International Civil Aviation Organization
South American Regional Office
SAM COM/MET IMPLEMENTATION MEETING 2012
Lima, Peru, 1 to 3 August 2012

Agenda Item 3: **Amendment 76 to Annex 3 – *Meteorological service for International air navigation* – Follow up to the analysis on requirements for the new OPMET (METAR/SPECI and TAF) messages format**

(Presented by the Secretariat)

SUMMARY

This working paper presents information on the follow up to the analysis of the requirements for the new OPMET messages format (METAR/SPECI and TAF).

REFERENCES

- Report of the Ninth Meeting of Aerodrome Meteorological Observation and Forecast Study Group, Montreal, from 26 to 29 September 2011 (AMOFSG/9-SN No. 8)

ICAO strategic objectives:	*A – Safety* *C – Environmental Protection and Sustainable Development of Air Transport*

1. Background

1.1 The eighth meeting of Aerodrome Meteorological Observation and Forecast Study Group (AMOFSG/8) decided to establish an *Ad hoc* group to develop a roadmap to amend Annex 3 provisions to accommodate the transition to table-driven data representation.

1.2 This roadmap was considered to be necessary to plan the required changes for Annex 3 — *Meteorological Service for International Air Navigation* and associated guidance material necessitated by the evolution towards a data-oriented environment. The principal argument for such a roadmap development was that the impact of the introduction of a data-oriented environment on the provisions was expected to be very significant.

1.3 In support of the roadmap development, the *Ad hoc* group elaborated a number of aspects related to the future air traffic management (ATM) system and information management for ATM in particular. Ultimately, this provides the rationale for the identified milestones.

2. Discussion

2.1 Table-driven data representation and information management for ATM

2.1.1 The ICAO *Global Air Traffic Management Operational Concept* (Doc 9854) describes the manner in which the ATM system will deliver services and benefits to airspace users by 2025. The guiding principle is that the ATM system is based on the provision of services. The service-based framework described in Doc 9854 considers all resources such as inter alia, 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 and making optimum use of all system resources. It is clearly evident that the future ATM system will be a network-based operation formed by four main components. These will dramatically increase the efficiency of it:

a) a robustly networked ATM System will improve information sharing;

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

c) shared situational awareness will enable collaboration and self-synchronization; and

d) deliver enhanced sustainability and speed of decision making.

2.1.2 The concept of common (collaborative) information sharing has been under development for a decade or more. It was born from a clear recognition that future ATM will be managed on a net (work)-centric basis, with each airport and each aircraft being considered as a node interlinked with all others within the system. The availability of timely, high quality information will provide a foundation for effective management of the air traffic system. Nevertheless, the system will continue to be subject to the effects of uncertainty, especially from adverse weather.

2.1.3 The transition towards table-driven data representation for MET is an extremely important component towards the implementation of net-centric oriented ATM. However, due consideration should be given to the fact that data representation is only one aspect of the required move towards net-centricity. The use of meteorological (MET) information in a net-centric ATM environment and satisfying the foreseen performance requirements for MET will have an impact on the information that needs to be made available and exchanged between information providers and users.

2.1.4 In this regard, an important consideration in this respect is to ensure global interoperability not only from a MET information perspective but also clearly focused on the interlinks with other identified data domains that are relevant for ATM. ATM systems, such as controller decision support tools, will not only use MET information but will fuse this information with other relevant information such as Aeronautical Information (AIS/AIM) and Flight Information to support knowledge based decision making. MET information should therefore be structured in accordance with generic ATM information management principles applicable to all data domains.

2.1.5 It is recognized that the level of maturity of other data domains in the transition toward net-centricity is different than for MET. Consequently, a fully established baseline for generic ATM information management principles and functions has not been fully established. Nevertheless, multi-data domain interoperability for MET information exchange can be assured by applying philosophies adopted in the AIS/AIM domain which are clearly performance based and by basing developments on technical specifications from organizations with a wide-industry base such as the International Organization for Standardization (ISO) and OGC.

