

# WORLD METEOROLOGICAL ORGANIZATION

## Workshop on Aircraft Observing System Data Management

Geneva, Switzerland, 5 – 8 June 2012

FINAL REPORT



## EXECUTIVE SUMMARY

The Workshop on Aircraft Observing System Data Management was hosted by the WMO Secretariat, over 5-8 June, 2012, in Geneva, Switzerland. The Workshop was a joint initiative of the WMO AMDAR Panel and the CBS Expert Team on Aircraft-based Observations (ET-AIR).

The aims and objectives, which are provided in full within [Appendix II](#), were chiefly concerned with furthering two tasks within the WIGOS Pilot Project for AMDAR, namely the “Development of a standardised Quality Management Framework for AMDAR data”, and, the “Application of WMO Metadata relevant to AMDAR”. The Workshop also covered a number of related issues and aspects which were considered to be important in the ongoing responsibility of developing and maintaining a Quality Management Framework for the aircraft observing system, as a sub-system of WIGOS.

The Workshop was attended by a number of experts from various Regions and meteorological centres (see [Appendix I](#)), all having skills and expertise in various areas associated either directly with Aircraft Observations (AO) data management or else from a data user background either in Numerical Weather Prediction (NWP) or other application areas. The Participants worked diligently in the lead up to the Workshop to produce a set of documents that summarized the relevant information and issues related to a range of aspects and areas associated with the development of the AO Data Management Framework. These documents were presented and discussed by the Participants during the first part of the Workshop, after which two Breakout Sessions were conducted. During these sessions, the Participants discussed in more detail the issues and ideas that had been formulated, began work on identifying and defining strategies for solutions for some areas and developed a set of recommendations to be further considered and taken up by the Panel and ET-AIR ([see Appendix VI](#)).

Importantly, the Workshop received presentations on, and took into consideration, various other over-arching or guiding aspects relevant to the AO Data Management Framework, including the WMO Information System (WIS), the (draft) Implementation Plan for WIGOS, the (draft) Implementation Plan for the Evolution of Global Observing Systems and the WMO Data Management Framework.

Significant outcomes from the Workshop include: a proposal for the definition of a new or updated Data Management Framework for the Aircraft Observing System, including the management of AMDAR and other AO data sources; the further review and refinement of the metadata requirements; and, recommendations for improvements to the Quality Management System for AO data, including Quality Control, Quality Monitoring and Quality Assurance procedures and processes.

This Final Report provides a summary of the documents, discussions and issues that were considered and documents the work carried out and the proposals and recommendations made during the Workshop.

The Workshop was considered by Participants to have been successful, beneficial and to have achieved the prescribed aims and objectives.

WMO and the AMDAR Panel thanked all Members and Participants that contributed.

## **ADOPTED AGENDA**

- 1 Opening
- 2 Aircraft Observing System Data Management - Current Status and Considerations
- 3 User Requirements for the AO DM Framework
- 4 Aircraft Observations Metadata Management
- 5 Data Quality Management
- 6 Workshop Breakout Sessions
- 7 New, Improved Data Management Framework for Aircraft Observations
- 8 Compiling the Final Report
- 9 Close

## **APPENDICES**

- Appendix I [List of Participants](#)
- Appendix II [WMO AMDAR Panel Workshop on Aircraft Observing System Data Management Aims and Objectives](#)
- Appendix III [Reports of Workshop Breakout Sessions](#)
- Appendix IV [Survey Results on AMDAR Programme Data Policy Status](#)
- Appendix V [Outline for the Definition of the Global AO DM Framework](#)
- Appendix VI [Recommendations and Actions](#)

## **GENERAL SUMMARY OF THE WORKSHOP**

### **1 OPENING**

- 1.1 The Workshop was opened at 9am on Tuesday 5 June by Dr Wenjian Zhang, Director of Observing and Information Systems on behalf of the WMO Secretary General and by the Chair of the WMO AMDAR Panel and the CBS Expert Team on Aircraft-based Observations, Mr Frank Grooters. Dr Zhang spoke of the importance and timeliness of the workshop, particularly taking into account the significant and positive role that aircraft observations have continued to play in the provision of global upper air observations for Numerical Weather Prediction (NWP) and other meteorological application areas, as demonstrated at the recent Workshop on the Impact of Observing Systems on NWP in Sedona, USA (May 2012). The Aircraft Observing System (AOS) and the AMDAR Observing System in particular, through the data management framework that underpins it, would also provide important input to the implementation of the WMO Integrated Global Observing System (WIGOS) and the Global Framework for Climate Services. Dr Zhang also emphasized the need to consider the requirements of developing countries and programmes, particularly within Regional Association I, where aircraft observations will be vital in the development or strengthening of viable upper air measurements. Mr Grooters thanked the workshop participants for their agreement to contribute to the Workshop and for the collaborative work they had undertaken in the lead-up to it, which had resulted in the submission by participants of a set of documents providing a firm basis for discussion and review. The Chair explained that the key objectives of the meeting were to resolve a range of issues related to the AOS Data Management Framework (DMF) that had been identified both before and in the lead-up to the workshop, with the chief aim to make recommendations towards the improvement and strengthening of the AOS DMF.
- 1.2 The agenda and schedule for the workshop were discussed and adopted with some minor alterations and were comprised of approximately one and a half days for presentation and discussion of submitted papers, their associated issues and recommendations, followed by two workshop/breakout sessions.

### **2 AIRCRAFT OBSERVING SYSTEM DATA MANAGEMENT - CURRENT STATUS AND CONSIDERATIONS**

#### **2.1 Status of the Aircraft Observing System**

- 2.1.1. The Secretariat presented an overview of the current status of the Aircraft Observing System, which consists of two main data sources: those data derived from ICAO systems such as Automatic Dependent Surveillance (ADS); and those derived from the WMO AMDAR Programme, with the latter providing the vast majority of Aircraft Observations (AO).
- 2.1.2. The AOS currently provides around 300,000 upper air observations per day with more than 250,000 of those from AMDAR. The AMDAR programme is comprised of 11 national and regional programmes, 35 airlines and over 3000 aircraft. Around 2400 aircraft report in WMO FM94 format, whilst the remainder provides observations in FM42 format. Data derived from the ADS system comprises around 15,000 observations per day from around 2000 aircraft.

2.1.3. Global aircraft observations vertical profile coverage is relatively dense over the USA, Western Europe and parts of Asia with good coverage also over the Australasian region and Southern Africa. Data from the upper troposphere is provided by AMDAR and ADS aircraft while at cruise level and is relatively dense over Europe, North America and the northern Atlantic and Pacific oceans. There is generally poor coverage over other areas of the globe where AMDAR programmes have not yet been developed.

## 2.2 **Definition of the Current Aircraft Observations Data Management Framework and Issues**

2.2.1. Dr Jitze van der Meulen presented an overview on the current practices in aircraft observations data management. The data management practices are largely based on the detailed recommendations in the AMDAR Reference Manual (WMO-No. 958). Other relevant WMO documentation on data management is published in manuals and guides including the Manual on the Global Data-processing and Forecasting System (Man. GDPFS, WMO-No. 485), the Guide to the Global Observing System (Guide to the GOS, WMO-No. 488), the Guide to Meteorological Instruments and Methods of Observation (CIMO Guide, WMO-No. 8). While it would be expected that the Guide on World Weather Watch Data Management (WWW/DM Guide, WMO-No. 788, 1993) would be a suitable publication for such material, Aircraft Observations (AO) and AMDAR data management is not covered well. Although CBS (OPAG ISS) was active with the further integration of data management in WMO programmes, no significant activity is currently underway.

2.2.2. Reference was made to current implementation of the WMO Quality Management Framework (QMF). This framework, largely based on ISO-9000 standards, focuses strongly of appropriate documentation of organizational processes or procedures. Nevertheless it is useful for further implementation of AMDAR data management in national and international organizations, providing a strategic, managing and operational structure. Such structure is found to be required for successful implementation of any data management practices.

2.2.3. For AMDAR data management and for aircraft observations in general, it is relevant that the whole chain of practices is covered (see AMDAR Reference Manual), i.e. from data input (in co-operation with the airlines and ICAO) up to data delivery (inclusive data displaying facilities). Within its framework, data management covers data quality assessment as well. This assessment shall be part of observational data quality assurance procedures as recommended by WMO (CIMO Guide, WMO-No. 8).

2.2.4. For quality assurance, reference was made to Manual on the GDPFS, which documents the criteria to indicate if aircraft data is suspect and the ongoing practice to prevent transmission of erroneous data over the GTS. After discussing these practices it was concluded that it was not feasible to require extensive QC processing of data in real time for checking and filtering data because of the requirement for minimal data latency (e.g. 15 minutes or less). However flagging the data (as suspect) before dissemination as a first step in the Q/C process will be a suitable solution. Within this context the various steps of quality control, monitoring and evaluation should be defined and standardized. Uniformity and standardization is relevant because of the required inter-comparison actions by the various regional data monitoring and data quality evaluation centres.

However, before implementing such standards more studies on the technology of comparing observational data with NWP references will be necessary.

#### 2.2.5. Recommendations:

- 1) A data management framework, in line with WMO's QMF and WIS policies and in line with the AMDAR reference manual, shall be further developed to such extent that implementation in national and regional bodies can be carried out. Such a framework may have a generic structure.
- 2) Universal procedures shall be developed for standard practices to [1] check and flag data in real-time before dissemination over the GTS, and [2] to monitor and evaluate data. Results of these practices should be in a standard format, to be use as metadata, capable for archiving purposes. Moreover these procedures shall be inclusive of feed back practices.
- 3) New guidance material on data management for WWW practices shall be developed to replace to current Guide on Data Management (WMO-No. 788), which is out of date.

#### 2.3 WMO Quality Management Framework (QMF) Concept, Requirements of Observations Systems & Requirements of AO DM Framework

2.3.1. Dr Herbert Puempel from the Secretariat made a presentation on the WMO Quality Management Framework (QMF) and relevant considerations for data management practices and processes for observing systems.

2.3.2. The fundamental basis for QMF development and in particular for WIGOS should be in accordance with Cg-XV Res. 32 and WMO Quality Policy. This aims to ensure that the best possible products and services are delivered to end users by embracing the QMF and the development, use and maintenance of the relevant WMO technical regulations to ensure that observations, records and reports on weather, water, climate and the natural environment are of documented quality for international exchange through the WMO coordinated systems and relevant joint standards with other international organizations. This involves the development of agreed-upon quality assurance and quality control standards, with the goals of developing and implementing an integrated quality management system that delivers reliable and timely data streams with adequate quality control and relevant metadata.

2.3.3. More specifically, NMHSs are requested to: carry out quality control of on-site observations; ensure traceability of measurement; and ensure that observations, records, reports, forecasts and warning services are of an identified quality for international exchange through the WMO coordinated systems (i.e. WIGOS) and relevant joint standards with other international organizations. For observing systems, the fundamental aspects required for a QMF are: to ensure quality control of observations, documentation of quality, provision of required metadata, implementation of Quality Management Systems (for components of the observing system), and, to implement relevant observing system interoperability and data compatibility arrangements.

2.3.4. In the development of a QMF and the QMSs that underpin it, managers should adhere to 8 principles: 1) Customer Focus (requirements from a customer base); 2) Leadership; 3) Involvement of People (all those in supply chain aware of QMF); 4) Process Approach

(quality of inputs, outputs and their interaction); 5) System Approach to Management; 6) Continual Improvement; 7) Factual Approach to Decision Making; and, 8) Mutually Beneficial Supplier Relationship.

