International Civil Aviation Organization

ICAO/WMO ASIA/PACIFIC METEOROLOGY/AIR TRAFFIC MANAGEMENT (MET/ATM) SEMINAR

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Discussion Topic 4: **Thorough review of future requirements – MET component of the CNS/ATM systems:**

1) ATM developments requiring additional/new MET information

INFORMATION ON PERSPECTIVE FUTURE FUNCTION OF THE WORLD AREA FORECAST SYSTEM

(Presented by the United States)

SUMMARY

This paper presents an overview of the meteorological service for performance-based navigation and its relationship to the World Area Forecast System.

1. INTRODUCTION

1.1 Concepts for Global Air Traffic Management (ATM) and Performance-based Navigation (PBN) are well documented in:

- Performance-based Navigation (PBN) concept in ICAO Doc 9613 "*Performance-based Navigation (PBN) Manual*",
- Global ATM concept in ICAO Doc 9854 "*Global Air Traffic Management Operational Concept*", and the associated requirements in
- ICAO Doc 9882 *"Manual on Air Traffic Management System Requirements*".

1.2 A new concept document *"Flight and Flow Information for a Collaborative Environment"* (FF-ICE), has been introduced by the Air Traffic Management Requirements Performance Panel (ATMRPP) to improve the efficiency of traffic flow with PBN.

1.3 All of the above documents mention or reference "weather" (meteorological services) in general terms, and do not specify or identify the meteorological services required for global ATM and PBN. The information in the discussion below provides an example of how meteorological information will be much more complex and different from today's simple weather text products and graphics.

2. NEXTGEN

2.1 The United States of America (U.S.) is progressing well with its Next Generation Air Transportation System (NextGen), and published in September 2009 the NextGen Weather Plan, http://www.jpdo.gov/library/NextGen_Weather_plan_1.1.pdf ,
and the NextGen ATM Weather Integration Plan
http://www.jpdo.gov/library/JPDO%20ATMWeather%20Integration%20Plan%20v10%5B1%5D.pdf

2.1.1 In the current air transportation system, weather information is not integrated into the ATM process. Instead, users (e.g., controllers) must interpret weather information and manually integrate this information into traffic decisions based on his or her understanding of the information presented. In NextGen, weather information will be integrated into Flight Management Systems, as well as air transportation systems and decision-support systems to support safe and more efficient flight.

2.1.2 This new paradigm promotes sharing weather information and data and replaces the use of individual and potentially conflicting weather products with network-enabled common weather information that supports a common situational picture. Enhanced tailored, probabilistic weather information that has been transformed and integrated into air transportation automation and decision-support systems enables users and service providers to more precisely identify specific weather impacts on operations (e.g., trajectory management and impacts on specific airframes, arrival/departure planning) to ensure continued safe and efficient flight.

2.1.3 Weather information for NextGen will come from many sources and be located in a virtual 4-Dimensional (4-D) data base known as the 4-D Weather Data Cube (4-D Cube). The 4-D Cube will contain aviation-specific observations, analyses and forecasts organized by 3-D spatial and time components (x, y, z, t) that extend from the surface to low earth orbit. The 4-D Cube will be fed by several numerical weather prediction (NWP) models. Often times, NWP models will differ in their forecasts thus NextGen will use a concept called the Single Authoritative Source (SAS). The SAS provides a single value at each grid point that is the “best representation” of a weather element (e.g., wind speed and direction, runway visual range, and turbulence) which will provide a common weather operating picture and enhance collaboration amongst the users.

2.1.4 ATM will require Decision Support Tools (DST) that can deal with the information from the 4-D Cube which has been translated into air transportation system impacts and provide ATM with best choice options. DSTs are generally software applications used to automate the weather impact evaluation and air traffic/customer response.

2.1.5 Integration of weather information from the 4-D Cube into ATM and the use of sophisticated DST will enable trajectory-based operations (TBO) and high-density operations. Integration incorporates weather information into the DSTs that formulate the most efficient air traffic routing solutions and continually account for inherently dynamic weather phenomena. The ultimate goal of integration is to translate weather information as purely meteorological data into weather impacts on air traffic operations – essentially making the background weather information transparent to its end users.

2.1.6 Another key precept of NextGen is the characterization of weather forecast uncertainty. Users require deterministic weather information, 0% or 100%, but forecasts can only be prepared in varying degrees of probabilities from 1 to 99%. Producers (human and machine) of weather forecasts must work to understand the terms that the various consumers (human and machine) of weather forecasts require to make an objective, deterministic decision.