2.1.6 These multi domain interoperable solutions will form the data-centric ATM environment and constitute the core building blocks of System Wide Information Management (SWIM). SWIM will increase the required agility of the ATM system by the ability to quickly develop applications and other support tools to meet evolving ATM business needs without having to revisit proprietary data provision standards.

2.1.7 The quality of service (QoS) is another important consideration in the context of information to support net-centric operations and the overall change and reorientation towards data/information services. From an information management perspective, the quality of the information that is exchanged, the so-called payload is not of direct concern. The concern lies in the intrinsic capability of making available information on the QoS aspect of the payload. An approved mechanism to convey QoS information is through the provision of metadata (data about data) attached to the payload.

2.1.8 In addition to QoS information, a number of other relevant 'data about data' aspects are crucial for the efficient sharing of information. Information on the provider issuing the information together with relevant time and source data attributes, limitations of the data, etc. will be extremely helpful in the functioning of a net-centric ATM environment and to decide on the applicability of the data in a specific user context.

2.1.9 Current Annex 3 provisions provide no explicit reference to metadata for MET information. However, in the evolution towards a data-oriented environment metadata is considered to be an essential component to be included in the transition, and in consequence reflected in the roadmap. From this perspective the logical approach would be to adopt technical specifications from organizations such as ISO and OGC to assure the earlier discussed multi data domain –interoperable-solution set. These technical specifications will provide the baseline for specific metadata profiles that could be used for aeronautical MET information.

2.1.10 The development of such a metadata profile requires domain expertise, both from an air transport perspective and a meteorology perspective. ICAO has recognized the value of adopting technical requirements developed by aviation industry bodies such as the European Organisation for Civil Aviation Equipment (EUROCAE) , RTCA and from more generally based organizations such as ISO, OGC and the Society of Automotive Engineers (SAE) to meet its future needs. In support of this philosophy, OGC and its Aviation Domain Working Group and the World Meteorological Organization (WMO) are the most likely candidate organisations for the (conjoint) development and maintenance of such a profile.

2.2 **Logical data model versus physical data models**

2.2.1 International consensus exists on an overall migration of the numerous code forms and code descriptions for operational meteorological (OPMET) data towards the notion of one weather information exchange model (WXXM). The WXXM provides the semantics and abstract structure of all the information that needs to be made available by MET service providers as prescribed by Annex 3. It includes the intrinsic data requirements and structural business process rules. It provides a so-called technology independent description[1] not concerned with code form specifications such as GRIB, binary universal form for the representation of meteorological data (BUFR), and TAC[2]s for aerodrome routine meteorological report (in meteorological code form) (METAR), aerodrome forecast (in meteorological code form) (TAF), etc.

2.2.2 From a system's architectural perspective, this WXXM suffices as the guiding logical data model[3] for all physical implementation of systems that exchange MET information in the ATM domain. However, for the purpose of the international exchange of OPMET data it is considered to be beneficial to provide an additional level of structure and as a consequence to describe a model for the physical implementation of OPMET exchange.

2.2.3 As a comparison between such a physical implementation and existing Annex 3 provisions, the GRIB and BUFR code forms could be considered physical implementations of a format to exchange information. What is not in the current provisions is the overarching structure and interrelations between the information conveyed by the two data formats and how it correlates with

[1] Technology independent description; A static description, in the Unified Modeling Language (UML), of the structure of the 'Meteorological Information Exchange system' by showing the system's classes, their attributes, operations(or)methods and the relationships between the classes.

[2] TAC: Traditional Alphanumeric Code.

[3] A logical data model is an operational view on the type of information exchanged, the frequency of exchanges and the nature of the information exchanges from an enterprise and system architectural perspective. This view is recognised and used in all the leading Architectural Reference Models, including the NATO Architectural Framework (NAF), US Department of Defense Architectural Framework (DoDAF) and the British Ministry of Defence Architecture Framework (MODAF).

the overall ATM business[4]. However, and especially true for the BUFR code form, these forms are considered to be relatively specific to MET, not widely adopted by ATM or other industries and are therefore expensive to integrate, use and maintain from a user application' perspective.