2.3.5. Related recommendations are made in [Appendix VI](#).

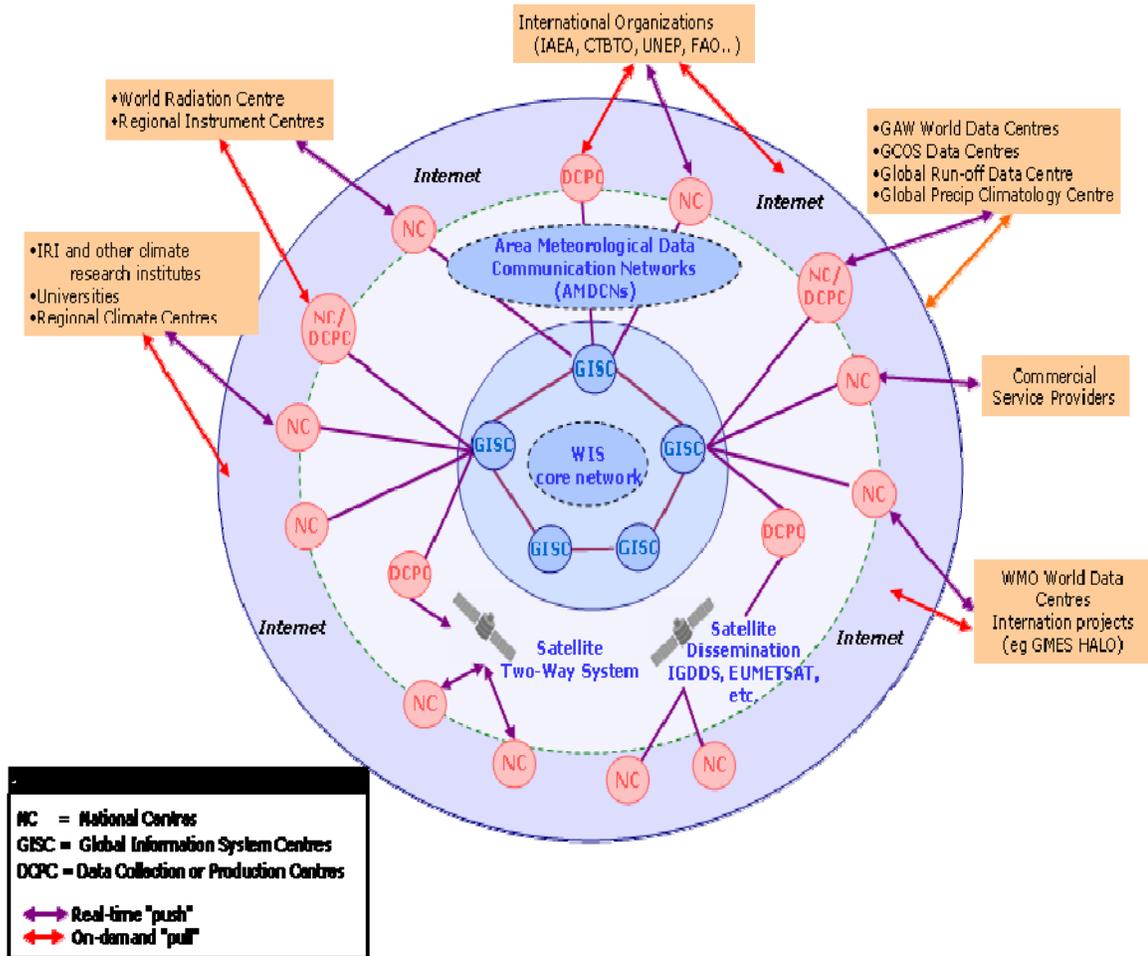
## 2.4 **WMO Information System Concept, Requirements of Observations Systems & Requirements of AO DM Framework**

2.4.1. Mr Stephen Foreman from the WMO Secretariat provided a paper and made a presentation on the WMO Information System (WIS) that outlined what it is, the aims for it, as well as the requirements for the AO DMF to support WIS and the ways in which WIS can support the AOS.

2.4.2. WIS is intended to build on the success of the GTS, and is taking an evolutionary approach, adding new access and telecommunications technologies to those of the GTS while allowing existing GTS users to maintain an unbroken service. The WIS Specifications (in the Manual on WIS) give the technical and procedural constraints that centres operating as information providers within WIS have to meet, and the Guide to the WIS provides guidance on how the WIS should operate. The basic aims of WIS are to: 1) Increase data and products visibility; 2) Broaden and streamline access; 3) Simplify the process for obtaining information on and access to data and products. WIS will meet the requirements for accessibility of information and products for all WMO Programmes that require such accessibility including: the Global Framework for Climate Services (GFCS), Global Cryosphere Watch (GCW), Global Atmosphere Watch (GAW), WIGOS, etc.

2.4.3. The fundamental building blocks of the WIS will be its data management centres, which consist of 3 basic types:

- Global Information System Centres, GISCs: Hold the metadata catalogues, ensure that the regularly required information is passed rapidly and reliably around the world, and act as a conduit between the other types of centre and the rest of the world;
- Data Collection or Production Centres, DCPCs: are those with a specialist role; this may be in creating numerical products (such as ECMWF), collecting observations (such as EUMETSAT), or channelling information to the GISCs (the current Regional Telecommunications Hub role), or providing support for particular Programmes (such as the Arctic Data Centre); and,
- National Centres, NCs: centres that have a national responsibility; the National Meteorological Service will provide an NC, for example, but there may be others (such as an oceanographic centre). NCs will usually provide the main interface between national users and the WIS.



2.4.4. To facilitate the exchange of data, products and related information using the WIS, programmes are required to submit WIS discovery metadata that supports the data discovery functionality. This information exchange process will be put in place through an arrangement between either a NC or a DCPC with a GISC, in which the relevant metadata describing the data or product is developed and provided to the GISC. The WIS metadata record that describes each product uses the WMO Core Profile of the ISO 19115 Standard and allows users of WIS to find the dataset, learn a little about it and find out how to get access to it. The data originator (e.g. an AMDAR Programme) is responsible for defining the scope of a dataset, which may be as little as a single metadata record to describe a routinely generated bulletin or data product, whilst data or a product archived at a data centre for example, would require an additional metadata record. The NC or DCPC is responsible for negotiation with their principal GISC how to upload the metadata records to the GISC, and the method for ensuring uniqueness of the metadata identifier within WIS will form part of that negotiation. In practice, GISCs provide standard tools for uploading metadata, and it is highly likely that the negotiations amount to agreement on which of the standard tools will be used. More information about the WIS discovery metadata standard is available from [http://www.wmo.int/pages/mediacentre/press\\_releases/pr\\_831\\_en.html](http://www.wmo.int/pages/mediacentre/press_releases/pr_831_en.html).

- 2.4.5. Actual data or product exchange via the WIS will be highly dependent on the data product, its requirements for availability and routine exchange and the IT and communications infrastructure available to support data delivery. Whilst this may be facilitated through normal GTS processes and protocols, WIS extends this functionality through mediums such as FTP, email and interactive data upload.
- 2.4.6. In the context of WIS, additional metadata required to describe data and data products which are above and beyond the requirements of the WIS data discovery function, are not held by WIS but would be a dataset or product in their own right requiring their own WIS metadata record. Data monitoring reports would also fall into this category.

## 2.5 **WIGOS Implementation Plan & Evolution of the Global Observing System Implementation Plan**

### *Implementation Plan for the Evolution of the Global Observing System*

- 2.5.1. Mr Dean Lockett from the Secretariat made a presentation on the Commission for Basic System (CBS) Implementation Plan for the Evolution of the Global Observing System (EGOS-IP), with particular focus on those aspects and actions that effect the developments of the AOS.
- 2.5.2. The EGOS-IP provides recommendations to WMO Members to guide the development and evolution of the GOS and is currently being updated by the CBS Expert Team on the Evolution of the GOS (ET-EGOS) for the period to 2025. The draft version is well advanced and expected to be finalized for presentation to CBS-XV in 2012. The 6 recommended actions (draft 11.02) associated with development and evolution of Aircraft Meteorological Stations were presented along with the plans and current activities underway within the Aircraft Observations Programme in support of their achievement. The Participants were advised that these long-term developments should be given consideration in the development of the DMF for the AOS.
- 2.5.3. The first action aims to “Improve AMDAR coverage...especially within Regions I and III, focusing on the provision of data at airports in the tropics and southern hemisphere where vertical profiles are most needed to complement current radiosonde data coverage and its likely evolution”. The AO Programme and particularly the WMO AMDAR Panel has a major focus on this activity. This includes: working with the Mexican meteorological service (SMN), NOAA and ARINC to establish an AMDAR Programme with Aeromexico; collaborating with aviation Data Service Providers (DSPs) towards a regional approach to programme development; and, promoting standardization of software and sensors with aircraft and avionics vendors and developers. It was very roughly estimated that AMDAR Programme development over the coming 10 to 15 years has the potential to see the data volume grow by 5 to 10 times and the DMF will need to be designed to manage these increased data levels.
- 2.5.4. The 2<sup>nd</sup> action encompasses the extension and enhancement of AMDAR coverage through both the expansion of AMDAR fleets operating internationally and the wider use of AMDAR data optimization systems so as to facilitate production of data outside of national and regional boundaries with appropriate agreements and cost-sharing to be put in place. The AO Programme has several activities and initiatives associated with

software and optimization capability development and standardization in line with this action. While optimization will act to reduce redundant data levels, overall these initiatives are expected to assist in AMDAR Programme expansion and increase data volumes.

- 2.5.5. The 3<sup>rd</sup> action encourages the development of standards for software, communications and sensors within the programme so as to facilitate greater and easier programme participation from the aviation industry as well as to ensure the reliability and continuity of the programme in the future. Whilst contributing to programme enhancement and data volume increases, the activities being undertaken in the AO Programme, which include maintenance and refinement of existing AMDAR software standards (ARINC 620 and AAA) should also standardize and simplify data management practices.
- 2.5.6. The 4<sup>th</sup> action urges the wider implementation of humidity measurement from the aircraft platform, which the AO Programme is diligently working towards. Wider implementation is expected in the short to medium term in the USA and Europe with a humidity measurement programme development also currently underway in Australia. The implication and challenge for the AO DMF is to be able to address the data and data quality management aspects of this additional variable.
- 2.5.7. The 5<sup>th</sup> action also addresses an extension of the reporting capability of the AMDAR programme to accommodate turbulence and icing variables, for which the AO Programme has several activities in progress and planned including a workshop on turbulence to take place in conjunction with the AMDAR Panel Session XV in November 2012. As with management of the water vapour variable, suitable data and data quality management processes will require development and implementation.
- 2.5.8. The final EGOS-IP action is to considerably broaden the scope of the AOS to include the activation of smaller (General Aviation) aircraft as technological capability and development allows. While this relies much on developments in private industry such as the AirDat TAMDAR and the AeroMechanical Services AFIRS systems, the AO Programme is also monitoring developments and expecting to benefit from activities in this area (i.e. reporting from GA aircraft) within ICAO with the development of the ADS-B and Mode S avionics systems. These systems, whilst serving the aviation community in providing for future needs in aircraft surveillance for Air Traffic Management, will also have the capacity to report large volumes of meteorological observations of temperature and winds. The challenge for the AO DMF will be to be able to manage the considerable expansion in the AO data volume and also, and most particularly, to be able to handle the quality control and quality assurance processes, which are expected to be very challenging.
- 2.5.9. Related recommendations are made in [Appendix VI](#).

#### ***The WMO Integrated Global Observing System Implementation Plan***

- 2.5.10. Dr Miroslav Ondráš from the Secretariat provided the Workshop with a presentation on the development of the Implementation Plan for WIGOS and set out the implications for the AOS as a WIGOS sub-system.

2.5.11. It was reiterated that the AOS is an important sub-system of the Global Observing System, which was itself a sub-component of the WMO Integrated Global Observing System (WIGOS) being formally defined to meet the requirements of all application areas and programmes tasked with monitoring the complete and complex atmosphere, land and ocean system. In addition to the systems traditionally associated with the GOS, WIGOS incorporates those operational observing systems and sub-systems from Global Atmosphere Watch (GAW), Global Cryosphere Watch (GCW) and World and Hydrological Cycle Observing System (WHyCOS) that provide observations in support of this wider monitoring function.

2.5.12. With the period of developing and testing the concept of WIGOS occurring over 2007 to 2011 and now complete, WIGOS was now moving to the implementation phase, which will occur over the period 2012 to 2015 and for which the WIGOS Framework Implementation Plan (WIP) will be finalized pending the approval of EC-LXIV in 2012. The WIP and the CBS EGOS-IP will together provide guidance and a global planning framework within which WMO Members can base their own plans for development and evolution of their observing systems.

2.5.13. The aspects of the WIP and desired features of WIGOS that have implications for the future management and operation of observing systems, including the AOS, are the following:

- **Design, planning and optimized evolution of WIGOS component observing systems:** Planning and design of systems is based on an efficient and standards-based approach to meeting the requirements of users and stakeholders;
- **Integrated Observing System Operation and Maintenance:** A uniform and integrated approach based on WMO regulations;
- **Integrated Quality Management:** Ensure that requirements and quality standards of users are met;
- **Standardization, System Interoperability and Data Compatibility:** Systems are designed to ensure products generated are delivered efficiently and fit for purpose;
- **The WIGOS Information Resource; and,**
- **Data Discovery, Delivery and Archival:** Users and stakeholders have ready access to the required products and the necessary information about them.

2.5.14. **Recommendation:** The DMF for the Aircraft Observing System should be developed and structured in such a way that is compatible with the plans for the implementation of WIGOS and for the evolution of the GOS.

### **3 USER REQUIREMENTS FOR THE AIRCRAFT OBSERVATIONS DATA MANAGEMENT FRAMEWORK**

#### **3.1 Requirements of AO data for NWP**

3.1.1. Dr Drasko Vasiljevic, ECMWF, led the collaborative work to research and present the requirements and related issues of NWP for the AO DMF.

