained by the register's governance policy.

Sub-register. A register may contain other registers, enabling creation of arbitrarily complex sub-register hierarchies.

Register item. A metadata record describing the relationship of an entity to a given register. The register item includes a graph of information properties that describe the entity as determined by the register manager enabling a local description of the entity to be maintained within the registry.

Data model of the registry. Derived from ISO 19135 — *Geographic information — Procedures for item registration.*

3. The WMO Codes Registry can be accessed at http://codes.wmo.int. Following with an entity identifier, it will be displayed on a web browser into a web page showing details of its definition. Figure C-1 shows the web page returned when referencing the entity "drizzle" described in Table 4678 of WMO No. 306 (http://codes.wmo.int/306/4678/DZ).

4. It is, however, anticipated that operational services will not have a direct dependency on the entry deployed at http://codes.wmo.int; local read-only copies of the registry content should be used to support validation of exchanged data products instead.

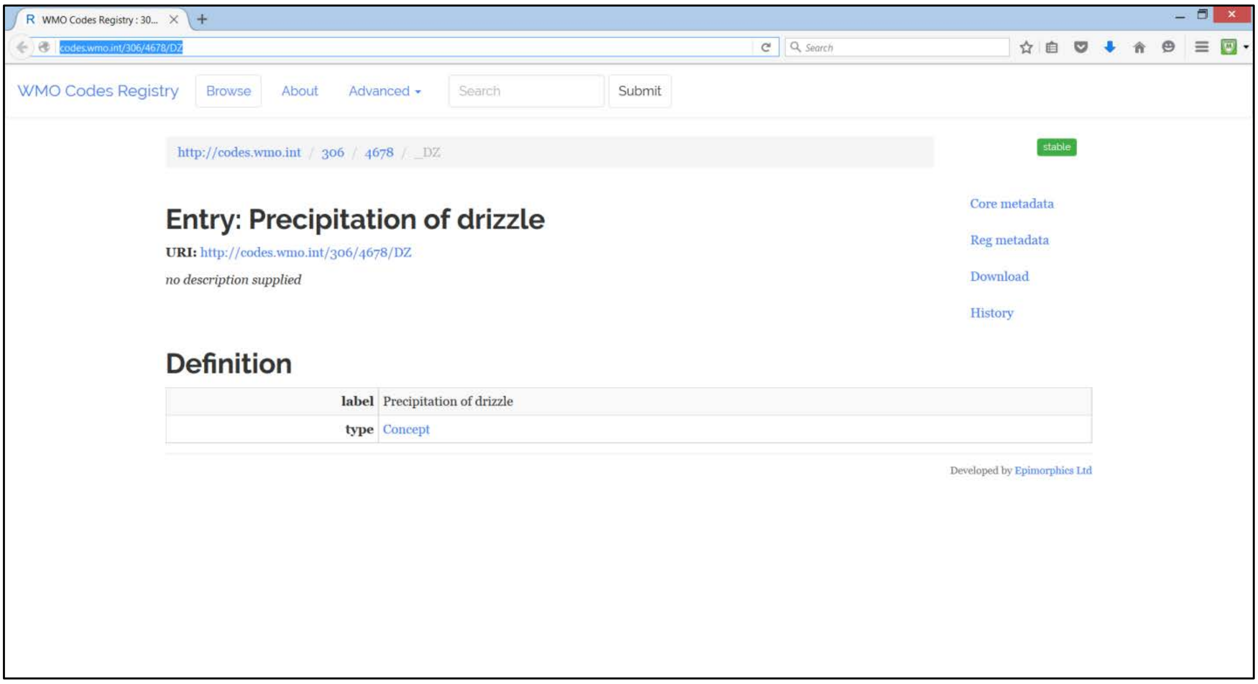

Figure C-1. Example of a web page shown when referencing http://codes.wmo.int/306/4678/DZ on a browser

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Appendix G

Update to IWXXM Guidelines

INTERNATIONAL CIVIL AVIATION ORGANIZATION

GUIDELINES FOR THE IMPLEMENTATION OF OPMET DATA EXCHANGE USING IWXXM

SECOND EDITION – SEPTEMBER 2018

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1 Introduction

1.1 Purpose

The main intention of this document is to describe the activities relating to the transition of intra- and interregional operational meteorological (OPMET) data exchange until 2020and operational exchange beyond . During this period, the amendments to ICAO Annex 3, *Meteorological Service for International Air Navigation*, requiring this transition towards digital data exchange will become applicable for the international exchange of OPMET data.

1.2 Background

The bilateral exchange of IWXXM (ICAO Meteorological Information Exchange Model) based information was introduced in Amendment 76 to ICAO Annex 3 from November 2013, enabling States to exchange their OPMET data not only in TAC (Traditional Alphanumeric Code form) but also in extensible markup language (XML) and more precisely geography markup language (GML).
This represented the start of a significant change from the provision and exchange of textual OPMET data towards a digital environment supporting SWIM (System Wide Information Management). Since their inception, OPMET data have been promulgated to end systems and they were initially designed to be human readable, with a requirement to be highly compact due to bandwidth limitations.

The exchange of IWXXM information became a recommendation through Amendment 77 to ICAO Annex 3 from November 2016, with some States exchanging digital products (IWXXM) from early 2017 and is expected to be a standard from November 2020.
The use of OPMET in a TAC format presents an obstacle to the digital use of the data as it is not geo-referenced. This makes the handling of global data difficult to use correctly and expensive to maintain. These significant difficulties have been highlighted during past code changes. The coding practices in text form also present an obstacle to efficient automation as State coding exceptions are commonly used.
IWXXM represents the first step to move to an environment where the systems handling this data can make more use of standard applications and techniques. The development of new systems which provide and support digital OPMET requires initial investment but the use of enabling data exchange standards for other domains such as AIXM (Aeronautical Information Exchange Model) and FIXM (Flight Information eXchange Model) along with IWXXM will lead to a cost reduction due to the implementation of widely used data modelling techniques including OGC (Open Geospatial Consortium) segments. Consequently, users are presented with opportunities to create new products at a lower cost by fusing this data.
It is essential that the transition towards the use of IWXXM is adequately planned and equipped to make reliable data sets available to users for exploitation as soon as possible at both a Regional and a Global scale. This guidance document provides elements and steps for consideration in achieving that aim by defining common definitions and concepts, as well as structured phases to be implemented in relation to the International exchange of OPMET data.

1.3 Intended Audience

This document is intended to be used by centres considering being involved in the exchange of IWXXM data, both within a region and inter-regionally.

2 Current Operations and Capabilities

2.1 Current Capabilities

The current capabilities are dedicated to Traditional Alphanumeric Code (TAC) data exchange, via the Aeronautical Fixed Service (AFS), primarily the aeronautical fixed telecommunications network through AFTN and AMHS protocols, SADIS and WIFS.
AMHS provides a mechanism for the exchange of IWXXM information as attachments by utilising the AMHS File Transfer Body Part (FTBP) feature over the AFS.

2.2 Data Producer/Originating Unit

The TAC Data Producer provides TAC data only.

2.3 Data Aggregator

The function of the Data Aggregator is to take individual TAC reports, perform limited data validation and aggregate them into bulletins. Bulletins shall consist of one or more reports of the same type (e.g. METAR).

2.4 Data Switch

A Data Switch will route the data according to the WMO abbreviated header structure, TTAAiiCCCC, of the bulletin. The bulletin header fulfils the regulations described in WMO doc No 386, *Manual on the Global Telecommunication System.*

2.5 National OPMET Centre (NOC)

The role of the NOC is to collect and validate all - international required OPMET messages – required AOP and agreed exchanged non AOP - (refer to the Regional (electronic) Air Navigation Plans for AOP) generated by all originating units within a State, to compile national data into bulletins and to distribute them internationally according to the regional distribution schema.

A NOC should perform the following functions:

- Data Aggregator;
- Data Validator; and
- Data Switch.

2.6 Regional OPMET Centre (ROC)

A ROC is responsible for the collection from NOCs and validation of all required AOP and agreed exchanged non AOP OPMET data in its area of responsibility (AoR) according to the regional distribution schema.
Each ROC is responsible for the collection of required OPMET data from the other ROCs in the region and the dissemination to the other ROCs of the required data from its AoR.

A ROC should perform the following functions:

- Data Aggregator; and
- Data Switch.

2.7 Interregional OPMET Gateway (IROG)

An IROG is responsible for the collection of all required OPMET data from its interregional area(s) of responsibility (IAoR) and its dissemination to the ROCs in its region.
Furthermore, the IROGs are responsible for collection and dissemination of their region's required AOP and agreed non AOP exchanged OPMET data to their partner IROGs.
The IROG is responsible for the validation of the bulletins sent to the IROGs of its IAoR and received from their IAoR.
For TAC data exchange, an IROG should perform the following functions:

- Data Aggregator; and
- Data Switch.

2.8 International OPMET Databank

An International OPMET Databank provides the capability for users to interrogate TAC data through the AFTN or AMHS. In some regions the databank is known as a Regional OPMET Databank (RODB).

Operational principles:

- OPMET Databank Requests
    - o Requests for TAC data can be sent via the AFS using AFTN or AMHS. These requests work as described in current Regional OPMET Data Bank (RODB) Interface Control Documents (ICD).
    - o The above example describes the syntax of TAC requests:
        - "RQM/" is used as the start of the query
        - only the new T_1T_2 message types defined by the World Meteorological Organization (WMO) are allowed
          For example: RQM/SALOWW/WSEBBR/WSLFFF=
        - the request is sent to the AFTN address of the International Databank

- OPMET Databank Replies
    - o Replies to TAC requests are described in the current RODB Interface Control Documents.
    - o Reply reports of a request will be aggregated into one or more messages, according to the same rules used by the Data Aggregators, e.g. no mixing of message types in one file.
    - o The RODB Interface Control Documents should specify a set of standardized information & error replies, specifically when the required data are not defined (example: request for a SIGMET with a wrong location indicator)

3 Inclusion of IWXXM within ICAO Annex 3

ICAO Annex 3 defines what IWXXM capability is required at different time frames. These capabilities can also be considered in context of the ICAO SWIM-concept (Doc 10039, *Manual on System Wide Information Management (SWIM) Concept*).

- Amendment 77 to Annex 3 recommends the international exchange of XML-formatted METAR/SPECI, TAF, AIRMET, SIGMET, VAA and TCA from November 2016.

- The planned Amendment 78 to Annex 3 will introduce the requirement for the international exchange of the aforementioned XML-formatted messages as a standard with effect from November 2020. In addition, Space Weather Advisories in XML format are expected to be a recommended practice and a standard from 2019 and 2020, respectively.

Note: The initial intention of this Guidelines document is not to define Net Centric services but to provide guidance as a stepping stone for a swift transition to IWXXM implementation as a first step towards SWIM.

4 Proposed service concept

4.1 Operating principles

This section outlines the general principles for transitioning the international exchange of OPMET data. These principles are still based on continued use of the WMO abbreviated header structure and all participating States using the ICAO Extended AMHS. The intention is to support the different identified phases that will lead to a managed IWXXM-based international exchange of METAR/SPECI, TAF, TCA, VAA, AIRMET and SIGMET, Space Weather data by the Amendment 78 to Annex 3 applicability date.

4.1.1 Managing the transition

A group responsible for managing the transition should be identified in each region, for the necessary intraregional and interregional coordination and should be guided by METP WG-MIE with the support of WMO. (**Recommendation 1**)

It is assumed that different regions will progress at different rates. It is necessary to create a plan that facilitates this different implementation pace.

The Meteorological Panel (METP) Working Group on Meteorological Information Exchange (WG-MIE) has developed this Guidelines document to assist all ICAO regions with the transition to IWXXM exchange. Each ICAO region may also establish a regional version of the document to provide regional information and references but it is important that this should maintain alignment to the global guidelines to ensure the inter-regional exchange is not affected. To simplify management of both the global and regional documentation, regions are encouraged to only modify or add appendices.

One example of regional information would be tests for National OPMET Centres for exchanging IWXXM via the Aeronautical Fixed Service using AMHS with FTBP and AMHS profile for IWXXM data, as indicated as guidance in the Appendix A and Appendix B of this document.

It would be recommended that this regional information be contained in an appendix to the main document, whereby it could be reviewed and agreed, in particular in those regions who have not yet established such regional information.

Note: Groups such as Data Management Group for EUR, the Bulletin Management Group for MID and the Meteorological Information Exchange working group (MET/IE) for APAC could be the right groups to manage this transition (or equivalent groups in other regions). Where AMHS is being used, close cooperation with the State COM Centre is advised to assure an efficient management of AMHS links and interconnections between adjacent regions.

4.1.2 Variances to the IWXXM Model

National extensions (such as remark sections) could only be supported when accompanied by necessary XML tags and in a globally agreed standard way. The international exchange of these extensions will only be supported for data fully compliant to the IWXXM model and abuse of extensions must be prevented.

Note: The term "*IWXXM model*" should be understood as the XML schema including all necessary GML components (including metadata) necessary for the exchange of IWXXM data. The use of extensions within the IWXXM is discouraged and should only be utilised where absolutely necessary.

4.1.3 Translation

A State will be required to produce IWXXM data **in addition** to TAC data for international exchange from November 2020. Generating both formats will help minimize, as much as possible, the translation between formats. It will also avoid operational translation/conversion from IWXXM to TAC and onward forwarding, as the bi-directional conversion will not necessarily result in the same TAC.

Where a translation from TAC to IWXXM is necessary and conducted, the translation centre and date/time of when the translation occurred will be identified within the XML message (refer to section 6.3).

4.1.4 Data collection

When creating a feature collection of the same type of IWXXM data (e.g. METAR), further named as "bulletin", the aggregating centre identifier and date/time group of when the collection was created will be indicated within the XML message. The aggregating centre metadata will be defined as part of a globally accepted GML/XML model.
Only regular reports (e.g. METAR and TAF) will be aggregated. Non-regular reports (e.g. SIGMET, SPECI, AIRMET and VAA) will NOT be aggregated.
A single bulletin will only contain TAC or XML, never both.
A single file will contain only one bulletin.

4.1.5 Transmission & Routing

Given the size and character set of IWXXM messages, it will not be possible for these messages to be transmitted via AFTN. The file containing the bulletin will be compressed and FTBP (**File Transfer Body Part**) under Extended AMHS (**ATS Message Handling System)** will be used to exchange IWXXM data internationally through the AFS.
The principles of exchanging IWXXM data on AMHS are further described in section 5.1.4 but, in general, rules close to the ones governing the TAC transmission are applied.
The WMO abbreviated header structure (TTAAiiCCCC) will be part of the filename of the FTBP and used as data identifier. The routing of IWXXM messages will associate this data identifier with AMHS address(es) that the message should be sent to.
As a file name extension, the appropriate suffix developed by WMO will be used to identify compressed data using globally agreed compression techniques such as gzip.
<u>Note</u>: The number of FTBPs and the maximum message size are subject to the AMHS specifications and recipients User Capabilities. It would be highly desirable to have a common agreed maximum limit size for AMHS messages between all ICAO regions. A total size of AMHS message (including FTBP) up to 4MB should be considered, as already defined in some regions. The available network path between the Originator and Recipient must be completely AMHS with FTBP support for successful message delivery. It does not necessarily require each COM Centre in the path to operate AMHS in Extended Services to relay an AMHS message with FTBP. To ensure that delivery is within the capabilities of the recipient, it is advised that the User Capabilities are coordinated before the establishment of regular communications. In some regions, this information may be available through Directory Services (X.500/EDS). The available bandwidth for each 'hop' in the network should be considered by COM Centres when switching to AMHS FTBP operations.

4.1.6 Compliance Testing

IWXXM compliance testing platforms or software will be made available in order to allow States to test the compliance of their XML data to the IWXXM model before operational international exchange. This is to assure that the future internationally disseminated data are operationally usable. (**Recommendation 2**)

4.1.7 International OPMET Databank

In order to allow IWXXM data retrieval from International OPMET Databanks, a standard set of queries for IWXXM data will also need to be developed, agreed and documented. An Interface Control Document will be provided to describe the query structure, structure of the answer(s) and bulletin header(s) to be used by the International Databank, as well as all other information necessary for the automatic use of the query answers. The proposed query language for IWXXM data will follow similar rules as the TAC-requests (refer to section 5.1.5).

4.1.8 Aeronautical Information Metadata

The aeronautical information metadata are part of the XML model and should be transported by the IWXXM data. (**Recommendation 3**)
The metadata is additional information relevant to the type of the aeronautical information object i.e. an airport, a flight information region (FIR). A challenge resides in getting the correct state of this aeronautical information, especially for centres that will perform translation from TAC to XML that will require this. Therefore, obtaining this from an authorized source (details to be determined) is implied, in order to provide the right piece of information that characterizes the data (e.g. for a METAR, which airport location indicator and official name, its altitude, longitude, latitude etc …).

The access to aeronautical metadata should be provided by a link to the AIXM model, therefore avoiding possible inconsistencies between the transported metadata inside the IWXXM data and the current status of this aeronautical information as part of the AIXM model.

5 Functional requirements - Framework

This section is intended to describe the generalized elements which can be used to establish a framework for the exchange of IWXXM data, both intraregional and inter-regionally, with the neighbour Regions. One key aspect is that the framework needs to be flexible to permit development of an intra-regional structure suitable to the requirements, but at the same time allowing establishment of controlled and coordinated exchange between Regions.
The framework is organized into a basic set of functions/type of operations as described in section 5.1. A list of requirements that should be met to carry out each respective function as well as illustrations on how these functions may be performed/combined are provided in the same section.
In section 5.2, more complex regional entities which comprise some of the above functions are described.

5.1 Functional definitions

5.1.1 Data Producer/Originating Unit

TAC Producer
This producer provides TAC data only.

IWXXM Producer
This producer provides IWXXM. The IWXXM Producer may provide information in both TAC (until no longer required in Annex 3) and IWXXM forms.
The Data Producer-function may be performed by an aeronautical meteorological station (e.g. producing a METAR), a MWO producing AIRMET or SIGMETS or by an Aerodrome Meteorological Office (AMO) providing TAFs.

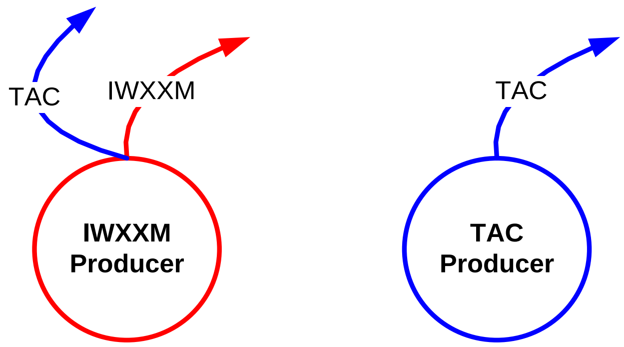

Figure 1: Comparison of IWXXM and TAC Producers

For an IWXXM Producer, the following functions could be the subject to compliance testing:

- The Producer output will conform to the IWXXM Schema;
- The Producer output will pass IWXXM Schematron/business rules; and
- The Producer will apply appropriate (defined) metadata following agreed ICAO rules and regulations.

5.1.2 Data Aggregator

This function takes individual IWXXM reports - decompresses them if already compressed – and aggregates them into bulletins and then compresses them. Bulletins shall consist of one or more reports of the same type (e.g. METAR).
When aggregating reports, the Aggregator shall collect and combine them as a bulletin – defined as a Feature collection - in conformance with the globally agreed GML/XML model. In particular, all required metadata information, as defined by the globally accepted GML model, should be indicated.

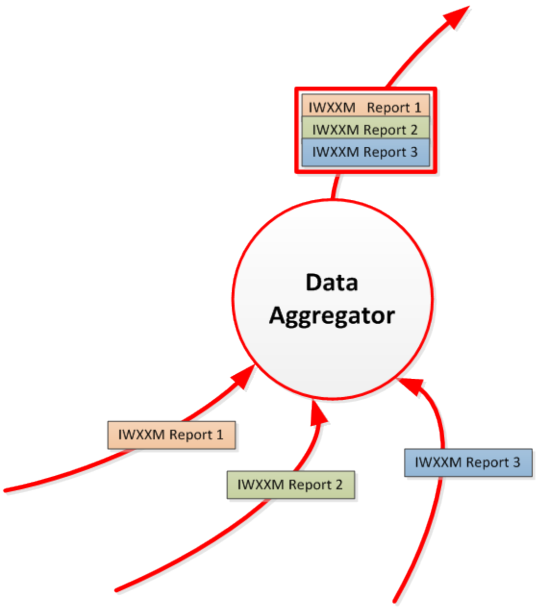

Figure 2: Data aggregation

For an IWXXM Aggregator, the following functions could be the subject of compliance testing.

- The Aggregator output will conform to the IWXXM Schema;
- The Aggregator output will pass IWXXM Schematron/business rules;
- The Aggregator will apply a correct filename to its output;
- The Aggregator correctly compresses data applying an appropriate suffix; and
- The Aggregator will apply appropriate (defined) metadata following agreed ICAO rules e.g. for monitoring and validation issues.

5.1.3 Data Translation Centre

A data translator converts TAC data into IWXXM on behalf of their State and/or another State (i.e. when the data producer is unable to do so). A bi-lateral or regional agreement should be defined for such circumstances. To do so, it shall be able to parse incoming TACs and apply the data to IWXXM schema. It is expected that this will be carried out on a bulletin basis so that the translator will always be associated with a Data Aggregator function.
It is highly likely that not all incoming TACs will be translatable due to of non-conformance with TAC standards. There will be a need to have procedures in place to deal with any non-compliant data, which may involve further translation where predefined arrangements have been made. Refer to section 6.3 for more details.

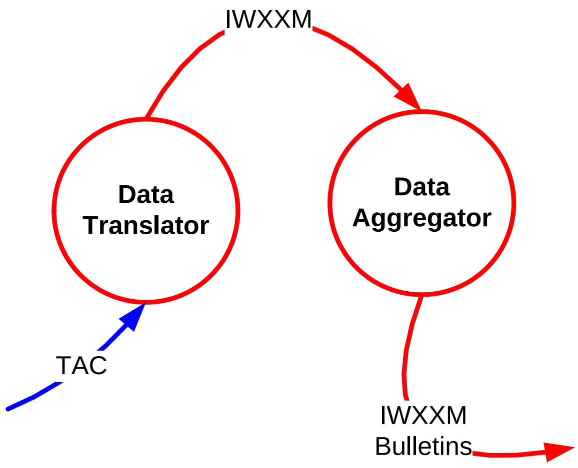

Figure 3: Data Translator generating IWXXM from TAC

Note: A Translation centre should also perform Aggregator functions. Whilst the IWXXM Schema may be extended for national translation purposes, an emphasis on maintaining the purity of the schema should be maintained. Where extensions to the schema are proposed to be disseminated internationally, these should follow an agreed method by ICAO for extending the schema and the extensions should be standardised where possible with other States, so that the benefits of the extensions use can be realised by all ICAO members.

5.1.4 Data Switch

A Data Switch will route IWXXM data according to the TTAAiiCCCC part of the filename of the File Transfer Body Part. The filename including the current WMO bulletin header will be structured as follows (WMO naming convention A):

A_TTAAiiCCCCYYGGgg*BBB*_**C_**CCCC_YYYYMMddhhmmss**.xml.[compression_suffix]**,

Where the elements in black and bold are fixed elements and:
TTAAiiCCCCYYGGgg is the current WMO header with the date time group

BBB is ***optional*** (as usual),
CCCC is the repeated CCCC part from TTAAiiCCCC,
YYYYMMddhhmmss is the date/time group

Note: [compression_suffix] is *typically gzip. The ideal situation is to define the same compression technique for all types of ICAO data. Compression software such as zip should be avoided as it may allow transportation of more than one file and directories as well. If different compression technique was to be required, this will need to be coordinated and agreed globally.*

The routing table will associate this TTAAiiCCCC data identifier with the AMHS addresses where the data should be sent to. The compressed file will be named with the suffix appropriate to the compression and sent onto AMHS.

FTBP name examples with METAR from LFPW:

A_LAFR31LFPW171500_C_LFPW_20151117150010.xml.**[compression_suffix]**

1st retarded bulletin: A_LAFR31LFPW171500RRA_C_LFPW_20151117150105.xml.**[compression_suffix]**

1st corrected bulletin: A_LAFR31LFPW171500CCA_C_LFPW_20151117150425.xml.**[compression_suffix]**

WMO defined T_1T_2 (from TTAAii) for the following data types:

- Aviation Routine Report (*METAR*) *LA*
- Aerodrome Forecast (*"short" TAF*) (VT < 12 hours) *LC*
- Tropical Cyclone Advisory *LK*
- Special Aviation Weather Reports (*SPECI*) *LP*
- Aviation General Warning (*SIGMET*) *LS*
- Aerodrome Forecast (*"long" TAF*) (VT >= 12 hours) *LT*
- Volcanic Ash Advisory *LU*
- Aviation Volcanic Ash Warning (*VA SIGMET*) *LV*
- AIRMET *LW*
- Aviation Tropical Cyclone Warning (*TC SIGMET*) *LY*
- *Space Weather Advisory (SWXA)* *LN **

*: T_1T_2 to be confirmed by WMO, Annex 3 recommendation from November 2019

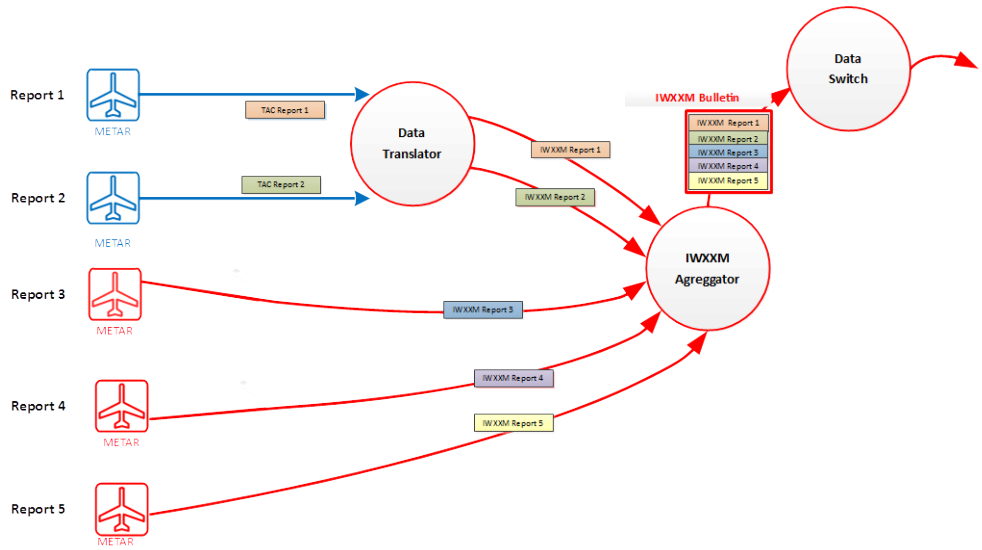

Figure 4: Aggregation of TAC and IWXXM data

5.1.5 International OPMET Databank

An International OPMET Databank (called Regional OPMET databank (RODB) in some regional documentation) will provide the capability for users to interrogate IWXXM data through the AFS in much the same way as the RODBs currently and provide global TAC data.

There will be no TAC to IWXXM translation taking place by the Databank in case the requested OPMET is only available in TAC, as this translation should be done upstream by a Translation Centre, unless the databank has formal arrangements to convert TAC to IWXXM on behalf of a State.
Although the implementation of Net Centric Services is beyond the scope of this document, the Databank element could provide Net Centric services in addition to the AFS based IWXXM interrogation capabilities. As soon as agreed descriptions of the interface to request data via web-services are available, this additional feature may be added for the databank.
For an IWXXM OPMET Databank, the following functions could be the subject of compliance testing.

- The Databank output shall conform to the IWXXM Schema;
- The Databank output shall pass IWXXM Schematron/business rules;
- The Databank has an AMHS interface supporting FTBP;
- Databank shall only send the response back to the originator;
- The Databank shall aggregate the reply reports according to the same rules used by the Data Aggregators;
- The Databank shall apply a correct filename to its output;
- The Databank base correctly compresses data applying an appropriate suffix; and
- The Databank shall respond correctly to the standard interrogations.

The picture below illustrates a possible implementation of an OPMET Databank with combined TAC and IWXXM functionalities.

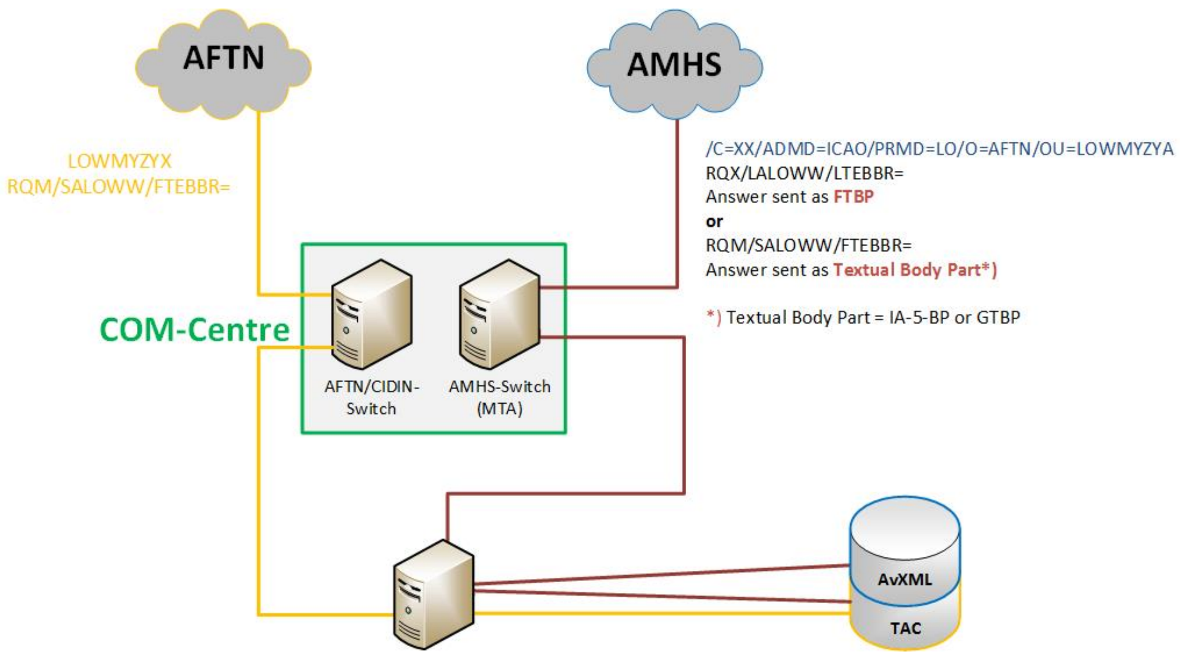

Figure 5: The implementation of a combined TAC & IWXXM Databank

Technical principles:

- Interfaces:
  - the Databank has an AMHS P3 connection to the AMHS Message Transfer Agent (MTA) of a COM centre; and
  - in case the COM Centre still serves AFTN users, the Databank may have a separate AFTN connection to the COM Centres AFTN switch or alternatively, the COM Centre will take care of the AFTN-AMHS conversion.