2.2.4 Consequently, there is already an established general agreement on the migration of the BUFR code form used on a bilateral basis for METAR/SPECI and TAF to be replaced by a format that is widely accepted and based on the earlier mentioned generic standards. A code form based on XML[5] was identified. Moreover, the same consensus extends to the need to migrate towards a specific XML grammar to express geographical features which meteorological information in essence is. This specific XML grammar to describe MET information in function of time, place, coverage, etc. is GML[6].

2.2.5 SESAR and NextGen, two of the regional ATM developments programmes have developed a GML based format for OPMET data called the weather information exchange schema (WXXS). This specific GML based format enables the exchange of information formally captured in TAC but also has the intrinsic capability to provide so called GML-wrappers for other code forms including GRIB.

2.2.6 The development and maintenance of a logical data model (WXXM) and physical data models for MET information, in the context of OPMET the XML schema[7] (WXXS) require domain expertise. The focus for a logical data model is in principal on the development of a technology independent description of the semantics and abstract structure of all the MET information in an ATM context. The move towards adopting technical requirements developed by aviation industry bodies and by more generally based organizations such as ISO, OGC and SAE to meet ICAO future needs was previously mentioned. It could be argued that a leading role in this development and the maintenance of the logical data model is reserved for an appropriate body that is close to the ATM industry.

2.2.7 However, as the logical data model is close to the performance-based information requirements and in a fully data-centric environment the only representation for information (exchange) needs and the interrelationships, the ownership should be with ICAO.

2.2.8 An XML schema for the exchange of OPMET is a development that is very much content oriented and close to the development of code forms in an OPMET context. Therefore, ownership of the OPMET XML schema should be with WMO.

2.3 Evolution of non-TAC code formats

2.3.1 The first instantiation of the evolution towards a data-oriented environment is foreseen by the earlier discussed introduction of table driven codes for TAC. However, a complete transition toward data-centricity will require a review of other existing code forms used for the exchange of OPMET.

2.3.2 The currently used code forms for OPMET, besides TAC, are GRIB and BUFR. Some limitations with respect to these code forms were discussed in paragraph 2.2.3 of this paper. In addition, the GRIB and BUFR code forms are proving to be difficult to utilize in a trajectory based ATM environment. There are intrinsic issues with respect to a required core capability of the trajectory planning and execution function using these code forms.

[4] In the ICAO AIS/AIM domain, consensus exists on a similar approach for a technology independent (UML) description of aeronautical information semantics, the abstract structure of AIS/AIM information, the intrinsic data requirements and structural business process rules. This is currently referred to in the AIS/AIM domain as the 'Conceptual Model for AIS/AIM'.

[5] XML: Extensible Markup Language.

[6] GML: Geography Markup Language.

[7] In the ICAO AIS/AIM domain, consensus exists on the development of provisions on an XML Schema for AIS/AIM Information. This is currently referred to in the AIS/AIM domain as the 'Data Encoding Specification for AIS/AIM'.

2.3.3 These issues are related to complexities associated with combining multiple files to cover the geographical footprint of a trajectory. The problem is that when the MET information required is in more than one (1) file, due to a mismatch between the geographical scope of the files and the trajectory, data manipulation becomes difficult, e.g. to intersect a trajectory with information contained in multiple GRIB- or BUFR-coded files is extremely complicated. In addition, to efficiently exchange information that is relevant for a trajectory by means of generic application services that could be used by ATM systems, without having to exchange the complete file that the information is extracted from, cannot be done without developing costly dedicated solutions.

2.3.4 It is recognized that the focus of the transition – and the remit of the Aerodrome Meteorological Observation and Forecast Study Group (AMOFSG) – towards a data-centric environment should be in the first instance through the evolution of TAC. However, in the evolution towards a data-oriented environment the existing (other) code forms should be considered and be included in the roadmap. This does not necessarily mean that every code format should be replaced by an XML based code format. Especially gridded data can be exchanged in other more efficient manners. However, XML could still be used as the so-called ‘wrapper’ of the information. Essential to it all is the fact that the information constructs, also for the gridded data, are captured at the technology and format independent layer of the WXXM.