3.1.2. It has been well established through many NWP observing system experiments that aircraft measurements are very valuable for NWP systems. This is due to several factors,

which include the large number, timeliness and high frequency of reports, the high quality of the data and the resolution of vertical profiles which are derived from the aircraft on ascents and descents near airports.

- 3.1.3. Given their value to NWP, it is obvious that NWP developers and users fully support the actions and imperative to expand and enhance the coverage of the AOS, which includes the extension of AMDAR to smaller aircraft operating out of smaller, regional centres and airports so as to extend the coverage of vertical profiles.
- 3.1.4. The Workshop considered that, whilst quality control and quality assurance prior to delivery of AO data to NWP was less important than for other application areas because NWP assimilation schemes incorporate their own sophisticated QC processes and algorithms, the NWP community certainly encourages improvement to upstream AO QC. However, one important consideration and issue is that of data latency levels and any additional QC measures implemented should seek to at least retain or improve current data latency standards.
- 3.1.5. It was agreed that the DMF would certainly benefit from a wider and standardized exchange of NWP quality monitoring information and also from the development of an “alerting” or “notification” system to provide data users with advice regarding sustained and systematic issues with AO data quality. It was also agreed that, while some standards should be prescribed for what monitoring should be undertaken by NWP centres and how the output should be provided to systems managers, the details of defining what constitutes gross and systemic errors and how data short be categorized for quality should be largely determined by monitoring centres based on analysis of results from NWP comparisons with AO data.
- 3.1.6. It was considered that NWP would benefit from a single point of AO data delivery or access based on the establishment of a single, centralized archive if this simplified the process, however, as for the issue of data QC, this should not compromise data latency levels. A central data and “online” archive would also benefit NWP by providing a convenient source from which data might be accessed for “re-analysis” experiments or tests and for use by climate models which require access to longer data series.
- 3.1.7. The requirements of NWP for AOS metadata are relatively small and defined by the requirements to be able to identify the type and quality of the data variables provided and also to be able to identify observations by aircraft and report back to programme managers for correction. For the latter, this essentially means the transmission of aircraft ID with each AO datum. However, with the advent of temperature bias corrections, there will likely be a requirement to provide and maintain relatively static but more detailed aircraft-related metadata such as aircraft model, avionics software and perhaps even sensor information. The AO DMF will need to be developed to meet this future requirement.
- 3.1.8. NWP would benefit from the wider availability of additional AMDAR variable including humidity, turbulence, icing and chemical constituents.
- 3.1.9. **Recommendations:**

- 1) Effort should be made to expand the AOS to smaller regional carriers;
- 2) Quality Control and Quality Assurance should be improved as much as possible prior to data delivery without compromising current data latency levels;
- 3) A system should be developed for the exchange of global monitoring data and information in support of improved data quality management of the AOS.
- 4) Additional observed quantities should be incorporated and/or expanded as elements of the AMDAR Observing System, including humidity, turbulence and icing;
- 5) The system for management and handling of metadata requirements to support both NWP data monitoring and temperature bias correction should be developed;
- 6) Centralisation of AOS data processing should be given consideration and may benefit NWP by providing a single source for access to AO data;
- 7) NWP would benefit from access to a long-term archival of AO data in support of NWP re-analysis and observing system experiments.

### 3.2 Requirements of AO data and DM Framework for Services and Other Data Users

- 3.2.1. Mr Michael Berechree, Australia, led the collaborative work to research and present the requirements and related issues of Services and Other Data Users for the AO DMF.
- 3.2.2. The Workshop was informed that the use of AO data has a significant positive impact on weather forecast operations and the delivery of forecasting and warning services. The real time use and availability of high quality vertical profiles of AO temperature and wind by NMHSs has proven to contribute significantly to improvement in now-casting to medium-term forecasting applications and plays a crucial role in the major tasks and applications associated with the delivery of effective Weather Services. For services to aviation, this includes the provision of an Aerodrome and Area Meteorological Watch and the undertaking of detailed surveillance of weather conditions over the aerodrome and its immediate vicinity.
- 3.2.3. With the move to the implementation of Quality Management Systems incorporating continuous improvement and a focus on customer requirements, it is becoming increasingly important for service areas to undertake verification of forecasting products, for which observing systems such as the AOS play a crucial role. In addition to the standard set of upper-air variables derived from AO, aviation forecasters are also looking to make use of additional variables, including turbulence and icing, however there is currently a lack of broad scale coverage of reliable turbulence and icing reporting and greater availability of such reports would provide a distinct benefit to forecasters for verification and identification of turbulence and icing location.
- 3.2.4. **Recommendation:** In order to improve forecasting and verification of turbulence and icing forecast products and services, there is a requirement for increased coverage of both turbulence and icing observations.
- 3.2.5. In order for forecasters to confidently use available observing system data they should have at least a basic understanding and an appreciation of a range of aspects, which include: how it is generated and measured, the variables being measured, the origin or location of the report, knowledge of its availability and timeliness, its accuracy or uncertainty in measurement, access to metadata and, most crucially, how the information can be made available, displayed and utilised. Currently there are many types of display

systems available that can provide varied degrees of functionality, from a basic stand-alone system to a fully integrated display system and it is possible that the AOS and its data users could benefit from the wider availability of such systems that better cater for the use and assessment of the availability and quality of AO data.

- 3.2.6. **Recommendation:** To investigate how AO data (and possibility other upper-air observations) can be displayed to forecasters, either by a COTS AO display system or the development of an inexpensive software tool.
- 3.2.7. It is well understood and accepted that data users often have insights into the quality of the data that they utilize for the generation and verification of products and services, particularly when having the opportunity to visualize the data interactively and alongside multiple observing and NWP system outputs. However, even in the context of the operation of a NMHS, the Quality Management System often does not have the functionality for data users to be able to quickly and reliably report gross and systematic quality issues to observing system managers. For an international system such as the AOS, this aspect of the QMS certainly does not currently reliably and procedurally extend beyond organizational and national boundaries and data users often do not have a means or a procedure to report issues with data quality. The data quality of observing systems in general and, in this case, the AOS, would benefit greatly from the development of an improved QMS that includes the functionality for data users to be able to report errors and data quality issues and have them (preferably automatically) routed to the relevant observing system managers (both national and international) for rectification. A necessary extension of this is that data users should also have access to this information to be alerted to those issues and errors that have been reported by others with this information to preferably be available from within data display systems.
- 3.2.8. **Recommendation:** Investigate a method for forecasters and/or users to flag suspect AO data to a responsible network/program manager.

### 3.3 International AO Data and Metadata Archival Requirements

- 3.3.1. Dr Bradley Ballish, USA, led the collaborative work to research and present the requirements and related issues for international or global AO data and metadata archival.
- 3.3.2. The Workshop was advised that metadata are important for monitoring and data analysis purposes, particularly having the ability to link each observation and variable with an aircraft and airline identity and, in some cases to be able to link the aircraft to a model or type and even the sensor type. However, this information can be difficult to obtain and it is clear that the AOS data monitoring and data analysis processes would benefit from an internationally coordinated approach to making metadata available at the global level. Other details such as time smoothing of observations, reporting rates, and data output formats can be important depending on the issue being analysed.
- 3.3.3. The history of the many minor and serious problems with aircraft data is metadata that is in danger of being lost as experts retire without documenting and recording this information. Current and future users of AMDAR data, particularly those using the data

for long-term climate or other studies would benefit greatly from a historical record of data quality issues and it is recommended that the DMF for the AOS addresses this issue.

### 3.4 Data Policy Aspects for Aircraft Observing System Data

3.4.1. Mr Dean Lockett from the Secretariat presented a document on the current status of data policy practices and agreements that are in place for the AOS, in particular looking at those agreements or contracts that might affect the DMF with respect to the AMDAR Observing System.

3.4.2. When designing a data management framework, it is critical to take into account intellectual property rights so as to ensure that neither Data Providers nor Data Users are infringing on, or illegally making use of the property rights of other parties. This is of particular concern for consideration of Aircraft Observations because the data always originates from the property of airlines or the aviation industry.

3.4.3. All operational AMDAR Programmes currently provide AMDAR data on the GTS in support of WMO Resolution 40. Currently, the global programme is comprised of 10 Programmes, 36 (or more) airlines and around 2700 aircraft. The programme provides between 250,000 and 300,000 observations per day on the GTS.

3.4.4. In the lead-up to compilation of this document, WMO Aircraft Observations Focal Points were contacted to survey the status of AMDAR Programme data policy from both a national and global data rights perspective. The questions posed and the responses made are provided in [Appendix IV](#). The following points are made in relation to the survey:

- The survey represents feedback from programmes covering 7 of 10 programmes, 31 of 35 airlines, the majority of participating aircraft and data derived.
- 27 of 31 airlines are covered by an agreement or contract under the programme operation.
- 26 of the 27 agreements specifically deal with the issue of data ownership or data use.
- All programmes are able to comply with the requirements of WMO Resolution 40; however 5 of the 7 programmes do not currently specifically address this issue in the agreement or do not have an agreement. The two largest programmes, the USA and E-AMDAR, which contribute around 80% of all AMDAR data are contractually compliant with WMO Resolution 40.
- Responses to Question 10, relating to the issue of contribution of AMDAR data to a long-term archive with unrestricted public access, suggest that this matter is not specifically dealt with in existing agreements and would require clarification possibly negotiation between NMHSs and airlines.
- Release of data for this purpose may also be subject to NMHS standards and requirements for quality control of such data, which are likely to be more stringent and lead to longer latencies than for data provided for real- or near-real-time use.

3.4.5. The following were put forward as issues that should be taken into consideration in the design and strategy for development of the Aircraft Observations Data Management Framework:

- 1) While Data Policies of current AMDAR Programmes generally allow compliance with WMO Resolution 40, it is important that future new and updated agreements are more carefully negotiated so as to ensure compliance with Resolution 40. Ideally, such agreements should also take into account the contribution of AMDAR data to longer-term, public data archive in support of climate application area requirements. WMO should ensure that Members are aware of the issue and seek to put in place agreements that ensure the ability of programmes to comply with WMO Resolution 40.
- 2) Varying Data Policies among AMDAR Programmes will need to be taken into account in the design and establishment of any online public archive of AMDAR data and it may be necessary to facilitate delayed release of some data so as to comply with specific programme policies.
- 3) Varying Quality Control or Quality Assurance practices and requirements among NMHSs will also require handling, which might be accomplished by delaying the release or access to AMDAR data until appropriate QA flags are set. This has implications for database or archive design.

### **3.5 International Aircraft Observations Data Access and Display Requirements & Functions for Data Users**

- 3.5.1. Dr Bill Moninger, USA, led the collaborative work to research and present the requirements and issues related to AOS data access and data display.
- 3.5.2. It was pointed out that there are now quite a few software systems and platforms providing the functionality to display AO data, with varying levels of integration into NMHS operational IT systems and varying levels of functionality. Some systems are limited to display of AO data only, while others incorporate the display of, and integration with other observing, NWP and satellite system outputs. Some systems have been developed by NMHSs, while others have been developed by private industry based on NMHS specification and are designed for direct interfacing to GTS data products. A short description of those known or made known was provided in the submitted document.
- 3.5.3. In considering how to improve access to AO data and display systems, it is important to carefully identify the potential user classes, who may have different needs. These include:
  - Weather forecasters in developed, high-infrastructure nations;
  - Weather forecasters in developing, low-infrastructure nations;
  - Airline weather departments;
  - Airline dispatchers/operations;
  - AOS programme and data managers.
- 3.5.4. While weather forecasters are generally well-catered for in developed nations there is certainly a requirement to propose and implement solutions for developing nations with low-infrastructure capabilities, where the required and desired development of AMDAR programmes and access to AO data are somewhat linked. Essentially, the issues in these countries are twofold: 1) Having the necessary communications infrastructure to support the delivery of either the data itself or the display output provided from a remote server

over the internet say; and, 2) Having the necessary hardware and or software on the ground to facilitate either data decode and display; or, data display via a remotely-served display application.