- Databank tables: data in IWXXM and data in TAC are stored in separate sets of tables.

Operational principles:

- DB Requests
    - Requests for TAC data can be sent via AFTN or via AMHS as international reference alphabet number 5 (IA5) text). These requests will continue to work as described in the current RODB Interface Control Documents;
    - Requests for IWXXM data shall be sent via AMHS as Textual Body Part;
    - Requesting data in IWXXM will work in a similar way as requesting TAC data. The above example uses a syntax similar to the TAC requests, but:
        - "RQX/" is used as the start of the query
        - only the new IWXXM T_1T_2 message types defined by WMO are allowed

        For example: RQX/LALOWW/LTEBBR/LSLFFF=
    - Requests for TAC data and requests for IWXXM data shall not be mixed
    - Any violation of the above principles (e.g. the request "RQX/LSLOWW=" received via AFTN), will result in an automatic reply sent by the databank, informing the user that this is not allowed.

- DB Replies
    - Replies to TAC requests will continue to work as described in the current RODB Interface Control Documents.
    - Reply reports of an IWXXM request will be aggregated into one or more files, according to the same rules used by the Data Aggregators, e.g. no mixing of message types in one file.
    - These files will be compressed and a correct file name with appropriate suffix supplied.
    - These files will be sent as FTBP through AMHS and directory services should be used to ensure the recipient is capable to receive this
    - The RODB Interface Control Documents will specify an extended set of standardized information & error replies.

5.2 Regional Centres Definitions

5.2.1 National OPMET Centre (NOC)

The role of the NOC is to collect and validate all required AOP and agreed exchanged non AOP OPMET messages generated by all originating units within a State, to compile national data into bulletins and to distribute them internationally according to the regional distribution schema.
Note: It is assumed that the data provided by NOCs is in accordance with the similar specifications as applicable for an International Data Aggregator

5.2.2 Regional OPMET Centre (ROC)

In its Area of Responsibility (AoR) according to the regional distribution schema, a ROC is responsible for the collection from NOCs of all required AOP and agreed exchanged non AOP OPMET data and for the validation of this OPMET data.
Each ROC is responsible for the collection of required OPMET data from the other ROCs in the region and the dissemination to the other ROCs of the required data from its AoR.
For IWXXM exchange, a ROC should perform the following functions:

- Data Aggregator;
- Data Translation centre; and
- Data Switch.

5.2.3 Interregional OPMET Gateway (IROG)

An IROG is responsible for the collection of all required AOP and agreed exchanged non AOP OPMET data from its Interregional Area(s) of Responsibility (IAoR) and its dissemination to the ROCs in its region. Furthermore, the IROGs are responsible for collection and dissemination of their Region's required OPMET data to their partner IROGs.
The IROG is responsible for the validation of the bulletins sent to the IROGs of its IAoR and received from their IAoR.
For IWXXM exchange, an IROG should perform the following functions:

- Data Aggregator
- Data Translation Centre
- Data Switch

5.2.4 International OPMET Databank

The International OPMET Databank(s) (called Regional OPMET databank (RODB) in some regional documentation and further labelled RODB in this document) are supplied with required OPMET data by the ROCs. These databases can be queried via the AFS by using a specified query language. Details on the query language as well as the supported data types can be found in Regional Interface Control Documents for OPMET Database Access Procedures. Those documents will be updated to integrate the new functions.
A RODB shall be able to fulfil the requirements to handle IWXXM-code as described in paragraph 5.1.5.

6 Generation and use of IWXXM

The IWXXM format is not intended to be read in its raw form by humans. It is intended as a structured, 'machine to machine' message that is then subsequently processed for human interpretation/interaction.

6.1 Operational Status Indicator (PermissableUsage)

Under certain circumstances it has been and will continue to be necessary to distribute meteorological information for test and exercise purposes. To support this need the IWXXM schema incorporates operational or non-operational flags.

6.1.1 Definition of Operational and Non-Operational messages

An operational message is one that is intended to be used as the basis for operational decision making. As such, the content of the message may result in decisions that may affect any or all phases of flight by any authorised and competent stakeholder (i.e. air navigation service providers, airport authorities, pilots, flight dispatchers etc). Recipients of such messages (either automatic or human) would therefore expect that the information is sourced from a competent entity and that originating equipment (sensors etc) are serviceable and that any human involvement is carried out by qualified, competent personnel.
A non-operational message is one that is not intended to be used for operational decision making, even though it may contain realistic data (particularly during an exercise). Recipients of such messages shall ignore the content of the message with regard to decision making. Non-operational messages may be further classified as either being related to TEST or EXERCISE.

Definition of Test and Exercise.
There is no known official definition of TEST or EXERCISE within the ICAO lexicon. In some instances, the two words are used interchangeably. Since the use of TEST or EXERCISE would only be used in messages identified as NON-OPERATIONAL, there are circumstances where one may be more appropriate than the other.
TEST messages may be issued for the following reasons:

- As an ad-hoc message to test distribution of a particular message, such as SIGMET when, for example, a new system is installed at an originating centre.
- As part of a more organised test of message routing for non-scheduled messages such as SIGMET.
- As part of the process to introduce IWXXM messages by a particular entity. In this instance, IWXXM messages may be issued on a regular basis over a period of weeks or months in advance of OPERATIONAL status.

In the above cases the messages may contain either realistic data or no data.
EXERCISE messages may be issued for the following reasons:

- As a national or regional (or more rarely 'global') organised event intended to permit stakeholders to become familiar with the data content of messages. An example would be for Regional Volcanic Ash Exercises where stakeholders wish to provide training and 'desk top' scenarios for rare events.
- Under exercise scenarios, the messages will contain realistic data (though not necessarily valid data). For instance, volcanic ash exercises sometimes use volcanic ash data based on historical

wind patterns to ensure that the requisite training is provided (i.e. to ensure the volcanic ash data impacts particular FIRs).

6.1.2 Technical Detail on the Operational Status Indicator

Operational Messages:

- Every IWXXM message that is issued for operational purposes shall set the IWXXM element name 'permissibleUsage' to OPERATIONAL.
- Under such circumstances no other information relating to OPERATIONAL status shall be included.

Non-Operational Messages:

- Every IWXXM message that is issued for non-operational purposes shall set the IWXXM element name 'permissibleUsage' to NON-OPERATIONAL.
- Under such circumstances, it will be necessary to provide additional information relating to the reason for the non-operational status.
- The 'permissibleUsageReason' field shall be set to either TEST or EXERCISE.
- The 'permissibleUsageReason' field should contain a short description to provide further information. This is a free text field and is intended to contain the reason for the TEST or EXERCISE. For example;
  - A Volcanic Ash Exercise message may include the name of the exercise in this field 'EUR VOLCEX16'.
  - An organised regional SIGMET test may likewise include 'APAC SIGMET TEST 02 Nov 2016'.
  - For an entity initially issuing IWXXM data as it enters the final phase of transition to IWXXM, production may include 'TEST IWXXM DATA PRE-OPERATIONAL' or similar.
  - Whilst the 'permissibleUsageReason' field may be left empty, this is not considered to be good practice. Where possible, the field should contain some description of the reason for the TEST or EXERCISE.

The examples below are provided for reference:

Example 1: Operational IWXXM data

<IWXXM:CLASSNAME ... permissibleUsage ="OPERATIONAL">...</IWXXM:CLASSNAME>

Example 2: 'Test' IWXXM data

<IWXXM:CLASSNAME ... permissibleUsage ="NON-OPERATIONAL" permissibleUsageReason ="TEST" permissibleUsageSupplementary ="EUR SIGMET TEST 17/09/2018">...</IWXXM:CLASSNAME>

Example 3: 'Exercise' IWXXM data

<IWXXM:CLASSNAME ... permissibleUsage ="NON-OPERATIONAL" permissibleUsageReason ="EXERCISE" permissibleUsageSupplementary ="EUR VOLCEX 12/03/2018">...</IWXXM:CLASSNAME>

Notwithstanding the explicit inclusion of TEST and EXERCISE indicators in all IWXXM messages, it is considered to be best practice to always forewarn stakeholders of TEST events, and in particular EXERCISE events, whenever possible. The message originator, and/or the EXERCISE coordinator where applicable, should consider the most appropriate method to notify stakeholders. A non-exhaustive list of methods would include, State Letter, Exercise Directives, administrative messages, and emails.
It should be noted that, independently of the status of the data, the distribution of data should remain the same (whether the permissibleUsage is OPERATIONAL or NON-OPERATIONAL).

6.2 Unique GML.ID

The gml.id attribute is required to be unique within a XML/GML document. it is not difficult for an IWXXM message creator to make all gml:id unique with the use of, say, natural keys, however when similar types of IWXXM messages like METAR/SPECI or TAF are aggregated (with the use of the COLLECT schema for example), there may be cases of overlap if natural keys are used.
Therefore it is recommended Version 4 of Universal Unique Identifier (UUID - a 128-bit number) is used for gml:id to uniquely identify the object or entity. A fragment of IWXXM METAR message aggregated with COLLECT schema showing the use of UUIDv4 in gml:ids is as follow:

```
<collect:MeteorologicalBulletin … gml:id= "uuid.6f353602-12a1-40a7-b6b5-3edb14c6241e">
<collect:meteorologicalInformation>
<iwxxm:METAR … gml:id="uuid.15ff064a-6dc4-41e0-bafa-8ee78ed4dc25">
…
```

A schematron rule has been added to IWXXM v3 to mandate the use of UUIDs in gml:id for IWXXM messages.

6.3 Translating TAC to IWXXM

A Translation Centre will typically be placed after the National OPMET Centre (NOC) or Regional OPMET Centre (ROC) or Regional OPMET Data Bank (RODB) and its correction facilities, if any. Correction will not typically be applied by the Translation Centre but the ROC, NOC or RODB.
When generating the IWXXM, the translator shall include IWXXM fields which define where and when the translation has been carried out in order to provide traceability. This shall be achieved by introducing agreed metadata elements (centre identifier and time stamp) that is part of IWXXM.
Amendment 78 to ICAO Annex 3 will include TEST and EXERCISE fields in the TAC templates for SIGMET, AIRMET, VAA and TCA (with applicability of November 2019) since these non-scheduled messages are from time to time issued during tests and exercises. Until the anticipated changes are formally incorporated into Annex 3 it will be difficult for the translator to identify test messages. When uncertain, such as when translation fails, the IWXXM should always be presumed to be operational (refer to section 6.1) so that the original TAC message is available for reviewing by a human.

6.3.1 Pre-requisites for Translation Centres

The following items are considered pre-requisite for data translation centres:

- Operate on a permanent 24/7 basis with 24-hour support;
- Robust network between MET node and national AFS node (example, double adduction for the telecommunication links);
- Access to the incoming TAC data and outgoing IWXXM (an AFS Centre connected with AMHS with FTBP enabled that is able to send the IWXXM data to AFS and provide the external AMHS addressing;
- Provide bulletin compilation capability; and
- Archive of at least the last 28 days data and logs of at least on the last 2 months translation details (at minimum, full WMO header received, time of reception, rejection or not).

6.3.2 Data Validation

The data validation should be based upon the following:

- Annex 3 provisions / WMO regulations should be used as the basis of validating received TAC information.
- The most recent official version of the IWXXM schema/Schematron should be applied, unless an explicit agreement between the requiring centre and the Translation Centre is agreed.
- The format should be based upon WMO – No. 306, Manual on Codes, Volume I.1, Part A – Alphanumeric Codes FM where applicable; and the WMO FM201 (collect) and FM 205 (Met Information Exchange Model) should be followed.
- The aeronautical metadata descriptions follow AIXM schema. The process for updating metadata should be documented.

6.3.3 Incomplete (Partial) Translation

When TAC to IWXXM translation is necessary but fails, an IWXXM message of the corresponding type (METAR, TAF, …) without any translated MET parameters but containing the original TAC message should be disseminated to users for their manual interpretation. It is also recommended that, if possible and where agreed, an error message be sent to the TAC originator encouraging the TAC originator to re-issue a valid TAC message for subsequent translation and distribution. Another possible policy would consist in having regular monitoring for a past period and communicate back pertinent elements on errors in coding policy to data originators, regional data exchange working groups and/or some users, where agreed.

Transmitting an IWXXM message with minimum data will allow users to monitor only a single meteorological data stream, reducing the dependency on the TAC stream.

The following minimum set of data should be considered:

METAR:

METAR (COR) CCCC YYGGggZ

TAF :

TAF (COR/AMD) CCCC YYGGggZ

SIGMET/AIRMET:

CCCC SIGMET | AIRMET ... VALID YYGGgg/YYGGgg

VAA :

DTG, VAAC

TCA:
DTG, TCAC
where " | " indicates a logical "OR", "(group)" indicates an optional group

6.3.4 Monitoring Functions

The Translation Centre should monitor incoming TAC messages and keep statistics on the data received and IWXXM generated. The statistics collected should be based upon the detail of IWXXM Validation Statistics to be Gathered by ROCs an RODBs (section 8.1).

6.3.5 Validation of the Translator

A TAC to IWXXM Translator could be the subject of compliance testing of the following:

- The Translator output will conform to the agreed IWXXM Schema;
- The Translator output will pass IWXXM Schematron/business rules;
- The Translator will successfully translate a standard set of TAC test data;
- The Translator provides metadata related to when and where data have been translated (section)- such metadata conforms to the agreed metadata structure; and
- The Translator will apply appropriate (defined) metadata following agreed ICAO rules e.g. for monitoring and validation issues.

The tests cases and operated tests to demonstrate the capability of the translator should be made available on request.
The expected data quality on incoming TAC data should be clearly stated and the limitation on the translator (what will be done/what will not or cannot be done) should be stated.

6.3.6 Commencement of Translation Services

It is recommended that initially the Translator should generate data and set the Operational Status Indicator field as "non operational" and disseminate the IWXXM to a reduced number of recipients wishing to receive the IWWXM to ensure that all the relevant procedures and operations are in place and are clearly understood.
If felt necessary, a learning strategy could be applied such as the reception for an agreed defined period, prior to the operational emission of the IWXXM data. During that period, there could also be another defined contact point on the TAC-producer side to be reached during business hours. In case of an incorrect/rejected TAC message, a procedure should be in place to contact the appropriate State and to request corrections to the incoming TAC.
The date to start the exchange of data operationally should be agreed.

6.3.7 Translation Agreement

The following elements should be contained in the service agreement between the Translation Centre and applicant State:

- Hours of Translation Centre operations (24 hours, 365 days a year);
- Business contact details (e.g. name, phone, email) for both the Translation Centre and the applicant State;
- Operational (24Hr) contact details for both the Translation Centre and the applicant State;
- Details of which data is to be translated (e.g. WMO Header(s) of TAC data, locations indicators, frequency);
- Details of whether and when the originator should be notified when translation of individual messages fails;
- IWXXM distribution details (AMHS addresses);
- Details of which metadata should be used to derive the limits of airspace (boundaries, base, top).
- The aeronautical metadata descriptions follow AIXM schema. The process for updating metadata should be documented.
- Archiving requirements; and
- Procedure on what will be done in case of a failure of all or part of the Translation Centre functionality.

7 Requirements to Transition

The first necessary step is to define the prerequisites in order to be able to exchange IWXXM OPMET data. This will impact not only the network itself, but also the Message Switching Systems and most of the end-user systems.

7.1 Phase 1: Pre–Requisites to Transition

Phase 1 was enabled by Amendment 76 to Annex 3 in November 2013.
To achieve an efficient transition towards IWXXM, Phase 1 activities focused in the following areas and the particular elements identified per area.

7.1.1 Managing the Transition

Regional group(s) should be designated to deal with the transition in order to further define and monitor:

- Intra-regional plan on AMHS infrastructure/links planning and IWXXM data exchange between the ROCs, and between the ROCs and RODBs.
- Intra-regional implementation plan on IWXXM data exchange planning by the States to their ROC.
- Agreement to define how the testing platform and software should be made available and accessible to each State.

It is desirable that responsible group(s) for managing the transition in each ICAO regions be identified and established, that could be responsible for defining the Regions structure and capabilities in the context of the framework.
Furthermore a full liaison should be established and maintained between the ICAO groups in charge of meteorology & data exchange and groups in charge of the AFS network.
For data translation purposes, if there is a systematic need for the translation of data on behalf of a State, this may be performed by the dedicated ROC for the part of the region under its Area of Responsibility and the IROGs for the interregional distribution.

7.1.2 Documentation

The region should define and have a plan in place to provide IWXXM data. This plan shall be published and maintained by the designated responsible groups (FAQ’s etc. should be available).
ICAO and WMO documentation and provisions should be published/available describing the IWXXM code itself as well as documentation referencing the appropriate schemas and rules made available in order to handle this new format.
Cyber Security
Appropriate AFS security elements should be defined by the ICAO groups in charge of information management / networks in order to introduce the operational exchange of IWXXM data via extended AMHS.
It is recommended that appropriate malware and anti-virus precautions are exercised as a bare minimum when dealing with FTBP messages.

7.1.3 Processes

An agreed process should be defined to ensure that data generated by Data Producers are compliant. In order to promote the use of IWXXM, the process should be widely known and shared and some tools to check the compliance state of the data easily accessible and usable.
An identical process should be agreed to initiate and enable the IWXXM exchange between regions.
An AMHS network will be available to support exchange IWXXM data by the use of FTBP between those States wishing to do so. Corresponding AMHS connections should be made available between those Regions exchanging IWXXM data.

Source of Metadata

Updated processes, or notification on modifications about Aeronautical information metadata by the States, should be in place at the end of the period, or metadata sources should be defined and agreed.

Action Plan to Reduce Formatting Errors

Actions plans based on monitoring results about OPMET data not following the agreed coding rules should be undertaken in order to assist States in detecting and correcting incorrect coding policies.
A task should be started to define a procedure that the ROC may use on how to deal with errors in IWXXM-messages, in particular taking into account errors detected in converting TAC-reports. This procedure would ideally provide a clear description on how to report errors to a State that provides these data and clearly define the service and its limitation.

Interregional Cooperation/Coordination

The following tasks should be started:

- The updated processes and notification on modifications on IWXXM bulletins headers between adjacent regions.
- Identification of the interregional exchanges solely based on required AOP and agreed exchanged non AOP required data: actions plans to define clearly the interregional data/bulletins to be exchanged.
- Interregional plan to follow the AMHS infrastructure/links planning between AFS nodes supporting interregional data exchange of neighbouring IROGs.
- Implementation plan for interregional exchange between IROGs.
- An update process to introduce IWXXM in the contingency plans for the IROGs.

7.2 Phase 2: From Nov 2016 until IWXXM Exchange is a Standard

The following elements should be ready prior to the exchange of OPMET data in IWXXM format becoming an ICAO Annex 3 standard, which is proposed to be defined in Amendment 78, with effect in November 2020:

7.2.1 Operations

- The ROCs & IROGs should have the capability to aggregate and switch IWXXM data.
- The ROCs & IROGs may have the capability to act as translation centres.
- Each NOC should to be ready to exchange IWXXM data at the end of the period.
- The RODBs should have all the capabilities to deal with IWXXM data as well as TAC data.
- Update process or notification on modifications about metadata should be in place not later than the end of the period.
- The standard set of queries for IWXXM data for a RODB should be implemented and documented.
- Updated processes and notification on modifications on IWXXM bulletins headers between adjacent Regions should be in place and tested.

7.2.2 Processes

Institutional and Technical Issues

- A communication plan should be established and enacted to inform States and users - both from ICAO and WMO - about the IWXXM code, the metadata use, and the new procedures to access the RODBs.
- The IWXXM model should integrate the metadata related to Data Aggregator and Data Translator functions.
- A procedure used by the ROC should be in place on how to deal with errors in IWXXM-messages, in particular taking into account errors detected when converting TAC-reports. This procedure includes items on how to report errors to a State that provides these data.

Action Plan about data validation

- 'Validation' (validation against the XML schema) is the specific monitoring and gathering of statistics on schema conformance rather than meteorological data quality.
- Action plans based on monitoring results about TAC data not following the agreed coding rules should be in place in order to assist States in detecting and correcting incorrect coding policies.
- A procedure that the ROC can use on how to deal with errors in IWXXM-messages, in particular taking into account errors detected in converting TAC-reports, should be agreed on and made available. This procedure would ideally provide information on how to report errors to a State that provides these data and clearly define this service and its limitation.
- Messages that do not pass validation against the XML schema will continue to be passed and not rejected by ROCs/RODBs.
- States shall arrange the validation of their IWXXM messages against the corresponding XML schema, and make corrections to the process of generating their IWXXM messages as necessary, as per quality management processes.
- The ROC/RODB should conduct validation of IWXXM messages within their region/area of responsibility, excluding validation of 'State extensions'.
- ROC/RODBs should collect statistics on long-term validation results, broken down by State and Region, and provide this information to the relevant ICAO Regional Office and the METP (in particular WG-MIE and WG-MOG) to identify common or troublesome data quality issues.
- Users should be encouraged to continue to validate messages and they will remain responsible for making sure that the received IWXXM messages are suitable for their purposes.
- Users should review the IWXXM PermissableUsage field to determine whether the message is suitable for operational, test or exercise purposes.

Regional Coordination/Planning

The regional group(s) designated to deal with the transition should define and monitor:

- Intra-regional plans regarding AMHS infrastructure/links and IWXXM data exchange between the ROCs, and between the ROCs and RODBs.
- Intra-regional plans regarding the IWXXM data exchange by the States to their ROC.
- The Contingency plans for the ROCs should integrate the IWXXM data and be ready before the end of the period.
- Testing platform and software are made available and accessible for every State.

Interregional Cooperation/Coordination

- The interregional mechanism to follow the AMHS infrastructure/links planning between AFS nodes supporting interregional data exchange between IROGs should be in place, as should the interregional procedure to notify the changes and new IWXXM bulletins introduction.
- The Contingency plans for the IROGs should include the IWXXM data exchange and be ready at the end of the period.
- It is proposed that bilateral agreements between neighbouring IROGs are set up for the translation of TAC data. This agreement should include notification processes on IWXXM data newly produced by the specific Region.

Figure 6 below provides an example of the ICAO Region 1 interfacing with two other ICAO Regions. In this example, it is assumed that:

- There is no operational exchange of IWXXM data between Region 1 and Region 3.
- There is operational exchange of IWXXM data between Region 2 and Region 1.

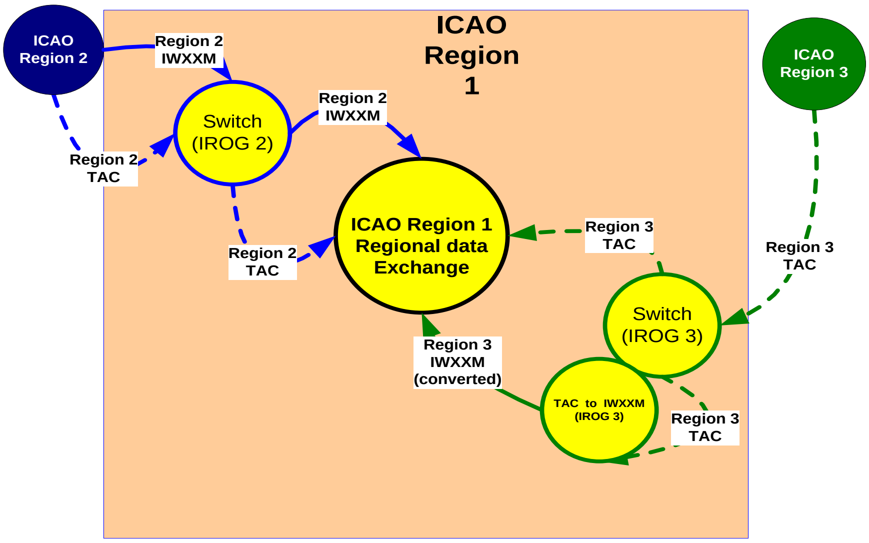

Figure 6: Phase 2, interregional exchange of OPMET with Region 2 (IWXXM & TAC capable) and Region 3 (TAC capable)

7.3 Phase 3: After IWXXM Exchange becomes a Standard

This section is reserved for capability that should be ready from ICAO Annex 3 Amendment 79 applicability date and is yet to be populated.

8 Data Validation and Statistics

8.1 IWXXM Validation Statistics to be Gathered by ROCs an RODBs

Regions should invite their ROCs, IROGs, and/or RODBs to provide statistics about IWXXM data reception, state of compliance of the received data, IWXXM version used, data volume etc. as a measure of the state of IWXXM implementation.
This section defines the general rules about gathering statistics with the aim of providing and proposing a globally consistent way of defining such statistics, assisting the inter-regional comparison and providing a solid bases for the regions to use those statistics as a way to measure IWXXM implementation progression.

8.1.1 Data and Type of Data

Regular Data
The location indicators for regular data should be ICAO compliant indicators (as available on integrated Safety Trend Analysis and Reporting System (iSTARS)) and in conformance with the MET tables defined in the eANPs. For METAR and TAF, it should be noted that the eANP is only required to reference the AOP aerodromes and therefore the minimum set of statistics should be the regular data (i.e. METAR, TAF) related to AOP aerodromes. In addition, if desired, statistics on the agreed exchanged non-AOP aerodromes data can be provided. A clear distinction should appear while presenting statistics to easily discriminate data related to AOP aerodromes from non-AOP aerodromes, where those last ones are presented.
The statistics for IWXXM data should be identical to those provided for TAC data, so as to provide a clear comparison between TAC and IWXXM data produced for the same location and to provide the number of received messages per day (not NIL, not corrected or amended).
Whilst the validation of all messages is encouraged, NIL data, TAF amendments and corrections should not be taken into consideration while producing statistics. The type of TAF (short or long) is defined in eANP Volume II and may be considered to measure the ad-equation to the requirements, if some indices are used in addition to basic statistics.

Non-regular data
The location indicators for non-regular data should also be ICAO compliant indicators (as available on iSTARS) and in conformance with the MET tables defined in the eANPs. For SIGMET, and where applicable AIRMET, they refer to FIR, FIR/UIR, CTA.
The statistics should also be available for VAA and TCA, and for space weather when implemented.

8.1.2 Proposed Statistics

Availability

Availability statistics for IWXXM data should be identical to those provided for TAC data, so as to provide a clear comparison between TAC and IWXXM data produced for the same location and provide the number of received messages per day, not NIL, not corrected, not amended (including not cancelled for TAF). For AIRMET and SIGMET, the cancelled data should not be considered. For VAA and TCA, the number of VAA and TCA per VAAC and TCAC respectively should be provided.

The statistics for VAA/TCA is by nature more complex as the VAA/TCA may refer to VA/TC in other regions, cover multiple FIRs and does not directly refer to location indicators. The distinction between a VAA/TCA that concerns specific region can only be derived by analysing the MET content. Therefore, basic statistics about VAA/TCA reception by the ROC/RODB from the VAAC/TCAC may be considered as a starting point, without any consideration of the content.

Timeliness

Timeliness statistics for IWXXM data should be identical to those provided for TAC data, so as to provide a clear comparison between TAC and IWXXM data produced for the same location. The statistics should take into consideration the same source of information as for availability.

Specific statistics about IWXXM model or version

IWXXM validation

The validation against schema/Schematron (i.e. success rate) should be provided. Statistics about the validation should be provided per IWXXM version, and will provide a good indication on what data are produced for which IWXXM version.

Acceptance of different versions of IWXXM model

It should be determined whether IWXXM data which is in conformance with a previous version of IWXXM could be considered as “valid” or only the last published official version of IWXXM by the World Meteorological Organization (WMO). A clear policy is yet to be developed by ICAO.
It should be understood that, for statistics purposes, the production of statistics for all received versions is the only correct way to have a good measure of the disseminated products. Therefore, a statistic per station and per version (with the limits previously explained) should be provided even if it should be unlikely to have different versions of IWXXM schema disseminated for the same location and same type of data. The statistics should provide which version is used for the dissemination of which data per location indicator (and VAAC/TCAC for VAA/TCA).

Operational/non-operational data

The statistics of non-operational versus the total number of data.

Incomplete/Partial Translations

The statistics of incomplete/partially translated versus the total number of reports.

Data volume

Statistics of total data volume for the same location indicator (VAAC/TCAC for VAA/TCA) and daily average/daily total volume.

Additional groups (extensions)

Some statistics could be presented about the number of data with extensions versus the total number of data (with and without extension) per location indicator (VAAC/TCAC for VAA/TCA).
Another statistic about the daily average/ daily total volume of extensions compared to the total volume of data per location indicator (VAAC/TCAC for VAA/TCA) could also be provided.

Optional statistics

ROCs/RODBs could also choose to provide additional statistics about validation failure, to identify deviations from the models, which could be used to derive systematic errors such as the inclusion of additional data elements via methods other than the global agreed way, non-conformance on cardinality or NIL reason for missing mandatory Annex 3 elements.

8.1.3 Statistics Presentation

Statistics should be made available and presented per ICAO region, then per State, then per location indicator (CCCC) with each time an aggregation of the provided statistics from the sub-levels to the upper level (CCCC → State → Region). For VAA/TCA, it should be presented per Region and then per VAAC/TCAC.
The statistics should be gathered on a daily basis, then by monthly basis. The statistics could be provided offline, the day after or some days after.

8.2 IWXXM Validation Statistics to be Gathered by SADIS & WIFS

The SADIS and WIFS Provider States are investigating the value and effort to produce global sets of statistics based upon the data received at their gateway. The details are likely to be the same or similar to those produced by ROCs or RODBs but this is yet to be confirmed.

9 Acronyms and Terminology

AFS	Aeronautical Fixed Service
AFTN	Aeronautical Fixed Telecommunication Network
AIXM	Aeronautical Information Exchange Model
AMHS	ATS Message Handling System
AMO	Aerodrome Meteorological Office
AoR	Area of Responsibility
APAC	ICAO Asia/Pacific Region
AvXML	Aviation XML
COM	Communication
DB	Databank
EUR	ICAO European Region
FAQ	Frequently Asked Questions
FASID	Facilities and Services Implementation Document
FIR	Flight information Region
FIXM	Flight Information Exchange Model
FTBP	File Transfer Body Part
GML	Geography Markup Language
IAoR	Interregional Area of Responsibility
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
IHE	IPM Heading Extension(s)
IPM	Interpersonal Messaging (AMHS)
IROG	Interregional OPMET Gateway
IUT	Implementation Under Test
IWXXM	ICAO Meteorological Information Exchange Model
METAR	Meteorological Aerodrome Report
METP	ICAO Meteorology Panel
MTA	Message Transfer Agent
MWO	Meteorological Watch Office
NDR	Non-Delivery Report
NOC	National OPMET Centre
OGC	Open Geospatial Consortium
OID	Object Identifier
OPMET	Operational Meteorological information
P3	Message Submission and Delivery Protocol
ROC	Regional OPMET Centre
RODB	Regional OPMET Databank (International OPMET Databank)
RQM	Meteorological Databank Request in TAC-format
RQX	Meteorological Databank Request in IWXXM-format
SIGMET	Significant Meteorological Information
SPECI	Special Meteorological Report
SWIM	System Wide Information Management
TAC	Traditional Alphanumeric Code Form
TAF	Aerodrome Forecast
TCA	Tropical Cyclone Advisory

UA	User Agent
VAA	Volcanic Ash Advisory
WMO	World Meteorological Organization
XML	Extensible Markup Language

1 Appendix A: AMHS Profile Information to Support IWXXM Exchange

This section contains recommended AMHS Profile Information. This section may be updated by each ICAO region with regional specific parameters.