2.3.5 In addition, the Meteorological Warnings Study Group (METWSG), during its third meeting, recognized and acknowledged already this overall move towards a data-oriented environment. It formulated two actions with respect to the migration of BUFR coded graphical SIGMET information. METWSG Action3/10 and 3/11 call for the development of the appropriate provisions and supporting XML coding specifications for graphical SIGMET information. Coordination between AMOFSG and METWSG is required, especially on the logical data modelling aspects, to develop a harmonized and concise logical data model to be made available through Amendment 76 to Annex 3.

2.3.6 Moreover, coordination between all other relevant operational and study groups is required when new or revised services and products are discussed and information exchange aspects need to be considered. In developing a data centric environment, all information and subsequently the associated products and services need to be captured in one WXXM.

2.4 Evolution of products structured according to ICAO templates and non-structured info

2.4.1 Similar to the discussion on non-TAC code formats, the different products currently supported by a template in Annex 3 only should be incorporated in the full evolution towards data-centricity. Therefore, within the evolution towards a data-oriented environment, the ICAO templates should be considered appropriately and included in the roadmap.

2.4.2 In addition, a number of MET information exchange provisions of Annex 3 are not expressed as a distinct product or service in line with a code format or template description. Requirements on the display of wind, cloud and runway visual range (RVR) information at a controller working position have implicit information exchange requirements. As a minimum, this information exchange needs to be reflected at the level of the WXXM. As such, the currently existing implicit information exchange requirements should be considered appropriately and included in the roadmap.

2.5 New information requirements

2.5.1 Significant consideration should be given to the fact that previous paragraphs mainly discussed the transition of existing Annex 3 provisions instead of future information requirements in a net-centric oriented ATM. The transition towards table-driven data representation for MET should not stop after the transposition of current and/or (considered) obsolete code formats has been completed.

2.5.2 Another AMOFSG' *ad-hoc* working group supports the activity of gathering new MET information requirements, the translation into the required data elements and the potential revision or development of provisions. The solutions proposed by the first group are considered to be technical enablers for these new information requirements coming from the second group. Consequently, close cooperation needs to be maintained between the activities to ensure alignment of what information and associated products and services will be required and what should be facilitated by the WXXM and potential exchange formats.

2.5.3 Fortunately, the proposed structure of the single WXXM and associated exchange schema(s) is extremely flexible. This will enable the agility of the ATM system as previously discussed. It will confer the ability to quickly satisfy information needs and to develop the appropriate applications and other support tools to meet evolving ATM business needs. This without having to revisit proprietary data provision standards as is currently seen as a limiting factor.

2.6 **Communications**

2.6.1 The physical communication infrastructure is an enabler of the data oriented environment that requires consideration. In principal, the ICAO aeronautical fixed services (AFS) and its increasingly available Air Traffic Services Message Handling System (AMHS) component are capable of exchanging information in the formats used and suggested (BUFR, GRIB, XML). AMHS and the underlying physical infrastructure required, places no known intrinsic constraints on the exchange of information with respect to file size, character sets, etc. Furthermore, the implementation of AMHS as suggested by ICAO is in line with the proposed transition and associated roadmap steps discussed in this information paper.

2.6.2 Whenever States decide that the Aeronautical Fixed Telecommunication Network (AFTN) / Common ICAO Data Interchange Network (CIDIN) is to be the only available means of communication for the exchange of XML-coded TAF, METAR and SPECI (and SIGMET). Due consideration should be given to potential constraints with respect to the character sets to use and limitations to file sizes. However, ICAO Annex 10, Volume 2, conditionally enables to mitigate for these potential constraints.

2.7 **Transition Approach**

2.7.1 In the evolutionary process of transiting from what is essentially a product-oriented environment towards a data-oriented one, clearly defined components need to be identified, as well as appropriate milestone dates. Taken together they will instantiate the transition process.

2.7.2 It should be recognized that the proposed transition approach is primarily focused on the digital data provision aspects of this transition towards a data-oriented environment. Generic aspects on how the service provision in totality should develop, including the evolution of the required data elements that need to be exchanged are not part of this roadmap (see paragraph 2.5). This roadmap is designed to enable the exchange of all aeronautical meteorological information in a flexible, easy expandable, open and transparent manner. Nevertheless it remains clearly focused on the transition of currently defined user products as prescribed by Annex 3.