- 3.5.5. Having been made clear that AO and AMDAR data are required from Africa and South America to bolster and improve the upper air coverage over RA I and RA III, it was pointed out to the Workshop that, in order to encourage African NMSs to participate in AMDAR, a display system is needed that can be used in those countries. Such a display system could be developed with support from the AMDAR Trust Fund but, unless there is buy-in from the planned recipients of the display system, it is unlikely to be used. In addition, training is critical: even in developed nations, forecasters won't use AMDAR data unless they are made aware of it and its advantages for forecasting applications. A possible solution would be to develop a system that could display AO data distributed by satellite. Such a system, targeting African countries, was proposed in 1997 by NOAA/ESRL/GSD at the request of the then AMDAR Technical Coordinator. The system was not adapted at that time because the target countries could not justify the cost. Nonetheless, the proposal describes in some detail the issues that would need to be addressed in implementing a system that could be useful in low-infrastructure nations. Some other possible solutions were also considered including "cloud computing", the use of an "open source" approach to display system development and the tailoring of existing commercial applications for AO display purposes through an approach to the market. The latter seems likely to be best solution to investigate first and would be ideal if the vendor is able to support and provide a range of solutions for data delivery and access.
- 3.5.6. Mr Michael Berechree gave a presentation on the integrated data display system, "Visual Weather" that the Australian Bureau of Meteorology will roll out under the Aviation Forecast and Visualisation System (Av4Vis) project and was developed commercially by IBL Software Engineering. Visual Weather is a software application for reception, processing, and representation of meteorological data, integrating many types of meteorological tasks and is able to receive, store, and process all types of WMO messages, conforming to WMO 306 Manual on Codes, including AMDAR (FM42) and BUFR. Visual Weather has flexible capabilities for data reception and transmission (i.e. a Message Switch functionality), including the UK MetOffice developed SAteellite DIStribution system, SADIS and is portable to a several hardware platforms. While this application provides a multi-function and complex solution for displaying a large range of meteorological and aviation data types, products and diagnostics that is far beyond the scope and requirements for delivering and displaying AO data, the software architecture and data management framework is consistent with the perceived requirements for such an application if it were considerably scaled down in functionality. The Workshop considered that it would be well worth investigating whether IBL might be considered for developing an AO-specific solution for display of AO data.
- 3.5.7. The Workshop was also provided with a presentation by Dr Tattiana Bazlova and Dr Nikolay Bocharnikov from the Institute of Radar Meteorology (IRAM), Russia on a software product developed by IRAM that has the capability to display FM42 and FM94 AMDAR data accessed from a connection to the WMO GTS. The application obtains and compiles upper air data profiles for display in the vicinity of a set of configurable locations such as airports or meteorological stations. Based on the constructed set of vertical profiles of AMDAR variables and some derivatives (e.g. wind shear and turbulence

index), the user is able to display the data in tabular, geographical or graphical (SkewT) form, including humidity when available. The system is used for a range of purposes and applications including: standard aviation forecasts, Regional and Global NWP, estimation of 0° and -22°C - levels (for radar data processing), wind shear warnings, verification of forecasts (wind, temperature, turbulence, icing) and validation of Doppler weather radar data. Given its simplicity of design and functionality and the fact that this application is already specifically tailored for AO data display from the GTS, the Workshop considered it to have great potential as a solution and should be investigated further.

#### 3.5.8. It was recommended that:

- 1) Contacts in African NMSs should be cultivated, and encouraged to ascertain the potential of AMDAR. If this task is not successful, subsequent tasks should not be pursued;
- 2) Insure that there is useful AMDAR data to be displayed in target African countries;
- 3) Develop and deploy an AMDAR display system tailored to the infrastructure available in the target African countries. Consider asking IBL to develop a suitable version of their "Visual Weather" system. Consider whether the IRAM system might meet these needs;
- 4) Develop and implement appropriate training;
- 5) Provide simple AMDAR quality information to forecasters as a part of their display systems. To do this, it may prove useful to add this quality metadata to the data BUFR messages themselves. (Current format seems to allow a little info to be transmitted.) This information should consist of multi-day bias of the aircraft with respect to one or more NWP models. This would require an NWP center to add this information before the data goes out on the GTS;
- 6) Maintain and enhance person-to-person relationships between AO Data Processing Centers and data providers, as E-AMDAR now does. Any Data Management Framework should encourage this kind of personal relationship-building; and,
- 7) Display systems should allow feedback from users to AO data managers. Feedback should be vetted by the data managers before any data are declared suspect or bad.

## 4 AIRCRAFT OBSERVATIONS METADATA MANAGEMENT

- 4.1.1. Mr Stewart Taylor, UK, the AMDAR Panel Coordinator for Improvement in Data Exchange and QC, led the collaborative work to research and present the requirements and issues related to AOS metadata management.
- 4.1.2. The Workshop was informed that the AO programme had made progress on the definition of a metadata template for AMDAR under a task within the WIGOS Pilot Project for AMDAR. The Metadata Template was designed to meet AMDAR requirements for quality control (QC) and asset tracking. It had been agreed that a subset of the AMDAR metadata dataset should be required to support the WMO Information System (WIS) data discovery functionality.
- 4.1.3. It was concluded that there is a clear need for the definition of a standard metadata dataset for the AOS that will incorporate requirements for metadata collection, maintenance and provision at 3 levels: the participating airline; the programme operations level and the international level. The management of metadata requires consideration as an important component of the full AO DMF and the structure that supports the management of the AO data product and its delivery should be designed so as to ensure

metadata is well managed and meets requirements to support quality management of the AOS.

- 4.1.4. A range of issues associated with the definition of AO metadata were raised and considered within Breakout Session 1, Group 2 (see [Appendix III](#)).

## 5 DATA QUALITY MANAGEMENT

### 5.1 AMDAR Air Temperature Bias

- 5.1.1. Dr Bradley Ballish, USA, provided a document and made a presentation on the long-identified issue of temperature bias in AMDAR data and the recent move to correct the data within the assimilation schemes of NWP systems.
- 5.1.2. Studies have shown that aircraft temperature biases tend to vary with several factors including aircraft type, and flight phase (i.e. whether the aircraft is on ascent or descent) but there are also variations in bias within these categories. This suggests that a NWP bias correction system would determine a bias correction on an aircraft-by-aircraft basis and rely on access to a metadata containing the required parameters.
- 5.1.3. A temperature bias correction system for the ECMWF assimilation scheme has recently been implemented (November, 2011), with reports indicating that the resulting impact has been positive. Specifically, the ECMWF results show much better fit of the analysis and forecast to both radiosonde and GPSRO data, but there was no significant impact on forecast skill.
- 5.1.4. Since most models seem to have bias impact from aircraft biases, it is recommended that aircraft temperatures be denied for a sufficient period of time for the model to have no impact from the aircraft biases. Then the analysis variational bias correction code (VARBC) routines can derive bias corrections. It is recommended that corrections be derived for level flight, but using aircraft vertical velocities a predictor for separate corrections for ascent and descent phases of flight. Once the bias corrections are derived, the aircraft temperatures can be turned on in the analysis, but used with the bias corrections applied. For aircraft with insufficient histories, they could either be used with no corrections or simply not used in areas with good aircraft data coverage. Since many aircraft have several reports all with the same time, we may only be able to estimate vertical velocities.
- 5.1.5. **Recommendation:** The global NWP community would benefit from publication of the ECMWF bias correction scheme including the method and units used to estimate aircraft vertical velocity.
- 5.1.6. The Workshop discussed whether it could be reliably determined from studies and inter-comparison results if the AO temperature data could be proven to be biased with respect to “truth” and if it were possible that differences could be due to NWP model bias arising from historical and current bias “anchored” by the radiosonde system.
- 5.1.7. The Workshop also discussed possible physical or systemic causes for a temperature bias in the aircraft data and, while it was conceded that a physical process or

measurement deficiency in the temperature probes might be responsible, it was thought more likely to be associated with a data processing issue within the avionics or software.

- 5.1.8. **Recommendation:** It was recommended that the AMDAR Panel and the CIMO Leader on Aircraft Measurements should determine a strategy for determining the cause, which might include approaches to and the involvement of each or any of sensor, avionics and airframe manufacturers.

## 5.2 **Data Quality Management, Assessment of Current Practices and Recommendations for Improvement**

- 5.2.1. Mr Gilles Verner, Canada, led the collaborative work to research and presented the requirements and issues related to data quality monitoring, which is an essential component of NWP data assimilation systems. CBS designated a number of Lead Centres to carry out this data quality monitoring beginning in the late 1980's. For Aircraft Observations WMC Washington was designated as the Lead Centre and has performed this responsibility since then. The monitoring has proved to be quite effective at detecting all kind of issues, ranging from data availability, major errors in the data (either the data itself, the processing or the NWP model itself). But with investigation and cooperation with data producers such as the airlines, a large portion of these issues have been explained and corrected.
- 5.2.2. Procedures and criteria for the quality monitoring, as well as for the exchange of the monitoring information between participating centres and data providers have evolved over the years, and have been well documented by the " WMO expert group on GDPS solutions for data quality monitoring " and are available on the WMO GDPFS web site and Manual. To be effective this type of monitoring requires a certain amount of metadata, some of which are essential such as unique aircraft identification. Also, although numerous examples of data issues have been discussed on many occasions, there is no repository of those issues and corrective/preventive actions taken. Such information would be very useful for many users and applications such as re-analyses.
- 5.2.3. Such comparisons of aircraft observations against model background fields are done routinely by most NWP centres and should be considered as a critical part of aircraft observations QC. Various tools, including interactive (or not) web sites, are used at many centres. Information can be displayed in many forms, such as profiles, time series, phases of flight, by aircraft, by types of aircraft, by AMDAR program, and so on. Such different displays are very useful to identify data issues, when they occur, and to assist in trying to resolve the issues being investigated. Access to such visualization tool by other than NWP users has proved to be quite useful to operational meteorologists (e.g. the experience at GSD). The regular feedback and contacts between monitoring groups and data producers, program managers and operational staff is very important to the success of such a program and is essential in ensuring that issues with data will be corrected when they arise. In addition the process in place at the present time includes the generation of monthly monitoring reports and their exchange. It has been expressed that more frequent monitoring and reporting would further improve the effectiveness of this program.

- 5.2.4. Semi-automatic information exchanges about data counts, usage, quality etc. between various NWP and data management centres on a regular basis would be useful for all involved. Some of this information is available from monitoring centres but it is passive. However, we should also consider a near-real time system which would again semi-automatically spot potential data problems as they are made available to users and raise "alarm/event".
- 5.2.5. Expansion of AMDAR into smaller regional carriers would be very beneficial. Not only would data user get more data over less traveled routes and remote locations, but also as they take off and land a number of times on a daily bases coverage of vertical profiles would also be improved. In additional smaller aircraft such as turboprops fly at lower altitudes, making their en-route data complementary to that of larger jet aircraft. The Canadian experience with regional airline AC Express (formerly AC Jazz) was discussed during the workshop. Data from the regional jets were found to have similar quality as that from larger jets; however significant issues were identified with data from the smaller turboprop DHC-8 aircraft. Although the situation was improved significantly following changes to instruments, they were still some differences between the quality of ascent and descent profiles which was not corrected. Additional efforts and funding would be required to fix this issue. It would be very useful to have trials with other regional carriers and types of smaller airplanes. In principle the data quality of large jet and regional aircraft should be comparable.

### ***Management of ICAO Meteorological Data***

- 5.2.6. Ideally quality management activities would be performed for all aircraft data, either WMO or ICAO based, recognizing that ADS data for example, is an ICAO-owned and sourced data set. According to ICAO regulation, it is the WAFCs that have responsibility for receiving and transmitting data on the GTS but this is not necessarily practical to enforce. In addition the WAFCs are not mandated to decode, QC and re-encode the data in WMO formats. In the present situation the standard practice appears to be than the ADS data in converted to ARPs (AIREP code) by the ATS units involved and then forwarded to the Met Authorities for dissemination to the WAFCs. However, this ADS data should be transmitted from aviation to meteorology in the standard ICAO format that this data is transmitted in and then, for the process of transmitting it on the GTS, it could conceivably be decoded and re-encoded into something more appropriate to meteorology such as BUFR.
- 5.2.7. The Workshop discussed the issues associated with transmission of ADS data in BUFR, a strategy for how it might be put into practice within the AO DMF and changes that might be necessary to the GTS headers and the BUFR headers, templates and tables in order to accomplish the standardization of such practice. It was pointed out that, while the AMDAR BUFR headers, template and tables could already support the transmission of ADS data adequately, the GTS header structure currently lacked the ability to allow discrimination between AMDAR and ADS BUFR (FM94) data and this was considered to be a critical issue to resolve for data management practice.
- 5.2.8. It is conceivable that ADS (and other ICAO sources of aircraft) data might be data that could be managed by just 1, 2 or 3 international data processing centres for processing and performing QC prior to GTS transmission. It is therefore probably quite feasible to

develop and establish an aircraft observation data processing model that could be applicable to both WMO and ICAO aircraft observations.