The following content is taken from the EUR AMHS Manual Appendix H (v12.0) detailing the proposed conformance tests for the IWXXM AMHS Profile. The conformance tests were adopted by the EUR AFSG/21 in April 2017.

References embedded in the Appendix H document are maintained throughout the Appendices presented herein. Please be aware that references are also made to earlier sections of Appendix H, Appendix D-UA and that some readers may wish to seek a full version of these documents for completeness.

3.2.4.4 Submission and delivery tests according to Appendix D-UA

3.2.4.4.1 The scope of the tests included in the following list is to ensure that UAs implemented for the sake of the exchange of OPMET IWXXM data will not malfunction upon reception of AMHS messages, fields or elements according to the standards but not defined by the profile specified in section 3.2.3. The main objective is to realize the behaviour of these specific UA implementations upon reception of such messages, fields or elements.

3.2.4.4.2 The execution of the delivery tests defined in EUR AMHS Manual Appendix D-UA is encouraged. However, if this is not possible the following test list is suggested.

Basic Delivery Operations (A2)	
CTUA201	Deliver an IPM to the IUT – basic capability (A2)
CTUA203	Deliver an IPM containing optional-heading-information in the ATS-message-header
CTUA204	Deliver an IPM containing different kinds of recipient addresses
CTUA206	Deliver an IPM with invalid originator address similar to CAAS
CTUA207	Deliver an IPM with invalid originator address similar to XF

Specific Delivery Operations	
CTUA401	Deliver a non-delivery report (NDR) to an AMHS user

Enhanced Delivery UA Capability	
CTUA601	Deliver an IPM with the implemented capability of one body-part
CTUA602	Deliver an IPM with the implemented capability of two body-parts

Delivery Operations (A2-IHE)	
CTUA1201	Deliver an IPM with IHE to the IUT – basic capability (A2-IHE)
CTUA1203	Deliver an IPM with IHE, containing optional heading information
CTUA1204	Deliver an IPM with IHE, containing different kinds of recipient address

Specific Submission Operations with IHE	
CTUA1303	Checking of default envelope elements (flag setting) in submitted IPMs with IHE

Specific Delivery Operations with IHE	

CTUA1401	Deliver a non-delivery report (NDR) to an AMHS user

Enhanced Delivery UA Capability with IHE	
CTUA1602	Deliver an IPM with IHE with the implemented capability of two body-parts

2

Appendix B: Sample Tests for NOCs to Conduct when Introducing IWXXM

This section contains sample tests for National OPMET Centres for exchanging IWXXM via the Aeronautical Fixed Service using extended AMHS and AMHS profile for IWXXM data. This section may be updated by each ICAO region with regional specific tests.

The following content is again taken from the EUR AMHS Manual Appendix H (v12.0) detailing the proposed conformance tests for the IWXXM AMHS Profile. The conformance tests were adopted by the EUR AFSG/21 in April 2017.

References embedded in the Appendix H document are maintained throughout the Appendices presented herein. Please be aware that references are also made to earlier sections of Appendix H, Appendix D-UA and that some readers may wish to seek a full version of these documents for completeness.

3.2.4 Proposed Conformance Tests

3.2.4.1 General description

3.2.4.1.1 This section proposes a list of functional tests that allows verification of conformance of User Agent (UA) implementations dedicated for OPMET IWXXM data exchange. UA conformance testing, as specified in Appendix D-UA, for such implementations needs to be adapted based on the profile specification defined in section 3.2.3.

3.2.4.1.2 The proposed conformance tests are divided to three categories:

- profile specific submission tests;
- profile specific delivery tests; and
- submission and delivery tests according to Appendix D-UA.

3.2.4.1.3 The scope of the profile specific submission and delivery tests is to ensure conformance of UA implementations specifically deployed for the conveyance of OPMET IWXXM data to the respective profile. A test identification scheme of the form WXMxnn has been used, where x=1 is used for submission tests and x=2 for delivery tests. Wherever applicable, reference to the respective Appendix D-UA test is made.

3.2.4.1.4 Reference to specific UA conformance tests as specified in Appendix D-UA is included in section 3.2.4.4, especially for the reception direction. The scope of these tests is to ensure that UA implementations dedicated for OPMET IWXXM data exchange will not malfunction upon reception of a field or element not defined by the specific profile, but classified as mandatory in the ISPs and thus also mandatory in AMHS.

3.2.4.2 Profile specific submission tests

WXM101	**Submission of an IPM including a bulletin consisting of METAR**
Test	The test is successful if the UA submits an IPM including a bulletin consisting of METAR

criteria	according to the profile defined in section 3.2.3.
Scenario description	Submit from the UA under test an IPM including a bulletin consisting of METAR. Check that: - the P3 submission-envelope includes the following parameters with the correct values: o *originator-name*: OR-name of the originator o *recipient-name*: OR-name of each recipient of the message o *content-type*: 22 o *encoded-information-types*: OID 2.6.1.12.0 o *priority*: non urgent - the following IPM heading fields are present with the correct values: o *originator*: address of the originating OPMET system (MET switch) o *primary-recipients*: recipient addresses as populated by the MET switch o *subject*: TTAAiiCCCCYYGGggBBB part of the filename of FTBP o *importance*: normal, if present o *authorization-time* of the IPM heading extensions field: equivalent to filing time o *precedence-policy-identifier* of the IPM heading extensions field: OID 1.3.27.8.0.0 o *originators-reference* of the IPM heading extensions field: absent - the following elements in the common data types are present with the corresponding values: o *precedence*: 28 o *formal-name*: originator address and recipient addresses - the elements *rn* and *nrn* in the common data types are absent - the message has exactly one file-transfer-body-part - the parameters composing FTBP are according to section A.2.4.2 of the EUR AMHS Manual Appendix B and the following elements are present with the correct values: o *document-type-name*: OID 1.0.8571.5.3 o *registered-identifier*: OID 1.3.27.8.1.2 o *user-visible-string*: ‘Digital MET’ o *incomplete-pathname*: bulletin file name as specified in section 5.1.4 of EUR Doc 033, for example: A_LAFR31LFPW171500_C_LFPW_20151117150010.xml.[compression_suffix] o If generated, check the element *date-and-time-of-last-modification*

	o If generated, check the element *actual-values*, the value of which represents the size of the Attachment data in bytes - the elements *related-stored-file*, *compression* and *extensions* of the FTBP parameters are absent - The IWXXM data itself are included in the FileTransferData element of the file-transfer-body-part; the octet-aligned encoding should be used.
Appendix D-UA ref:	CTUA1501, FTBP Capability

WXM102	**Submission of IPMs including bulletins of different file size consisting of METAR**
Test criteria	The test is successful if the UA submits several IPMs including bulletins of different file size consisting of METAR according to the profile defined in section 3.2.3.
Scenario description	Submit from the UA under test a sequence of several IPMs including each time a bulletin of different file size consisting of METAR. The size of the message should not exceed the limit defined in Appendix B, F.2.4.3 Check all parameters listed in test case WXM101, with the corresponding values. If the element *actual-values* is generated check each time the respective value, which represents the size of the Attachment data in bytes.
Appendix D-UA ref:	CTUA1501, FTBP Capability with different body-part size

WXM103	**Submission of an IPM including a bulletin consisting of SPECI or TAF**
Test criteria	The test is successful if the UA submits an IPM including a bulletin consisting of SPECI or TAF according to the profile defined in section 3.2.3.
Scenario description	Submit from the UA under test an IPM including a bulletin consisting of SPECI. Check that all parameters and their respective values are in accordance to test case WXM101, except that the value of the element *incomplete-pathname* is according to the bulletin file name as specified in section 5.1.4 of EUR Doc 033. The test is repeated with the submission of an IPM including bulletin consisting of TAF.
Appendix D-UA ref:	CTUA1501, FTBP Capability

WXM104	**Submission of an IPM including a bulletin consisting of AIRMET**
Test criteria	The test is successful if the UA submits an IPM including a bulletin consisting of AIRMET according to the profile defined in section 3.2.3.
Scenario description	Submit from the UA under test an IPM including a bulletin consisting of AIRMET. Check that all parameters and their respective values are in accordance to test case WXM101, except that: - the *priority* abstract value of the P3 submission-envelope is normal - the value of the element *precedence* is 57 - the value of the element *incomplete-pathname* is according to the bulletin file name as specified in section 5.1.4 of EUR Doc 033.
Appendix D-UA ref:	CTUA1501, FTBP Capability

WXM105	**Submission of an IPM including a bulletin consisting of SIGMET or VAA or TCA**

Test criteria	The test is successful if the UA submits an IPM including bulletin consisting of SIGMET or VAA or TCA according to the profile defined in section 3.2.3.
Scenario description	Submit from the UA under test an IPM including a bulletin consisting of SIGMET. Check that all parameters and their respective values are in accordance to test case WXM101, except that: - the *priority* abstract value of the P3 submission-envelope is normal - the value of the element *precedence* is 57 - the value of the element *incomplete-pathname* is according to the bulletin file name as specified in section 5.1.4 of EUR Doc 033. The test is repeated with the submission of an IPM including bulletin consisting of VAA. The test is repeated with the submission of an IPM including bulletin consisting of TCA.
Appendix D-UA ref:	CTUA1501, FTBP Capability

3.2.4.3 Profile specific delivery tests

WXM201	**Delivery of an IPM including a bulletin consisting of METAR**
Test criteria	The test is successful if an IPM, including a bulletin consisting of METAR, sent by an MTA is received by the UA under test and the parameters specified by the profile defined in section 3.2.3 are properly received.
Scenario description	The MTA sends an IPM including a bulletin consisting of METAR. Check that the UA under test receives the IPM with the following parameters: - the message delivery envelope includes the following parameters with the correct values: o *originator-name*: OR-name of the originator o *this-recipient-name*: OR-name of the recipient to whom the message is delivered o *content-type*: 22 o *encoded-information-types*: OID 2.6.1.12.0 o *priority*: non urgent o *message-delivery-identifier*: it shall have the same value as the message-submission-identifier supplied to the originator of the message when the message was submitted (X.411, section 8.3.1.1.1.1) o *message-delivery-time*: it contains the time at which delivery occurs and at which the MTS is relinquishing responsibility for the message (X.411, section 8.3.1.1.1.2) - the following IPM heading fields are present with the correct values: o *originator* o *primary-recipients* o *subject*: TTAAiiCCCCYYGGggBBB part of the filename of FTBP o *importance*: normal, if present

	o *authorization-time* of the IPM heading extensions field: equivalent to filing time o *precedence-policy-identifier* of the IPM heading extensions field: OID 1.3.27.8.0.0 o *originators-reference* of the IPM heading extensions field: absent - the following parameters in the common data types are present with the corresponding values: o *precedence*: 28 - the elements *rn* and *nrn* in the common data types are absent - the message has exactly one file-transfer-body-part - the parameters composing the FTBP are according to section A.2.4.2 of the EUR AMHS Manual Appendix B and the following elements are present with the correct values: o *document-type-name*: OID 1.0.8571.5.3 o *registered-identifier*: OID 1.3.27.8.1.2 o *user-visible-string*: ‘Digital MET’ o *incomplete-pathname*: bulletin file name as specified in section 5.1.4 IWXXM CONOPS, for example: A_LAFR31LFPW171500_C_LFPW_ 20151117150010.xml.[compression_suffix] o If generated, check the element *date-and-time-of-last-modification* o If generated, check the element *actual-values*, the value of which represents the size of the Attachment data in bytes - the elements *related-stored-file*, *compression* and *extensions* of the FTBP parameters are absent - The IWXXM data itself are included in the FileTransferData element of the file-transfer-body-part; the octet-aligned encoding should be used.
Appendix D-UA ref:	CTUA1601, FTBP Capability

WXM202	**Delivery of IPMs including bulletins of different file size consisting of METAR**
Test criteria	The test is successful if several IPMs, including bulletins of different file size consisting of METAR, sent by an MTA are received by the UA under test and the parameters specified by the profile defined in section 3.2.3 are properly received.
Scenario description	The MTA sends a sequence of several IPMs including each time a bulletin of different file size consisting of METAR. Check that the UA under test receives all IPMs and that the parameters described in test case WXM201 are received with the corresponding values. If the element *actual-values* is present check each time the respective value, which represents the size of the Attachment data in bytes.
Appendix D-UA ref:	CTUA1601, FTBP Capability with different body-part size

WXM203	**Delivery of an IPM including a bulletin consisting of SPECI or TAF**

Test criteria	The test is successful if an IPM, including a bulletin consisting of SPECI or TAF, sent by an MTA is received by the UA under test and the parameters specified by the profile defined in section 3.2.3 are properly received.
Scenario description	The MTA sends an IPM including a bulletin consisting of SPECI. Check that the UA under test receives the IPM and the parameters described in test case WXM201 are received with the corresponding values, except the element *incomplete-pathname* which value is according to the bulletin file name as specified in section 5.1.4 of EUR Doc 033. The test is repeated with the delivery of an IPM including a bulletin consisting of TAF.
Appendix D-UA ref:	CTUA1601, FTBP Capability

WXM204	**Delivery of an IPM including a bulletin consisting of AIRMET**
Test criteria	The test is successful if an IPM, including a bulletin consisting of AIRMET, sent by an MTA is received by the UA under test and the parameters specified by the profile defined in section 3.2.3 are properly received.
Scenario description	The MTA sends an IPM including a bulletin consisting of AIRMET. Check that the UA under test receives the IPM and the parameters described in test case WXM201 are received with the corresponding values, except that: - the *priority* abstract value of the P3 submission-envelope is normal - the value of the element *precedence* is 57 - the value of the element incomplete-pathname is according to the bulletin file name as specified in section 5.1.4 of EUR Doc 033.
Appendix D-UA ref:	CTUA1601, FTBP Capability

WXM205	**Delivery of an IPM including a bulletin consisting of SIGMET or VAA or TCA**
Test criteria	The test is successful if an IPM, including a bulletin consisting of SIGMET or VAA or TAF, sent by an MTA is received by the UA under test and the parameters specified by the profile defined in section 3.2.3 are properly received.
Scenario description	The MTA sends an IPM including a bulletin consisting of SIGMET. Check that the UA under test receives the IPM and the parameters described in test case WXM201 are received with the corresponding values, except that: - the *priority* abstract value of the P3 submission-envelope is normal - the value of the element *precedence* is 57 - the value of the element incomplete-pathname is according to the bulletin file name as specified in section 5.1.4 of EUR Doc 033. The test is repeated with the delivery of an IPM including a bulletin consisting of VAA. The test is repeated with the delivery of an IPM including a bulletin consisting of TCA.
Appendix D-UA ref:	CTUA1601, FTBP Capability

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Appendix H

Proposed update to Job Card METP.004

Missing text (as agreed by METP/2) is highlighted in Yellow.
Changes highlighted in Grey and ~~Strikethrough~~.

METP.004.023	Inclusion of aeronautical meteorological information in the SWIM-enabled environment and further development of the SWIM concept relating to meteorology.
Source	MET Divisional Meeting 2014 (Recommendation 2/2, 3/2 and 3/3)
Problem Statement	Aeronautical meteorological information needs to be integrated into the SWIM-enabled environment which introduces unique issues relating to governance and data management.
Specific Details	It was recommended by the Meteorology~~ET~~ Divisional Meeting (MET/14, Doc 10045) in Recommendations 2/2, 3/2 and 3/3), that an appropriate ICAO expert group, in close coordination with World Meteorological Organization (WMO), develop provisions to enable the inclusion of aeronautical information in the future system-wide information management (SWIM) environment consistent with the ~~Fifth Edition Doc 9750,~~ Global Air Navigation Plan (Doc 9750). Further principles were also identified to guide the development of the SWIM concept relating to meteorology as provided in Appendix B of Agenda Item 3 of the MET/14 ~~Meteorology Divisional Meeting 2014 (Doc 10047)~~. The transition from the Internet-based SADIS/WIFS system is an integral part of these considerations as are the intermediate steps towards full SWIM by making the Annex 3 products compliant with the ICAO Meteorological Information Exchange Model (IWXXM)~~-compliant~~. This will involve the resolution of institutional issues that solely relate to the management and use of aeronautical meteorological information and the necessary links between information supporting other domains in the aviation field and in meteorology supported by the WMO~~orld Meteorological Organization~~. Further development should take into consideration the main legacy tasks from the ~~m~~Meteorological ~~a~~Aeronautical ~~r~~Requirements and ~~i~~Information ~~e~~Exchange ~~p~~Project ~~t~~Team (MARIE-PT), Satellite Distribution System for Information Relating to Air Navigation Operations Group (SADISOPSG) and the World Area Forecast System Operations Group (WAFSOPSG) that relate to information exchange. Enable the exchange of new meteorological information services in line with the GANP requirements.
Expected Benefit	The full integration of aeronautical meteorological information into the SWIM environment will enable the full benefits to be derived relating to safety and efficiency.
Reference Documents	ICAO Annex 3 - Meteorological Service for International Air Navigation ICAO Doc 8896 - Manual of Aeronautical Meteorological Practice ICAO Doc 9750 - Global Air Navigation Plan ICAO Doc 10003 - Manual on the Digital Exchange of Aeronautical Meteorological Information ~~ICAO Doc 10045 - Report of the Meteorology Divisional Meeting 2014~~ ICAO Doc 10039 – Manual on System Wide Information Management (SWIM) Concept ICAO Doc 10045 - Report of the Meteorology Divisional Meeting 2014
Deliverable Expert Group	Meteorology Panel (METP)

ID	Document affected	Description of Amendment proposal or Action	Supporting Expert Group	Status	Expected Dates:		
					Delivery Date	Effective	Applicability

1705	Annex 3	Standards for IWXXM compliant METAR, SPECI, TAF, SIGMET, AIRMET, VAA, ~~and~~ TCA SWXA and SIGWX exchange	-	Completed On-schedule	Q3 2016 Q3 2018	Jul 2018 Jul 2020	Nov 2020 Nov 2020
tbc	PANS-MET (Doc ###)	Technical specifications for meteorological information exchange	-	On-schedule	Q3 2020	Jul 2022	Nov 2022
1686	Manual of Aeronautical Meteorological Practice (Doc 8896)	Update related guidance material to support the implementation of Annex 3 Amendments	-	Delivered On-schedule	Q2 2016 Q2 2018 Q2 2020 Q2 2022	Jul 2016 Jul 2018 Jul 2020 Jul 2022	Nov 2016 Nov 2018 Nov 2020 Nov 2022
1687	Manual on Digital Exchange of Meteorological Information (Doc 10003)	Update related guidance material to support the implementation of Annex 3 Amendments	-	Completed On-schedule	Q2 2016 Q2 2018 Q2 2020 Q2 2022	Jul 2016 Jul 2018 Jul 2020 Jul 2022	Nov 2016 Nov 2018 Nov 2020 Nov 2022
1706	PANS-MET (Doc ###)	Amendment to facilitate the introduction of the meteorological component of SWIM.	CP, IMP	~~On-schedule~~ Delayed	Q2 20~~18~~20	Jul 20~~18~~22	Nov 202~~0~~2
9665	Annex 3	Amendment to facilitate the introduction of the meteorological component of SWIM.	IMP	~~On-schedule~~ Delayed	Q2 20~~18~~20	Jul 20~~18~~22	Nov 202~~0~~2
tbc	Guid~~ance~~elines for the Implementation of OPMET data exchange using IWXXM	Update to the document ~~(*updated yearly)~~	CP	Completed On-schedule	Q2 2017 Q2 2018 Q2 2019 Q2 2020	Nov 2017 Oct 2018 Oct 2019 Oct 2020	Nov 2017 Nov 2018 Nov 2019 Nov 2020
tbc	Manual on SWIM Concept (Doc 10039)	Ensure that Doc 10039 supports MET in SWIM ~~Introduce MET related guidance material~~	IMP	On-schedule	Q~~2~~4 2018	Q1 2019~~Jul 2018~~	Q1 2019~~Nov 2020~~
tbc	MET-SWIM Plan	Develop a plan for the implementation of MET information into a SWIM environment	IMP	On-schedule	Q2 2018 Q2 2019 Q2 2020	Jul 2018 Jul 2019 Jul 2020	Nov 2018 Nov 2019 Nov 2020
tbc	MET-SWIM Roadm~~Map~~	Develop ~~an initial~~ roadmap for the implementation of MET~~met~~ information into a SWIM environment	IMP	On-schedule	Q1 2018 Q2 2019 Q2 2020	Jul 2018 Jul 2019 Jul 2020	Nov 2018 Nov 2019 Nov 2020
Status: Approved		Priority:	Initial Issue Date: 17 Jun 2015	Date approved by ANC: ~~07 Jun 2017~~ tbd		Session / Meeting: ~~205-4~~ tbd	

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MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Headquarters, 10 to 14 September 2018

AGENDA ITEM 6

The attached constitutes the report on Agenda Item 6 and should be inserted at the appropriate place in the yellow folder.

(11 pages)

Agenda Item 6: Meteorological operations group:

6.1 General

6.1.1. The Panel reviewed **WP/4001**, presented by Colin Hord, Rapporteur of MET Operations Group, concerning a revision of Job Card METP.008.02, *Further development of the Secure Aviation Data Information Service (SADIS)*, and Job Card METP.010.02, *Further development of the World Area Forecast System (WAFS).* In this regard the Panel noted that elements of both Job Cards proposed to be updated to reflect the planned activities and work stream for WAFS, SADIS and WIFS (WAFS Internet File Service) were developed by the WG-MOG. With regard to Job Card METP.008.02 the Panel noted the changes related to the further development of the SADIS that were mainly related to the expansion of the scope of the job card to include the WIFS and update of "Specific Details" and "Expected Benefits" and in various places across the job card concerning to the introduction of IWXXM format and SWIM environment. With regard to Job Card METP.010.02 the changes were related to the further development of the WAFS. In this regard the Panel noted that the WAFCs would like to adjust the remit of this Job Card to concentrate solely on developments that relate to changes in the data provided by both WAFCs, therefore the tasks to update the SADIS and WIFS User guide was proposed to be transferred to Job Card 8. The Panel also noted various suggestions for updates related to; inter alia, the "Specific Details" and "Expected Benefits".

6.1.2 The Panel agreed with the suggested updates for both job cards and formulated the following recommendation:

> **Recommendation 6/1 — Revision to Job Cards METP.008.01 and METP.010.02**
>
> That the proposed revisions to Job Card METP.008.01 *Further development of the Secure Aviation Data Information Service (SADIS) and WAFS Internet File Service (WIFS)* and METP.010.02 *Further development of the World Area Forecast System (WAFS),* as given in **Appendices A and B** to this report and endorsed by the Panel, be presented to the ANC for its consideration.

6.1.3 The Panel reviewed **WP/4002**, presented by Colin Hord, Rapporteur of the MET Operations Group, on a proposed update of the Regional SIGMET Guide. In this regard the Panel noted that, for consistency, the former MET Warnings Study Group (METWSG) had identified that the existing Regional SIGMET Guide Template should be updated to be aligned with ICAO Annex 3, thereby permitting the Regional Offices to update their own SIGMET guides to be consistent with other regions. Concerning this issue a small ad-hoc group from the METP-WG/MOG had updated the Guide to reflect changes to Amendment 78 to ICAO Annex 3, whilst at the same time incorporating several recommendations made at METP/2, and the most recent update to EUR Doc14 – EUR SIGMET and AIRMET Guide.

6.1.4 It was also noted that the issue of the absence of a Job Card that relates to updating the Regional SIGMET Guide Template was raised at METP/2. This matter was discussed once more by the METP-WG/MOG and it was decided that no further updates to the Guide would be prepared by the METP-WG/MOG and the ICAO Secretariat suggested that it would be the responsibility of the ICAO Regional MET Officers to coordinate any required Annex 3 changes and update the various documents as appropriate. Additionally, the panel discussed whether a single consolidated SIGMET guide should replace the regional versions. However, this was not agreed. Therefore the Panel formulated the following recommendations:

Decision 6/1: Endorsement of update to Regional SIGMET Guide Template

That the proposed update to the Regional SIGMET Guide Template (as given in the attachment to METP/4-WP/4002) be endorsed by the Panel.

Note: The Secretary should subsequently distribute the updated Regional SIGMET Guide Template to Regional Offices

and,

Recommendation 6/2: Regional SIGMET guide updates

That the ICAO Regional Offices be invited to keep regional SIGMET Guides under continuous review, especially with every Annex 3 amendment, and also to ensure consistency across the Regions.

6.1.5 In a related issue the Panel noted **IP/6204** presented by Sue O'Rourke that suggested some additional changes to the Regional SIGMET Guide Template. In this regard the Panel was of the view that the additional changes proposal could be beneficial for the users of the referred guidance and agreed to consolidated this material in the previous recommendation concerning (Recommendation 6/2 Regional SIGMET guide updates)

6.2 Operation of the International Airways Volcano Watch (IAVW) Job Card METP.003.01

6.2.1 With regard to the IAVW, the Panel considered **WP 4102**, presented by Colin Hord, Rapporteur of the MET Operations Group, concerning the updated Version 3.0 of the *Roadmap for International Airways Volcano Watch (IAVW) in Support of International Air Navigation*. The Panel noted that Version 1.0 was written for ICAO's IAVW Operations Group (IAVWOPSG) in 2013. Version 2.0 was completed in early 2016 for the METP/WG-MISD/VA/2 meeting. The WG-MOG/IAVW Work-stream took over the responsibility to maintain the roadmap in 2017 at their Fifth Meeting (12-14 June 2017, Tokyo, Japan) (MOG/5). Additionally it was noted that version 3.0 of the Roadmap has been sent to the work stream via email. Final changes based on input from the work stream were completed in December 2017. The Meeting noted with appreciation the involvement of WMO/IUGG experts in this task through the work of the Volcanic Ash Scientific Advisory Group (VASAG). After review, the Panel endorsed Version 3.0 and formulated the following recommendation:

Recommendation 6/3 — Update to Roadmap for International Airways Volcano Watch (IAVW) in Support of International Air Navigation

That,

a) the proposed update to the roadmap for the IAVW as given at **Appendix C** to this report be endorsed by the Panel; and

b) the Secretary publish the updated roadmap on the WG-MOG public webpage.

6.2.2 In a related issue the Panel noted **IP/6201** concerning to the provision of annotated satellite images for enhance decision making, in particular the paper suggested changes to the current volcanic ash advisories and graphical SIGMETs. The meeting noted that this matter will be discussed by the MOG in its work on volcanic ash.

6.2.3 The Panel then considered **WP/4103**, presented by Greg Brock, the WMO-nominated expert member of the METP and Colin Hord as the Rapporteur of the WG-MOG, concerning a proposed amendment to Annex 3 – Meteorological Service for International Air Navigation in respect of the model charts used in Appendix 1 to represent the location and extent of volcanic ash clouds. In this regard the Panel noted the paper was a follow-up action of deliberations within the METP WG-MOG (IAVW) in 2016 and 2017. It was noted that there was a need to overcome identified shortcomings in the existing MODEL VAG and MODEL SVA used in Appendix 1 to Annex 3, notably they related to the map projections, the depiction of polygons to describe the coverage of volcanic ash cloud(s) and cloud layers.

6.2.4 It was also noted that since WMO is the custodian of (all) the model charts used in Appendix 1 to Annex 3, WMO accepted the responsibility to develop a maximum of two examples per MODEL VAG and MODEL SVA. It was noted that following coordination with VAAC representatives, the proposals contained at the Appendix to WP/4103 were considered to be the most reliable, up-to-date examples for appropriate inclusion into Appendix 1 to Annex 3 and were consistent with the 20th Edition of Annex 3 (July 2018). The Rapporteur of the WG-MOG informed that the proposals in Appendix to WP/4103 have been coordinated with members of the WG-MOG. The Panel agreed with the proposal and formulated the following recommendation:

RSPP

Recommendation 6/4: Draft Amendment 79 to Annex 3 concerning MODEL VAG and MODEL SVA used in Appendix 1

That, the proposed amendment to Annex 3 – *Meteorological Service for International Air Navigation*, Appendix 1 concerning MODEL VAG (volcanic ash advisory information in graphical format) and MODEL SVA (SIGMET for volcanic ash in graphical format), as given at **Appendix D** to this report, be included as part of proposed Amendment 79 to Annex 3 with intended applicability in November 2020.

6.2.5 The Panel reviewed **WP/4104,** presented by Greg Brock as the WMO-nominated expert member of the METP and Colin Hord as the Rapporteur of the WG-MOG, concerning re-suspended volcanic ash. The Panel noted that this paper presented a proposed amendment to Annex 3 – *Meteorological Service for International Air Navigation* in respect of the reporting of re-suspended volcanic ash, in particular in the context of the template for advisory message for volcanic ash (Table A2-1). It was also noted that WP/4104 was in response to deliberations within the METP WG-MOG (IAVW) in 2016 and 2017.

6.2.6 The Panel agreed that to properly address the re-suspended volcanic ash issue in an ICAO Annex context, the definition of a VAAC (Chapter 1 to Annex 3) and the template for the advisory message for volcanic ash (Appendix 2 to Annex 3) would have to be amended. Consequently, the Panel reviewed the proposed amendment to Annex 3 presented at the Appendix of WP/4104. The proposed amendment simply consisted in the deletion of the words “following volcanic eruptions” in the definition of a VAAC, thereby eliminating an existing constraint and better enabling the VAACs to provide advisory information when there is and when there isn't an erupting volcano, as can be the situation for a re-suspended volcanic ash event. It was also proposed to modify the Examples column of the template for the advisory message for volcanic ash (Table A2-1 of Annex 3), since the extant VA ADVISORY template(s) column already permits appropriate terminology to be used, including as a component of free-text where applicable. Finally it was proposed to amend the Examples column for re-suspended volcanic ash and to also propose improvement to two other items – namely the number of the Karymsky volcano to align with the (latest) IAVCEI database and the replacement of the MTSAT-1R satellite reference with a reference to the (latest) Himawari-8 satellite.

6.2.7 After consideration about the impact of the proposed changes on the WAFS significant weather (SIGWX) charts issued by the WAFCs and the SIGMET messages for volcanic ash issued by MWOs the Panel agreed that there was no need to a introduce change.