2.2 The information provided above clearly shows that the meteorological services for the next decade will be far more complex than the traditional services currently provided.

3. WAFS – A GLOBAL 4-D WEATHER CUBE

3.1 The WAFS program has provided the frame work for a 4-D Weather Cube since the introduction of the grid point wind and temperature forecasts in Amendment 65 to Annex 3 (1983). Amendment 75 has added turbulence, icing and cumulonimbus (CB) clouds in grid point format to the WAFS global data set which now consists of:

-Upper air wind (FL050 and above)
-Upper air temperature (including tropopause) (FL050 and above)
-Upper air humidity (FL050 to FL180)
-Turbulence (CAT) (FL240 and above)
-Turbulence (in-cloud) (FL100 to FL300)
-Icing (FL060 to FL300)
-Cumulonimbus (CB) Cloud
-Direction, speed and flight level of maximum wind (jet stream)

All the above elements are provided in 4 dimensions.

x and y = Spatial resolution of 1.25 degree of latitude and longitude.

z = Vertical resolution in layers from 850 hPa (FL 050) up to 100 hPa (FL 530) (depending on the element).

t = 3 hourly temporal resolution from 6 hour through 36 hour.

Production is 4 times a day based on 00Z, 06Z, 12Z, and 18Z data.

3.2 The WAFS upper-air gridded data set provides users with the opportunity to plan more efficient flights, especially long-haul flights. Flight planning systems can ingest the data to produce flight profiles that take advantage of the most favorable winds, as well as consider turbulence forecasts and the other WAFS gridded hazardous weather elements, depending on the needs of their flight operations.

3.3 In an effort to harmonize the WAFS upper-air gridded forecasts from the two WAFCs, the WAFCs have considered a blended output of certain elements, such as turbulence. This is being considered since each WAFC uses distinct numerical weather prediction models, and differences in output occur because of the characteristics of each model. This blending of certain WAFC Washington and London gridded forecasts into one gridded forecast could provide users with the first generation of a single source, i.e., an example of a SAS.

3.4 The data listed in 3.1 above may be sufficient for today's flight planning needs, but is not sufficient for the needs of tomorrow's PBN. The WAFS gridded data set only provides MET information for en-route flight planning, not the entire ground and flight operations (taxi-takeoff-climb-cruise-approach-landing-taxi), and is very coarse in temporal and spatial resolution, as well as update frequency.

4. REGIONAL SYSTEMS

4.1 At the eighth meeting of the Aerodrome Meteorological and Observing Forecast Study Group (AMOFSG/8), a briefing was provided by the WMO Expert Team (ET) on the concept of a New Terminal Forecast. This briefing provided examples of several MET systems being tested or used in many parts of the world to accommodate the short-falls of today's MET information for Terminal Control Area (TMA) and aerodromes.

4.2 At the second meeting of the Meteorological Warnings Study Group (METWSG/2), the concept of regionalized SIGMET advisory centers was proposed and tasked for study by an ad hoc group. One of the considerations by the ad hoc group was the use of WAFS gridded data sets for the preparation of SIGMET Advisories, which Meteorological Watch Offices (MWO) could use to prepare and issue SIGMET Information (a.k.a., SIGMET). The conclusions to be presented to METWSG/3 regarding the use of WAFS gridded data was that these data could be used in conjunction with other data sets and forecaster expertise to formulate SIGMET advisories, but that the concept of automated SIGMET production/issuance from model output alone was not to be endorsed.

5. SARPS

5.1 Annex 3 is structured for today's weather forecasts and products, such as paper-based Significant Weather (SIGWX) Forecasts, and teletype generation-based coded TAFs, METARs and SIGMETs. Global MET for global ATM and PBN will require much more information than is provided by these traditional chart and txt based products. To support PBN the MET data will be drawn from a 4-D Cube that will be integrated into risk-based flight path trajectories.

5.2 The current content and structure of Annex 3 does not support the future evolutionary changes to accommodate MET for ATM and PBN. ICAO will have to determine how best to accommodate these new operational requirements. One possibility is to provide a stand alone manual which has enabling clauses in Annex 3. Another possibility is to add a new chapter on MET for ATM and PBN to Annex 3, but place the details in a manual instead of an appendix due to the complexity of integrating MET information in the ATM process and PBN.

5.3 Figure 1 is a conceptual diagram of the MET information for various kinds of airspace depending on density of traffic and use of traditional navigation or PBN. The figure also begins the process of categorizing the functions and the services needed. But more work is needed to flush out the details of these functions. As noted above a manual would likely be the best way to capture and convey this information versus an annex.