#### 5.2.9. Recommendations:

- 1) Recognize comparisons of aircraft observations to NWP model background fields as a critical component of AO QC.
- 2) Consider whether or not such comparisons should be done before AO data are exchanged on the GTS.
- 3) Promote and support the development of a universally available (and interactive) AO data monitoring display system, for use by program managers, airlines, NWP centres and other clients.
- 4) Consider more frequent reporting of monitoring reports and reject lists, including a daily report and possibly an alerting mechanism.
- 5) With the concept of an archive of Aircraft Observation being developed as part of the new AO Data Management Framework, consideration should be given to include records of documented aircraft data quality issues and associated corrective action.
- 6) Semi-automatic near real time monitoring information such as data counts, missing data, higher than normal rejects by the assimilation system, etc. should be exchanged regularly (monthly or more frequently as required and agreed to) between designated centres and data managers (and/or producers). This could include an Alarm/Event system.
- 7) Consideration should be given to the designation of centres to carry out international QC of Aircraft Observations (WMO and ICAO), possibly before insertion on the GTS.
- 8) That the data processing model developed as part of the Aircraft Observation Data Management Framework be established in such a way as to accommodate the processing and distribution of WMO and ICAO observations.
- 9) The AMDAR Panel and ET-AIR to work with CBS OPAG-ISS and IPET-DRC to investigate changes necessary to the GTS headers for FM94 in order to readily distinguish AMDAR BUFR data from ADS BUFR data.
- 10) That distribution of ICAO automated aircraft observations on the GTS be done using WMO approved format (BUFR) with an appropriate template (similar to the AMDAR ones) for clear identification of the source of the data (ADS, MODE-S, Aircraft ID, etc.).
- 11) Ideally, the AO data processing model would be agreed to by ICAO.
- 12) Further experience and studies with data quality aspects from smaller airplanes and regional carriers are needed. Current AMDAR programmes could be encouraged to perform (as permitted) trials with smaller airplanes and regional carriers. Sharing of this experience between AMDAR programmes is very important.

## 6 BREAKOUT SESSIONS

- 6.1 The Workshop undertook two breakout sessions which were held during the 2<sup>nd</sup> and 3<sup>rd</sup> days and provided the opportunity for participants to discuss in detail and deliberate over, a range of issues that were raised in the lead-up to the Workshop and during the presentation of discussion papers.
- 6.2 The topics and groups for each session were the following:

**Workshop Session 1, Group 1: Devising an Improved Data Management Framework**, Lead: Jitze van der Meulen

- WIGOS Considerations
- Data processing
- Data archival
- Interaction with National programmes
- Data display

**Workshop Session 1, Group 2: AO Metadata Management**, Lead: Stewart Taylor

- Defining the metadata set
- Metadata provision and interface to national programmes
- Metadata processing and handling

**Workshop Session 2, Group 1: Quality Control and Quality Assurance**, Lead: Bradley Ballish

- Improving quality control practices, national and Global
- Quality assurance practices and the use of data quality metadata and flags.

**Workshop Session 2, Group 2: Quality Monitoring and Reporting**, Lead: Gilles Verner

- Improving quality monitoring practices national and global
- Improving reporting practices

6.3 The reports of Leads for each Session and Group are provided within [Appendix III](#).

## **7 NEW, IMPROVED DATA MANAGEMENT FRAMEWORK FOR AIRCRAFT OBSERVATIONS**

### **7.1 Definition of a New Global AO DM Framework**

7.1.1. One of the primary objectives of the Workshop and a focus throughout was to at least commence the process of developing and defining a Data Management Framework (DMF) that can be documented within the WMO regulatory material as a component of the Quality Monitoring System (QMS) for the Aircraft Observing System. Under this agenda item, that task was given to Dr Jitze van der Meulen to undertake during the Workshop, taking into account the relevant aspects, issues, discussions and recommendations throughout the Workshop. An initial Outline for the Definition of the Global AO DM Framework is provided in [Appendix V](#).

7.1.2. It is recommended that the Outline of the Definition of the Global AO DM Framework is further developed and is eventually integrated into appropriate WMO regulatory material as part of the Quality Management System for Aircraft Observations and AMDAR.

### **7.2 Review of WMO World Weather Watch AO Guidance Material and Recommendations for Updating**

- 7.2.1. The CBS guidance material (the Manual on the GOS, Edition 2010 and the Guide to the GOS, Edition 2011) was reviewed.
- 7.2.2. It was found that the CBS guidance material was not reflecting the current status of the Aircraft Observing System and the current Data Management Framework.
- 7.2.3. The AMDAR Data Management Workshop discussed and formulated, in accordance with the outcome of the Workshop, recommendations to the WMO AMDAR Panel and the CBS ET-AIR for updating the relevant paragraphs in the CBS Guidance Material and to also inform other Technical Commissions that AMDAR related information should be updated.
- 7.2.4. The workshop agreed on the following recommendations for reviewing and updating the CBS Guidance Material in relation to AO:
  - (a) The Guide to the Global Observing System, Edition 2010, needs to be updated to reflect the current status in Aircraft Observations, taking into account the results of the WIGOS Pilot Project for AMDAR, the ET-AIR Workplan and the outcome of the Workshop on Aircraft Observations Data Management;
  - (b) The Manual on the Global Observing System, Volume I, Edition 2011, needs to be updated to reflect the current status in Aircraft Observations, taking into account the results of the WIGOS Pilot Project for AMDAR, the ET-AIR Workplan, the requirements for the AO elements as formulated in the WMO Observing Requirements Database (<http://www.wmo-sat.info/db/requirements>) and the outcome of the Workshop on Aircraft Observations Data Management;
  - (c) The requirements for AO for the Regional Associations and Antarctica as stated in the Manual on the Global Observing System, Volume II, Edition 2011, need to be updated in accordance with the current status of other observing systems, preferably is support by and cooperation with the Regional Offices, the EC Panel of Experts on Polar Observations and GCW;
  - (d) Other Technical Commissions (in particular CIMO) should be informed about the need for updating the CIMO Guide in those parts where AO is mentioned;
  - (e) The necessary update of the CBS Guidance Material should be included in the ET-AIR workplan and recommended for adoption by the ET-AIR in their forthcoming meeting.

## **8 COMPILING THE FINAL REPORT**

- 8.1 Workshop participants provided summaries of their submitted documents and presentations made, which are included in this report.
- 8.2 A summary of recommendations and actions made during the Workshop are provided within [Appendix VI](#).

## **9 CLOSURE OF THE SESSION**

The Workshop closed at 3pm on 8 June 2012.



**APPENDIX I**  
**List of Participants**

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## APPENDIX I

### List of Participants

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**APPENDIX II**  
**WMO AMDAR Panel Workshop on Aircraft Observing System Data Management**  
**Aims and Objectives**

The Workshop on Aircraft Observing System Data Management shall:

- (a) Review, propose and report on the current data management standards and practices employed for the WMO Aircraft Observing System, taking into account:
  - i. National aspects;
  - ii. Global aspects;
  - iii. AMDAR data;
  - iv. ICAO-generated data;
- (b) Devise and recommend a national and global framework for the reporting, monitoring and management of Aircraft Observing System data; (AMDAR and ICAO) taking into account:
  - i. Data archival;
  - ii. Data access and display (data and monitoring diagnostics);
  - iii. WIS structure and requirements.
- (c) Data Quality Assessment:
  - i. Review and make recommendations on the requirements for Aircraft Observing System Data Quality Assessment (taking into account the status of the activities concerning the WIGIS AMDAR Pilot Project and the Quality Management Framework).
- (d) Metadata:
  - i. Devise and recommend a national and global framework for the reporting and management of Aircraft Observing System metadata; (AMDAR and ICAO), taking into account WIS structure and requirements;
  - ii. Review and make recommendations on the requirements for Aircraft Observing System metadata (taking into account the status of the activities concerning the WIGOS AMDAR Pilot Project and the Inter-programme on Metadata and Data Interoperability);
- (e) Propose ways of integration into the governance for the AMDAR Programme in line with item (a) above;
- (f) Consider and recommend Data Policy aspects for Aircraft Observing System data;
- (g) Provide advice on the implementation of Aircraft Data Management into the WIGOS concept;
- (h) Identify and recommend on the establishment of (a) Lead Centre(s) and Participating Centres for:
  - i. Data management and archival;
  - ii. Metadata management;
  - iii. Data quality monitoring;
- (i) Make an assessment and report on the current state of WMO guidance material in relation to Aircraft Observing System data management and determine requirements for improvement and update;
- (j) Prepare a report to be submitted to the Chairperson of OPAG-ISS on the progress made on Aircraft meta-data.

**APPENDIX II**  
**WMO AMDAR Panel Workshop on Aircraft Observing System Data Management**  
**Aims and Objectives**

**Deliverables (Expected Results) of the Workshop on AMDAR Data Management**

1. Final Report reflecting the discussions, decisions, proposals and recommendations as the result of the Workshop;
2. Draft recommendations to be submitted by the AMDAR Panel to CBS;
3. Draft covering documentation to the recommendations for inclusion into the WMO Regulatory Material.

**Proposed Workshop Participants (Provisional)**

Brad Ballish	NOAA(QA, modelling)	USA
Jitze van der Meulen	E-AMDAR QEvC (QA)	The Netherlands
Stewart Taylor	E-AMDAR TC (Metadata, QC)	UK
Drasko Vasiljevic	ECMWF (QC, global modelling)	UK
Gilles Verner	CMC (Data Monitoring, modelling)	Canada
Xiaohua Yang	HIRLAM/Harmonie (Local Area Modelling, monitoring)	Denmark
Bill Moninger	NOAA/ESRL/GSD (AMDAR Data Display)	USA
Backshow Berejena	Regional Association I	Zimbabwe
Steve Foreman	WMO/WIS	Switzerland
Michael Berechree	Bureau of Meteorology (Data Use, Services)	Australia

**Workshop Support** Dean Lockett (AMDAR Panel TC, WMO Secretariat);  
Frank Grooters (Workshop Chairperson)

**Venue** Geneva (WMO Secretariat)

**Dates** 5 to 8 June 2012

## APPENDIX II

### WMO AMDAR Panel Workshop on Aircraft Observing System Data Management Aims and Objectives

#### Basic Reference Material

- Aircraft Meteorological Data Relay (AMDAR) Reference Manual, WMO-No. 958 (2003)
- Manual on the Global Data-Processing System, WMO-No. 485, VOL. 1 (2010)
- WMO Guide to Meteorological Instruments and Methods of Observation, WMO-No. 8 (2008), Part III

**Other references, related to WMO activities on data management, quality assessment and meta data can be found on the following URLs (web links)**

- WMO interlinks, *functioning on 2012-02-01*:

#### **Data Management**

WWW Data Management

<http://www.wmo.int/pages/prog/www/WDM/wdm.html>

#### **Quality Assessment**

Quality Management Framework

[http://www.bom.gov.au/wmo/quality\\_management/index.shtml](http://www.bom.gov.au/wmo/quality_management/index.shtml) (restricted access)

currently not available !: <http://www.wmo.int/pages/prog/amp/QMF-Web/home.html>

Final Draft edition of WMO-No.49 - WMO Technical Regulations, Volume IV - Quality Management

currently not available !: [http://www.wmo.int/pages/prog/amp/QMF-Web/documents/Tech\\_Reg\\_Volume\\_IV\\_FinalDraft\\_March2010.pdf](http://www.wmo.int/pages/prog/amp/QMF-Web/documents/Tech_Reg_Volume_IV_FinalDraft_March2010.pdf)

The Global Data-Processing and Forecasting System

<http://www.wmo.int/pages/prog/www/DPS/gdps.html>

WWW Monitoring

[http://www.wmo.int/pages/prog/www/WDM/wdm\\_monitoring.html](http://www.wmo.int/pages/prog/www/WDM/wdm_monitoring.html)

Data Quality monitoring

<http://www.wmo.int/pages/prog/www/DPS/Monitoring-home/mon-index.htm>

with links to Participating Centres, Lead Centre Monitoring, Procedures and Formats, Report Types and Focal Points:

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### WMO AMDAR Panel Workshop on Aircraft Observing System Data Management Aims and Objectives

- Participating Centres:  
<http://www.wmo.int/pages/prog/www/DPS/Monitoring-home/mon-participating-centres.htm>
- Lead Centre Monitoring:  
<http://www.wmo.int/pages/prog/www/DPS/Monitoring-home/mon-leadcentre.htm>
- Report Types:  
<http://www.wmo.int/pages/prog/www/DPS/Monitoring-home/mon-report-types.htm>

#### **Metadata**

Data and metadata representation

[http://www.wmo.int/pages/prog/www/WDM/wdm\\_representation.html](http://www.wmo.int/pages/prog/www/WDM/wdm_representation.html)

Development of the WMO Core Profile of the ISO Metadata standard

<http://www.wmo.int/pages/prog/www/WDM/Metadata/documents.html>

#### **Regulatory and Authoritative Documents**

Aircraft Meteorological Data Relay (AMDAR) Reference Manual, WMO-No. 958, 2003; Par. 5 and App. IV

[http://www.wmo.int/amdar/Publications/AMDAR\\_Reference\\_Manual\\_2003.pdf](http://www.wmo.int/amdar/Publications/AMDAR_Reference_Manual_2003.pdf)

and other links on the WMO AMDAR website

[http://www.wmo.int/amdar/index\\_en.html](http://www.wmo.int/amdar/index_en.html)