2.7.3 Activities related to the implementation -by States- of provisions developed in the context of identified roadmap (steps) are not included in this information paper. An implementation roadmap or general guidance to support implementation could be considered by the Secretariat in conjunction with the publication of an amendment of Annex 3. Potential issues to consider in this context are:

- XML coding at source (e.g weather observation system at an airport) versus XML coding exclusively by collecting centres that will distribute information international;

- Transition of OPMET Databanks towards new formats including XML;

- Implication for information providers to fulfil metadata requirements.

2.7.4 A proposed logical structured flow of actions to be considered in the transition, thus roadmap, are the development of:

- XML/GML format for TAC OPMET;

- Metadata requirements;

- Weather Information Exchange Model;

- Information Management for ATM / SWIM.

2.7.5 The associated milestone dates for these components are linked to the currently known revision cycle of ICAO Annex 3 to provide the timing dimension of the required transition. However, this does not suggest that the listed components all need to be included in the Annex itself. Some of the identified steps are clearly related to guidance material, specifications or otherwise and not a Standard or Recommended Practice per se. Table 1 outlines the revision cycle / time schedule involved.

Edition	***Applicability date***	***Publication date***	***Start State consultation***
18th / amd.76	November 2013	July 2013	January 2012
19th / amd 77	November 2016	July 2016	January 2015
20th / amd 78	November 2019	July 2019	January 2018

Table 1 Amendment cycle time schedule

2.8 **Roadmap**

2.8.1 **Annex 3 | 18th edition | Amendment 76**

2.8.1.1 The following evolutionary improvement steps need to be incorporated:

- **XML/GML format for TAC OPMET;** States in a position to do so should exchange METAR, SPECI and TAF in a digital form under bilateral agreement;

- **Metadata requirements;** States in a position to exchange METAR, SPECI or TAF in a digital form under bilateral agreement should include metadata;

- **Weather Information Exchange Model;** States in a position to exchange METAR, SPECI or TAF in a digital form under bilateral agreement should structure this information in accordance with defined features, attributes and associations[8].

- **Information Management for ATM / SWIM;** N/A.

Note 1: The overall notion of ATM Information Management from an ICAO perspective needs to develop further to justify the inclusion of relevant provisions on ATM Information Management for amendment 76. However, extreme caution should be applied to not include provisions or modifications to existing provisions that could be contradictory with what is known today of the overall transition towards common (collaborative) information sharing. Currently under development is the notion of an overarching ATM Information Reference Model (AIRM). This AIRM is the 'glue' between the earlier discussed interoperable data

[8] Whilst this improvement step is formulated in the context of TAC migration only, sufficient coordination is required with the METWSG on their ambition to migrate graphical SIGMET elements from BUFR to XML and the associated logical data model implications.

domain specific information exchange solutions. To apply common standards and specification in every data domain is already a significant step in the move towards a data-centric ATM environment. But to link the data domains with one reference model for ATM information will improve the consistency and coherency of all the ATM information considerably and will remove the apparent overlaps between data domains. To ensure a first level of convergence, the alignment with associated information sharing principles developed for AIS/AIM (Annex 15) should be assured.

2.8.1.2 A series of activities can be summarized to support the aforementioned improvement steps. These need to be completed before January 2013:

- Develop and publish[9] a first iteration of the weather information exchange model (WXXM) which will specify the semantics and abstract structure (features, attributes and associations) for aeronautical MET information. There should be a clear focus on METAR, SPECI and TAF exchange in a digital form[10].

- Develop and publish a first iteration specification for METAR, SPECI and TAF exchange in digital form which shall:

  - use XML;
  - comply with the GML specification for the encoding of geographical information;
  - be expressed in the form of an XML schema;
  - be structured in accordance with defined features, attributes and associations (WXXM).

- Develop and publish a first iteration metadata profile for METAR, SPECI and TAF exchange in compliance with ISO 19115 and ISO 19139.