6.2.8 Additionally, it was agreed that there was a need to further review the elements of the VONA template, of the NOTAM format and of the ASHTAM format and/or the associated guidance, particularly in the interest of ensuring consistency across the various products that users receive.

6.2.9 Concluding the review the Panel agreed with all the changes and actions proposed and formulated the following recommendation:

RSPP **Recommendation 6/5: Draft Amendment 79 to Annex 3 concerning re-suspended volcanic ash**

That:

a) the proposed amendment to Annex 3 – *Meteorological Service for International Air Navigation*, Chapter 1 and Appendix 2 concerning re-suspended volcanic ash, as given at **Appendix E** to this report, be included as part of proposed Amendment 79 to Annex 3 with intended applicability in November 2020; and,

b) the METP-WG-MOG (IAVW) be tasked to:

1) further review and, if necessary, propose an update to the VONA template and/or associated guidance within ICAO Doc 9766 in respect of the reporting of re-suspended volcanic ash; and

2) review the NOTAM format and the ASHTAM format in respect of the reporting of re-suspended volcanic ash with a view to providing a paper to the Information Management Panel (IMP) which discusses potential changes to ICAO Annex 15 – *Aeronautical Information Services*.

6.2.10 The Panel noted **IP/4101**, presented by Colin Hord, Rapporteur of the MET Operations Group, regarding the status of the activities of the METP Meteorological Operations Working Group (MOG) with respect to the International Airways Volcano Watch (IAVW). The Panel congratulated the working group and expressed its satisfaction with the information contained therein.

6.2.11 The Panel noted the concern from IFALPA on the pending removal of the colour code from the VA advisory. In this regard IFALPA was encouraged to engage with MOG experts particularly with regard to the work currently being carried out to elevate the status of the VONA from a Note to a Recommended Practice in Annex 3.

6.2.12. In a related issue, the Panel was made aware that an out-of-date version of the Handbook on the IAVW (Doc 9766) was currently hosted on the ICAO iStars site, while other out-of-date versions were available on various sections of the ICAO website. This highlighted the necessity to ensure that only the most recent version of any ICAO documents is available to users on the ICAO website.

6.3 Operation of the world area forecast system (WAFS) Job Card METP.010.01

6.3.1 The Panel considered **WP/4205**, presented by Colin Hord, Rapporteur of the MET Operations Working Group, concerning a proposed amendment to Annex 3 – *Meteorological Service for International Air Navigation* in respect of a revision to: a) paragraph 1.2.1 of Appendix 2 of ICAO Annex 3 in relation to the availability of WAFS Upper Air grid point forecasts and, b) paragraph 1.3.1.1 of Appendix 2 of ICAO Annex 3 in relation to the availability of WAFS SIGWX forecasts. In this regard the Panel noted that the proposal was originated by the 2014 ICAO/WMO Meteorology Divisional Meeting (MET/14) which set requirements for improvements to the World Area Forecast System (WAFS) forecasts. These requirements included increases in resolution and changes to the parameters being forecasted (MET/14 Recommendations 2/1 and 2/5 along with Appendices A and B to the MET/14 report on Agenda Item 2 refers) to fully meet the emerging needs of the aviation industry.

6.3.2 The panel noted that the proposal included a first phase, planned for November 2020, which will consist in an increase in the resolution of the hazard grids (turbulence, icing and cumulonimbus cloud forecasts) from the current 1.25 degrees to 0.25 degrees. The grid point resolution for the remainder of the WAFS grid point elements (e.g., wind, temperature, humidity) will remain at 1.25 degrees for Amendment 79 but a proposal for increase to 0.25 degree will be forthcoming to METP/5 for Amendment 80. Moreover, coupled with this increase in resolution of the hazard grids will be the replacement of turbulence and icing potential with turbulence and icing severity information. In addition, in-cloud turbulence grid point forecasts will be retired, in favour of extending the new turbulence severity grid point forecasts downward to FL100, FL140 and FL180. These new turbulence levels, when used in combination with the CB cloud grid, will provide more scientifically sound turbulence information than the outgoing in-cloud turbulence algorithm. The Panel agreed with the proposal the Panel formulated the following recommendation:

RSPP

Recommendation 6/6: Draft Amendment 79 to Annex 3 concerning WAFS information

That, the proposal given in **Appendix F** to this report concerning WAFS information be included as part of draft Amendment 79 to Annex 3 — *Meteorological Service for International Air Navigation* with intended applicability in November 2020.

6.3.3 The Panel also agreed on the need to provide guidance material in the Manual of Aeronautical Meteorological Practice Doc 8896 pertaining to exact pressure levels in WAFS information. Therefore the Panel formulated the following recommendation:

Recommendation 6/7 — Proposed changes for Doc 8896 - Manual of Aeronautical Meteorological Practice pertaining to exact pressure levels in WAFS information

That, the proposed changes pertaining to exact pressure levels in WAFS information, as given in the **Appendix G** to this report, be included in Doc 8896 - *Manual of Aeronautical Meteorological Practice*.

6.3.4 With regard to this agenda item the Panel considered **WP/4202,** presented by Colin Hord, rapporteur of the WG-MOG on behalf of WAFC Washington, concerning the provision of feedback on World Area Forecast System (WAFS) SIGWX forecasts. In this regard, the Panel noted that WG-MOG has identified two methods for aerodrome meteorological offices to assist the WAFCs: a) by providing feedback immediately prior to SIGWX forecast issuance, through a chat room facility operated by WAFC Washington and b) by reporting discrepancies between observed or reported weather phenomena and the SIGWX forecasts after SIGWX forecast issue. In the first case the draft forecasts are made available approximately half an hour prior to the chart issue time, and chat room participants are able to comment on the SIGWX forecast. In the second case the information would be particularly useful for forecast verification purposes. The Panel agreed with a suggested update to the *Manual of Aeronautical Practice* Doc 8896 which provides guidelines for aerodrome meteorological offices regarding the provision of feedback on World Area Forecast System (WAFS) SIGWX forecasts and formulated the following recommendation:

Recommendation 6/8: Guidance on the revision of SIGWX discrepancy reporting procedures

That, the changes pertaining to the reporting of SIGWX forecast discrepancies to WAFCs, as given in the **Appendix H** to this report, be included in Doc 8896 - *Manual of Aeronautical Meteorological Practice.*

6.3.5 The Panel noted **WP/4207**, presented by Colin Hord, Rapporteur of the MET Operations Group, regarding next generation SIGWX depiction of tropical cyclones. In this regard the Panel noted that when considering the implementation of multi time-step SIGWX charts (planned to commence in 2022) the WAFCs have identified that including tropical cyclones information is difficult due to the fact that tropical cyclone positions would not be available for all planned SIGWX chart time steps (i.e. every 3 hours from T+6 to T+48). In this regard it was noted that Tropical Cyclone Advisory Centres (TCACs) currently only provide tropical cyclone (TC) positions in 6 hour time steps from T+0 to T+24 in the tropical cyclone advisory (TCA) message. This makes it impossible to provide a TC position on the interim SIGWX chart time steps and the extended period. For example, a TC position is available for the T+24 chart, but not for the T+21 and T+27 charts. The Panel have assessed all the solutions presented by the WAFCs to the WG-MOG, and agreed that the preferred solution to solve this issue is to request WMO to consider the provision, by tropical cyclone advisory centres (TCACs), of position information for extra time-steps.

6.3.6 Noting that any request regarding TCAC provision of information must be addressed to WMO, the Panel formulated the following recommendation:

Recommendation 6/9 – Provision of Tropical Cyclone Information

That, WMO be invited to consider the planned improvements to WAFS SIGWX forecast information and how these improvements can be enhanced with the inclusion of additional tropical cyclone advisory information provided by the TCACs, i.e. the position of tropical cyclones from T+0 to T+48 hours, at 3-hourly time-steps.

6.3.7 The Panel noted **WP/4208**, presented by Colin Hord, Rapporteur of the MET Operations Group, regarding a proposed revision of values of eddy dissipation rate (EDR) for aircraft turbulence within Annex 3. In this regard it was noted that EDR is the index-based metric for reporting aircraft turbulence and has been included in Annex 3 since Amendment 72 (2001). These EDR values were revised for Amendment 74 (2007) as an improved EDR algorithm had been developed and the results indicated that the EDR thresholds for reporting turbulence should be revised. Since then scientific studies of over 100 million aircraft turbulence reports have shown that EDR values in Annex 3 require another revision.

6.3.8 The Panel noted the current thresholds for EDR in Annex 3 (which have existed since Amendment 74 in 2007) and was presented by scientific evidence contained in WP/4208 shows that the EDR threshold values in Annex 3 were too high. The Panel also noted the work done under the WG-MOG WAFS work-stream to review the EDR thresholds. The Panel also considered the proposed changes relating to EDR for draft Amendment 79 to Annex 3 and some proposed adjustments regarding terminology and the addition of one note related to EDR. Therefore the Panel agreed with the suggested changes and formulated the following recommendation:

RSPP **Recommendation 6/10: Draft Amendment 79 to Annex 3 concerning revised eddy dissipation rate (EDR) threshold values**

That, the proposal given in **Appendix I** to this report concerning revised eddy dissipation rate (EDR) threshold values be included as part of draft Amendment 79 to Annex 3—*Meteorological Service for International Air Navigation* with intended applicability in November 2020.

6.3.9 In a related issue the Panel noted that coordination between the METP Secretary and the Secretary of the FLTOPSP indicated that the Flight Operations Panel (FLTOPSP) would welcome an information paper informing about the changes to EDR values in Annex 3. Therefore the Panel formulated the following decision:

Decision 6/2 — Information Paper to the next meeting of the FLTOPSP on the revised eddy dissipation rate (EDR) threshold values in Annex 3

That, in light of METP/4 Recommendation 6/11, the Rapporteur of WG-MOG prepare an information paper on the proposed changes to EDR values in Annex 3 for its presentation at the next meeting of the FLTOPSP.

6.3.10 The Panel noted **IP/4201**, presented by Colin Hord, Rapporteur of the MET Operations Group, regarding the status of the activities of the METP Meteorological Operations working Group

(MOG) with respect to the World Area Forecast System (WAFS). The Panel expressed its satisfaction with the information contained therein and congratulated the working group.

6.3.11 The Panel noted **IP/4203** presented by Colin Hord, Rapporteur of the MET Operations Group, regarding the WAFS development activities planned for the next 10 years and a related presentation. In this regard the Panel expressed its appreciation for this very useful contextual information on the planned improvements.

6.3.12 The Panel noted **IP/4204** presented by Colin Hord, Rapporteur of the MET Operations Group, regarding the plans developed by the WAFCs on how to deliver gridded forecasts fit for the next 10+ years through the introduction of new forecast algorithms and higher resolution grids. The Panel congratulated the WAFCs for the planned improvements to WAFS gridded forecasts, which will benefit the aviation industry by enabling improved fuel load calculations, by improving the ability to resolve and describe hazards, and by providing probabilistic information suitable for risk management.

6.3.13 Finalising the consideration of WAFS issues the Panel noted **IP/4206** presented also by Colin Hord, Rapporteur of the MET Operations Group, regarding the plans to introduce the next generation of significant weather (SIGWX) forecast products from November 2022. In this regard the Panel noted that the plans for provision of the next generation of SIGWX information that the aviation industry has long requested to the WAFCs, will be further developed and presented at the next METP meeting in 2020.

6.4 Secure Aviation Data information Service (SADIS) (Job Card METP.008.01)

6.4.1 The Panel considered **WP/4303**, presented by Colin Hord, Rapporteur MET Operations Group, concerning the dissemination of area forecasts for low-level flights (AIRMET and GAMET) on SADIS and WIFS. In this regard, the Panel noted that the proposal mainly considered two elements to this issue, which were constraints in the current ICAO Annex 3, and the desire by users for greater international distribution of these products in general.

6.4.2 It was noted that requirements for the dissemination of GAMET and AIRMET are included in Annex 3, Appendix 5 and Appendix 6, respectively. Currently only AIRMET and GAMET from EUR States are available on SADIS since no other regions have stated a requirement in their Air Navigation Plans to distribute such type of messages. However it was noted that WG-MOG/6 discussed changing the requirement to enable a more comprehensive AIRMET and GAMET data set thereby benefiting SADIS and WIFS users around the world. It had been noted, following a quick check of the available data feeds that AIRMETS are available from South Africa, Brazil, Georgia, Malaysia, Chile and the Republic of Korea, and GAMETS are available from Azerbaijan, Iran, Belarus, Ukraine, Georgia and Brazil. However, it was pointed out that the requirement for the issuance of AIRMET information by MWOs in accordance with regional air navigation agreement is a standard in Annex 3 and the States mentioned above had not stated a requirement for the issuance of AIRMET/GAMET information. Moreover, according to ICAO Doc 9161- Manual on Air Navigation services Economics, Appendix 2 paragraph 2, only those facilities and services to be provided by the meteorological service provider concerned to meet the aeronautical requirements stated in ICAO Annexes (Annex 3), PANS, and regional Air Navigation Plans, can be subject to air navigation service charges and therefore to cost recovery schemes. In conclusion, the WG-MOG/6 meeting agreed that it was necessary to raise the international distribution of AIRMET/GAMET for consideration by METP/4.

6.4.3 During discussion the Panel noted that users have requested to the SADIS and WIFS Provider States the availability on SADIS and WIFS of all AIRMETs and GAMETs. However, these requests have had to be turned down as ICAO policy, as noted above, means only AIRMET messages and GAMET forecasts from the Regions which have expressed an aeronautical requirement for these products in the ICAO ANPs would be included. It was also noted that one issue that has been raised in the past was the potential difficulty for SADIS users to be able to visualise these products but current software capability suggests that software can easily cope with more AIRMET/GAMET data as long as the bulletin headers for the data are correct.

6.4.4 The Panel noted that some AIRMET products produced by some States do not comply with the ICAO AIRMET template and that the process for checking and validating the information for the SADIS and WIFS provider States could be onerous. It was agreed that SADIS and WIFS provider states would undertake an annual sampling exercise, which would highlight any products that are being disseminated are assessed as not compliant with Annex 3 template. A list of products that were assessed as non-compliant will be detailed at the MOG / SADIS meeting and added to the SADIS and WIFS web pages.

6.4.5 The Panel proposed an amendment to Annex 3 stating that where low level forecasts, in support of international air navigation are prepared and produced in accordance with Regional Air Navigation Agreement they should be transmitted to SADIS and WIFS. Therefore the Panel formulated the following recommendation:

RSPP

Recommendation 6/11: Draft Amendment 79 to Annex 3 concerning AIRMET and GAMET information

That, the proposal given in **Appendix J** to this report concerning AIRMET and GAMET information be included as part of draft Amendment 79 to Annex 3 — *Meteorological Service for International Air Navigation* with intended applicability in November 2020.

6.4.6 The Panel noted **IP/4301**, presented by Colin Hord, Rapporteur of the MET Operations Group, regarding the status of the activities of the METP Meteorological Operations Working Group (MOG) with respect to the Secure Aviation Data Information System (SADIS). The Panel congratulated the working group and expressed its satisfaction with the information contained therein.

6.4.7 In a related issue the Panel noted **IP/4302**, presented by Jonathan Dutton for Colin Hord on behalf of the MET Operations Group, on the implementation strategy for the provision of IWXXM format data on SADIS and WIFS. In this regard the Panel was informed on the plans that plans that the World Area Forecast Centres (WAFCs) had been developing regarding how these new data sets can be disseminated to users of the Secure Aviation Data Information Service (SADIS) and WAFS Internet File Service (WIFS). In addition the WAFCs are planning to start operationally producing WAFS SIGWX forecasts in IWXXM format from November 2022.

APPENDIX A

Proposed changes to Job Card METP.008.02

METP.008.02	Further development of the Secure Aviation Data Information Service (SADIS) and WAFS Internet File Service (WIFS).
Source	MET Divisional Meeting 2014 (Recommendations 2/2 and 2/3 a) and b)), METP/2
Problem Statement	The Secure Aviation Data Information Service (SADIS) and WAFS Internet File Service (WIFS) providing meteorological information for air navigation needs to be managed to ensure that it meets the requirements of States and users ~~through the necessary transition from a satellite-based system to one supported through an Internet-based system~~ for the provision of global OPMET and WAFS information. These systems must be developed to meet the objectives of the Aviation System Block Upgrades (ASBU) within the Global Air Navigation Plan (Doc 9750).
Specific Details	~~The~~ SADIS and WIFS provide~~s~~ global OPMET and WAFS information to States and users via a secure FTP system. It was recommended by the MET Divisional Meeting (Recommendation 2/2) that an appropriate ICAO expert group be tasked to ensure that the SADIS and the WIFS continue to meet user expectations and further develop in a manner consistent with the Global Air Navigation Plan (Doc 9750). The Met Panel ~~and its associated WGs~~ will work on the future improvements to deliver data in a way that is suitable for the system-wide information management (SWIM) environment. Planned activities are detailed below ~~Furthermore Recommendation 2/3 a) and b) call for ICAO to undertake a transition from the satellite-based service to the Internet-based services available (now completed) and. this is to include consideration of the role of SADIS and WIFS within the future system-wide information management (SWIM) environment underpinning the globally interoperable air traffic management system; and alignment with future activities to be undertaken by ICAO in the information management domain.~~ ~~Further development should take into consideration the main legacy tasks from the Satellite Distribution System Operations Group (SADISOPSG)~~
Expected Benefits	~~Continues provision~~ Provision of global OPMET and WAFS information as specified in Annex 3 through an Internet-based system via a SWIM compliant based delivery system that can deliver higher resolution WAFS data sets to the aviation community.
Reference Documents	SADIS User Guide, WIFS User Guide, ICAO Annex 3

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Deliverable Expert Group		Meteorology Panel (METP)					
ID	Document Affected	Description of Amendment proposal or Action	Supporting Expert Group	Status	Expected Dates Delivery Date	Effective	Applicability
1701	SADIS User Guide	Update SADIS guidance material in line with Annex 3 Amendment 78 , when Space Weather advisories become available, and when IWXXM OPMET data becomes available. ~~Update related guidance material to support the implementation of Annex 3.~~	IMP	On-schedule	Q3 2018 to Q3 2020	Jul 2018	Nov 2018 to Nov 2020
1702	WIFS User Guide	Update WIFS guidance material in line with Annex3 Amendment 78.	IMP	On-schedule	Q3 2018 to Q3 2020	Jul 2018	Nov 2018 to Nov 2020
1703	SADIS User Guide	Update SADIS guidance material in line with Annex 3 Amendment 79.	IMP	On-schedule	Q3 2020	Jul 2020	Nov 2022
1704	WIFS User Guide	Update SADIS WIFS guidance material in line with Annex 3 Amendment 79.	IMP	On-schedule	Q3 2020	Jul 2020	Nov 2022
1716	Action	Assist ICAO in the coordination of the arrangements by the SADIS Provider State in ensuring that the global requirements for the dissemination of global OPMET and WAFS information are met.	IMP	On-schedule			Nov ~~2018~~ 2020
	Action	Delivery of IWXXM format OPMET data on SADIS and WIFS					Nov 2020
	Action	Update of SADIS and WIFS systems to deliver OPMET data in IWXXM format and WAFS data in a SWIM compliant manner		In planning		Nov 2022	Nov 2022
Status: Approved		Priority:	Initial Issue Date: 17 Jun 2015	Date Approved by ANC: 07 Jun 2017		Session / Meeting: 205-4	

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APPENDIX B

Proposed changes to Job Card METP.010.02

METP.010.02	Further development of the World Area Forecast System (WAFS)
Source	MET Divisional Meeting 2014 (Recommendations 2/1, 2/4 b) i), 2/5 and 2/12), METP/1, METP/2
Problem Statement	The world area forecast system (WAFS) is a worldwide system established to provide aeronautical meteorological en-route forecasts in uniform standardized formats. The WAFS needs to be maintained and further developed, including the integration of the information provided into the future system wide information management (SWIM), in support of the aviation system block upgrade (ASBU) methodology.
Specific Details	The WAFS ~~consists of the provision of~~ provides global aeronautical meteorological en-route WAFS forecasts in digital form to meteorological authorities and other users on a global basis by two Provider States. The WAFS information is made available via ~~one satellite distribution system for information relating to air navigation~~ the Secure Aviation Data Information Service (SADIS)~~) and two Internet-based services (the Secure SADIS FTP Service~~ and the WAFS Internet File Service (WIFS)). Following the recommendation ~~It was recommended~~ by the MET Divisional Meeting (Recommendations 2/5, 2/5 and 2.12), the METP, ~~that an appropriate ICAO expert group~~, in close coordination with WMO, continue to further develop the requirements for the WAFS consistent with the Global Air Navigation Plan (Doc 9750), including the integration of the information produced by the system into the future system wide information management (SWIM) environment. ~~Further development should take into consideration the main legacy tasks from the world area forecast system operations group (WAFSOPSG) such the provision of guidance concerning the operation of the WAFS and its effectiveness in meeting current and future operational requirements.~~ It was further recommended by the MET Divisional meeting (recommendation 2/4 b) iv)) that this includes the development of guidance for States concerning how their ICAO obligations may be met in the context of local, sub-regional, regional, multi-regional and global MET, including cost recovery and governance considerations.
Expected Benefits	~~Keep the system operational and integrate the information produced by WAFCs into the SWIM environment in line with the GANP maintaining and increasing flight efficiency and safety.~~ The resolution of WAFS gridded data sets will be increased vertically, horizontally and temporally, and SIGWX data will be provided for multiple time-steps in IWXXM format. This will assist aviation users in accurate flight planning, and will be delivered in a way which meets GANP and SWIM objectives. SIGWX forecast provision will be extended to cover multiple time-steps.
Reference Documents	Annex 3 — Meteorological Service for International Air Navigation, Global Air Navigation Plan (Doc 9750), Manual of Aeronautical

		Meteorological Practice (DOC 8896), Manual on Coordination between Air Traffic Services, Aeronautical Information Services and Aeronautical Meteorological Services (Doc 9377), Meteorology (MET) Divisional Meeting Report (Doc 10045) Agenda Item 2, Appendices A, B and F, Meteorology Panel (METP) deliverables (through its Working Groups), SADIS User Guide (Part 1 and Part 2), WIFS User Guide and guidance material available at the MOG Website.					
Deliverable Expert Group		Meteorology Panel (METP)					
ID	**Document Affected**	**Description of Amendment proposal or Action**	**Supporting Expert Group**	**Status**	**Expected Dates** Delivery Date	**Effective**	**Applicability**
~~1700~~	~~Annex 3~~	~~Proposals for inclusion in Amendment 78 to Annex 3 to meet operational requirements in line with the GANP and to integrate WAFS information into the ATMRPP SWIM environment.~~	~~FLTOPSP ATMRPP~~	~~On-schedule~~	~~Q3 2018~~	~~Jul 2020~~	~~Nov 2020~~
	Annex 3	Develop proposals for inclusion in Amendment 79 to Annex 3 to meet operational requirements in preparation for the operational implementation of the next generation of WAFC services.	FLTOPSP ATMRPP	On-schedule	Q3 2018	Jul 2020	Nov 2020
	Annex 3	Develop proposals for inclusion in Amendment 80 to Annex 3 to meet operational requirements in preparation for the operational implementation of the next generation of WAFC services.	FLTOPSP ATMRPP	In Planning	Q3 2020	Jul 2022	Nov 2022
	Actions	Increase the horizontal, temporal and vertical resolution of WAFC gridded data in line with the GANP requirements. Deliver scientific improvements to the algorithms used into the production of hazard data sets.		In planning	2022	Nov 2022	Nov 2022
	Actions	Develop the WAFC SIGWX data provision to provide multiple time-steps of data in SWIM compliant format		In planning	2022	Nov 2022	Nov 2022
~~1704~~	~~WIFS User Guide~~	~~Update related guidance material to support the implementation of Annex 3 Amendment.~~	~~-~~	~~On-schedule~~	~~Q3 2018~~	~~Nov 2020~~	~~Nov 2020~~
1708	Actions	Assist ICAO in the coordination of the arrangements between the Provider States comprising the WAFS and in ensuring that the global	-	On-schedule			Nov 2020

		requirements for WAFS information are met.					
9594	Electronic Air Navigation Plans (eANP)	Based on Annex 3 amendment, update of the eANPs as necessary.		On-schedule	Q3 2018	Nov 2020	Nov 2020
9595	GANP (Doc 9750)	Review latest version of GANP to ensure that WAFC deliverables are on schedule	-	On-schedule	Q3 2018	Nov 2020	Nov 2020
9596	Manual of Aeronautical Meteorological Practice (Doc 8896)	Update guidance material to support the implementation of Annex amendment	-	On-schedule	Q3 2018	Nov 2020	Nov 2020
9597	Manual on Coordination between ATS, AIS and AMS (Doc 9377)	Update guidance material to support the implementation of Annex 3 amendment	-	On-schedule	Q3 2018	Nov 2020	Nov 2020
~~9598~~	~~SADIS User Guide~~	~~Update guidance material to support the implementation of Annex 3 amendment~~	~~-~~	~~On-schedule~~	~~Q3 2018~~	~~Nov 2020~~	~~Nov 2020~~
Status: Approved		**Priority:**	**Initial Issue Date:** 17 Jun 2015	**Date Approved by ANC:** 07 Jun 2017		**Session / Meeting:** 205-4	

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APPENDIX C

Roadmap for International Airways Volcano Watch (IAVW) in Support of International Air Navigation

11 December 2017

Version 3.0

Revision	Date	Description
0.1	29 July 2013	Initial draft. Based on draft ConOps for the IAVW in response to IAVWOPSG Conclusion 7/17. Aligns with *Meteorological Information Supporting Enhanced Operational Efficiency and Safety* from ICAO's Aviation System Block Upgrades (ASBU).
0.2	27 September 2013	Revised draft based on comments from IAVWOPSG ad hoc group.
0.3	24 October 2013	Revised draft based on comments on version 0.2 from the IAVWOPSG ad hoc group.
0.4	10 November 2013	Revised draft based on comments on version 0.3 from the IAVWOPSG ad hoc group
1.0	19 November 2013	Submitted to IAVWOPSG Secretariat
1.0 rev	21 November 2013	Revised to include additional comments from WMO
1.1	11 December 2015	Key changes were the move of sulphur dioxide and other gases from block 3 timeframe (2028[1] and beyond) to block 1 timeframe (2018-2023). Removed functional goals, which will be placed in a requirements document. Minor updates to other sections as needed.
1.2	19 January 2016	Internal revision based on comments from MISD VA Work Stream.
2.0	29 April 2016	Complete revision. Document focuses on the on time-line of the roadmap as well as brief descriptions of the anticipated changes.
2.1	10 May 2016	Minor revision to reflect comments received at METP/WG-MISD/VA/2 meeting (29 April 2016, Buenos Aires, AR).
3.0	11 December 2017	Major revision, which includes input from METP WG-MOG/IAVW Work Stream and others. Changes include the consolidation of several concepts in the document.

[1] Footnote added with Version 3.0: ASBU block timeframes for Blocks 1, 2 and 3 in the Fourth Edition of the GANP were slightly different from those in the Fifth Edition of the GANP,

Table of Contents

1.0 Introduction

This document provides a plan for the development and implementation of volcanic ash and gas related information in support of International Civil Aviation Organization's (ICAO) Global Air Navigation Plan, 2013-2031, and associated Aviation System Block Upgrades (ASBU) for modules B0-AMET[2], B1-AMET and B3-AMET, time frames up through 2018, 2019 through 2030, and 2031 and beyond respectively[3].

This document is intended to provide aviation users and providers of meteorological and volcanological information within the International Airways Volcano Watch (IAVW) with a roadmap that defines improved services including the integration of volcanic ash-related information into decision support systems for performance-based navigation. The roadmap is not intended to provide detailed descriptions on all the areas presented in the document, rather it presents a high-level overview for the user.

The roadmap for the IAVW is a living document to support ICAO's Meteorology Panel (METP) and applicable working groups and work streams.

[2] Advanced Meteorological Information (AMET).
[3] Module B1-AMET encompasses the timeframes of Block 1 (2019-2024) and Block 2 (2025-2030).

2.0 Roadmap

Roadmap for the International Airways Volcano Watch (IAVW) in support of the Aviation System Block Upgrades (ASBU)	Block 0 (through 2018)	Block 1 (2019-2024)	Block 2 (2025-2030)	Block 3 (2031 and beyond)
Collaborative decision analysis, forecasting and information sharing	X	X		
Increase the use of the aviation colour code alert system and provision of Volcano Observatory Notice for Aviation (VONA) by State Volcano Observatories	X	X		
Improve ground-based, in-situ airborne and space-based observing networks	X	X	X	X
Scientific research in support of reducing risks from volcanic ash and gas hazards including understanding the impact of ash and gases on aircraft structure, systems, engines and occupants, and the provision of enhanced guidance to operators	X	X	X	X
Review of the IAVW for the provision of improved, consistent and efficient volcanic hazard information	X	X		
Transition to all digital format for all volcanic ash information		X		
Develop next generation volcanic ash cloud forecasts that include contamination levels coupled with probabilistic (uncertainty) information		X	X	
Develop other volcanic derived contaminant forecasts, specifically sulphur dioxide (SO_2)		X		
Integrate volcanic contaminant forecasts into decision support systems for performance-based navigation			X	

3.0 Description of Roadmap

Future IAVW-related services focus on a number of changes that are intended to match the time frames of the Blocks of the ASBUs. The IAVW strives to represent a uniform capability to provide the high quality, consistent, globalized information required by all aviation users.

Note. — While the following ASBU descriptions use the abbreviation 'MET' for meteorological information, it is to be understood that this encapsulates a range of meteorological and non-meteorological phenomena that includes volcanic ash clouds and gases.

Module B0-AMET (through 2018) of the ASBUs is the baseline services for Block 0. This baseline describes the services as they were at the beginning of Block 0 (2013). During Block 0, several improvements were planned and implemented, which are briefly described in this section.

Module B1-AMET (2019 through 2030) - *Enhanced Operational Decisions through Integrated Meteorological Information* enables the identification of solutions when forecast or observed meteorological conditions impact aerodromes or airspace. Full air traffic management (ATM) and meteorology (MET) integration is needed to ensure that: MET information is included in decision-making process and the impacts of the MET conditions (including the extent and movement of volcanic ash clouds) are automatically taken into account. Module B1-AMET covers the timeframes of both Block 1 (2019-2024) and Block 2 (2025-2030)[4]. B1-AMET improves upon current operations where ATM decision makers manually determine the change in capacity associated with an observed or forecast MET condition (e.g., volcanic ash clouds), manually compare the resultant capacity with the actual or projected demand for the airspace or aerodrome, and then manually devise ATM solutions when the demand exceeds the MET-constrained capacity value. Module B1-AMET also improves in-flight avoidance of hazardous MET conditions by providing more precise information on the location, extent, duration and severity of the hazard(s) affecting specific flights, including volcanic eruptions and volcanic ash clouds in the atmosphere.