MANUAL ON THE GLOBAL DATA-PROCESSING SYSTEM, WMO-NO. 485, VOL. 1 (2010) ATTACHMENT II.9,  
PROCEDURES AND FORMATS FOR EXCHANGE OF MONITORING RESULTS

<http://www.wmo.int/pages/prog/www/DPS/Monitoring-home/mon-procedures.htm#Aircraft%20Data>

MANUAL ON THE GLOBAL DATA-PROCESSING SYSTEM, WMO-NO. 485, VOL. 1 (2010) PART III, DATA  
MANAGEMENT ASPECTS

[http://www.wmo.int/pages/prog/www/DPFS/Manual\\_GDPFS.html](http://www.wmo.int/pages/prog/www/DPFS/Manual_GDPFS.html)

WMO GUIDE TO METEOROLOGICAL INSTRUMENTS AND METHODS OF OBSERVATION, WMO-No. 8  
(Seventh edition, 2008), Part III, QUALITY ASSURANCE AND MANAGEMENT OF OBSERVING SYSTEMS

<http://www.wmo.int/pages/prog/www/IMOP/publications/CIMO-Guide/CIMO%20Guide%207th%20Edition,%202008/Part%20III/Part%20III.pdf>

WMO GUIDE TO METEOROLOGICAL INSTRUMENTS AND METHODS OF OBSERVATION, WMO-No. 8  
(Seventh edition, 2008), , PART II, OBSERVING SYSTEMS, Chap. 3 Aircraft observations

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**WMO AMDAR Panel Workshop on Aircraft Observing System Data Management**  
**Aims and Objectives**

<http://www.wmo.int/pages/prog/www/IMOP/publications/CIMO-Guide/CIMO%20Guide%207th%20Edition,%202008/Part%20II/Chapter%203.pdf>

***Relevant WWW components:***

WDM = WMO data management

WWWDM = WWW data management

AMDARDM = AMDAR data management

DPS = Data Processing System

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**Reports of Workshop Breakout Sessions**

**SESSION 1 GROUP 1, AO DATA MANAGEMENT, LEAD: JITZE VAN DER MEULEN**

The Group was asked to consider the following issues and aspects as time allowed:

1. Develop a framework for DM of ICAO data.
2. Define issues to be directed to ICAO for the DMF for ADS data.
3. Define the ToR for a AO Global Data Archival Centre.
4. Define a Framework for the implementation of DQFs by AO.
5. Define a process for updating data in real-time as a result of data processing.
6. Consider how the DMF might need to change to cater for increasing data volumes through expansion of AMDAR, ADS-B and Mode S.
7. Consider how the DMF might need to be structured to support short and medium term data targeting.
8. Consider how the DMF can support a more coordinated approach to access to NWP comparison information. Define a framework to support lodging of NWP comparison data.
9. Consider in the design of the DMF how to ensure that data latencies are not made worse – and preferably made better. [Centralised processing might actually allow improvements in DL.]
10. Consider how to store NWP blacklisting of aircraft centrally for access by other NWP centres and AO Programme Managers.
11. Consider whether data derived from the IAGOS program should be integrated with the AO Data Archive.
12. How can the DMF support a turbulence forecasting, notification and verification system(s)?
13. Consider the documentation of data quality issues in the high level design of the DMF.
14. In the design of the DMF, consider how best to handle the fact that data sources from different programs and fleets may require different data access arrangements, depending on the contracts in place between NMHSs and 3<sup>rd</sup> parties.
  - a. Consider proposing 3 models for a AO DPC System as part of the AO DMF with advantages and disadvantages:
    - i. A single centralized system taking on all functions of reception, QC, redistribution, archival, QC, QM, data targeting, etc.
    - ii. A system of regional DPCs with centralized DPC-functionality for each region only.
    - iii. An improved decentralized system with central archival and QA
  - b. Consider the best solutions for delivery of global data display for:
    - i. AO Programme Management (including QC, QM, QA);
    - ii. Provision of basic meteorological diagnostic delivery in support of developing countries.
15. Incorporate into the DMF design, a proposal to include provision and storage of multiple comparison statistics in a AO Centralised Data Archive.
16. As a high priority, design a DMF for ICAO derived AO data. Consider:
  - a. ICAO requirements for use of ADS data and requirements for WAFCS;
  - b. How QC should be carried out and where;

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### Reports of Workshop Breakout Sessions

- c. Centralisation;
- d. Future data volumes;
- e. Requirements for new formats/templates.
- f. Resource requirements.

#### **Considerations and Requirements for the Design of the DMF for AO**

In considering a solution for the design of the AO Data Management Framework, the Group took into account the following requirements and issues:

1. Take into account current best practice in the operation of AO programmes and the structuring of regional DMFs;
2. Must be compatible with the design and requirements of WIS (see agenda item 2);
3. Must take into account the aims and objectives for WIGOS (see agenda item 2);
4. Must take into account the objectives and aims for AO of the CBS Implementation Plan for the Evolution of the GOS:
  - a. Handle expected increases in data volume;
  - b. Cater for optimization requirements;
  - c. Cater for data targeting;
  - d. Manage data associated with new variables such as humidity, turbulence and icing; and,
  - e. Cater for development of AMDAR capability and implementation of GA aircraft and associated data volume increases.

Other identified requirements and issues from above:

5. Must allow management of all AO current and envisaged future data types including data derived from ICAO systems;
6. Include functionality of global data archive and access supporting:
  - a. AO data;
  - b. AO metadata;
  - c. AO quality monitoring data.
7. Improved and more integrated approach to management of global QM practice, including:
  - a. Reporting to a centralised repository for storage and access by program managers and data users;
  - b. Documentation of systemic data quality issues including aircraft blacklisting;
8. Advantages and disadvantages of centralized versus distributed (regional, sub-regional and national) approach to DMF design;
9. Provision of a data access and display functionality supporting:
  - a. Technical AO Programme operation and management;
  - b. System and Data Quality Monitoring;
  - c. Data User requirements;
10. Cater for 3<sup>rd</sup> party provision of services and functions;
11. Provide enough flexibility to support variations in requirements and practices of national and regional stakeholders (meteorological and aviation).

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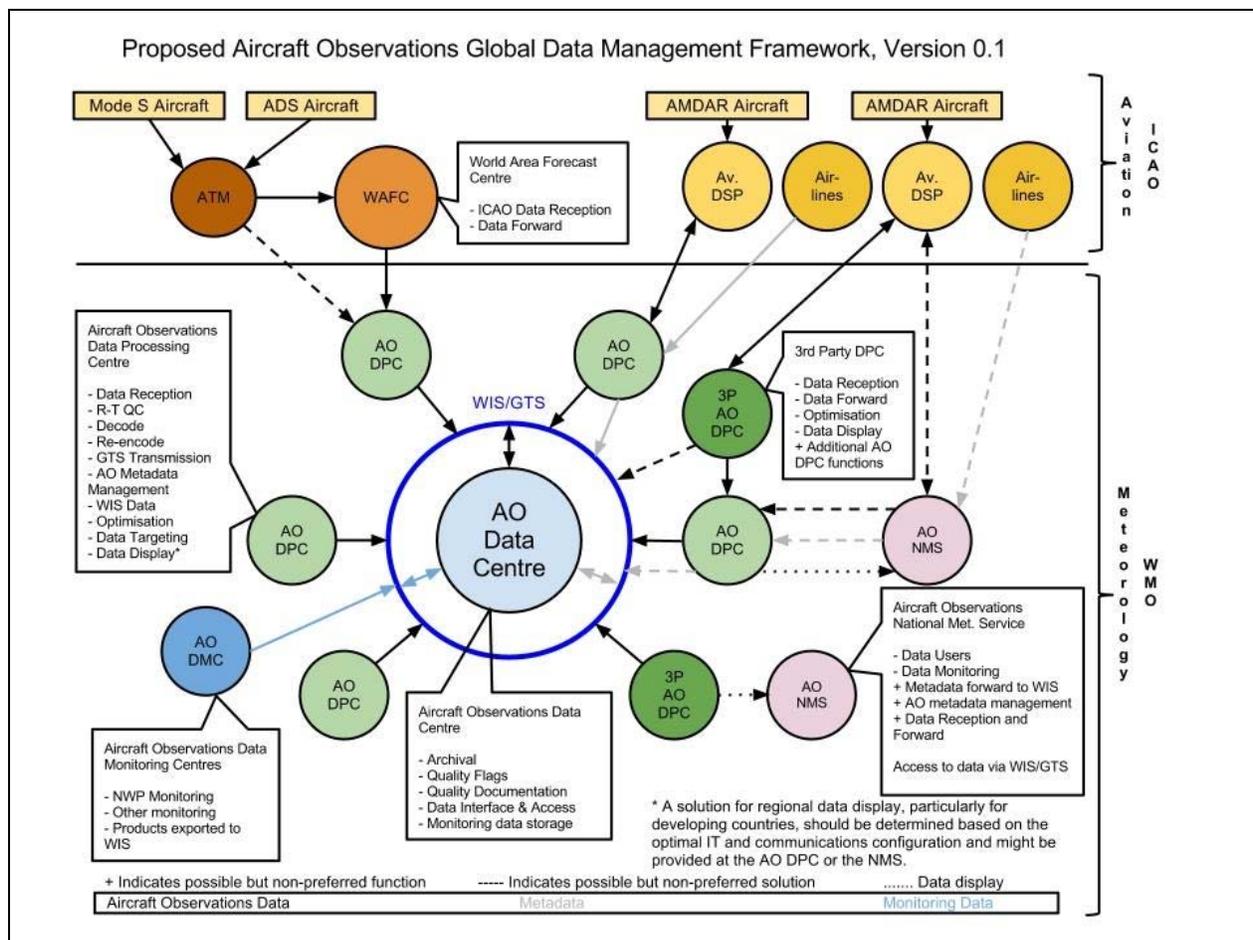
### Reports of Workshop Breakout Sessions

The Group first considered the current DMF for Aircraft Observations and, in particular those aspects already in place that worked well and either already complied with envisaged requirements for the DMF (Workshop agenda item 3), or could readily be adapted to do so. The issues above were then considered, along with those actions for the EGOS-IP and the requirements and utility of WIS that have implications for the design of the DMF.

#### Schematic Design of the Data Management Framework for Aircraft Observations

The results of the discussion and DMF design lead to a visual depiction of a proposed DMF that was clarified and improved throughout the course of the workshop and is shown in figure 1 below.

The definition of the AO DMF in this way allows for the identification of basic elements or building blocks around which formal and standardized roles, functions and practices can be defined.



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*Figure 1: Schematic depiction of the proposed Aircraft Observations Global Data Management Framework.*

#### **Description of Elements with Roles and Functions**

##### ***Mode S Aircraft***

An aircraft that transmits an ADS-B message via the Mode S communications system between the aircraft and the ATM.

##### ***ADS Aircraft***

An aircraft that transmits ADS-C and/or ADS-B messages in support of ICAO regulations for air traffic management.

##### ***AMDAR Aircraft***

An aircraft that transmits AMDAR data via ACARS.

##### ***ATM – Air Traffic Management Centre***

The ATM fulfills its role under ICAO regulation. ICAO regulations prescribe that ATMs transmit received ADS (ADS-C, ADS-B and Mode S) data to WAFCs for provision of meteorological components of the data on the GTS.

##### ***WAFC – World Area Forecast Centres***

The WAFC fulfills its role under ICAO regulation. ICAO regulations prescribe that WAFCs receive ADS data from ATM centres and transmit the meteorological component of the data on the GTS.

##### ***AO DPC – Aircraft Observations Data Processing Centre***

An AO DPC is a NMS or other centre that fulfills the following role and functions. In effect and in practice, the AO DPC would be a WIS DPC.

- Data Reception : Reception of Aircraft Observations data
- R-T QC : Performs prescribed real-time quality control on AO data.
- De-code : Decodes raw AO data
- Re-encode : Encodes decoded AO data into WMO compliant AO data for transmission on the GTS
- GTS Transmission : Transmits the WMO compliant AO data on the GTS
- AO Metadata Management : Manages the primary level AO metadata provided by NMSs and Airlines

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- WIS Data: Management and provision of WIS metadata through an arrangement with the WIS GISC.
- Optimisation: Performs the optimization function for those AMDAR Programmes that are serviced by the AO DPC
- Data Targeting: Provides an interface to the Optimisation process in support of Data Targeting as a requirement of the EGOS-IP.
- Data Display\*: Provides an interface and function for data display in support of 1) regional and sub-regional forecast applications; and, 2) AMDAR Programme monitoring.

#### ***3P AO DPC – 3<sup>rd</sup> Part Aircraft Observations Data Processing Centre***

A 3<sup>rd</sup> Party AO DPC is a non-WMO affiliated entity that would take on some of the functions of the AO DPC in support of the ground-processing of AO data.