- Propose and obtain the approval of States for the modification of the appropriate provisions in Annex 3. It is fully recognized that the Secretariat will develop the proposal for the appropriate amendments. It is also not intended to cover all necessary changes to provisions. The aim is to highlight the important aspects of change.

2.8.2 Annex 3 | 19th edition | Amendment 77

2.8.2.1 The following evolutionary improvement steps need to be incorporated:

- **XML/GML format for TAC OPMET;** METAR, SPECI and TAF should be exchanged in a digital form.

- **Metadata requirements;** METAR, SPECI and TAF in a digital form should include metadata.

- **Weather Information Exchange Model;** When METAR, SPECI and TAF are exchanged in a digital form, the information should be structured in accordance with defined features, attributes and associations. States in a position to do so, under bilateral agreement, should structure all meteorological information in accordance with defined features, attributes and associations.

- **Information Management for ATM / SWIM;** States in a position to do so, under bilateral agreement, should adhere to general principles with respect to

[9] When the words 'develop' and 'publish' are used in paragraph 4, these are transparent processes to the stakeholder inclusive of a)the coordination with other Operational and Study groups and b)the appropriate verification and validation of developed specifications including version control.

[10] See footnote 8.

information management and consequent communication services and digital data provision.

Note 2: It is expected that global and regional developments of ATM Information Management, sometimes referred to as SWIM, and the development of the notion of an overarching ATM Information Reference Model (AIRM) will be sufficiently mature to have an impact on data domain / interest area specific provisions such as encapsulated in Annex 3. A first set of general principles of information management and exchange and associated Communication Services and Digital Data Provision should be agreed, introduced and commonly applied to all data domains.

2.8.2.2 A series of activities to support the aforementioned improvement steps which need to be completed before January 2016 are summarized as follows:

- Publish a Major Release of the WXXM which will specify the semantics and abstract structure (features, attributes and associations) for aeronautical MET information.

- Publish a Major Release specification for METAR, SPECI and TAF exchange in digital form which shall:

  - use XML;
  - comply with the GML specification for the encoding of geographical information;
  - be expressed in the form of an XML schema;
  - be structured in accordance with defined features, attributes and associations (WXXM).

- Develop and publish a first iteration specification for MET information exchange (exclusive of the METAR, SPECI and TAF schema) in digital form which shall:

  - use XML;
  - comply with the GML specification for the encoding of geographical information;
  - be expressed in the form of an XML schema;
  - be structured in accordance with defined features, attributes and associations (WXXM);
  - allow for the exchange of gridded information and associated exchange formats.

- Publish a Major Release metadata profile for METAR, SPECI and TAF exchange in compliance with ISO 19115 and ISO 19139.

- Develop and publish a first iteration metadata profile for aeronautical MET information exchange (exclusive of the METAR, SPECI and TAF) in compliance with ISO 19115.

- Develop or modify existing guidance on the application of generic information management principles for MET.

- Modify and obtain States approval of the appropriate provisions in Annex 3. The **Appendix** to this information paper provides a first indication of change especially the foreseen incorporation of relevant provisions with respect to information management. It is fully recognized that the Secretariat will develop the proposal for the appropriate amendments in due course. The intention is not to cover all necessary changes to provisions but mainly to illustrate the important aspects that need to be included.

2.8.3 **Annex 3 | 20th edition | Amendment 78**

2.8.3.1 The following evolutionary improvement steps need to be incorporated:

- **XML/GML format for TAC OPMET;** METAR, SPECI and TAF shall be exchanged in a digital form.

- **Metadata requirements;** METAR, SPECI and TAF in a digital form shall include metadata.

- **Weather Information Exchange Model;** When METAR, SPECI and TAF are exchanged in a digital form, the information shall be structured in accordance with defined features, attributes and associations. All other MET information should be structured in accordance with defined features, attributes and associations.

- **Information Management for ATM / SWIM;** To be further developed for AMOFSG/10.

2.8.3.2 A series of activities to support the aforementioned improvement steps which need to be completed before January 2019 are summarised as follows:

- Publish a Major Release of the Weather Information Exchange Model (WXXM) to specify the semantics and abstract structure (features, attributes and associations) for aeronautical meteorological information.