The aim of Module B3-AMET (2031 and beyond) - *Enhanced Operational Decisions through Integrated Meteorological Information* is to enhance global ATM decision-making in the face of hazardous MET conditions in the context of decisions that should have an immediate effect. Key points are a) tactical avoidance of hazardous MET conditions especially in the 0-20 minute timeframe; b) greater use of aircraft based capabilities to detect MET parameters; and c) display of MET information to enhance situational awareness.

3.1 Changes through 2018:

The following briefly describes changes within the timeframe of Block 0 (2013-2018) to support Module B0-AMET *(Meteorological Information Supporting Enhanced Operational Efficiency and Safety)*.

[4] The development of a specific MET module for Block 2 is being considered by the METP, per Job Card METP.002.01, in time for the sixth edition of the GANP in 2019.

3.1.1 Collaborative decision analysis, forecasting and information sharing

The term Collaborative Decision Making (CDM) is a process used in ATM that allows all members of the ATM community, including airspace users and providers of aviation-relevant information, to participate in the ATM decisions affecting all members. CDM means arriving at an acceptable solution that takes into account the needs of those involved. CDM is described in ICAO Document 9971 – *Manual on Collaborative Decision-Making*, Document 9854 - *Global Air Traffic Management Operational Concept,* and Document 9982 – *Manual on Air Traffic Management System Requirements.*

A similar process has been implemented for volcanic ash and is called Collaborative Decision Analysis and Forecasting (CDAF). From a high level perspective and as an example, collaboration on the location and extent of a discernible volcanic ash cloud can be done, at a minimum, for events that affect high density traffic areas, or several FIRs and extend beyond the area of responsibility of one or more of the Volcanic Ash Advisory Centres (VAAC). This collaboration is currently in place for the VAACs and is detailed in ICAO Doc 9766 *Handbook on the International Airways Volcano Watch (IAVW)*, Part 4, section 4.10.

It is desired that the VAAC's collaboration process be expanded to include other participants, e.g., Meteorological Watch Offices (MWO) and other meteorological offices serving aviation, State Volcano Observatories (VO), aviation regulatory authorities (or equivalent), airports, operators and ATM. To be effective with all these groups involved there needs to be a transparent CDM structure developed so that, for example, when an eruption occurs participants will know who is talking to whom and how subsequent information is communicated. This structure should contain procedures and guidance showing how the total process delivers more informed decision-support information for the users, especially ATM and operators.

Performance based operations (where the operator is responsible for where it operates) will necessitate operators to seek, integrate and use high quality, meteorological and volcanological information. For these future operations, the use of CDM practices will become increasingly integrated into aviation decision-making. ATM and users have begun using this practice to derive acceptable and more informed solutions.

3.1.2 Increase the use of the aviation colour code alert system and provision of VONA by State VOs

Per ICAO Annex 3 – *Meteorological Service for International Air Navigation*, State VOs may use the Volcano Observatory Notices to Aviation (VONA) and its aviation colour code alert system for the provision of volcano information in support of aviation. Despite being intended to provide a concise statement describing the activity at the volcano, as well as the specific time of the onset and duration of the eruptive activity, not all State VOs currently have the capacity or capability to issue VONA messages.

The VONA is the only volcano-related product that provides pre-eruption activity information to aviation users, which is considered as safety critical information by aircraft operators. In support of this, VONAs allow for the inclusion of a colour code in the message. The colour codes reflect the activity level assessed by volcanologists at or near the volcano and does not pertain to any hazard downwind of the volcano, e.g., the ash cloud. Although the World Organization of Volcano Observatories (WOVO)[5] has established a recommended colour code scale, some States have developed their own activity alerting code to address unique needs of the State.

The METP continues to progress with this effort, which is being conducted by the Working Group of the Meteorological Operations Group's (WG-MOG) IAVW Work Stream.

3.1.3 Improve ground-based, in-situ airborne and space-based observing networks

Observation and forecast information on volcanic ash requires continued improvement of observational capabilities globally, including volcano-monitoring networks, ground-based aerosol networks, satellite platforms and sensors, and in-situ airborne sampling. Improvements in observational capabilities will also aide in verification and validation of volcanic cloud forecasts and may be used to produce quantitative forecasts.

During this timeframe improvements in volcanic ash detection were realized with new satellites from Japan (Himawari-8) and the United States (GOES-16). These satellites contributed greatly to the improvement of volcanic ash analysis techniques and methods, enabling VAACs to provide aviation users with more reliable information on the presence of discernible volcanic ash clouds and gases in the atmosphere, their extent and movement.

This improving capability offers users the ability to request more flexible and increasingly detailed requirements, as needed, for operations in airspace impacted by volcanic ash. Meeting these requirements with improved information, when supplied timely and consistently, will enhance both the safety and efficiency of flying operations.

Notwithstanding the advances that continue to be made, it is worthwhile to note however that the different observing and forecasting techniques have strengths and weaknesses in their application. In particular, remote sensing has not replaced the need for ground-based seismic monitoring of volcanoes, particularly for advance warning of eruptions at dormant volcanoes. Given the often-unique circumstances and uncertainties that can prevail at the time of a volcanic eruption, making optimal use of a suite of available methodologies rather than applying any single methodology in isolation often offers the optimum approach to the detection and parameterization of volcanic eruptions and the observation and forecasting of volcanic ash clouds and gases.

3.1.4 Scientific research in support of reducing risks from volcanic ash and gas hazards including understanding the impact of ash and gases on aircraft

[5] WOVO is a volunteer science organization and a commission of the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI).

structure, systems, engines and occupants, and the provision of enhanced guidance to operators

Scientific research in support of reducing risks from volcanic ash and gas hazards continues to aim for tangible improvements in the detection and quantitative measurement of volcanic plumes, ash and gas clouds during eruptions and in the accuracy of model forecasts of ash and gas transport and dispersion. In addition, the ability to detect and track the movement of a re-suspended volcanic ash cloud (that may or may not be associated with an ongoing eruption) is garnering attention. Research topics (both new and on-going) pertinent to these goals include the following:

- Characterizing volcanic plumes at/near the source
- Characterization (including quantitatively-based assessments) of volcanic ash and gas clouds in time and space and expressions of the uncertainty associated with the observations and forecasts
- Developing sets of quantitative ash-cloud data that can be used to validate models and track improvements in forecast accuracy
- Verification of the model forecasts
- Assess the relationship between gases emitted from volcanic eruptions, specifically sulphur dioxide (SO_2), in the atmosphere and their health risks to aircraft occupants and affect to the lifetime of aircraft components.

In addition,

- Scientific research continues to aim for tangible understanding of the impact of ash and gas on aircraft structure, systems, engines and occupants to provide enhanced guidance to operators
- Scientific research to support service delivery for volcanic ash and gas hazard risk reduction information

3.1.5 Review of the IAVW for the provision of improved, consistent and efficient volcanic hazard information

The IAVW was formed in the late 1980s, with the nine VAACs being implemented in the early 1990s and covering the globe since December 2016. The International Air Transport Association (IATA) has strongly suggested that the current structure of the nine VAAC system is not optimal in terms of delivering a consistent, high quality, and cost-efficient service in an increasingly global capable and interoperable environment.

IATA has suggested that ICAO conduct a review of the IAVW to establish the optimal number of service providers required to deliver future volcanic ash services. The process should begin with the development of the framework and terms of reference for conducting a review. The review should also include and conclude how State MWO's support and collaborate in the future system. IATA believes it would be beneficial to undertake this review as part of the development of the system to address phenomenon-based regional advisory information for select en-route hazardous meteorological conditions.

3.2 Changes intended within 2019-2024:

The following briefly describes desired changes within the timeframe of 2019-2024 (i.e., Block 1 timeframe) to support Module B1-AMET *(Enhanced Operational Decisions through Integrated Meteorological Information).*

3.2.1 Transition to all-digital format for all volcanic ash information

There is a need to provide users with a four-dimensional (4-D) view of the observed and forecast position of a volcanic ash cloud. Today's products are primarily text-based (e.g., VAA and SIGMET), with some supplementation of graphic-based products (e.g., VAG and SVA[6]). Future volcanic ash cloud-related information must be provided in a digital format that can be fully integrated into flight planning and other operational systems in order to better serve aviation users and decision makers. The visualization of volcanic information must be capable of being displayed on moving maps, cockpit displays, radar screens, etc.

The transition from text and graphic-based products to all-digital formats is progressing as the supporting data representations and infrastructures are developed. Therefore, there will continue to be a need for legacy products to be available for several years during the transition.

It should be noted that both the SIGMET and VAA/VAG will be made available in digital form based on the ICAO Meteorological Information Exchange Model (IWXXM) schema by the year 2020 as a first step in the envisaged transition. Consideration should be given to add the VONA to the list of products to be put in digital form.

It is expected that Aeronautical Information Services (AIS) pertaining to volcano eruption and volcanic ash clouds, i.e., ASHTAMs and NOTAMs will also transition to digital form.

3.2.2 Develop next generation volcanic ash cloud forecasts that include contamination levels coupled with probabilistic (uncertainty) information

In 2017, a major original equipment manufacturer[7] (OEM) announced that certain models of their engines could safely operate for a specified time in a specified level and dose of volcanic ash. This milestone together with others recent developments such as the advancement of satellite-based detection of volcanic ash clouds and gases may, potentially, pave the way for the development of quantifiable volcanic ash contamination forecasts.

Such quantitative volcanic ash contamination forecasts can be considered a second generation of the ash concentration forecasts developed in 2010 following the Eyjafjallajökull eruption in Iceland, which were issued by the national meteorological service providers of some States in Europe according to their local directives or agreements.

Current volcanic ash forecasts, such as the VAA/VAG, are qualitative, deterministic forecasts. They are a yes/no forecast with respect to the depiction of the airspace impacted by discernible volcanic ash and they give a single forecast with no uncertainty information. Volcanic ash

[6] VA advisory information in graphical format and SIGMET for VA in graphical format respectively.
[7] Other OEMs need to follow suit to achieve maximum results.

transport and dispersion models can produce an array of solutions (e.g., forecasts) by varying the model input. Changes in meteorological parameters and eruption source parameters (ESP) can result in different forecast outputs that affect the 4-dimensional (4-D) shape (3-dimensional shape and change of shape with time) of the volcanic ash cloud and gases.

The next generation volcanic ash cloud forecasts will provide both deterministic and probabilistic forecasts for contamination levels that will allow decision makers to use, taking into account their risk management practices and the quantitative exposures allowed by the engine manufacturers. Specifically, the addition of probabilistic forecasts will provide decision makers with an assessment of the likelihood of the volcanic ash exceeding a defined magnitude (or threshold) at a particular time and place. The probabilistic element further helps decision makers apply their own operational constraints (i.e. business rules) to determine the risk to their operations.

From a high-level perspective, probability forecasts may be based on an ensemble approach. An ensemble is one way to account for some degree of uncertainty. For instance, a model or models can be run many times, each time with a realistic variant of one of the uncertain parameters (e.g. ash amount, ash column height, eruption start time and duration, input meteorology dataset, dispersion model used, with and without wet deposition, etc.). Taken as a whole, the variability of the ensemble members' output gives an indication of the uncertainty associated with that particular volcanic ash forecast.

The application of probabilistic forecasts will suit both high and low density airspaces, where decision makers can benefit from more than just a deterministic forecast to determine route or flow. Decision support systems can be adapted to use probabilistic information to provide efficient route and altitude selections, as well as maintenance alerts, based on user's dosage thresholds.

For decision makers (i.e., operators, flight crew, air traffic control) to effectively use 'probabilities' for the initial and ongoing risk assessments, a thorough understanding of the output from the VAAC is needed by the users. This will require educational/training efforts that will be suitable for all decision makers.

To achieve the greatest utility for decision makers the next generation forecasts must have finer temporal resolution (e.g., hourly), be valid beyond 18 hours (e.g., 2 days or more), and be updated more frequently (e.g., every 2 hours) than current volcanic ash cloud forecasts.

3.2.3 Develop other volcanic derived contaminant forecasts, specifically sulphur dioxide

During volcanic eruptions, a number of hazardous gases may be emitted in addition to volcanic ash; these include SO_2, hydrogen fluoride (HF), and hydrogen sulphide (H_2S) amongst many others. These are problematic because aircraft occupants breathe air that originates from outside the aircraft. Outside air is drawn in through the engines, compressed (i.e., pressurized) then passes through the aircraft's ventilation system. Each gas will likely have different eruption source parameters and atmospheric dispersion properties, and so gas clouds may be found coincident with or wholly separate from volcanic ash clouds.

The importance of these gases for aviation varies. Gaseous volcanic HF has not so far been found at high concentrations in locations where it would have an adverse effect on people's health[8] , and so is not discussed further here. H_2S has caused fatalities, but is generally localized and it is likely that this can be well managed from a ground-based, civil defence perspective. Volcanic SO_2 has also caused only local fatalities, but is of importance more generally to aviation as it may be emitted in large quantities to cruising altitudes during large eruptions and is frequently detected by remote sensing techniques

Depending on the levels of concentration, SO_2 can also have an adverse effect on the performance of aircraft engines and systems. This effect is not immediate; rather it is long-term and affects the service life of the aircraft components. Thus it is an economic impact rather than a safety of flight impact.

Following the scientific (medical) determination of a critical level or levels of SO_2 (in the atmosphere) that could pose a health threat to aircraft occupants, or any determination of concentrations above which OEMs do not recommend flight within an SO_2 cloud, provisions for the detection and forecasts of gas clouds, including concentration of SO_2, can be developed.

3.2.4 Continued development of collaborative decision analysis, forecasting and information sharing processes

The development of the CDM process is expected to continue in Block 1.

3.2.5 Continued increase use of the aviation colour code alert system and provision of VONA by State VOs

The increased use of the aviation colour code alert system and provision of VONAs by State VOs is expected to continue in Block 1.

3.2.6 Continued improvements in ground-based, in-situ airborne and space-based observing networks

Improvements to volcano-monitoring networks, ground-based aerosol networks, satellite platforms and sensors, and in-situ airborne sampling will continue in Block 1, building on the accomplishments from Block 0.

Volcanic ash and gas detectors on aircraft are expected to be introduced, with downlink capability to better inform the stakeholders on the ground about actual conditions and thus improve the overall awareness of the volcanic cloud.

Given improving technology, there is the potential to have on-board ash detection equipment incorporated into the aircraft avionics suite, possibly providing the aircrew with real-time information. The addition of a crosslink capability could inform other aircraft in the vicinity about the ash cloud. The provision of information to support this new capability will require additional consideration for both preflight and in-flight information.

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[8] International Volcanic Health Hazard Network, IVHHN,
http://www.ivhhn.org/index.php?option=com_content&view=article&id=86

It is important that the information retrieved from on-board ash detection be rapidly shared with VAACs so that they can incorporate the data into their subsequent forecasts, inputs to their dispersion models, and verification of forecasts.

In addition, to allow operators to take full advantage of tactical on-board volcanic ash detection equipment, ATM processes and procedures will need to be developed and incorporated into ATM Contingency Plans.

3.2.7 Continued scientific research in support of reducing risks from volcanic ash and gas hazards

Scientific research in support of reducing risks from volcanic ash and gas hazards will continue in Block 1.

3.2.8 Continued review of the IAVW for the provision of improved, consistent and efficient volcanic hazard information

It is anticipated that the IAVW review in Block 0 will extend into Block 1.

3.3 Changes intended within the time frame of 2025-2030

The following briefly describes desired changes within the timeframe of Block 2 (2025-2030), which is an extension of ASBU Block 1, to support Module B1-AMET *(Enhanced Operational Decisions through Integrated Meteorological Information)*.

3.3.1 Continued development of the next generation volcanic ash cloud forecasts

Development of the next generation volcanic ash cloud forecasts will likely continue into Block 2.

Once uniformly accepted volcanic ash thresholds are determined for aircraft and engine types, and volcanic ash detection is consistently capable, there should be an agreed range of volcanic ash contamination forecasts made available, on a global scale perhaps similar to World Area Forecast System (WAFS) gridded forecasts, for improved use and airframe dosage monitoring by operators.

These thresholds will be linked to the operator’s Safety Management System and risk assessment.

3.3.2 Integrate volcanic ash forecasts into decision support systems for performance-based navigation

One of the key elements in Module B1-AMET[9] of the ASBUs is the integration of meteorological information into decision support systems. Future ATM decision support systems need to directly incorporate volcanic ash cloud observations and forecasts, allowing decision makers to determine the best response to the potential operational effects and minimize the level of traffic restrictions. This integration of information, combined with the use of probabilities to address

[9] Module B1-AMET is applicable for both Blocks 1 and 2.

uncertainty, can reduce the effects of the presence of volcanic ash clouds on air traffic operations.

3.3.3 Continued improvements in ground-based, in-situ airborne and space- based observing networks

Improvements to volcano-monitoring networks, ground-based aerosol networks, satellite platforms and sensors, and in-situ airborne sampling will continue in Block 2.

3.3.4 Continued scientific research in support of reducing risks from volcanic ash and gas hazards

Scientific research in support of reducing risks from volcanic ash and gas hazards will need to continue in Block 2.

3.4 Changes intended by 2031 and beyond

The following briefly describes desired changes intended for 2031 and beyond (i.e., Block 3 timeframe) in support of Module B3-AMET (*Enhanced Operational Decisions through Integrated Meteorological Information)*.

3.4.1 Continued improvements in ground-based, in-situ airborne and space- based observing networks

Improvements to volcano-monitoring networks, ground-based aerosol networks, satellite platforms and sensors, and in-situ airborne sampling will continue in Block 3.

3.4.2 Continued scientific research in support of reducing risks from volcanic ash and gas hazards

Scientific research in support of reducing risks from volcanic ash and gas hazards will need to continue in Block 3.

- END OF DOCUMENT -

APPENDIX D to the Report on Agenda Item 6

Draft Amendment 79 to Annex 3 concerning MODEL VAG and MODEL SVA in Appendix 1

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

PART II

APPENDICES AND ATTACHMENTS

APPENDIX 1. FLIGHT DOCUMENTATION — MODEL CHARTS AND FORMS

(See Chapter 9 of this Annex.)

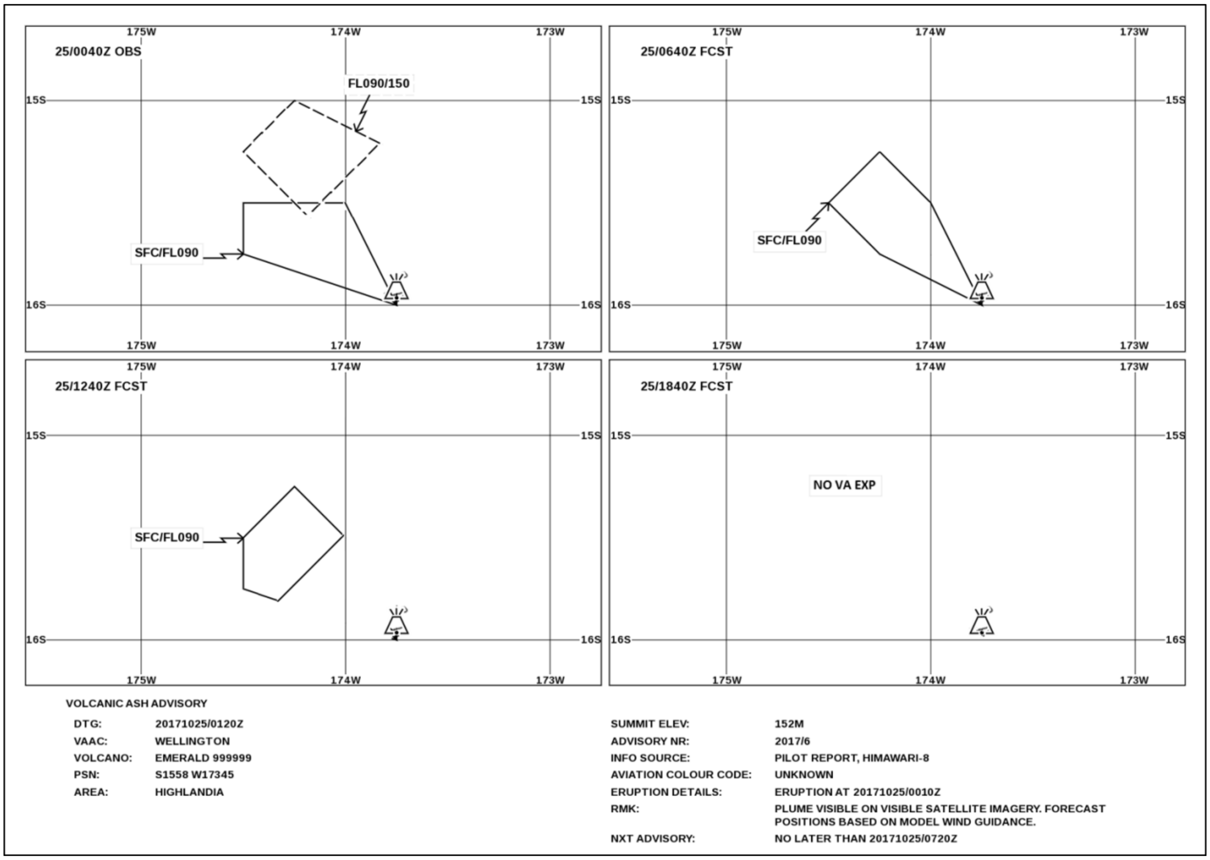
MODEL A	OPMET information
MODEL IS	Upper wind and upper-air temperature chart for standard isobaric surface Example 1. Arrows, feathers and pennants (Mercator projection) Example 2. Arrows, feathers and pennants (Polar stereographic projection)
MODEL SWH	Significant weather chart (high level) Example. Polar stereographic projection (showing the jet stream vertical extent)
MODEL SWM	Significant weather chart (medium level)
MODEL SWL	Significant weather chart (low level) Example 1 Example 2
MODEL TCG	Tropical cyclone advisory information in graphical format
MODEL VAG	Volcanic ash advisory information in graphical format Example 1. Mercator projection. Example 2. Polar stereographic projection.

MODEL STC	SIGMET for tropical cyclone in graphical format
MODEL SVA	SIGMET for volcanic ash in graphical format Example 1. Mercator projection. Example 2. Polar stereographic projection.
MODEL SGE	SIGMET for phenomena other than tropical cyclone and volcanic ash in graphical format
MODEL SN	Sheet of notations used in flight documentation

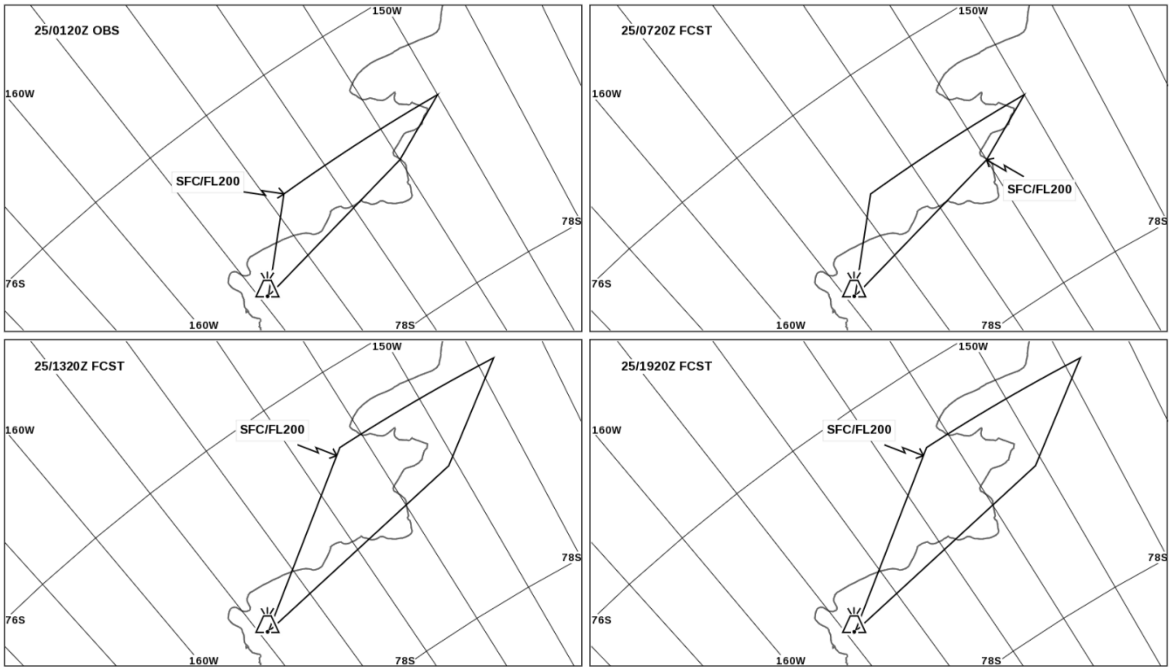
VOLCANIC ASH ADVISORY INFORMATION IN GRAPHICAL FORMAT **MODEL VAG**

Editorial note. — Replace the existing MODEL VAG example in toto by the following two MODEL VAG examples.

Example 1



Example 2



VOLCANIC ASH ADVISORY

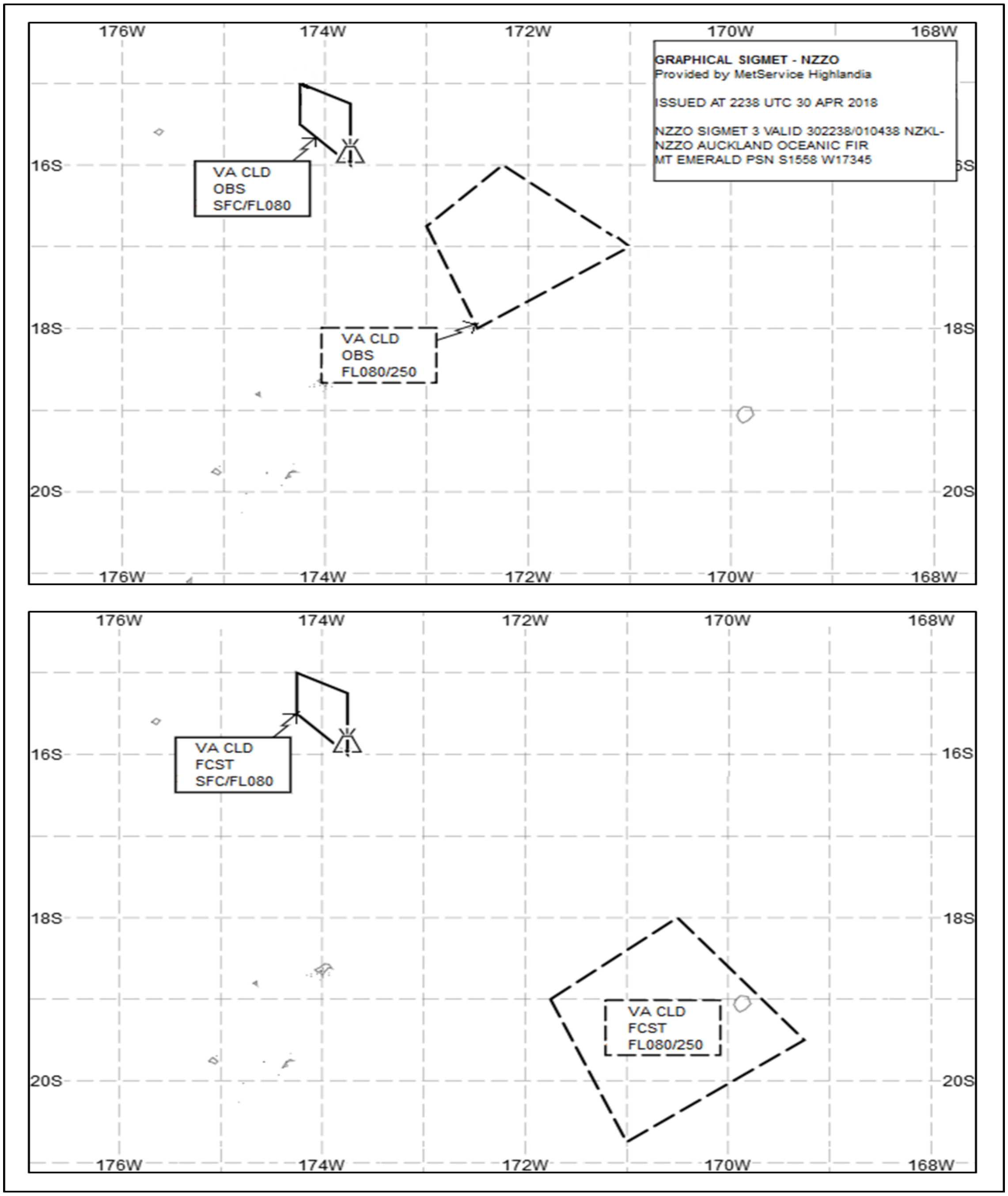
DTG:	20171025/0135Z	SUMMIT ELEV:	321M
VAAC:	WELLINGTON	ADVISORY NR:	2017/7
VOLCANO:	SAPPHIRE 999999	INFO SOURCE:	SATELLITE IMAGERY
PSN:	S7715 W15747	AVIATION COLOUR CODE:	UNKNOWN
AREA:	LOWLANDIA	ERUPTION DETAILS:	CONTINUOUS EMISSIONS TO FL200
		RMK:	VA PARTIALLY OBSCURED BY MET CLOUD ALONG SOUTHERN BOUNDARY.
		NXT ADVISORY:	NO LATER THAN 20171025/0735Z

[…]

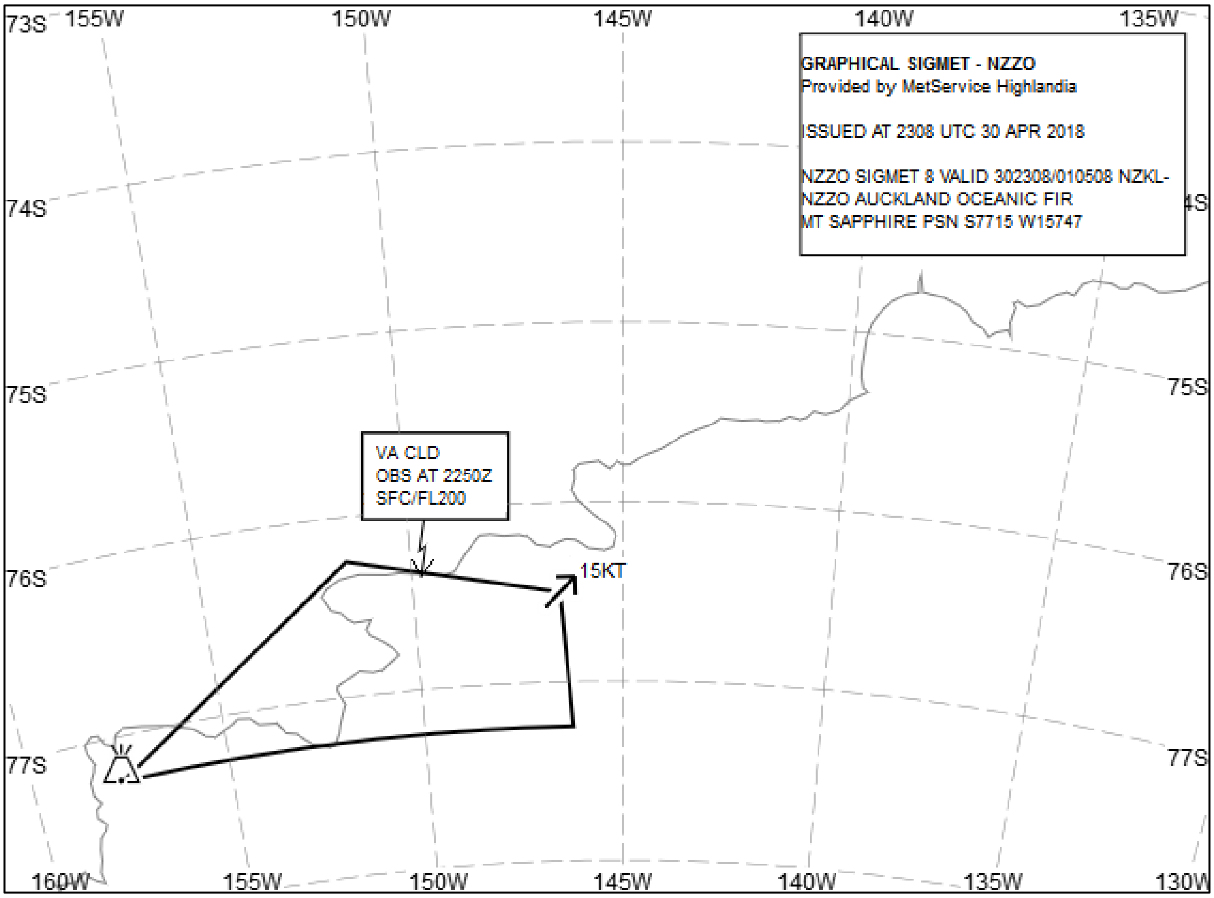
SIGMET FOR VOLCANIC ASH IN GRAPHICAL FORMAT **MODEL SVA**

Editorial note. — Replace the existing MODEL SVA example in toto by the following two MODEL SVA examples.