ARINC and SITA are examples of such entities that might take on this role. Ideally, the 3P AO DPC would undertake only the roles of Data Reception, Data Forward (to an AO DPC), Optimisation and Data Display, however, if the centre is able to meet the requirements for some or full AO DPC functionality, it might have additional functions.

#### ***AO NMS – Aircraft Observations National Meteorological Centre***

An AO NMS is a WMO Member that would primarily have the usual roles as a Data User and also has a formal role in the QMS as an agent for system and data Quality Monitoring.

Some NMS centres may take on one or more of the roles or functions of an AO DPC.

#### ***AO DMC – Aircraft Observations Data Monitoring Centre***

The AO DMC provides the standardized data monitoring role and functions for the data monitoring component of the AO QMS:

- NWP Monitoring: The AO DMC provides a NWP comparison function and produces standardized data QM reports on the WIS.
- Other monitoring: The AO DMC provides other monitoring services.
- Products exported to WIS: The AO DMC will make standard DM products available on the WIS.

#### ***AO Data Centre***

The AO Data Centre is likely to be a single, centralized centre that undertakes the role and functions associated with the provision of a global, long-term data storage and access service. The AO DC would have the following functions and roles:

- Archival: Receive, decode and store AO data and metadata in a format suitable for the provision of other functions and roles.

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### Reports of Workshop Breakout Sessions

- Quality Flags: Facilitate the required Quality Assurance functions and associated processes through the maintenance of a set of Quality Flags and indicators.
- Quality Documentation: Facilitate the required storage and access to documentation of periodic or systemic data quality issues.
- Data Interface & Access: Provide the required interfaces and accesses to the archived AO data (including metadata and monitoring data).
- Monitoring data storage: Receive, decode and store standard QM data produced by the AO DMC.

#### Implications of the AO DMF Design

1. The DMF will utilize the WIS for the following purposes:
  - a. AO data discovery;
  - b. Definition and transmission of AO data;
  - c. Definition and transmission of AO metadata;
  - d. Definition and transmission of QM data including QM reports from AO DMCs and Quality Assurance data from AO DPCs.
2. The design implies a regional (e.g. WMO regional) or at least a sub-regional approach to the ground-processing and management of AO data. This design initiative is derived from several important factors or considerations:
  - a. The design is modeled on the E-AMDAR Programme, which has demonstrated best practice when it comes to meeting requirements of optimization and a data targeting functionality that might serve the purposes of program efficiency and meeting both global, regional and national data user requirements;
  - b. If Data Targeting is to become a function of the AO System, then there will be a requirement for NMSs to be able to coordinate and implement such a practice at the international or regional level in line with the geographical scale of synoptic weather systems;
  - c. It has been demonstrated that many countries do not have the capacity and technological capability to operate as an AO DPC and so an international, regional or sub-regional approach, particularly to ground-based data processing will be necessary if the AMDAR programme is to grow.
3. Cooperation with Regional Associations will likely become a more critical component of the AO Programme that requires strengthening.
4. Notwithstanding implication 2 above, the DMF has the flexibility for a single NMS entity to take on the role of an AO DPC;
5. Standards (new, strengthened or improved) or requirements for the following functions and practices will require definition and implementation:
  - a. Role of ATMs and WAFCs in management of ICAO AO data;
  - b. WIS:
    - i. AO data;
    - ii. AO metadata;
    - iii. AO QM and QA reports and data.
  - c. AMDAR software:
    - i. downlink data formats to minimize the requirements on AO DPCs;

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### **Reports of Workshop Breakout Sessions**

- ii. uplink data formats to support optimization and data targeting by AO DPCs;
  - d. AO DPCs
    - i. Optimisation functionality requirements;
    - ii. Data targeting functionality requirements;
    - iii. Data formats for ICAO derived AO data;
    - iv. AO DPC Real-time QC (AMDAR and ICAO data streams);
    - v. Raw Data Decoding;
    - vi. Metadata management;
    - vii. WIS metadata management;
    - viii. Data display.
  - e. AO DMC
    - i. NWP monitoring;
    - ii. Other monitoring;
    - iii. Monitoring products for exchange on the WIS and for transmission to the AO DC.
  - f. AO Data Centre:
    - i. Archival;
    - ii. User interface, access, products etc
    - iii. Quality Assurance
- 6. Requirements associated with optimization and data targeting should be taken into account at the earliest stages of new AMDAR Programme design and implementation.

### **Recommendations**

- 1. The AMDAR Panel and CBS ET-AIR:
  - a. further consider the proposed DMF structural design and its implications if adopted;
  - b. The DMF structural design, once approved and adopted, is incorporated into the documentation of the DMF and the QMS for the Aircraft Observing System within the appropriate WMO regulatory material.

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**Reports of Workshop Breakout Sessions**

**SESSION 1 GROUP 2, AO METADATA MANAGEMENT, LEAD: STEWART TAYLOR**

**1. BRIEF SUMMARY.**

The Aircraft Observation (AO) Data Management (DM) Workshop Breakout Session on Metadata discussed the following:

- a. Current status of National and Regional Metadata datasets,
  - i. The varying degree of differences in these datasets clearly showed the need for a generic dataset,
- b. What was envisaged as Mandatory and Optional parameters,
- c. What parameters would be achievable in the near and long term,
- d. Metadata and the relation to ARINC620 and BUFR Template upgrades,
- e. Look at requirements for a “global” AMDAR Metadata dataset – not just US and Europe, to account for developing countries.
- f. Definition of customer – and associated requirements,
- g. Being mindful of overloading the dataset,
- h. Inclusion of Quality Flags and Event Records,
- i. Willingness of the airlines to provide information, any proprietary and IP issues and restrictions on data usage.
- j. Metadata Management responsibilities – population and maintenance of dataset,
- k. Any resource issues in maintaining the dataset.

**2. RECOMMENDATIONS.**

The following recommendations were put forward by the group for consideration;

- a. Ensure that the dataset meets the requirements of WMO WIS as well as considering the needs of AMDAR, NWP, Climate and NWS communities,
- b. Population of the Metadata dataset(s) to be the remit of the Regional AMDAR Programme,
  - Responsible for contact with airlines, avionics vendors, DSPs and Aviation Authorities for data input,
  - There is a clear need for a good working relationship with the airlines to ensure the data input will be supplied – if available; being mindful not to put unnecessary resource demand on the airline.
- c. Consider infrastructure of developing countries with regards to accessing AMDAR Metadata dataset,
- d. Historical Records/Event Log – this would be used to track events relative to AMDAR Metadata:
  - This should be separate from the AMDAR Metadata dataset. Would this dataset be the responsibility of the AMDAR Programme Metadata Manager?
  - Need to agree what constitutes an “Event”,
    - i. Typical examples could be changes to software configuration, reporting resolution, sensor upgrade etc,

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#### Reports of Workshop Breakout Sessions

- Not to include Quality Control (QC) issues – this is not seen as pertaining to the AMDAR Metadata dataset,
- e. Event Log would need to be intuitive and have “filter” capabilities;
  - Input by Metadata Manager,
  - Plain text with information boxes to be completed (Aircraft ID, Date, Types of Event etc). A VBasic script or perhaps utilisation open source application for Fault Ticketing.
  - Ability to track an event,
  - Data retrieval - select Aircraft ID (option of airline for fleet-wide changes?),
  - Selectable time period – otherwise an Aircraft Event Log could provide a lot of information!
  - Drop down menus to search for Types of Event (Configuration change, software upgrade/change etc).

**M = Mandatory**

**O = Optional**

**C= Conditional** (if an optional component is recorded, an associated conditional component may be required).

Parameter	Description	Examples	Additional Comments
Programme	AMDAR Programme responsible for AMDAR data.	E-AMDAR	
Country/Member	Country Member responsible for AMDAR report	UK	
Originating Centre	Centre for issuing the AMDAR report (ICAO Code)	EGRR	
Metadata File Identifier		amdar-bulletin-eamdar-en	To be defined
Metadata Publication Date		yyyymmdd	
Resource Name		AMDAR data	Aircraft Observations?
Publisher Person Name		Stewart Taylor	
Publisher Organization Name		Met Office	
Publisher Phone		+44 (0)1695 555 128	
Publisher Fax		+44 (0) 1392 88 5681	
Publisher Person Email		<a href="mailto:stewart.taylor@metoffice.gov.uk">stewart.taylor@metoffice.gov.uk</a>	
Resource Publication Date		2012	
AMDAR Programme	Unique AMDAR aircraft	EU1234	List of aircraft

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<b>Identifier</b>	<b>identifier</b>		decodes should be held by Regional Programme TC
<b>Aircraft Tail Number</b>	<b>Assigned by Airline</b>	<b>BA123</b>	
<b>Aircraft Registration</b>	<b>CAA dataset</b>	<b>G-ABCD</b>	
<b>Airline Organization Name</b>		<b>British Airways</b>	Ensure proprietary requests are maintained.
<b>Airline Contact Name</b>	<b>Person (s) responsible – aircraft configuration, calibration &amp; maintenance</b>	<b>AMDAR Point of Contact – this should be nominated from technical/ operational staff.</b>	Contact details should include deputy contacts.
<b>Airline Phone</b>		<b>Contact details at airline</b>	
<b>Airline Fax</b>		<b>Contact details at airline</b>	
<b>Airline Person Email</b>		<b>Contact details at airline</b>	
<b>Airline operating Quality Management System (QMS)</b>	<b>Do the airline's calibration and maintenance procedures conform to ISO Standards.</b>	<b>Yes/No</b>	<b>Airline responsible for updating the AMDAR Programme on any amendments to their Standards.</b>
<b>Airline QMS Details</b>		<b>ISO9001</b>	
<b>Date Aircraft was activated for AMDAR</b>		<b>yyyymmdd</b>	
<b>Aircraft Manufacturer</b>		<b>Boeing/Airbus/ Embraer</b>	<b>All AMs to be included</b>
<b>Aircraft MSN</b>	<b>Airframe unique identifier</b>	<b>nxxx</b>	
<b>Aircraft Model</b>		<b>B747</b>	<b>All types to be identified, Next Gen aircraft and beyond</b>
<b>Aircraft Series</b>		<b>436</b>	
<b>AMDAR Software</b>	<b>Software type/format.</b>	<b>AAA</b>	
<b>AMDAR Software Version</b>		<b>v3</b>	
<b>Software configurable</b>		<b>Yes/No</b>	<b>Via optimization systems</b>
<b>Aircraft Type</b>		<b>Fixed-wing Landplane</b>	

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<b>Aircraft Engine</b>		<b>4 x RR RB211-524G2-19</b>	
<b>EASA Category</b>		<b>CS-25 Large Aeroplane</b>	This could be FAA or other Aviation Authority.
<b>Avionics manufacturer</b>		<b>Teledyne/Honeywell/ Rockwell Collins</b>	All vendors to be included
<b>Avionics Hardware part no.</b>		<b>222-100-3-45</b>	Airline to update if any changes to aircraft.
<b>Avionics Software part no.</b>		<b>212-100-2-44</b>	Airline to update if any changes to aircraft.
<b>Navigation System</b>	<b>(GPS or Inertia)</b>	<b>GPS</b>	For issues with magnetic north
<b>GNSS reporting</b>		<b>Yes/No</b>	??
<b>AMDAR Software Temperature Smoothing</b>	<b>Yes/No</b>	<b>Yes</b>	Information in the avionics software.
<b>AMDAR Software Wind Speed &amp; Direction Smoothing</b>	<b>Yes/No</b>	<b>Yes</b>	
<b>AMDAR Software Humidity Smoothing</b>	<b>Yes/No</b>	<b>Yes</b>	
<b>Ascent/Descent interval (reporting resolution) Default Settings</b>		<b>nnn seconds nnn hPa</b>	Do we need to know if these reporting resolutions are configurable
<b>En-route interval (reporting resolution) Default Settings</b>		<b>nnn seconds</b>	
<b>Aircraft Temperature Sensor Manufacturer</b>	<b>All information relating to the measurement of temperature</b>	<b>Rosemount</b>	Is this a requirement for all onboard sensors? (1,2,3)
<b>Aircraft Turbulence (EDR software) Version</b>		<b>??</b>	Parameter requirement.
<b>Aircraft Temperature Sensor Type</b>	<b>Is the sensor “aspirated or non-aspirated”?</b>	<b>A/NA</b>	
<b>Aircraft Temperature Sensor Part no.</b>		<b>PT100</b>	Which sensor(s) is used for AMDAR – primary etc?
<b>Aircraft Temperature Sensor Serial no.</b>		<b>nnnn</b>	
<b>Aircraft Temperature Sensor Measurement</b>		<b>°C</b>	

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Aircraft Temperature Sensor Resolution		1.0 0.1 0.01	
Aircraft Pressure Sensor Manufacturer	All information relating to the measurement of Pressure	Rosemount	
Aircraft Pressure Sensor Part no.		PT100	
Aircraft Pressure Sensor Serial no.		nnnn	
Aircraft Pressure Sensor Measurement		hPa	
Aircraft Pressure Sensor Resolution		0.1 hPa?	
Aircraft Pitot Sensor Manufacturer	All information relating to the measurement of Pitot	Rosemount	
Aircraft Pitot Sensor Part no.		PT100	
Aircraft Pitot Sensor Serial no.		nnnn	
Aircraft Humidity Sensor Manufacturer	All information relating to the measurement of Humidity	Spectrasensors	
Aircraft Humidity Sensor Part no.		PT100	
Aircraft Humidity Sensor Serial no.		nnnn	
Aircraft Humidity Sensor Measurement		g/kg	
Aircraft Humidity Sensor Resolution		0.001	
Aircraft Turbulence Sensor Manufacturer	All information relating to the measurement of Turbulence	??	
Aircraft Turbulence Sensor Part no.		PT100	
Aircraft Turbulence Sensor Serial no.		nnnn	
Aircraft Icing Sensor Manufacturer	All information relating to the measurement of Icing	??	Parameter requirement.
Aircraft Icing Sensor Part no.		PT100	
Aircraft Icing Sensor Serial no.		nnnn	

The shaded parameters are seen as long term requirements. These will be dependant on willingness of airline to provide information – if available.