- Publish a Major Release specification for MET information exchange in digital form which shall:

  - use XML;
  - comply with the GML specification for the encoding of geographical information;
  - be expressed in the form of an XML schema;
  - be structured in accordance with defined features, attributes and associations (WXXM);
  - allow for the exchange of gridded information and associated exchange formats.

- Publish a Major Release metadata profile for MET information exchange in compliance with ISO 19115 and ISO 19139.

- Modify and obtain States approval on the appropriate provisions in Annex 3.

- - - - - - -

APPENDIX

Annex 3 | 19th edition | Amendment 77

Introduction of a new Chapter on General Principles (for Information Management) and subsequently overlaps between this new Chapter and already existing (duplicated) provisions should be removed:

General Principles

#.1 Use of ICAO abbreviations

#.1.1 ICAO abbreviations shall be used in the meteorological information services whenever they are appropriate as their use will facilitate distribution of information/data.

#.2 Place names

#.2.1 Any place names used shall be spelt in conformity with local usage, transliterated, when necessary, into the Latin alphabet.

#.3 Common reference systems for air navigation

#.3.1 Horizontal reference system

#.3.1.1 World Geodetic System — 1984 (WGS-84) shall be used as the horizontal (geodetic) reference system for international air navigation. Consequently, geographical coordinates used (indicating latitude and longitude) shall be expressed in terms of the WGS-84 geodetic reference datum.

Note 1.— Comprehensive guidance material concerning WGS-84 is contained in the World Geodetic System — 1984 (WGS-84) Manual (Doc 9674).

Note 2.— Specifications governing the determination and reporting (accuracy of field work and data integrity) of WGS-84-related coordinates for geographical positions established by air traffic services are given in Annex 11, Chapter 2, and Appendix 5, Table 1, and for aerodrome/heliport-related positions, in Annex 14, Volumes I and II, Chapter 2, and Table A5-1 and Table 1 of Appendices 5 and 1, respectively.

#.3.1.2 **Recommendation**.— In precise geodetic applications and some air navigation applications, temporal changes in the tectonic plate motion and tidal effects on the Earth's crust should be modelled and estimated. To reflect the temporal effect, an epoch should be included with any set of absolute station coordinates.

Note 1.— The epoch of the WGS-84 (G873) reference frame is 1997.0 while the epoch of the latest updated WGS-84 (G1150) reference frame, which includes plate motion model, is 2001.0. (G indicates that the coordinates were obtained through Global Positioning System (GPS) techniques, and the number following G indicates the GPS week when these coordinates were implemented in the United States of America's National Geospatial-Intelligence Agency's (NGA) precise ephemeris estimation process.)

Note 2.— The set of geodetic coordinates of globally distributed permanent GPS tracking stations for the most recent realization of the WGS-84 reference frame (WGS-84 (G1150)) is provided in Doc 9674. For each permanent GPS tracking station, the accuracy of an individually estimated position in WGS-84 (G1150) has been in the order of 1 cm (1σ).

Note 3.— Another precise worldwide terrestrial coordinate system is the International Earth Rotation Service (IERS) Terrestrial Reference System (ITRS), and the realization of ITRS is the IERS Terrestrial Reference Frame (ITRF). Guidance material regarding the ITRS is provided in Appendix C of Doc 9674. The most current realization of the WGS-84 (G1150) is referenced to the ITRF 2000 epoch. The WGS-84 (G1150) is consistent with the ITRF 2000 and in practical realization the difference between these two systems is in the one to two centimetre range worldwide, meaning WGS-84 (G1150) and ITRF 2000 are essentially identical.

#.3.2 Vertical reference system

#.3.2.1 Mean sea level (MSL) datum, which gives the relationship of gravity-related height (elevation) to a surface known as the geoid, shall be used as the vertical reference system for international air navigation.

Note 1.— The geoid globally most closely approximates MSL. It is defined as the equipotential surface in the gravity field of the Earth which coincides with the undisturbed MSL extended continuously through the continents.