Example 1



Example 2


73S
155W
150W
145W
140W
135W
GRAPHICAL SIGMET - NZZO
Provided by MetService Highlandia
ISSUED AT 2308 UTC 30 APR 2018
NZZO SIGMET 8 VALID 302308/010508 NZKL-
NZZO AUCKLAND OCEANIC FIR
MT SAPPHIRE PSN S7715 W15747
74S
75S
VA CLD
OBS AT 2250Z
SFC/FL200
15KT
76S
77S
160W
155W
150W
145W
140W
135W
130W

[…]

— — — — — — — —

APPENDIX E

Amendment to Annex 3, Chapter 1 and Appendix 2 concerning re-suspended volcanic ash

TEXT OF PROPOSED AMENDMENT TO THE

**INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES**

METEOROLOGICAL SERVICE FOR INTERNATIONAL AIR NAVIGATION

**ANNEX 3
TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION**

PART I. CORE SARPs

CHAPTER 1. DEFINITIONS

Note.— The designation (RR) in these definitions indicates a definition which has been extracted from the Radio Regulations of the International Telecommunication Union (ITU) (see Handbook on Radio Frequency Spectrum Requirements for Civil Aviation including Statement of Approved ICAO Policies *(Doc 9718)).*

1.1 Definitions

When the following terms are used in the Standards and Recommended Practices for Meteorological Service for International Air Navigation, they have the following meanings:

[…]

Volcanic ash advisory centre (VAAC). A meteorological centre designated by regional air navigation agreement to provide advisory information to meteorological watch offices, area control centres, flight information centres, world area forecast centres and international OPMET databanks regarding the lateral and vertical extent and forecast movement of volcanic ash in the atmosphere~~ following volcanic eruptions~~.

[…]

PART II. APPENDICES AND ATTACHMENTS

[…]

APPENDIX 2. TECHNICAL SPECIFICATIONS RELATED TO

GLOBAL SYSTEMS, SUPP[ORTING CENTRES AND METEOROLOGICAL OFFICES

(See Chapter 3 of this Annex.)

[…]

Table A2-1. Template for advisory message for volcanic ash

Key: M = inclusion mandatory, part of every message;
O = inclusion optional;
= = a double line indicates that the text following it should be placed on the subsequent line.

Note 1.— The ranges and resolutions for the numerical elements included in advisory messages for volcanic ash are shown in Appendix 6, Table A6-4.

Note 2.— The explanations for the abbreviations can be found in the Procedures for Air Navigation Services — ICAO Abbreviations and Codes *(PANS-ABC, Doc 8400).*

Note 3.— Inclusion of a colon after each element heading is mandatory.

Note 4.— The numbers 1 to 19 are included only for clarity and are not part of the advisory message, as shown in the example.

	Element	*Detailed content*	*Template(s)*		*Examples*	
1	…	…	…		…	
2	…	…	…		…	
3	…	…	…		…	
4	…	…	…		…	
5	Name of volcano (M)	Name and IAVCEI[1] number of volcano	VOLCANO:	nnnnnnnnnnnnnnnnnnnnnn [nnnnnn] *or* UNKNOWN *or* UNNAMED	VOLCANO: VOLCANO: VOLCANO:	KARYMSKY ~~1000-13~~300130 UNNAMED UNKNOWN
6	…	…	…		…	…
7	State *or* region (M)	State, *or* region if ash is not reported over a State	AREA:	nnnnnnnnnnnnnnn	AREA: AREA:	RUSSIA UNKNOWN
8	Summit elevation (M)	Summit elevation in m (*or* ft)	SUMMIT ELEV:	nnnnM (*or* nnnnnFT)	SUMMIT ELEV: SUMMIT ELEV:	1536M 0M
9	…	…	…		…	…
10	Information source (M)	Information source using free text	INFO SOURCE:	*Free text up to 32 characters*	INFO SOURCE:	~~MTSAT-1R~~ HIMAWARI-8 KVERT KEMSD
11	…	…	…		…	…

	Element	*Detailed content*	*Template(s)*		*Examples*	
12	Eruption details (M)	Eruption details (including date/time of eruption(s))	ERUPTION DETAILS:	*Free text up to 64 characters* *or* UNKNOWN	ERUPTION DETAILS: ERUPTION DETAILS:	ERUPTION AT 20080923/0000Z FL300 REPORTED NO ERUPTION – RE-SUSPENDED VA[6]
13	…	…	…		…	23/0100Z
14	…	…	…		…	…
15	…	…	…		…	…
16	…	…	…		…	…
17	…	…	…		…	…
18	Remarks (M)	Remarks, as necessary	RMK:	*Free text up to 256 characters* *or* NIL	RMK: RMK: RMK:	LATEST REP FM KVERT (0120Z) INDICATES ERUPTION HAS CEASED. TWO DISPERSING VA CLD ARE EVIDENT ON SATELLITE IMAGERY RE-SUSPENDED VA[6, 7] NIL
19	…	…	…		…	…

Notes.—

1. …
2. …
3. …
4. …
5. …
6. To be included (as free text) only for those situations where volcanic ash has been re-suspended.
7. To be included (as free text) where space in the remarks section allows.

[…]

— — — — — — — —

APPENDIX F to the Report on Agenda Item 6

Draft Amendment 79 to Annex 3 concerning WAFS information

APPENDIX 2. TECHNICAL SPECIFICATIONS RELATED TO GLOBAL SERVICES, THEIR ASSOCIATED CENTRES AND METEOROLOGICAL OFFICES

(See Chapter 3 of this Annex.)

…

1. WORLD AREA FORECAST SYSTEM

…

1.2 Upper-air gridded forecasts

1.2.1 The forecasts of upper winds; upper-air temperature; and humidity; direction, speed and flight level of maximum wind; flight level and temperature of tropopause, areas of cumulonimbus clouds, icing, ~~clear-air and in-cloud~~ turbulence, and geopotential altitude of flight levels shall be prepared four times a day by a WAFC and shall be valid for fixed valid times at 6, 9, 12, 15, 18, 21, 24, 27, 30, 33 and 36 hours after the time (0000, 0600, 1200 and 1800 UTC) of the synoptic data on which the forecasts were based. ~~The dissemination of e~~Each forecast ~~shall be in the above order and~~ shall be ~~completed~~ made available as soon as technically feasible but not later than ~~6~~ 5 hours after standard time of observation.

1.2.2 The grid point forecasts prepared by a WAFC shall comprise:

a) wind and temperature data for flight levels 50 (850 hPa), 80 (750 hPa), 100 (700 hPa), 140 (600 hPa), 180 (500 hPa), 210 (450 hPa), 240 (400 hPa), 270 (350 hPa), 300 (300 hPa), 320 (275 hPa), 340 (250 hPa), 360 (225 hPa), 390 (200 hPa), 410 (175 hPa), 450 (150 hPa), 480 (125 hPa) and 530 (100 hPa);

b) flight level and temperature of tropopause;

c) direction, speed and flight level of maximum wind;

d) humidity data for flight levels 50 (850 hPa), 80 (750 hPa), 100 (700 hPa), 140 (600 hPa) and 180 (500 hPa);

e) horizontal extent and flight levels of base and top of cumulonimbus clouds;

f) icing for layers centred at flight levels 60 (800 hPa), 100 (700 hPa), 140 (600 hPa), 180 (500 hPa), 240 (400 hPa) and 300 (300 hPa);

g) ~~clear-air~~ turbulence for layers centred at flight levels 100 (700 hPa), 140 (600 hPa), 180 (500 hPa), 240 (400 hPa), 270 (350 hPa), 300 (300 hPa), 340 (250 hPa), 390 (200 hPa) and 450 (150 hPa); and

~~h) in-cloud turbulence for layers centred at flight levels 100 (700 hPa), 140 (600 hPa), 180 (500 hPa), 240~~

~~(400 hPa) and 300 (300 hPa)~~; and

Note 1.— Layers centred at a flight level referred to in f) ~~and h)~~ have a depth of 100 hPa.
Note 2.— Layers centred at a flight level referred to in g) have a depth of 100 hPa for flight levels below 240, then 50 hPa for flight levels 240 and above.

h~~i~~) geopotential altitude data for flight levels 50 (850 hPa), 80 (750 hPa), 100 (700 hPa), 140 (600 hPa), 180 (500 hPa), 210 (450 hPa), 240 (400 hPa), 270 (350 hPa), 300 (300 hPa), 320 (275 hPa), 340 (250 hPa), 360 (225 hPa), 390 (200 hPa), 410 (175 hPa), 450 (150 hPa), 480 (125 hPa) and 530 (100 hPa).

Note.— The exact pressure levels (hPa) for a), d), f), g), and i) is provided in the Manual of Aeronautical Meteorological Practice *(Doc 8896).*

1.2.3 The foregoing grid point forecasts shall be issued by a WAFC in binary code form using the GRIB code form prescribed by the World Meteorological Organization (WMO).

Note.— The GRIB code form is contained in the Manual on Codes *(WMO-No. 306), Volume I.2, Part B* — Binary Codes.

1.2.4 The foregoing grid point forecasts a) through d) and h) shall be prepared by a WAFC in a regular grid with a horizontal resolution of 1.25° of latitude and longitude.

1.2.5 The foregoing grid point forecasts e) through g) shall be prepared by a WAFC in a regular grid with a horizontal resolution of 0.25° of latitude and longitude.

…

1.3 Significant weather (SIGWX) forecasts

1.3.1 General provisions

1.3.1.1 Forecasts of significant en-route weather phenomena shall be prepared as SIGWX forecasts four times a day by a WAFC and shall be valid for fixed valid times at 24 hours after the time (0000, 0600, 1200 and 1800 UTC) of the synoptic data on which the forecasts were based. ~~The dissemination of e~~Each forecast shall be ~~completed~~ made available as soon as technically feasible but not later than ~~9~~ 7 hours after standard time of observation under normal operations and not later than 9 hours after standard time of observation during backup operations.

1.3.1.2 SIGWX forecasts shall be issued in binary code form using the BUFR code form prescribed by WMO.

Note.— The BUFR code form is contained in the Manual on Codes *(WMO-No. 306), Volume I.2, Part B* — Binary Codes.

1.3.1.3 **Recommendation**.— *From 04 November 2021, in addition to 1.3.1.2, SIGWX forecasts should be made available in IWXXM form.*

Note.— Guidance on IWXXM is provided in the Manual on the ICAO Meteorological Information Exchange Model (IWXXM) *(Doc 10003).*

…

2. AERODROME METEOROLOGICAL OFFICES

2.1 Use of world area forecast system (WAFS) products

…

2.1.2 In order to ensure uniformity and standardization of flight documentation, the WAFS GRIB, ~~and~~ BUFR and from 04 November 2021, IWXXM data received shall be decoded into standard WAFS charts in accordance with relevant provisions in this Annex, and the meteorological content and identification of the originator of the WAFS forecasts shall not be amended.

2.2 Notification of WAFC concerning significant discrepancies

Aerodrome meteorological offices using WAFS BUFR or IWXXM data shall notify the WAFC concerned immediately if significant discrepancies are detected or reported in respect of WAFS SIGWX forecasts concerning:

a) icing, turbulence, cumulonimbus clouds that are obscured, frequent, embedded or occurring at a squall line, and sandstorms/duststorms; and

b) volcanic eruptions or a release of radioactive materials into the atmosphere, of significance to aircraft operations.

The WAFC receiving the message shall acknowledge its receipt to the originator, together with a brief comment on the report and any action taken, using the same means of communication employed by the originator.

Note.— Guidance on reporting significant discrepancies is provided in the Manual of Aeronautical Meteorological Practice *(Doc 8896).*

…

APPENDIX 8. TECHNICAL SPECIFICATIONS RELATED TO SERVICE FOR OPERATORS AND FLIGHT CREW MEMBERS

…

2. SPECIFICATIONS RELATED TO INFORMATION FOR PRE-FLIGHT PLANNING AND IN-FLIGHT REPLANNING

…

2.2 Format of information on significant weather

2.2.1 Information on significant weather supplied by WAFCs for pre-flight and in-flight replanning shall be in the BUFR code form.

Note.— The BUFR code form is contained in the Manual on Codes *(WMO-No. 306), Volume I.2, Part B —* Binary Codes.

2.2.2 **Recommendation**.— *From 04 November 2021, in addition to 2.2.1, information on significant weather supplied by WAFCs for pre-flight and in-flight replanning should be in the IWXXM form.*

Note 2.— Guidance on IWXXM is provided in the Manual on the ICAO Meteorological Information Exchange

Model (IWXXM) *(Doc 10003)*.

— — — — — — — —

APPENDIX G

Proposed changes for Doc 8896 - Manual of Aeronautical Meteorological Practice pertaining to exact pressure levels in WAFS information

Exact pressure levels for WAFS grid point forecast information into Doc 8896 – *Manual of Aeronautical Meteorological Practice.*

Replace the existing listing of flight levels and corresponding pressure levels in 3.7.2.2 with the following table:

Flight Level	Geopotential Altitude (FT)	ICAO Standard Atmosphere pressure level (hPa)	Pressure levels (hPa) referenced in Annex 3, Appendix 2
FL 50	5000	843.1	850
FL 60	6000	812.0	800
FL 80	8000	752.6	750
FL 100	10000	696.8	700
FL 140	14000	595.2	600
FL 180	18000	506.0	500
FL 210	21000	446.5	450
FL 240	24000	392.7	400
FL 270	27000	344.3	350
FL 300	30000	300.9	300
FL 320	32000	274.5	275
FL 340	34000	250.0	250
FL 360	36000	227.3	225
FL 390	39000	196.8	200
FL 410	41000	178.7	175
FL 450	45000	147.5	150
FL 480	48000	127.7	125
FL 530	53000	100.4	100

— — — — — — — —

APPENDIX H

Guidance on the revision of SIGWX discrepancy reporting procedures

Chapter 3 "FORECASTS"

….

3.7 FORECASTS OF EN-ROUTE CONDITIONS

…

3.7.3 WAFS forecasts of significant en-route weather phenomena

3.7.3.6 In order to assist WAFCs in improving their SIGWX forecasts ~~keeping their SIGWX forecasts~~ under continuous review, it is an important responsibility of aerodrome meteorological offices receiving WAFS forecasts to notify the WAFCs concerned of significant discrepancies between SIGWX forecasts and observed conditions.

There are two options for aerodrome meteorological offices to assist in WAFC SIGWX forecast production.

a) immediately prior to chart production, to assist in finalising the SIGWX forecasts through participation in a WAFS SIGWX chat room

The chat room is open half an hour prior to standard SIGWX chart issue times, and participants can view or comment on a draft version of the chart prior to it being issued. To participate in the chat room please contact wifs.admin@noaa.gov to arrange for a chat room user account.

b) by providing feedback relating to discrepancies between issued SIGWX charts and observed or reported conditions.

To report discrepancies that occur with issued SIGWX charts, the ~~The~~ notification by aerodrome meteorological offices should be based on the criteria given in Appendix 5 of this manual. Abbreviated plain language should be used in preparing the notification in accordance with the guidance material given in Appendix 5. E-mail ~~or fax messages~~ should be used for transmission of notifications of discrepancies to the relevant WAFC. The WAFC, after receiving such a notification, should acknowledge receipt and make a brief comment including, if necessary, a proposal for follow-up action.

…..

Appendix 5

NOTIFYING WAFCS OF SIGNIFICANT DISCREPANCIES

(See 3.7.3.6)

b) 1. PURPOSE OF THE REPORT

The purpose of the report is to:

a) enable the aerodrome meteorological offices to inform the WAFCs about significant discrepancies between observed conditions and ~~in~~SIGWX forecasts issued by WAFCs, in accordance with Annex 3 criteria (see Annex 3, Appendix 2, 2.2); and

b) report significant discrepancies efficiently and unambiguously.

c) 2. BENEFITS OF THE REPORT

A WAFC benefits from being informed because the report:

a) provides valuable feedback on the content of the forecasts;

b) enables forecasters to take feedback into account in future forecasts; and

c) enables formal review of the quality of WAFC output, if necessary.

d) 3. STEPS TO BE FOLLOWED BY AN AERODROME METEOROLOGICAL OFFICE

The process for notifying a WAFC of significant discrepancies is as follows:

a) WAFS SIGWX forecast is received by an aerodrome meteorological office;

b) the aerodrome meteorological office detects a significant discrepancy in accordance with the criteria for the amendment of SIGWX forecasts in Annex 3 (see Annex 3, Appendix 2, 2.2)~~, and no other differences should be reported~~;

c) the aerodrome meteorological office describes the significant discrepancy using the following rules:

1) a notification of significant discrepancy concerning a forecast should be sent within 24 hours of the validity period of the forecast if possible ~~is to be sent between six and nine hours before the commencement of the validity period of the forecast~~;

2) the notification is to be sent only to the WAFC concerned;

3) the notification is to be sent via email ~~or fax~~ using the following e-mail addresses ~~or fax numbers~~:

Centre	~~*Fax number*~~	*E-mail address*
WAFC Washington	~~+1 816 880 0652~~	wifs.admin@noaa.gov
WAFC London	~~+44 1392 885681~~	servicedesk@metoffice.gov.uk and sma@metoffice.gov.uk

Note.— Any correspondence with WAFC London to be clearly marked with the following text: “For the attention of WAFC London forecasters.”

4) the notification of significant discrepancies is to be prepared using the form in the attachment to this appendix;

5) the notification is to be written in English.

e) 4. STEPS TO BE FOLLOWED BY A WAFC

The WAFC concerned acknowledges the receipt of the notification of the significant discrepancy to the aerodrome meteorological office that originated it, together with a brief comment ~~thereon and~~ on any action taken. ~~, using the same means of communication employed by the aerodrome meteorological office.~~

…..

FORM TO BE USED FOR THE NOTIFICATION OF A SIGNIFICANT DISCREPANCY ON SIGNIFICANT WEATHER FORECASTS

f) **FORECAST INVOLVED**

Originating WAFC	
~~ICAO Area~~	
Flight Level	
Validity Time	
Validity Date	

g) DESCRIPTION OF THE SIGNIFICANT DISCREPANCY(IES)

Discrepancy Type:	Yes/No
Error in position of forecast phenomena	
Error in intensity of forecast phenomena	
Significant phenomena observed which is not present in the SIGWX forecast	
Other	

~~Error in expected position or intensity of phenomena; new expected phenomena~~

	WAFC Forecast			*~~Proposal~~ Observed phenomena*			
Phenomena Type[1]	*FL*	*Position*	*Intensity*	*FL*	*Position*	*Intensity*	*Reference*[2]
~~Turbulence~~							
~~Icing~~							
~~Cumulonimbus~~[*]							
~~Sandstorms~~							
~~Duststorms~~							
~~Volcanic activity~~							
~~Radioactive material into the atmosphere~~							

~~* Cumulonimbus clouds that are obscured, frequent, embedded or occurring at a squall line.~~

Note - [1] Hazardous phenomena as specified in Annex 3, Appendix 2, Paragraph 1.3.3.

Note -[2] *The column "Reference" is to specify, for example, the observation, aircraft report or the ~~forecast model field~~ that directed the aerodrome meteorological office to inform of a significant discrepancy. A copy of this information may be added to the form, if necessary.*

— — — — — — — —

APPENDIX I

Draft Amendment 79 to Annex 3 concerning revised eddy dissipation rate (EDR) threshold values

The following are proposed revisions to Appendix 4, 2.6.2 and 2.6.3, and Appendix 6, 4.2.6 of Annex 3:

(*Changes proposed are highlighted as* ~~deletions~~ *or* additions)

APPENDIX 4. TECHNICAL SPECIFICATIONS RELATED TO AIRCRAFT OBSERVATIONS AND REPORTS

…

2.6 Turbulence

…

2.6.2 Interpretation of the turbulence report

Turbulence shall be considered:

a) severe when the peak value ~~of the cube root~~ of EDR equals or exceeds ~~0.7~~ 0.45;

b) moderate when the peak value ~~of the cube root~~ of EDR is equal to or above ~~0.4~~ 0.20 and below ~~or equal to 0.7~~ 0.45;

c) light when the peak value ~~of the cube root~~ of EDR is above 0.10 and below ~~or equal to 0.4~~ 0.20;

d) nil when the peak value ~~of the cube root~~ of EDR is below or equal to 0.10.

Note 1.— The EDR is an aircraft-independent measure of turbulence. However, the relationship between the EDR value and the perception of turbulence is a function of aircraft type, and the mass, altitude, configuration and airspeed of the aircraft. The EDR values given above describe the severity levels for a medium-sized transport aircraft under typical en-route conditions (i.e. altitude, airspeed and weight).

Note 2.— EDR refers to the cube root of the energy or eddy dissipation rate estimated from aircraft data parameters (e.g., vertical wind velocity or aircraft vertical acceleration).

2.6.3 Special air-reports

Special air-reports on turbulence shall be made during any phase of the flight whenever the peak value ~~of the cube root~~ of EDR equals or exceeds ~~0.4~~ 0.20. The special air-report on turbulence shall be made with reference to the 1-minute period immediately preceding the observation. Both the average and peak value of turbulence shall be observed. The average and peak values shall be reported in terms of the cube root of EDR. Special air-reports shall be issued every minute until such time as the peak values ~~of the cube root~~ of EDR fall below ~~0.4~~ 0.20.

…

APPENDIX 6. TECHNICAL SPECIFICATIONS RELATED TO

SIGMET AND AIRMET INFORMATION, AERODROME WARNINGS AND WIND SHEAR WARNINGS AND ALERT

…

4.2 Criteria related to phenomena included in SIGMET and AIRMET messages and special air-reports (uplink

…

4.2.6 Turbulence shall be considered:

a) severe whenever the peak value ~~of the cube root~~ of EDR equals or exceeds ~~0.7~~ 0.45; and

b) moderate whenever the peak value ~~of the cube root~~ of EDR is equal to or above ~~0.4~~ 0.20 and below ~~or equal to~~ ~~0.7~~ 0.45.

…

— — — — — — — —

APPENDIX J

DRAFT AMENDMENT 79 TO ANNEX 3 CONCERNING AIRMET AND GAMET INFORMATION

Appendix 5

…..

4.4 Exchange and Dissemination of area forecasts for low-level flights

4.4.1 Area forecasts for low-level flights prepared in support of the issuance of AIRMET information shall be exchanged between aerodrome meteorological offices and/or meteorological watch offices responsible for the issuance of flight documentation for low-level flights in the flight information regions concerned.

4.4.2 **Recommendation -** Area forecasts for low-level flights in support of international air navigation prepared in accordance with regional air navigation agreement and in support of the issuance of AIRMET information should be transmitted to aeronautical fixed service Internet-based services.

……

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MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Headquarters, 10 to 14 September 2018

AGENDA ITEM 7

The attached constitutes the report on Agenda Item 7 and should be inserted at the appropriate place in the yellow folder.

(6 pages)

Agenda Item 7: Cost recovery guidance and governance *(Ref: Job Card METP. 011.01)*

7.1 Regarding this Agenda Item the Panel reviewed **WP/5001**, presented by Greg Brock as the METP Member nominated by WMO and Rodrigo Fajardo as the Rapporteur of the WG-MCRGG, regarding the clarification of the notion of meteorological authority. In this regard it was noted that WG-MCRGG has addressed, as part of its tasks, the 'meteorological authority' issue highlighted by Recommendation 4/2 of the ICAO Meteorology Divisional Meeting in 2014.

7.2 The Panel noted that WP/5001 included an overview of the most recent considerations of the WG-MCRGG arising from its third and fourth meetings (WG-MCRGG/3 and WG-MCRGG/4) held in July 2017 and May 2018 respectively. In this regard the Panel noted that according to outcomes of the 2016/17 CAeM global survey on aeronautical meteorological service provision, it was acknowledged that the notion of meteorological authority was not applied uniformly by States (or across regions) and that States typically apply the notion of meteorological authority in the context of the regulatory function (the arranger), the service provider function (the provider) and/or the oversight function (the overseer). It is, for example, the situation in many States that the meteorological authority has been designated to perform the regulatory function and the aeronautical meteorological service provider function, either as a combined, single entity or as two separate entities. In other States – actually in a majority (more than 70%) of States according to the responses there is a functional separation between those entities performing the regulatory function, the provision function and the oversight function.

7.3 The Panel noted information contained in the WP regarding the different SARPs in Annex 3 – *Meteorological Service for International Air Navigation* and Annex 19 – *Safety Management* related to this issue. The Panel concluded that the introduction of an amended definition for meteorological authority and a new definition for meteorological service provider could overcome much of the current ambiguity in the interpretation and implementation of the prevailing meteorological authority definition used in Annex 3, provided that it was elaborated through appropriate ICAO guidance material.

7.4 In combination with the introduction of such amended and new definitions, a review of all other existing provisions in Annex 3 would need to be undertaken to ensure that there is a clear, unambiguous determination of whether the Annex 3 provisions concern: a) the arranging of the service (i.e. meteorological authority as regulatory function) *or* b) the providing of the service (i.e. meteorological service provider as provider function). Additionally it was noted that it might be necessary to also review other Annexes.

7.5 The Panel agreed that the undertaking of such a review of Annex 3 provisions and supporting guidance will require resources that were not available for the WG-MCRGG. Moreover, the Panel acknowledged the potentially significant changes to the structure and content of Annex 3 brought about by the (re)introduction of a *Procedures for Air Navigation Services – Meteorology (PANS-MET)* in the 2022 timeframe which may (will) have a bearing on when it would be appropriate to address this meteorological authority issue. The Panel supported expert opinions expressed at WG-MCRGG/4 which were generally supportive of making changes to Annex 3 no earlier than Amendment 80 (November 2022 applicability).

7.6 The Panel reviewed **WP/5002**, presented by Rodrigo Fajardo, as the Rapporteur of WG-MCRGG, concerning an update to Job Card METP.011.01. In this regard the Panel noted that the changes to the Job Card considered necessary, were mainly related to updating the original deadlines, improvements in the Problem Statement for better comprehension and an inclusion in the Specific Details of the necessary coordination with WMO in related topics. The Panel noted the extraordinary and complex nature of the issues being dealt with by the Working Group and in this regard agreed with the proposed update and formulated the following recommendation:

Recommendation 7/1: Proposed Revision of Job Card METP.011.02

That the proposed revision of Job Card METP.011.02 *Development of cost recovery implementation, guidance and governance considerations*, as given at **Appendix A** to this report and endorsed by the Panel, be presented to the ANC for its consideration.

7.7 The Panel reviewed **WP/5101**, presented by Dennis Hart, on behalf of WG/MCRGG, concerning a “White Paper” on Future Aeronautical Meteorology Information Service Delivery. In this regard the Panel noted that the development of a white paper on Future Aeronautical Meteorology Information Service Delivery (‘white paper’) was an initiative launched to provide the Meteorology Panel (METP) and other relevant stakeholders with a set of guiding principles that the METP and its working structures will apply in developing revised or new provisions.

7.8 The Panel noted that the first iteration of a draft white paper (version September 29th) was introduced at METP/2 and that subsequently the WG/MCRGG have worked and discussed next iterations during its meetings It was noted that the white paper, as developed by the WG/MCRGG, was mature enough for wider socialization. It was noted that the white paper is aims at describing the vision rather than the specific details of how the service delivery may evolve. In this regard it was noted, for example, that WMO would consider the white paper in developing its long term planning. Additionally, the Panel noted a presentation was provided by the METP Rapporteurs and ICAO Secretariat (**IP/5201** refers) at a dedicated MET session of the Second ICAO Global Air Navigation Industry Symposium (GANIS/2 held in December 2017). Therefore the Panel formulated the following decision:

Decision 7/1: “White Paper” on Future Aeronautical Meteorology Information Service Delivery

That,

a) the “White Paper” on Future Aeronautical Meteorology Information Service Delivery (as given at **Appendix B** to this report) is endorsed by the Panel;

b) the White Paper be applied as a set of guiding principles, by the METP, in developing revised or new provisions;

c) METP experts be invited to keep the White Paper under continuous review and to inform the METP, through its WG-MCRGG, when changes or updates may be required; and

d) ICAO make the White Paper available on the METP websites to facilitate its wider socialization.

7.9 The Panel reviewed **WP/5201**, presented by Michael Berechree on behalf of Rodrigo Fajardo, as the Rapporteur of the WG-MCRGG, related to the development of cost recovery mechanisms for the provision of aeronautical meteorological information. In this regard the Panel noted that the Meteorology Divisional Meeting in 2014 (MET/14) recognized the need to review how States, national meteorological service providers, and designated charging authorities currently recover costs associated with the provision of aeronautical meteorological service. Based on the Recommendation 4/4 adopted by the MET/14 meeting, the Secretariat was directed to develop guidance through the Air Transport Bureau (ATB), and in coordination with the World Meteorological Organization (WMO), addressing equitable cost recovery practices where aeronautical meteorological service is fulfilled on a multi-regional, regional, or sub-regional basis. (Doc 10045, refers) Subsequently, Recommendation 4/4 from the MET/14 meeting resulted in the development of Job Card METP.011.01 assigned to the Meteorology Panel (METP) by the Air Navigation Commission (ANC).