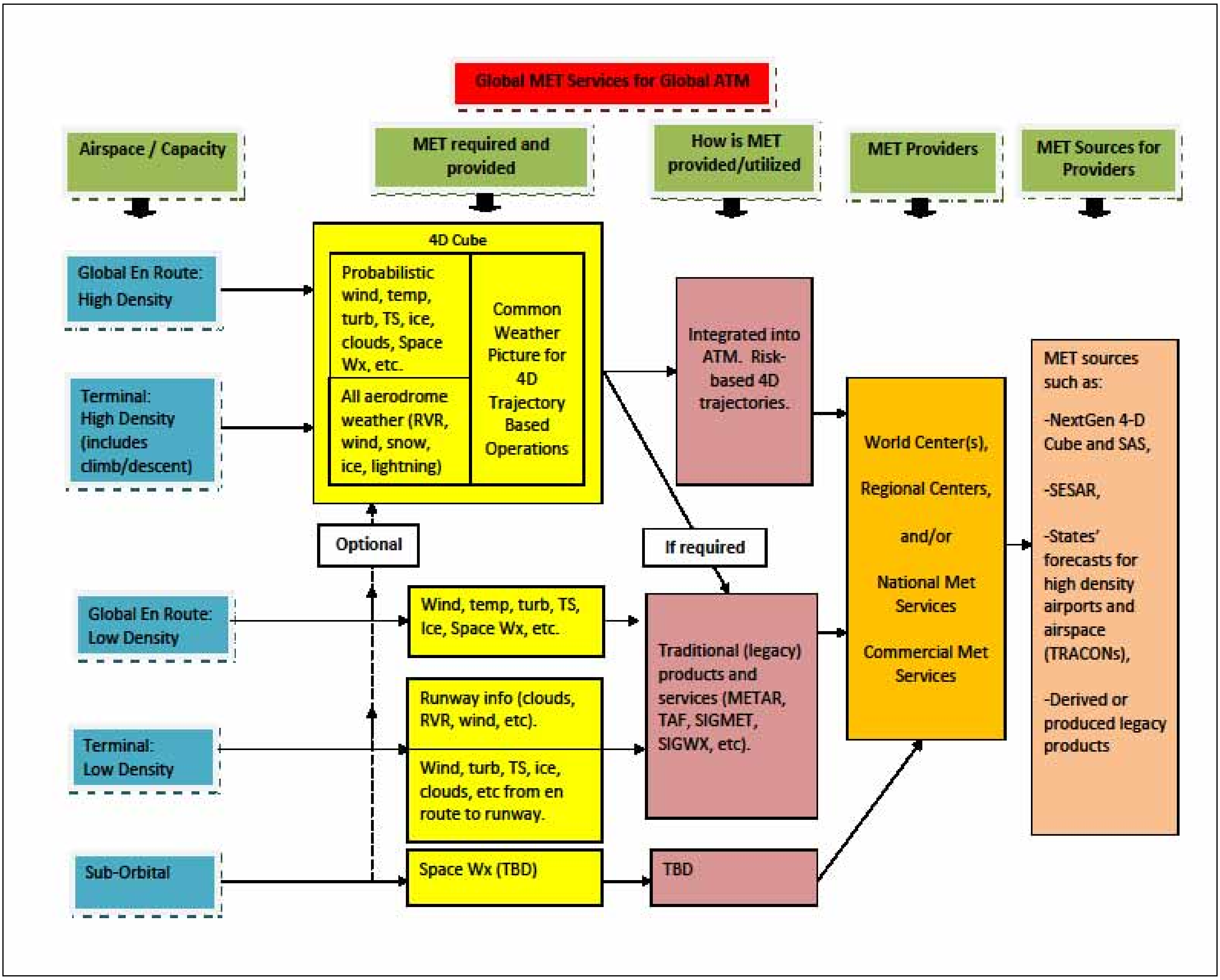

Figure 1

6. CONCLUSIONS

6.1 MET services for global ATM and PBN will become much more complex and different from today's simple weather text products and graphics.

6.2 There is a clear need to identify the functional requirements or MET in support of ATM and PBN. It should be noted that in part this is being accomplished through work conducted by an ad hoc group of the AMOFSG.

6.3 On completion of this work, it will also be necessary to identify how WAFS can support the implementation of integrated weather information in the ATM process and PBN.

6.4 It is likely that Annex 3 will need to evolve from product-centric to data-centric requirements.

7. ACTION BY THE WAFSOPSG

7.1 The group is invited to note the information in the paper.

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