Note 2.— Gravity-related heights (elevations) are also referred to as orthometric heights while distances of points above the ellipsoid are referred to as ellipsoidal heights.

#.3.2.2 The Earth Gravitational Model — 1996 (EGM-96), containing long wavelength gravity field data to degree and order 360, shall be used by international air navigation as the global gravity model.

Note.— Guidance material concerning EGM-96 is contained in Doc 9674.

#.3.2.3 At those geographical positions where the accuracy of EGM-96 does not meet the accuracy requirements for elevation and geoid undulation specified in Annex 14, Volumes I and II, on the basis of EGM-96 data, regional, national or local geoid models containing high resolution (short wavelength) gravity field data shall be developed and used. When a geoid model other than the EGM-96 model is used, a description of the model used, including the parameters required for height transformation between the model and EGM-96, shall be provided.

#.3.2.4 In addition to elevation referenced to the MSL (geoid), for the specific surveyed ground positions, geoid undulation (referenced to the WGS-84 ellipsoid) for those positions specified in Appendix 1 shall also be published.

#.3.3 Temporal reference system

#.3.3.1 For international civil aviation, the Gregorian calendar and Coordinated Universal Time (UTC) shall be used as the temporal reference system.

Note 1.— A value in the time domain is a temporal position measured relative to a temporal reference system.

Note 2.— Coordinated Universal Time (UTC) is a time scale maintained by the Bureau International de l'Heure (BIH) and the IERS and forms the basis of a coordinated dissemination of standard frequencies and time signals.

Note 3.— See Attachment D of Annex 5 for guidance material relating to UTC.

Note 4.— ISO Standard 8601 specifies the use of the Gregorian calendar and 24-hour local or UTC for information interchange while ISO Standard 19108 prescribes the Gregorian *calendar and UTC as the primary temporal reference system for use with geographic information.*

#.3.3.2 When a different temporal reference system is used for some applications, the feature catalogue, or the metadata associated with an application schema or a data set, as appropriate, shall include either a description of that system or a citation for a document that describes that temporal reference system.

Note.— ISO Standard 19108, Annex D, describes some aspects of calendars that may have to be considered in such a description.

#.4 Units of measurement

#.4.1 **Recommendation**.— Units of measurement used in the origination, processing and distribution of meteorological information should be consistent with the decision taken by the State in respect of the use of the tables contained in Annex 5 — Units of Measurement to be Used in Air and Ground Operations.

#.5 Metadata

#.5.1 Each Contracting State shall collect metadata for meteorological information/data processes and/or exchange points. This metadata collection shall be applied throughout the data supply chain, from survey/origin to distribution to the next intended user by the meteorological information service.

Note.— ISO Standard 19115 specifies requirements for geographic information metadata.
The metadata to be collected shall include, as a minimum:
-the name of the organization or entity performing the function;
-the function performed; and
-the date and time of operation.

#.6 Copyright

#.6.1 Any product of a State's Meteorological Service which has been granted copyright protection by that State shall only be made available to a third party on the condition that the third party is made aware that the product is copyright protected and provided that it is appropriately annotated that the product is subject to copyright by the originating State.

#.7 Cost recovery

#.7.1 **Recommendation**.— The cost of originating, collecting and compiling meteorological information/data should be included in the cost basis for airport and air navigation services charges, as appropriate, in accordance with the principles contained in ICAO's Policies on Charges for Airports and Air Navigation Services (Doc 9082).

#.8 Information Management[11]

#.8.1 Process management

#.8.2 Data quality

#.8.2.1 Data quality requirements

[11] For the purpose of the SN, only the foreseen provision headers are provided as a first indication for the specific Information Management Principles part; detailed content potentially needs to be developed further.

#.8.2.2 Evidence of data quality

#.8.2.3 Order of accuracy

#.8.2.4 Integrity of data

#.8.3 Uncertainty

#.8.4 Data exchange

#.8.5 Data traceability

#.8.6 Data protection

#.8.7 Use of automation

#.8.8 Timeliness

#.8.9 Personnel management

#.8.10 Tool management

#.8.10.1 Specification

#.8.10.2 Validation and verification.

— END —