7.10 It was also noted that in response to a need for improved observations and forecasts of hazardous meteorological conditions articulated by aviation users, the MET/14 adopted recommendation 2/9 calling for "implementation of a regional advisory system for select en-route hazardous meteorological conditions." This recommendation resulted in the METP being tasked by the ANC, through Job Card METP.007.01, to develop such a regional advisory system. Further discussion of the issue within the METP and refinement of the aviation users' needs resulted in a shift to focus on the provision of phenomena-based hazardous meteorological information that is not confined to FIR boundaries. Thus, the METP is leading the change in the provision of aeronautical meteorological service called for by MET/14 and affirmed by the ANC). In this regard the Panel agreed that as new meteorological services become available and legacy information is provided in a more efficient manner, it may be necessary to update the mechanisms used to recover aeronautical meteorological service costs. To address this challenge, the METP will need to work closely with both the Airport Economics Panel (AEP) and the Air Navigation Service Economics Panel (ANSEP).

7.11 The Panel then reviewed and discussed key principles and governing documentation related to cost recovery for aeronautical meteorological service in ICAO. It was noted that the existing cost recovery mechanisms were not applied globally and that, in many places, it was not possible to relate the cost assigned with the services provided. It was thus agreed to include further work in this respect in the METP work programme. Also the Panel took note of action taken in various ICAO bodies related to aeronautical meteorology and cost recovery over recent years. These included, inter alia, the Conference on the Economics of Airports and Air Navigation Services (CEANS), AEP and ANSEP joint meetings, and the Sixth Worldwide Air Transport Conference (AT/Conf/6). In this regard it was noted that as a follow-up of Recommendation 2.7/1b of the AT/Conf/6 ICAO established the Multi-disciplinary Working Work linked to the implementation of Aviation System Block Upgrades (MDWG-ASBUs). The MDWG-ASBUs was tasked to report to Council on, inter alia, the applicability of economic and operational incentives to air traffic management modernization programs, the definition of financial incentives, and how such incentives could be reflected in ICAO policies and guidance material.

7.12 Concluding the discussion the Panel agreed that the provision of aeronautical meteorological information for civil aviation is expected to undergo a transformation over the next decade. It is important that any change in how the associated costs are recovered remain consistent with ICAO's key charging principles. It was recognized that the METP is eager to move forward, but it requires the dedicated assistance of experts with the knowledge of the economics of airports, air navigation services and ICAO charging polices. Consequently, the METP would benefit from engaging with key experts from the AEP and ANSEP, to assist WG-MCRGG to identify potential new charging mechanisms to recover costs associated with the provision of aeronautical meteorological services. Therefore the Panel formulated the following recommendation:

Recommendation 7/2 – Development of Cost Recovery Mechanisms for the Provision of Aeronautical Meteorological Information

That ICAO establish, in support of Job Card METP.011.01, an Ad Hoc working group, composed of experts from METP (Rapporteur), AEP and ANSEP with the required knowledge and expertise, and in close coordination with WMO, to review deficiencies in current cost recovery systems, how services have changed, what new cost recovery challenges have arisen, and identify possible mechanisms to recover costs in equitable manner consistent with ICAO's key charging principles. The findings of this group should then be presented to the METP, AEP and ANSEP for further consideration.

7.13 The Panel noted **IP/5001**, presented by Bill Maynard based upon deliberations of the WG-MCRGG and WG-MIE, concerning data use by non-aviation users. In this regard it was noted with interest that the implementation of meteorological (MET) information into System Wide Information Management (SWIM) must encompass means to restrict access to the intended aviation and other defined users. It was also noted that the METP should work on the establishment of related policy guideline, in cooperation with the Information Management Panel (IMP).

APPENDIX A

Draft New Job Card (removed red text, grey shade and blue for new text)

METP.011.02	Development of cost-recovery implementation guidance and governance considerations
Source	MET Divisional Meeting 2014 (Recommendation 2/4, 2/7, 2/9, 4/1, 4/2 and 4/4)
Problem Statement	MET services are being provided at a range of scales (local, sub-regional, regional, multi-regional or global). When these services are provided in a sub-regional, regional, multi-regional or global context there is a lack of suitable guidance with respect to applicable cost-recovery mechanisms and insufficient governance arrangements, and definitions, to support such initiatives.
Specific Details	It was recommended by the MET Divisional Meeting that an appropriate ICAO expert group, in coordination with WMO, should develop appropriate guidance on the governance and cost recovery aspects of sub-regional, regional, multi-regional or global service provision as one of the essential governance aspects of MET service provision that need to be reviewed.
Expected Benefits	Enable MET service provision to be provided at an appropriate scale to enable greater efficency of operations and ensure that governance and associated cost recovery issues are resolved including aspects on the required core MET infrastructure.
Reference Documents	Manual on Air Navigation Services Economics (Doc 9161) Annex 3 ICAO Policies on Charges for Airports and Air Navigation Services (Doc 9082) Manual on Aeronautical MET Practice (Doc 8896)
Primary Expert Group:	Meteorology Panel (METP)

	WPE No.	Document Affected or Actions Needed	Description of Amendment proposal or Action	Supporting Expert Group	Status	Expected dates:		
						Delivery	Effective	Applicability
✓	9846	Annex 3	Enablement of local, sub-regional, regional, multi-regional or global MET service provision, including governance arrangements and definitions		~~On-schedule~~ Delayed	~~Q4 2017~~ Q4 2020	~~Jul 2018~~ Jul 2022	~~Nov 2018~~ Nov 2022

✓	1717	Manual on Air Navigation Services Economics (Doc 9161)	Improved guidance on the provision of MET services on a local, sub-regional, regional, multi-regional or global basis – including governance and cost recovery.	ICAO-ATB	~~On-schedule~~ Delayed	~~Q4 2017~~ Q4 2020	~~Nov 2018~~ Nov 2022	~~Nov 2018~~ Nov 2022
✓	9845	SWIM Manual (Doc 10039)	Develop an initial roadmap for the implementation of MET information into a SWIM environment	IMP ATMRPP	~~On-schedule~~ Delayed	~~Q4 2017~~ Q4 2020	~~Nov 2018~~ Nov 2022	~~Nov 2018~~ Nov 2022
✓	9847	Manual of Aeronautical Meteorological Practice (Doc 8896)	Improved guidance on governance and cost recovery aspects		~~On-schedule~~ Delayed	~~Q4 2017~~ Q4 2020	~~Nov 2018~~ Nov 2022	~~Nov 2018~~ Nov 2022

Status:	Priority:	Initial Issue Date:	Date Approved by ANC:	Session / Meeting:
Approved	-	17 June 2015	07 June 2017	205-4
RATIONALE				

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METEOROLOGY PANEL

Future Aeronautical Meteorological Information Service Delivery

White Paper

Developed by the ICAO Meteorology Panel

11 October 2018

The Meteorology Panel white paper presents an agreed high level understanding on how meteorological service provision will most likely evolve, relevant for the stakeholders to consider in the next steps of planning, including concept and provision development, and providing further context for stakeholders involved in implementation[1].

The white paper is therefore an important set of guiding principles that the Meteorology Panel and its working structures will apply in developing revised or new provisions.

At the same time, the purpose of the white paper is also to invite informed opinions on the high-level vision posed, and where alterations may be needed.

Given this declared purpose, the white paper does not include detailed proposed provisions nor does it include detailed implementation considerations.

1 Introduction

To enable international air navigation, Annex 3 to the Convention on International Civil Aviation 1947 (the Chicago Convention), *Meteorological Service for International Air Navigation,* contains the standards and recommended practices (SARPs) for the provision of aeronautical meteorological (MET) information services by ICAO Contracting States. Together with these core aeronautical meteorological information requirements, Annex 3 contains provisions relating to the organisation of national aeronautical meteorological 'functions'[1]. Additionally, Annex 3 contains provisions requiring select Member States to provide regional and global functions.

The ICAO *Global Air Navigation Plan* (GANP) (Doc 9750) and *the Concept for the integration of Meteorological information for Air Traffic Management* (not yet formally published) together provide guidance on how international civil aviation will evolve and what the conceptual relationship is between operational improvements identified and the aeronautical MET information required to enable this. It is important to note that the guidance provided by the GANP is not specifically designed, but where appropriate, supports discussions on how aeronautical MET functions could support the GANP objectives and the evolving air transport system in general.

Accordingly, this white paper on the *'Future Aeronautical Meteorological Information Service Delivery'* has been developed to provide the strategic view needed in addition to the GANP. It outlines the wider context of what is required by describing the most likely development scenario of how aeronautical MET information will be delivered to users in the future, based on observed trends in the business and relevant ICAO plans. It additionally considers the functions and governance required to meet GANP objectives, whilst ensuring that the change described is proportional to the user's needs and expectations, and adds value to the current system of aeronautical MET information service delivery.

The described evolution of aeronautical meteorology in this white paper is generally written from the perspective that the complete air traffic management (ATM) system will continuously evolve to meet emerging GANP objectives. The white paper follows the same logic of describing the coming 20 years and updates should be considered every time a new version of the GANP is published.

While the white paper has a basis in discussions and endorsed outcomes from the Meteorology Divisional Meeting 2014 (MET/14) goes beyond the views of that time to meet emerging GANP objectives and evolving ideas in its terms of vision and approach on how future MET service provision delivery should progress.

The Meteorology Panel (METP) white paper presents an agreed high level understanding on how MET service provision is likely to evolve, relevant for the stakeholders to consider in the next steps of planning, including concept and provision development, and providing further context for

[1] Functions in this context refer to organisational entities that are assigned to perform certain duties to provide defined MET information relevant for an associated aerodrome or airspace. This includes Aerodrome Meteorological Office, Meteorological Watch Office, etc.

stakeholders involved in implementation[2]. The white paper is therefore an important set of guiding principles that the METP and its working structures will apply in developing revised or new provisions.

At the same time, the purpose is to invite informed opinions on the high-level vision posed, and identify where alterations may be needed. Given this declared purpose, the white paper does not include detailed proposed provisions nor does it include detailed implementation considerations.

[2] Further implementation aspects based on the white paper are addressed by the METP and its working structures for consideration by the appropriate ICAO bodies. When included in revised or new provisions, the PIRGs will have a key role in the implementation of these provisions related to the MET information service delivery.

2 Evolution of International Air Navigation

For the period 2011-2030, world economic growth[3] is expected to continue at an average annual rate of 4.0% in real terms. World scheduled airline passenger traffic, measured in terms of Revenue Passenger Kilometers, is forecasted to increase at a "most likely" average annual rate of 4.6%. International and domestic traffic in 2030 are expected to be 2.6 times and 2.3 times that of 2010, respectively [*Reference: Global Air Transport Outlook to 2030 and trends to 2040 (ICAO Circular 333, 2013)]*

The period to 2030 is likely then to witness a significant growth in airline operations with an associated increase on sound aeronautical MET information to mitigate increased competition and airspace saturation logistics[4].

The GANP approach essentially responds to this growth in airline operations and related airspace issues.

Where the overall GANP objective is to globally evolve towards full four dimensional trajectory based operations, the global ATM model in 20 years from now will probably still be a hybrid of procedural control, radar control and trajectory based operations based on local, national or regionally based performance needs.

However, in 20 years local (national) airspaces and aerodromes in most of the ICAO Regions will no longer be regarded as singular and isolated components of ATM. Each will serve as a node interlinked with all other nodes within a region or even globally. This transition to a 'whole-of-network-management' approach within many regions is essential in starting to manage air traffic within a regional, and increasingly global, partnership context to enable the greater demand for flights, to reduce delays and to improve the environmental and economical sustainability of air transport in general.

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[3] Gross Domestic Product (GDP) at Purchasing Power Parity (PPP).

[4] In 2030, overall airline yields are expected to remain unchanged in real terms. However, traffic and passenger volumes will have increased markedly:

- Airlines in the Middle East, Latin America, the Caribbean, and Asia/Pacific regions are expected to experience the highest growth in passenger traffic at 7.6%, 6.1%, and 6.2 % per year, respectively. Forecasts suggest that North America will experience the slowest growth of any region, at 2.3% per year. Aircraft movements, as measured by the number of aircraft departures, are expected to grow by 3.6% per year.
- World scheduled air cargo traffic measured in terms of FTKs is forecast to increase at a "most likely" average annual rate of 5.3%. By 2030, world scheduled air cargo traffic is expected to be 2.8 times that of the 2010 figure.
- Airlines of the Middle East, Latin America and the Caribbean, and Asia/Pacific regions are expected to experience the highest growth in air cargo traffic at 7.6%, 5.7%, and 5.7% per year, respectively. Forecasts suggest that North America, Europe and Africa will experience slower growth — below 5 % per year.
- In terms of flows to, from, and within regions, the fastest growing passenger and air cargo traffic are expected to appear in South-West Asia, China, and the Middle East with an annual average growth rate of 6.9%, 6.4%, and 6.2%, respectively, for passenger traffic, and 6.1%, 6.6%, and 5.9% per cent, respectively, for air cargo traffic.
- The European region will become the largest in terms of passenger traffic with a 4.4% average annual growth rate. China will become the largest region for air cargo traffic by 2030, winning two places in the ranking compared to 2010.

[*Reference: Global Air Transport Outlook to 2030 and trends to 2040 (ICAO Circular 333, 2013)]*

A fundamental element to this increasingly 'borderless' operation is to start managing the risk and costs for all ATM stakeholders by employing fully supportive and collaborative processes that take due account of the impacts MET conditions have – both positive and negative. This is especially important since MET phenomena have no regard for national or flight information region (FIR) boundaries. This dynamic management of airspace, of flight demand and of flight operations, requires an increased focus on fully understanding the impacts of MET conditions and how to translate this impact into actionable, borderless, aeronautical MET information provision. This includes embracing the notion of managing quantified uncertainty, and maximising the quantified certainty of the MET conditions. The aeronautical MET information required, therefore needs to evolve and become a truly common, harmonized, and consistent set of information to support a common operating picture for all 'networked' (regionally or globally) operational users.

The increased complexity of ATM decision making, especially for areas around the globe that are considered complex and/or congested, and the general need to cater for more flights, or to reduce delays, promotes the use of decision support systems to manage complex information. This development has an extremely high reliance on automation and an increase in the portfolio of services provided and consumed by the various stakeholders in the system. This networked approach is enabled by the implementation of System Wide Information Management (SWIM) with the air transport system improvements increasingly designed using the principles of Service Oriented Architecture (SOA).

The SOA perspective introduces an environment where qualified parties (e.g. authorized organisations including States, private organisations and hybrids) provide information for the benefit of civil aviation information consumers. The SWIM architecture will establish interconnected registries that list the information services, the information that these services exchange and the related details, including metadata, for consuming them. Traditional consumers such as pilots, airline operations staff, air traffic controllers, flow managers, airport operations staff can make use of the information to make operational decisions. However, the advent of SWIM will allow other domains and stakeholders to make use of the information as part of the complex decision making for the issues at hand and for which, up until now, were unable to be undertaken due to the lack of time critical, easily accessible and tailored aeronautical MET information available to them.

In general, aviation stakeholders, including aeronautical MET information providers, over the coming 20 years will become more empowered to capitalize on opportunities, create new and more tailored services and increase their capabilities by becoming more agile in data mining, information construction, service delivery, systems simplification, and by lowering integration costs. This will lead to better informed and more consistent decision making.

Importantly the aeronautical MET community and, more particularly, the METP will need to exercise its newly developed abilities to clearly identify user needs as the first step in identifying what MET information, and supporting infrastructure, will meet those needs best.

3 MET Technology and Science Outlook

The role of MET as a key enabler to aviation's vision for a globally interoperable, harmonized ATM system of the future that is safer, more efficient and more environmentally responsible, will be realised through the accelerated transition of research into operations, based on aviation user needs and supported by new and improved community partnerships.

The 2017 WMO Aeronautical Meteorology Scientific Conference (AeroMetSci-2017) formulated recommendations for three key areas of science and research developments over the next 15 years in support of aviation.

3.1 Observations, forecasts, advisories and warnings

The foreseen improvements required on the observations, forecasts, advisories and warning to meet emerging user needs focus around:

a) enhanced meteorological information with global coverage for flight planning and en-route operations;
b) enhanced 4-dimensional information for meteorological hazards of any type, and;
c) enhanced high-resolution 4-dimensional meteorological information for airport and terminal area operations.

Specific research areas under consideration include:

1. Ice crystal icing and airframe icing;
2. Turbulence; Significant convection;
3. Detection and prediction of low-level wind shear and wake vortex;
4. Low visibility including fog;
5. Space weather;
6. Atmospheric aerosols and volcanic ash;
7. Advances in observing methods and use of observations;
8. Seamless nowcast and numerical weather prediction, and
9. probabilistic forecast and statistical methods.

For these developments to contribute to a safer and more efficient air transportation system, further research is required on:

1. Improved access to data, especially aircraft-based observations, to support validation, verification and calibration of MET research;
2. How to accelerate and communicate the transition from research to operations following validation;
3. Conveying 'uncertainty' to inform risk management, which remains a challenge that needs further research and guidance, and;
4. The understanding of how sensitive air transport decision-making is to MET (hazards).

3.2 Integration, use cases, fitness for purpose and service delivery

Closely related to the prospect of having improved observations, forecasts, advisories and warnings available is the issue of integrating this meteorological information into the globally interoperable air traffic management (ATM) system.

System-wide information management (SWIM) based MET information exchange is a prerequisite to ensure that enhanced situational awareness is obtained. Decision-making support for strategic, pre-tactical and tactical ATM decisions can be provided, and concepts such as collaborative decision-making (CDM) and trajectory-based operations (TBO) can be supported.

Specific research under consideration, related to supporting the operational stakeholders on the integration of MET information,:

- in-cockpit and on-board MET capabilities,
- terminal area and impact-based forecast,
- en-route hazards information systems,
- translation of MET information for impact and risk assessment,
- collaborative decision-making (CDM),
- air traffic flow management (ATFM) and network management,
- trajectory-based operations (TBO),
- flight planning and user-preferred routing,; and
- use of MET information for climate-optimized trajectories.

For these development to contribute even more to a safe and efficient air transportation system, further research is required on:

1. How to establish improved, closer collaboration within and across MET and ATM communities;
2. Blending of MET parameters through ensemble approaches that yield a higher quality, more usable forecast should be further pursued but with an acknowledgement of the potential masking of extremes. In addition, probabilistic methodologies with proper verification and calibration should be applied to better convey to users where and to what extent inherent forecast uncertainties exist;
3. Machine-learning to optimize MET support to ATM;
4. Emerging standardisation needs for systems that deliver harmonized MET information to pilots and other stakeholders, and;
5. Emerging training or education needs for end-users when an increasingly automated ATM operating environment will become the norm.

3.3 Impacts of climate change and variability on aviation

Besides the daily operational considerations related to weather, the improvements required to the information and how this information can be integrated; there are also considerations with respect to climate change and its impact on aviation, and potentially changing needs for operational MET information.

Specific research under consideration, to address these aspects including generic aspects of the variability of earth's atmosphere are related to:

- building awareness of expected climate change impacts such as changes in jet stream position and intensity and related phenomena, including CAT,
- changing extreme weather events and airport impacts,
- changes to the frequency and intensity of typical scenarios (storm surges, heat waves, visibility regimes, etc.),
- re-evaluation of airframe/avionics resilience standards and certification; and
- focus on the downscaling of aviation impacts to regional and local scale.

Additional research considerations to support this are:

1. The potential impacts of climate change and variability on aviation operations on the ground and in the air, downscaled to the local level, must be well communicated;
2. The mitigation of extreme weather events and the adaptation to a changing climate demands a multidisciplinary effort involving both the physical and the social sciences;
3. Responding to climate variability will require a high degree of flexibility on the aviation users' side. While the incidences of high-impact extreme weather events are expected to increase, they will be infrequent relative to the norm. The foreseen continued growth of aviation worldwide in a changing climate scenario may present new challenges as demand for airspace capacity increases;
4. Improved availability of and access to high-quality in-situ observations of meteorological parameters, including water vapour, is a key enabler to improving climate prediction model capabilities. The preservation of such data is essential for validating and calibrating climate predictions;
5. A changing climate scenario may render some of today's aerodrome, airspace and airframe design and operation standards inadequate in the years or decades to come. Using past climatological records alone as an indicator of future climate at an airport, say, may be insufficient given the (current) rate at which the world's climate is changing (warming).

4 Today's Challenges and Opportunities

4.1 Challenges

The ATM needs set out in the GANP are one aspect in considering the evolution of aeronautical MET information service delivery. Various other perspectives, such as existing limitations with service delivery provide further justification to significantly evolve the current aeronautical MET information system.

Initiatives to overcome some of these limitations are planned but require further work and coordination to meet the final objectives. This white paper puts these developments in the wider context and identifies other challenges where a fundamental change is required. The key challenges are:

1. *Aeronautical MET information is not universally available*. For infrastructure or staff capacity reasons, some States are not in a position to meet their existing Annex 3 obligations.
2. *Aeronautical MET information not universally cost recovered by all States or not transparently cost recovered.* Where costs are recovered, there is often inadequate transparency and often these recovered costs from the user are not factored back to aeronautical meteorological provider or sometimes considered not to be appropriate to ensure a fair and equitable management and financing.
3. *Governance not always in place.* A consistent management, cohesive policies, guidance, processes and decision rights of stakeholders involved for aeronautical MET information service provision is not always in place.
4. *Aeronautical MET information may not always be provided in the most cost efficient manner.* The aeronautical MET infrastructure and service provision architecture is essentially designed around a model dating back to the 1950's which has evolved slowly. A complete re-design of the architecture appreciating the existing capabilities, the current and foreseen state-of-the-science that could provide services more cost effectively and efficiently.
5. *ATM user requirement and state of aeronautical MET capabilities or aeronautical MET science often incompatible.* For a variety of reasons, the ATM user need and the existing or foreseen aeronautical MET capabilities are not compatible. In most cases, this is related to the desire of the user community to have a precise description of the state of the atmosphere without uncertainty, instead of information with indicated objective levels of uncertainty that can directly support risk management decision making processes.[5]
6. *Aeronautical MET information generally not expressed in objective and quantitative terms, or in a machine-readable format, that would support automated decision support aids.* Controllers, operators and pilots will increasingly rely upon automated decision support tools into which quantified meteorological information must be automatically integrated.

[5] Meteorological forecast information is not absolutely certain. It is better viewed as information useful for reducing uncertainty. The concept needs work with various user communities to be further matured, creating an environment where information on aeronautical meteorological conditions with the associated uncertainty can contribute to the goals of safety and efficiency. In this regard, users' requirements that exceed scientific and technological capabilities by a significant margin may require expectation management

4.2 Opportunities

Many opportunities already exist or will emerge over the coming 20 years. From a MET perspective, this includes important changes in observations, including satellite remote sensing of Earth, in-situ airborne measurements, and automated ground/surface-based observations as indicated in chapter 3. The quality of analyses and forecasts are constrained by current, sparse (in many parts of the globe) surface based observations and this will be greatly enhanced by both satellite and airborne automated observations. Data from these platforms will have a greater spatial and temporal resolution updated more frequently and will fill the gaps over oceans and in data sparse continental areas. These improvements are important to the more globalized service provision envisioned in this paper. It is however worthwhile to note that uncertainty exists as to whether remote sensing will be able to adequately provide near-surface parameters where currently such parameters are missing.

The needs for more useful forecasts and analyses enabled by enhanced observations, improved Numerical Weather Prediction Models and data analysis techniques, faster computers and data communication, and almost unlimited possibilities with respect to data storage and data mining. Along with consistency of information across FIR boundaries, reduced cost of producing and disseminating the enhanced information, and integration of MET into decision support systems with operational information, are the main drivers for the global MET infrastructure presented in this paper. Appropriate business models and equitable cost recovery arrangements to foster implementation of these aspirations are however essential.

5 Evolution of Service Delivery

5.1 Objectives

To better exploit underpinning science and technology advances, addressing existing challenges, and to support the evolving global ATM system towards full 4-dimensional trajectory based operations, performance based planning and the supplementary needs of international airspace users, a number of significant changes to the aeronautical MET information services in support of international air navigation are identified. These changes need to be implemented within the next 20 years.

The main two themes for change are:

1. Improve the availability and quality of aeronautical MET information being provided in regions of the world where there are currently insufficient resources (mainly lack of infrastructure and staff) that have led to gaps in aeronautical MET service provision, and;
2. Provide all, existing and newly required, aeronautical MET information in a cost efficient, consistent, and globally harmonized manner that meets user needs for integration into risk management and operational decision-making systems.

5.2 Service Delivery in twenty years from now

The future aeronautical MET information service delivery model in twenty years from now is envisioned to reflect the significant changes to the roles, responsibilities, and functions of aeronautical MET service providers, globally, regionally and locally, including the creation of new functions to provide the required aeronautical MET information.

At the heart of the changes to be implemented is the notion of *phenomenon-based service provision*, sometimes referred to as the borderless service provision concept.

5.2.1 Phenomenon-based service provision (PBSP)

The Chicago Convention, from its onset, enabled international air navigation and operations while respecting States complete and exclusive sovereignty over airspace above their territory (Article 1 of the Chicago Convention). This resulted in a well-organized system of providing Air Traffic Services (ATS) and aeronautical MET Services on a State-by-State basis. However, only fifteen years after the Chicago Convention came into effect, it was recognized that State by State provision of services to support international air navigation was not always the most effective or efficient methodology. As a result, various initiatives with respect to multi-State ATS and flow management provisions commenced in the early 1960's .

Similar developments were observed in aeronautical MET information provision in support of international air navigation. Most notable was the implementation of the World Area Forecast System and its Centres (WAFCs) from the mid-1980s to the mid-2000s as the single function providing global aeronautical MET en-route forecasts for flight planning purposes. Responsive developments also included the establishment of regional advisory functions such as the Tropical Cyclone Advisory Centres (TCACs) and the Volcanic Ash Advisory Centres (VAACs).

The establishment of these global ICAO systems was an effective and efficient contribution to the improved safety and efficiency of flight. Importantly, it should be recognized that these improvements in service provision still reflected a strong 'geographically-based' approach (ICAO Region(s) or a grouping of States and/or respective FIRs) in defining the respective areas of responsibility.

The significant difference between today and the envisaged situation 20 years from now, is that all of these functions develop into a unified *global system* that is in a position to provide services directly to the end-user communities. This direct servicing is not the ICAO-norm today. At present, only the WAFS products can be used directly by end-users. Other functions such as VAAC and TCAC were set in place primarily to serve MET Watch Offices in support of their SIGMET provision responsibilities. Notably however, end-users increasingly take their guidance products directly from the VAAC and TCAC advisory products as they are regionally based, are more convenient to use and are recognized by national authorities for use by airlines; recognising that this practice is beyond the scope of the current Annex 3 provisions.

From an aeronautical MET service provider capability perspective, it is observed that for decades, only a limited number of providers had the required technical and information capabilities at their disposal to meet the majority of global air transport development needs for global or regional aeronautical MET functions. From 2010 onwards, additional providers gained the ability to provide regional or global aeronautical MET information with the required quality of service, which was in the past only possible locally. It should be understood that the term “provider” in this context is notional and does not exclude the concept of a “consortium of providers” designated to perform the appropriate function; as such, the notion is more reflecting the authoritativeness rather than physically being one provider. This change will have significant ramifications on how the aeronautical MET information services delivery framework will evolve over the next 20 years, which is discussed in the following paragraphs.

One of the biggest conceptual evolutionary steps in service provision introduced as follow-up to the MET/14 Recommendation 2/9 (endorsed by ICAO Air Navigation Commission (ANC) and approved by Council late 2014), was the call for a move towards phenomena-based service provision of aeronautical MET information when and wherever possible[6]

This concept of phenomenon-based service provision hinges on four considerations:

1. the four dimensions of the MET phenomena;

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[6] Recommendation 2/9 — Implementation of a regional advisory system for select en-route hazardous meteorological conditions.
That an appropriate ICAO expert group, in close coordination with WMO, be tasked to:
a) expeditiously develop provisions supporting the implementation of a phenomenon-based regional advisory system for select en-route hazardous meteorological conditions consistent with the
evolving Global Air Navigation Plan (GANP) (Doc 9750), in considering users’ long-standing requirements, especially in those States where notable SIGMET-related deficiencies persist using, as appropriate, the strategic, governance and cost recovery assessments provided in Appendices D and E;
b) integrate the information produced by the referred system into the future system-wide information management environment underpinning the future globally interoperable air traffic management system; and
c) develop appropriate guidance material to support the selection criteria of regional hazardous weather advisory centres taking account of cost-effectiveness, the processes for the preparation and dissemination of the advisory information, mutual cooperation, sustainability of the existing meteorological infrastructure and use of local expertise.

2. the required quality of services (QoS) for the associated information that needs to be provided around these phenomena;
3. the required aeronautical MET capabilities including the state of the science to provide this information; and
4. satisfactory arrangements are in place for governance and cost recovery.

Developments around all four aspects will result in the introduction, from 2020 onwards, of the first elements of the phenomenon based service provision concept that will need to reach its completion by 2030.

As indicated, significant progress is expected soon on the phenomenon-based service provision concept for a number of hazardous MET phenomena, with regionally produced advisories becoming available as a transitional phase to global provision.

However, it will take until at least 2020 before provisions and guidance can be amended to remove selected phenomena from the criteria to issue a SIGMET for each FIR, and entrusting this wider responsibility to regionalized ICAO systems. In parallel, new provisions will need to be introduced to support the *borderless service provision* approach that enables all stakeholders to use information issued by a regional or global function, as authoritative for all associated decision making.

Note.— Select hazardous meteorological conditions in this context includes, as a minimum, thunderstorms, icing, turbulence and mountain waves, but excludes volcanic ash and tropical cyclones.

5.2.2 Core MET service provision versus Aviation MET provision

The principal concept to evolve towards a phenomena-based system, and thus a more harmonized and standardized approach for the provision of aeronautical MET information services required by international air navigation, is a far-reaching proposal. As such, raising a number of issues regarding the future role and funding of the currently designated aeronautical MET service providers, including those that are a National MET Service.

Implementing a borderless, phenomena-based approach will require additional thought as to how aeronautical MET information service provision should be considered. This relates more to how States could structure and finance their core MET facilities and services[7] in support of aeronautical meteorology for international air navigation than to the science and capabilities required to provide such services in a more centralized manner.

From 2020, it is expected that ICAO and the World Meteorological Organization (WMO) will have developed guiding principles acknowledging that an equitable cost associated with the core MET facilities and services of a State could be recovered from civil aviation even if a State is not providing

[7] 'Core MET facilities and services' are described in the Manual on Air Navigation Services Economics (Doc 9161); where it is indicated that usually meteorological services engage in general meteorological activities, i.e. core activities, in fulfilment of a primary system requirement for meteorological information which is jointly used by all service recipients. Examples of core activities include general analysis and forecasting, automated data processing, weather radar and satellite data processing, surface and upper-air observations, telecommunications to collect and exchange basic data, training, research and development (Doc 9161 (5th edition, 2013) §5.70 and 5.115, and Appendix 2).

MET services to international air navigation directly. This should for example ensure that the provision of real-time non-aviation-specific observational data to support global or regional aeronautical MET information provision could be cost recovered when the attribution of this cost is legitimate and equitable.

This will initially require the development by WMO of detailed requirements for each State, in terms of MET observing information, as well as the core facilities required, to deliver observations to the regional and global (hazardous) weather centres.

It should be noted that many of the least developed States require substantial investments to satisfy these requirements and consequently may not be able to provide all the data needed. As a consequence, a capacity-building programme or another approach to obtaining the data will still be required to improve the availability and quality of core MET information provided to support the MET information provision to aviation directly or indirectly.

5.2.3 Non-Annex 3 User Requirements

Currently, a clear differentiation exists between MET information and service provision that is provided on the basis of Annex 3 requirements and MET information services that are provided to users based on arrangements that sit outside the ICAO context.

It is expected that for the next 20 years, this separation between information that is required to ensure safe, efficient and timely international air navigation, and information that is seen by an individual stakeholder or group of stakeholders to bring them specific benefits, will not change.

Debate is however expected to continue as to what extent augmented or new information services used by a stakeholder or group of stakeholders, for their specific benefit, becomes relevant for a larger community and de facto becomes a requirement for safe, efficient and timely international air navigation. Thus evolving into a service that may need to be covered by Annex 3 provisions. This will become more relevant progressing towards performance-based requirements; recognising that some needs are local, regional or for a specific sub-set of stakeholders.

Accepting that for the foreseeable future, MET information services will exist based on Annex 3 provisions and based on other arrangements, the overall context how aviation MET providers will generate revenue will continuously evolve.

5.2.4 MET Provider Revenue and Selection Principles

Independent of the type of information service, either in the scope of Annex 3 or outside, the way providers of this information should recover their (full[8]) costs is subject to many different approaches. The traditional approach is based on applying transparent cost recovery principles based on the Manual on *Air Navigation Services Economics*. (Doc 9161) by the provider or State that designated the provider to provide Annex 3 based services.

[8] Cost allocation of MET is subject to a State's decision either to be financed partially or completely by its public budget. In the latter case, MET could be available for free. See Manual on Air Navigation Services Economics §5.72 (Doc 9161).

For the coming two decades, a significant factor for consideration is the increased application of market principles[9] to aeronautical MET service provision. Today, consumers and providers exchange aeronautical MET information that is usually considered outside the scope of ICAO Annex 3 prescribed services on this basis. For example, airlines obtain services from MET service providers that apply market principles, sometimes residing within a National Meteorological Service that is also the designated provider for Annex 3 related services, in support of their demanding operations.

Increasingly, States will need to progressively move toward market principles between the State and a provider to recover costs. This will provide opportunities for other than traditional providers to provide for MET information services, even within an Annex 3 context, with the objective of delivering the best and most (cost-) efficient service for the stakeholders.

Also, in the context of adopting new technologies and means of delivering information to the stakeholder, the likelihood that providers of these services and underpinning capabilities will need to deliver these services in a market context is very high. An example of this relates to the data link provision of MET information to the flight deck. States will most likely rely on market principles based services that are developing rapidly across the globe rather than develop a State-based data link service.

Any evolution of aeronautical MET service provision for the decades to come therefore needs to consider the various models[10] of operational governance of the newly foreseen functions, including the management of the global initiatives and the funding of those initiatives that could be applied including an aeronautical MET information marketplace.

5.3 Aeronautical Meteorology Information Delivery Framework

It is expected that within the coming 20 years, a seamless global ICAO aeronautical MET information service delivery framework will be developed focusing around 3 main elements, together creating a system that provides seamless and borderless aeronautical MET information services for international air navigation:

- Global Aeronautical MET Information Centres (GMC) and supporting Specialized Forecast Centres (SFC);
- Aerodrome Forecast Centres (AFC); and
- Aerodrome MET Stations (AMS).

5.3.1 Global Aeronautical MET Information Centres (GMC)

5.3.1.1 General

The framework to deliver seamless global aeronautical MET information is made up of a network of Global Aeronautical MET Information Centres (GMC), each specialising in forecasting specific

[9] The notion Market Principles in the white paper is used to indicate some basic principles, such as preventing unfair advantage from one provider over the other and applying low barriers for newcomers. This should not be confused with delivering a service for a profit (commercial).

[10] These consideration could include models around Public Private Partnerships (PPP), cooperative arrangement between two or more public and private sectors that share risks and develop innovative, long-term relationships between these sectors to deliver a service.

phenomena (all of which have formalized and tested backup arrangements in place). By 2024, these GMCs work closely together to provide a fully harmonized set of services to an agreed QoS standard that enable users to use information from different centres seamlessly. From a user perspective, there is no differentiation as to what State or GMC is providing the product.

Differing from the historical segmented approach, except for WAFS, the network of GMC is a unified system providing services with global coverage.

Depending on the evolving requirements, the end-state of the network of GMC could be a single global duty centre at any one time, with both hot and cold back-up centres that may or may not be co-located.

The GMC aeronautical MET information services are authoritative and can therefore be used directly by users for decision-making. This enables a common global reference, maintaining a level of consistency between operators and other aviation actors with respect to the information they use and base their decision on.

5.3.1.2 Information Service Scope

The GMC provides all of the aeronautical MET Information that the existing WAFS system currently provides but in higher resolution. The GMC will also provide all of the information previously provided by the VAACs and the TCACs. It should be noted that the function of the TCAC is closely related with the established WMO Tropical Cyclone Warning Centres and the evolution of TCAC in this context should be coordinated with WMO.

The provided information services by GMC will be finely tuned to the demands of full four dimensional trajectory based operations and other international aviation factors.

5.3.1.3 Transitional considerations

The currently existing ICAO system distinguishes various specialized capabilities, in this white paper referred to as Specialized Forecast Centres (SFC), that provide clearly scoped MET information services. These are:

1. Specialized *Volcanic Ash Advisory Centres* – VAACs. The International Airways Volcano Watch (IAVW) system, comprises nine VAACs, has been successful over its 30-year life. As a result, multi-disciplinary knowledge about the characteristics of volcanic ash and gas transport is now well developed. These capacities and capabilities are now integral parts of overall meteorological understanding.
2. *Tropical Cyclone Advisory Centres* –TCACs. The meteorology around tropical cyclone development, movement and decay has been intrinsic to the field of meteorology for many decades and capabilities and capacity to work in the area is now relatively common.
3. *Space Weather Centres* – SWCs (from November 2018). These centres will be formalized before 2020 and comprise capabilities and capacities outside that of the traditional aeronautical MET field of expertise and technology. These centres are likely to remain operating as Specialized Centres allocated as defined in ICAO documents for the foreseeable future.

In addition to the existing SFC, the temporarily creation of so-called Specialized Regional Forecast Centres (SRFCs) supporting the GMC is envisaged for those phenomena or activities where the global consensus is that this cannot yet be covered by a global capability. These centres could therefore be implemented as a transitional phase toward the full global coverage of the GMC and providing regional aeronautical MET Information on significant phenomena.

It is expected that in 20 years from now all SRFCs, VAACs, TCACs will transit into the network of GMC. The SWCs however, due to their specific nature (relatively decoupled from aeronautical MET) will be the only remaining type of SRFC.

5.3.2 Governance of Global Initiatives

With the establishment of the GMC a new phase of global-service-provision-governance will be introduced. Therefore, a different approach should be introduced to the traditional selection and governance of regional or global functions compared to that covering the 1990s era of establishing WAFCs, VAACs, and TCACs.

The traditional governance regime was based on the understanding that only a select number of States were in a position to provide regional or global functions based on the aeronautical MET capabilities required and available. Given this context, these States were requested by ICAO to provide these services and were governed by a group of experts reporting to the Air Navigation Bureau and from 2015 onwards by experts in the METP reporting to the Air Navigation Commission. In the future it is expected that States providing a GMC will have to demonstrate compliance with exacting QoS requirements not only for forecast accuracy but to resilience and commitments to ongoing service development as set out in the Global Air Navigation Plan.

Alongside the work undertaken by ICAO and the METP to continue the development and optimisation of global aeronautical MET information provision, the formal operational governance of the newly foreseen functions, including the management of the global initiatives and the funding of those initiatives, needs to be considered. The principles for such a Global Aeronautical Meteorology Operations governance framework should be established in Annex 3 and detailed in the Working Arrangements between ICAO and WMO (Doc. 7475).

This governance framework should consider the selection, removal, and management of the selected provider(s) of GMC and the remaining SFCs, including the financing. Preliminary arrangements should be in place from 2022 onwards to support the end state of GMC and SFC.

5.3.3 Aerodrome Forecast Centres (AFC)

5.3.3.1 General

The responsibilities of the traditional Aerodrome MET Offices (AMO), as known in 2018, have increased through the introduction of the GANP to include a greater area than the defined aerodrome (16km radius from centre point).

This work is now undertaken by the AFCs that have evolved from the old AMOs. They have an extended responsibility to provide forecast information for the terminal movement areas (TMA).

These TMA differ in size between respective aerodromes, the nature of operations using the aerodrome, and reflect the extended requirements of full 4-dimensional trajectory based operations.

5.3.3.2 Information Service Scope

The responsibility for providing TMA and extended TMA aeronautical MET information and warnings remains a core responsibility of States alongside their real-time observing obligations. It is accomplished through the work of the AFCs.

From 2020, ICAO will increasingly encourage States to centralize their aeronautical MET functions to produce the required TMA aeronautical MET information in order to achieve greater efficiencies. In 2030, it will be usual to find States with a single centralised AFC, while some larger States maintain several AFC sites for logistical reasons. The AFCs will often be located away from the aerodromes they are responsible for.

Where there are overlapping or proximate TMA locations, States should ensure that the TMA aeronautical MET information they provide is harmonized with neighbouring TMAs regardless of whether that TMA lies within a neighbouring State.

Importantly, States should ensure that the TMA aeronautical MET Information produced by AFCs is harmonized with the GMC (and SRFC) provided aeronautical MET Information – hence a completely aligned spatial and temporal MET picture of the atmosphere is achieved.

The AFC information will be provided in IWXXM compliant formats and used directly by users to build a real-time dynamic 3D MET picture of the forecast TMA picture, to contrast with the real-time picture assembled from AMS information (see below).

5.3.3.3 Governance

Responsibility and governance of AFCs operations along with the supporting real-time observational network, both at aerodromes and at supporting locations, remains the responsibility of the State as defined in Annex 3. However, in 2030 it will be common for smaller States to have a joint approach to both AFC and AMO obligations, within a single shared management and funding system.

5.3.4 Aeronautical MET Stations

5.3.4.1 General

The traditional Aerodrome MET Station (AMS) concept continues in 2030 but has been modernized in application.

5.3.4.2 Scope

Almost exclusively real-time aeronautical MET observational information from aerodromes and their TMA surroundings are provided by automatic systems. These systems now have integrated abilities to sense MET parameters at a distance (cloud height and location, slant range visibility on the extended centre line, background turbidity, vertical wind profiles, etc.). The information will be provided in IWXXM compliant formats and is used directly by users to build a real-time dynamic 3D MET picture of the TMA to contrast with the forecast picture.

5.3.4.3 Governance

Refer 5.3.3.3 above.

5.4 System Wide Information management - SWIM

The definition, scope, purpose and operation of SWIM is provided in the Manual on System Wide Information Management (SWIM) Concept (ICAO Doc 10039). SWIM will be well established over the next 20 years, providing vastly improved aeronautical MET information distribution and accessibility. It will address the challenge of creating an “interoperability environment” allowing the SWIM IT systems to cope with the full complexity of operational ATM information exchanges including that of aeronautical MET Information.

The advent of SWIM has and will continue to be seen in an increased number of providers and consumers of aeronautical MET information. These stakeholders can easily access a wide range of global information, including all aeronautical observational information from around the globe. The information will be in standardised digital formats, which will lead to it being easily ingested into aviation systems. With the implementation of SOA, the consequential agile and fast-paced software development environment will further highlight the value aeronautical MET information has, enabled by SWIM. It will further support initiatives of major global airlines with a need to have aeronautical MET information tailored to their own operation through their own aeronautical MET department or partner.

Access to SWIM, for providers and consumers, will be subject of ICAO governance principles. This governance ensures that the quality of the information and the service will be known and the use of the information is within a well-defined set of authorized users.

SWIM based information exchange will replace all of the traditional regional and global ICAO MET information exchange systems, such as OPMET data base systems, SADIS (WIFS). The structures around the traditional OPMET Databanks will however be transformed into the aeronautical MET-specific regional contribution to SWIM governance.

6 ICAO-WMO Cooperation

ICAO and the World Meteorological Organization have long-standing working arrangements[11] designed to record the understanding reached between the two organizations to delineate their respective sphere of activities in the field of aeronautical meteorology, to provide machinery for their collaboration when necessary and to give guidance for the conduct of meetings of representative bodies and the Secretariats of the two organisations.

An evolving MET information service delivery context could lead to a revised understanding of the various roles and responsibilities in the aeronautical MET domain between WMO and ICAO, to meet the end-user expectation of receiving authorized fit-for-purpose aeronautical MET information.

The separation of concern between ICAO and WMO[12] reflected in updated working arrangements should lead, for instance, to a similar approach adopted between ICAO and standardisation organisations. Consequently, specifications external to ICAO (in this case developed and maintained by WMO) are simply referenced in the ICAO provisions. The standardisation organisation itself however refrains from replicating the requirements for such a specification in their formal documentation that then becomes subject of their approval process. This approach completely removes the need to duplicate provisions in formal documentation by the two organizations, as is currently the norm.

[11] The working arrangements are not falling within the category of formal interagency agreements referred to in Article XVII of the Agreement between the United Nations and ICAO, or Article XIV of the Agreement between the United Nations and WMO.

[12] In the context of the white paper, an ICAO originated document, the roles and responsibilities of WMO and its Members should be understood in the context of four key capabilities WMO as an organisation and through its Members provides:

1) Centre of Expertise; providing the required expertise and capabilities to enable aeronautical MET service provider to deliver their services, primarily focusing on Least Developed Countries (LDCs);

2) Standardisation Organisation; acting as a standardisation organisation for all issues related to meteorology including aeronautical meteorology;

3) Core Infrastructure Provider; managing and enabling the WMO Members to operate and evolve their core, and a collective, MET infrastructure in support of aeronautical meteorology, and;

4) Aeronautical MET Function Provider; managing and enabling these WMO Members that operate an ICAO Aeronautical Meteorology Function.

7 Constraints

As indicated early in the document, the described future aeronautical MET information service delivery is only possible when two significant constraints are addressed. These constraints are:

- Aeronautical MET Capabilities not available;
  The evolution towards GMC and SFC, and supporting AFC and AMS, requires aeronautical MET capabilities that are assumed to become gradually available. This firstly requires the availability of funding to implement these capabilities or to develop capabilities. In the likelihood of shortfalls in required capabilities, the transition from the intermediate SFCs to GMC could be delayed.
- Political and institutional barriers;
  The evolution towards GMC and SFC, and supporting AFC and AMS, require States to accept that roles and responsibilities that were traditionally with the individual State, could be delegated in a controlled manner to other States or organisations. It also includes the basic principle that information produced outside the State concerned, for instance by the GMC, is as authoritative and essentially fit-for-purpose as information that was traditionally produced within the State territory.

8 Summary

The METP white paper presents a high-level understanding on how meteorological service provision is most likely to evolve over the next two decades. It provides indications and directions that support further work in moving towards a more detailed implementation planning, including concept development.

These indications and directions are an important set of guiding principles for the METP to consider when sketching its work programme, based on the objectives laid down by the ANC, for developing revised or new provisions related to MET service provision.

METP/4
14/9/18

MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Headquarters, 10 to 14 September 2018

AGENDA ITEM 8

The attached constitutes the report on Agenda Item 8 and should be inserted at the appropriate place in the yellow folder.

(5 pages)

Agenda Item 8: Annex 3 amendment proposals from other sources

8.1 The Panel reviewed **WP/6101,** presented by Greg Brock as the WMO-nominated member of the METP, concerning the need to review references to quality management system guidance material. In this regard the Panel noted that the paper referred to the discontinuation of ICAO Doc 9873/WMO-No. 1001, *Manual on/Guide to the Quality Management System for the Provision of Meteorological Service for International Air Navigation* and their replacement by WMO-No. 1100, *Guide to the Implementation of Quality Management Systems for National Meteorological and Hydrological Services and other Relevant Service Providers*. In addition, the paper referred to associated consequential implications on ICAO Annex 3 provisions**.**

8.2 With regard to the first issue, the Panel noted all the background information, including updates, since the first edition of ICAO Doc 9873 and WMO-No. 1001, as a joint ICAO-WMO publication, were approved by the Secretaries General of both organizations and published under their authority.

8.3 The Panel noted that while ICAO Doc 9873/WMO-No. 1001 was originally developed to support the introduction/implementation of quality management systems for aeronautical meteorological services – initially as a recommended practice and later as a Standard under ICAO Annex 3 provisions – the bulk of its content was not specific to aeronautical meteorology. Rather, the manual/guide set forth the concepts and anatomy of the ISO QMS standard in a general/generic sense. Additionally, ICAO Doc 9873/WMO-No 1001 had not been updated to accommodate the introduction of the ISO 9001:2015 QMS standard. In this regard the Panel noted that, recognizing these latter issues, WMO has developed and published a major update to WMO-No. 1100, *Guide to the Implementation of Quality Management Systems for National Meteorological and Hydrological Services and other Relevant Service Providers*.

8.4 In view of the foregoing, the Panel acknowledged the WMO position that WMO-No.1001 was now considered obsolete and should therefore discontinued (Decision 5 of the sixteenth session of the WMO Commission for Aeronautical Meteorology (CAeM-16) refers). The discontinuation of WMO No-1001 would result in the accompanying discontinuation of ICAO Doc 9873. In their place, any and all references to WMO-No. 1001 and ICAO Doc 9873 should be replaced by reference to WMO-No. 1100 unless for historical context. It was also agreed that there was a need to amend ICAO Annex 3, Chapter 2, paragraph 2.2.3. Concluding the discussion the Panel formulated the following decision and recommendation:

Decision 8/1: Quality management system guidance material

That, in view of the 2017 publication of WMO-No 1100, *Guide to the Implementation of Quality Management Systems for National Meteorological and Hydrological Services and other Relevant Service Providers*, ICAO Doc 9873 *Manual on the Quality Management System for the Provision of Meteorological Service for International Air Navigation* should be discontinued and any and all references to ICAO 9873 should be replaced by WMO-No. 1100 unless for historical context.

Note. — ICAO Doc 9873/WMO-No 1001 is a joint ICAO-WMO publication. In view of the scope and availability of WMO-No 1100, Decision 5 of CAeM-16 (24 to 27 July 2018) decided that WMO-No. 1001 should be discontinued.

RSPP

Recommendation 8/1: Draft Amendment 79 to Annex 3 concerning references to quality management system guidance material

That, the proposal to amend Annex 3 – *Meteorological Service for International Air Navigation* concerning the note to Annex 3, Chapter 2, paragraph 2.2.3 as given at **Appendix A** to this report, be included in Amendment 79 to Annex 3 with intended applicability in November 2020.

8.5 The Panel reviewed **WP/6201**, presented by Sue O'Rourke, concerning a proposal for amendment to Annex 3 regarding the special air reports. In this regard it was noted that the format and content of Special Air-reports (AIREP) differs between ICAO Annex 3 – *Meteorological Service for International Air Navigation* (and subsequently Doc 8896 – *Manual of Aeronautical Meteorological Practice*) and Doc 4444 – *Procedures for Air Navigation Services – Air Traffic Management*. This situation presents challenges for operational units, specifically with respect to the processing and onward dissemination of the Special Air-report information.

8.6 The Panel decided also to note the related **IP/6205**, presented by Yuliya Naryshkina, concerning a proposal to update Annex 3 – *Meteorological Service for International Air Navigation* to improve AIREPs provision based on practical experience of the Russian Federation. In this regard the panel noted that it would be useful to make a change in Annex 3 to allow the reporting of heavy dust storms (HVY DS). Therefore the Panel agreed with the suggested change and formulated the following recommendation

RSPP

Recommendation 8/2: Draft Amendment 79 to Annex 3 concerning the inclusion of heavy dust storms in special air reports

That, the proposal to amend Annex 3 – *Meteorological Service for International Air Navigation* concerning the inclusion of heavy dust storms (HVY DS) in special air reports in Table A6-1B and Table A4-1, as given at **Appendix B** to this report be included in Amendment 79 to Annex 3 with intended applicability in November 2020.

8.7 With regard of both papers the Panel agreed that a review of AIREP provisions is needed to ensure consistency and utility of AIREP information. Additionally, the paper raised the following points:

a) Whether there is a need to have two points for element of *Location* and abbreviation SFC/FL[nnnnM or nnnnnFT] for *Element of Level*;
b) Whether there is a need to change from C *(inclusion conditional)* to M *(inclusion mandatory)* for elements of *Location* and *Level*;

c) Whether there is a need to change the sequence order for *Location*, *Level and Time* to align with the Table A4-1 for AIREP SPECIAL (downlink);
d) Whether to remove indication of one-point coordinates from Table A6-1A Template for SIGMET and AIRMET messages; and,
e) a request for additional guidance material detailing the time period from when the phenomenon is observed by pilots and issued as an AIREP to when an AIREP is issued by the MWO.

8.8 The meeting discussed whether the AIREP template should reside in a single ICAO publication with other publications referencing this. It was noted that it should be coordinated with ATM experts. Therefore, the Panel agreed with the proposed amendment and formulated the following decision:

Decision 8/2: Improvements to Special AIREP

An inter-Panel ad-hoc team consisting of METP and ATMOPSP experts undertake the following:

a) Review the provisions and information relating to special air-reports in Annex 3, Annex 11, Doc 8896 and Doc 4444;
b) Consider whether the templates for AIREP and Special AIREP should reside in a single document without duplication, either Doc 4444 or Annex 3; and,
c) Present findings and any draft recommendations to the next meetings of the METP and ATMOPSP.

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APPENDIX A

Draft Amendment 79 to Annex 3 concerning references to quality management system guidance material

METEOROLOGICAL SERVICE FOR INTERNATIONAL AIR NAVIGATION
ANNEX 3
TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

PART I. CORE SARPs

[…]

CHAPTER 2. GENERAL PROVISIONS

[…]

2.2 Supply, use, quality management and interpretation of meteorological information

[…]

2.2.3 **Recommendation.**— *The quality system established in accordance with 2.2.2 should be in conformity with the International Organization for Standardization (ISO) 9000 series of quality assurance standards and should be certified by an approved organization.*

Note.— The ISO 9000 series of quality assurance standards provide a basic framework for the development of a quality assurance programme. The details of a successful programme are to be formulated by each State and in most cases are unique to the State organization. Guidance on the establishment and implementation of ~~a~~ quality management systems is given in the ~~Manual on the Quality Management System for the Provision of Meteorological Service for International Air Navigation~~ ~~*(Doc 9873)*~~ Guide to the Implementation of Quality Management Systems for National Meteorological and Hydrological Services and Other Relevant Service Providers *(WMO-No. 1100)*.

[…]

APPENDIX B

Draft Amendment 79 to Annex 3 concerning the inclusion of heavy dust storms in special air reports

[…]

Annex 3 –Appendix 6, Table A6-1B and Appendix 4, Table A4-1

Table A6-1B. Template for special air-reports (uplink)

Key: M = inclusion mandatory, part of every message;
C = inclusion conditional, included whenever applicable;
= = a double line indicates that the text following it should be placed on the subsequent line.

Note.— The ranges and resolutions for the numerical elements included in special air-reports are shown in Table A6-4 of this appendix.

Element	*Detailed content*	*Template*[1,2]	*Examples*
Identification (M)	Message identification	ARS	ARS
Aircraft identification (M)	Aircraft radiotelephony call sign	nnnnnn	VA812[3]
Observed phenomenon (M)	Description of observed phenomenon causing the issuance of the special air-report[4]	TS TSGR SEV TURB SEV ICE SEV MTW HVY DS HVY SS VA CLD VA [MT nnnnnnnnnn] MOD TURB MOD ICE	TS TSGR SEV TURB SEV ICE SEV MTW HVY DS HVY SS VA CLD VA VA MT ASHVAL[5] MOD TURB MOD ICE
Observation time (M)	Time of observation of observed phenomenon	OBS AT nnnnZ	OBS AT 1210Z
Observed Location (C)	Location (referring to latitude and longitude (in degrees and minutes)) of observed phenomenon	NnnnnWnnnnn *or* NnnnnEnnnnn *or* SnnnnWnnnnn *or* SnnnnEnnnnn	N2020W07005 S4812E01036
Observed Level (C)	Flight level *or* altitude of observed phenomenon	FLnnn *or* FLnnn/nnn *or* nnnnM (*or* [n]nnnnFT)	FL390 FL180/210 3000M 12000FT

Notes.—

1. No wind and temperature to be uplinked to other aircraft in flight in accordance with 3.2.
2. See 3.1.
3. Fictitious call sign.
4. In the case of special air-report for volcanic ash cloud, the vertical extent (if observed) and name of the volcano (if known) can be used.
5. Fictitious location.

Table A4-1. Template for the special air-report (downlink)

Key: M = inclusion mandatory, part of every message;
C = inclusion conditional; included whenever available.

Note.— Message to be prompted by the pilot-in-command. Currently only the condition "SEV TURB" can be automated (see 2.6.3).

Element as specified in Chapter 5	*Detailed content*	*Template(s)*	*Examples*
Message type designator (M)	Type of air-report (M)	ARS	ARS
Aircraft identification (M)	Aircraft radiotelephony call sign (M)	nnnnnn	VA812
DATA BLOCK 1			
Latitude (M)	Latitude in degrees and minutes (M)	Nnnnn *or* Snnnn	S4506
Longitude (M)	Longitude in degrees and minutes (M)	Wnnnnn *or* Ennnnn	E01056
Level (M)	Flight level (M)	FLnnn *or* FLnnn to FLnnn	FL330 FL280 to FL310
Time (M)	Time of occurrence in hours and minutes (M)	OBS AT nnnnZ	OBS AT 1216Z
DATA BLOCK 2			
Wind direction (M)	Wind direction in degrees true (M)	nnn/	262/
Wind speed (M)	Wind speed in metres per second (*or* knots) (M)	nnnMPS (*or* nnnKT)	040MPS (080KT)
Wind quality flag (M)	Wind quality flag (M)	n	1
Air temperature (M)	Air temperature in tenths of degrees C (M)	T[M]nnn	T127 TM455
Turbulence (C)	Turbulence in hundredths of $m^{2/3} s^{-1}$ and the time of occurrence of the peak value (C)[1]	EDRnnn/nn	EDR064/08
Humidity (C)	Relative humidity in per cent (C)	RHnnn	RH054
DATA BLOCK 3			
Condition prompting the issuance of a special air-report (M)		SEV TURB [EDRnnn][2] *or* SEV ICE *or* SEV MTW *or* TS GR[3] *or* TS[3] *or* HVY DS[4] *or* HVY SS[4] *or* VA CLD [FLnnn/nnn] *or* VA[5] [MT nnnnnnnnnnnnnnnnnnnn] *or* MOD TURB [EDRnnn][2] *or* MOD ICE	SEV TURB EDR076 VA CLD FL050/100

Notes.—

1. The time of occurrence to be reported in accordance with Table A4-2.
2. The turbulence to be reported in accordance with 2.6.3.
3. Obscured, embedded or widespread thunderstorms or thunderstorms in squall lines.
4. Duststorm or sandstorm.
5. Pre-eruption volcanic activity or a volcanic eruption.

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MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Headquarters, 10 to 14 September 2018

AGENDA ITEM 9

The attached constitutes the report on Agenda Item 9 and should be inserted at the appropriate place in the yellow folder.

(3 pages)

Agenda Item 9: Panel structure

9.1 The Meeting noted that the structure and summarized responsibilities of the Panel continue to be domiciled on the METP website and updated time to time as may be necessary.

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METP/4
14/9/18

MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Headquarters, 10 to 14 September 2018

AGENDA ITEM 10

The attached constitutes the report on Agenda Item 10 and should be inserted at the appropriate place in the yellow folder.

(3 pages)

Agenda Item 10: Future meetings

10.1 The Panel agreed that the Fifth Meeting of the Panel be held at ICAO Headquarters from 14 to 18 September 2020.

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MEETING OF THE METEOROLOGY PANEL (METP)

FOURTH MEETING

Headquarters, 10 to 14 September 2018

AGENDA ITEM 11

The attached constitutes the report on Agenda Item 11 and should be inserted at the appropriate place in the yellow folder.

(2 pages)

Agenda Item 11: Any other business

Mr. Greg Brock as the WMO-nominated Member of the METP presented the following Information Papers to the Meeting:

11.1 The **IP/6101**, concerning the 2016-2017 WMO CAeM global survey on aeronautical meteorological service provision. In this regard the Panel was pleased to note an overview of the outcomes of the referred survey conducted by the WMO Commission for Aeronautical Meteorology (CAeM) between November 2016 and February 2017. It was also noted with satisfaction that the survey yielded a response rate in excess of 90% of WMO Members.

11.2 The **IP/6102**, concerning the WMO Aeronautical Meteorology Scientific Conference held in Toulouse, France in November 2017. It was noted an overview of the outcomes and also that it was the first such international conference in almost 50 years addressing the broad underpinning aspects of current and future scientific and technological advances in support of aeronautical meteorological service provision.

11.3 The **IP/6103**, concerning the outcomes of a WMO Executive Council Special Dialogue on the future of aeronautical meteorological services held in May 2017 during the sixth-ninth session of the Executive Council (EC-69).

11.4 The **IP/6104**, concerning the outcomes of a bilateral meeting between the Secretary-General of WMO and the Secretary General of ICAO held in April 2018.

11.5 The **IP/6105**, which provided an overview of the outcomes of the sixteenth session WMO Commission for Aeronautical Meteorology (24 to 27 July 2018) and its preceding Technical Conference (23 July 2018).

11.6 The **IP/6106**, which provided an outline of the status of WMO constituent body reform and envisaged next steps for the information of the Meteorology Panel (METP). In this regard it was noted that over the past several years, as a follow-up to outcomes of the WMO Congress and Executive Council on the continuous improvement of organizational process and practices, WMO has been engaged in a dialogue on the reform of its constituent bodies (so-called ‘WMO reform’), including the Executive Council, Regional Associations and Technical Commissions including the Commission for Aeronautical Meteorology (CAeM).

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