**APPENDIX III**  
**Reports of Workshop Breakout Sessions**

**WORKSHOP SESSION 2, GROUP 1: QUALITY CONTROL AND QUALITY ASSURANCE,  
LEAD: BRADLEY BALLISH**

The Group was asked to consider the following tasks and issues:

1. Consider the incorporation of NWP comparison into pre-distribution QC.
2. Propose and define a set of DQFs for use by the AO DMF.
3. Propose a standard set of QC procedures for Level 1 data.
4. Propose a standard set of QC procedures for Level 2 data.
5. Consider how the QC/QA system can be designed so as to cater for different requirements by NMHSs and AMDAR Programmes for QA processing levels.

The following summarises the outcomes and recommendations of the Group:

Taking into account that Workshop Session 2 Group 2 concluded that most data monitoring experts may not have the time to study monthly monitoring reports from other centres in detail, and since monthly reports are considered not timely enough, we should consider that, rather than changing monthly data quality monitoring reports, more timely alerts identifying particular issues should perhaps be sent by email. Such emails might be automatically generated for some well-definable issues but would predominantly be subject to manual assessment and transmission procedures so as to facilitate reporting of potential issues by a wide range of data users, allow analysis by appointed experts and minimise false alarms.

***Email alerts for data QC, location or quantity problems***

1. For identified issues or errors, there should be 2 priorities high and low:
  - a. High Priority should be for serious problems, for example: AMDAR data being transmitted with wrong wind units; data being transmitted that is incorrectly time-stamped, missing data, etc.;
  - b. Low Priority should be for issues or errors such as: an aircraft has indicated a warm bias for the past three days; or, an aircraft has had a large number of position errors, etc.
2. Only identified and recognised experts, such as an AO Data Monitoring Centres for example, should have the authority to compile and/or transmit such alerts.
3. It is preferable that QC Alerts should be sent to designated operational staff who can take timely action to respond to problems.
4. Recipients of the email alerts should have the option to stop receiving reports or to unsubscribe.
5. There should be a process for people who want to be added to the email list or subscribe.

## **APPENDIX III**

### **Reports of Workshop Breakout Sessions**

6. New monitoring codes need to be developed to help create diagnostics needed for such timely data alerts.
7. Data Users that find and identify potential data quality issues should have an identified contact who can transmit data QC alerts if and when an error or issue is confirmed.

#### ***Flagging of data before transmission on the GTS***

The following points and recommendations were made in relation to the flagging of data for quality assurance purposes and for potential use by Data Users:

1. NWP Data Users should be surveyed to determine their requirements and preferences for data flagging.
2. Current BUFR encoding rules allow for the use of 2 data bits, which might provide 4 possible QC flags for each variable such as temperature, latitude, wind speed etc. For use of the 2-bit QC flag, criteria for the flagging of data would need to be developed and might be comprised of categories such as: “not checked”, “non-suspect”, “suspect” and “bad”.
3. There are additionally available, in the BUFR format, 63 bits that could be used to give more precise information of the reasons for flagging the data. We need a future action to decide on a BUFR table for such flags that would require WMO approval.

#### ***Other Issues on Quality Control of Level II Data***

1. It was identified that there was a requirement for improved practices to be implemented for the monitoring and documentation of QC processes for AO data that is carried out by “upstream” processing centres such as ARINC. For example, in the USA, location rejections were being made by ARINC but not reported.

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**Reports of Workshop Breakout Sessions**

**WORKSHOP SESSION 2, GROUP 2: QUALITY MONITORING AND REPORTING, LEAD: GILLES VERNER**

- **Quality Monitoring and Reporting**
- **Improving quality monitoring practices national and global**
- **Improving reporting practices**

1. Propose and recommend how DQFs (framework) might be utilized by DPCs and a AO Data Archival Centre
  - Current system is organized with Lead Centres. Do similarly in the DPCs but only for aviation data. Reporting by DPCs to the Lead Centre. But only for the program area that they are responsible for.
  - Concept requires good coordination by the Lead Centre and the DPCs for real-time and non real-time reporting. Using same monitoring rules by all DPCs and the Lead Centre.
  - Designation process needed for the DPCs (similar to Lead Centres) under WIS centres designation (e.g. for WIS DCPCs). AO programme is under CBS so DPCs should be designated by CBS (evolution under WIGOS).
  - AO DC/archive – related to long term time series work such as reanalyses. The concept for the archive centre is to use for example a NWP assimilation system already in place (for example the ECMWF long term re-analyses and associated data archive).
  - Number of DPCs : not necessarily designated by WMO RA due to the more global nature of AO. But a large number of DPCs would probably be difficult to manage and coordinate (for monitoring and alerting).
  - If needed CBS could allocate more than one Lead Centre (2 probably sufficient), with coordination. Possibly this could be one of the archival centre. The rationale being the sharing of the responsibilities as the numbers of AO DPCs increases.
    - This topic is linked to the following recommendation above: With the concept of an archive of Aircraft Observation is developed as part of the new AO Data Management Framework, consideration should be given to include records of documented aircraft data quality issues and associated corrective action.

**Suggested activities:**

- Determine the designation process and requirements for the AO DPCs, considering the monitoring activities as well.
  - Further elaborate the split responsibilities for the quality monitoring between the Lead Centre and the DPCs
  - Establish a list of potential candidate centres who could host and perform the activities of the AO data archival centre. Investigate what sort of designation would be required for a centre to accept responsibility and begin activities.
2. Devise a system to support better and near-real-time Quality Monitoring **feedback** to the data providers to ensure more timely fault rectification.

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### Reports of Workshop Breakout Sessions

- Example of E-AMDAR as a successful system, including human interactions and interventions. Maintenance of relationships with providers (airlines) and operational staff.
- Similar approach should be taken for ICAO based data.
- DPCs would be the contact point between data providers and the lead centre, and also with program managers under their area of responsibility.
- Concept of a gridded AO quality statistics (as described by Drasko) with associated data counts in order to easily compare information from different monitoring centres (would help to increase confidence from users, especially for shorter monitoring periods). The grid and quality statistics need to be defined.
- Other comparisons that could be made in addition to comparison with NWP models background fields: co-location of aircraft and radiosonde data (would need to agree on criteria to define an acceptable co-location for comparison); comparisons with other aircraft data in common locations (again area needs to be defined and agreed).

#### **Suggested activities:**

- Document and develop the concept of gridded AO quality statistics, and get a few (2 or 3 initially) monitoring centres to begin generation and exchange of this information initially on a monthly basis, including the Lead Centre. Expand into more frequent reporting as agreed to by the contributing monitoring centres. After some trial period, make this information widely available (web sites, etc), and also expand the number of contributors (eventually to all DPCs).
  - Monitoring centres should consider including more frequently updated monitoring statistics and reject list (in addition to the current monthly lists). Proposal should be made by the Lead Centre to contributing monitoring centres. Suggestion: initially start with weekly updates.
3. Consider how the DMF can be structured to allow Data Users (other than NWP) to provide input to the Quality Assurance process.
- Allow bench forecasters, (nowcasting, aviation, AQ) to feedback information to the DPC or program manager. How to use or vet this information?
  - Need for Data Quality Management to be responsive to such request for this feedback mechanism to be effective, with a documented procedure.
  - It is expected that feedback would tend to be regional, and near real-time (from forecaster or other users to the DPC)
  - A suggestion on how to do this would be to have some flag associated with the data on the AMDAR data display system, defined by user.
4. Design a component of the DMF that might support current and historical documentation of aircraft data quality issues. Consider a system that supports both an aircraft-by-aircraft and datum-by-datum quality flagging application as well as a more subjective methodology. Consider how the system might handle reported problems as opposed to real, confirmed problems.

#### **Suggested activities:**

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### Reports of Workshop Breakout Sessions

- Set up a google (or other) forum to which people can post AMDAR-related messages.
- Select a set of AMDAR data managers to moderate this forum (I.e., approve posts) and respond to messages.
  
- NWP Centres with a bias correction scheme for AO in their assimilation system can include bias correction information as part of the database. This information can therefore be used as an estimate (from the Centre's NWP system) of the bias on an aircraft by aircraft basis, for each assimilation model run.
- Information from assimilation black lists is available (and used) and should be archived with the data. Black list information is available upon retrieval of data from archive. The same mechanism is there for current data as the active blacklist is available (this is the status at ECMWF, and appears as a good model to target).
- Similarly data quality flags from the assimilation systems are associated with each datum and are archived, as well as the innovation values (observed minus background). This information is presently used by the monitoring centres to generate the quality monitoring statistics and reports.
- The E-AMDAR system uses a fault event logging system to track operational issues with their AMDAR data and contributing aircraft. A standard form is used to enter information about the issue, and this ticket will remain open until resolved. A similar ticketing approach could also be used to track issues with aircraft data quality as identified by the monitoring centres (DCPs in real-time or delayed).

#### Recommendations:

- A fault event logging system, both for operational issues as well as data quality issues should be part of the operational responsibilities of the AO DPCs.
- Issues about aircraft data biases to be included in the fault logging system.

#### Suggested activities:

- Convert the E-AMDAR (EUCOS) fault log spreadsheet into a google spreadsheet and allow wide access (read mode only).
  - Consider making the fault log mentioned above editable by users at centers other than the E-AMDAR center.
  - OR - BETTER - use bugzilla (<http://www.bugzilla.org/about/>) or similar system to allow more complete tracking of faults, and more broad participation for adding faults and reporting them fixed.
5. Review and update or redefine standard practices for AO data monitoring at the **National** level.
- It was not clear to the breakout group if this is needed (AO monitoring at the National level) with the concept of DPCs. Usually, AO monitoring centres will monitor all aircraft data within the coverage area of the NWP model used. Most of the time, the area covered will extend beyond the boundaries of the country running the model.

### APPENDIX III

#### Reports of Workshop Breakout Sessions

- The current situation and standard practice for NMHS under the DMF would be to consider the information received from the Lead Centres and the DPCs.
  - However, for feedback to airlines or program managers, each airline should have a single point of contact at a particular DPC. The responsibility for contacts would rest with the DPC.
6. Review and update or redefine standard practices for NWP monitoring at the global/international level.
- Presently done on a monthly basis, by Lead Centres and contributing monitoring centres. Changes to monitoring criteria were not considered but the group agreed with earlier recommendations for more frequent reporting and an alerting mechanism.
    - This topic is linked to the following recommendations above:
      - Consider more frequent reporting of monitoring reports and reject lists, including a daily report and possibly an alerting mechanism.
      - Semi-automatic near real time monitoring information such as data counts, missing data, higher than normal rejects by the assimilation system, etc. should be exchanged regularly (monthly or more frequently as required and agreed to) between designated centres and data managers (and/or producers). This could include an Alarm/Event system.
7. With more frequent statistics (e.g. daily statistics based on last 7-days), we could identify issues more quickly (e.g. bias, sudden change in behaviour, etc.). Daily feedback would become possible, e.g. by a distribution list or other mechanism. This information could also be made available in some of the AO display systems.
- This topic is linked to the suggested activities under item 2) above,
  - Suggested activity: Monitoring centres should be encouraged to begin the generation of a daily statistic (e.g. based on last 7-days) (criteria need to be developed, and be adapted as experience is gained). Initially generation and exchange of the information between 2 or 3 centres, with later expansion with the designation of DCPs. It would be useful if one display system could be adapted to make this information available, initially to selected users for evaluation.
8. Consider adding multi-days statistical monitoring information to AO data that goes onto the GTS. This would be information obtained from previous days NWP model runs and associated monitoring information (such as innovations), but not from the latest one which is not available when the observation is taken). This may require an adaptation of the BUFR template use to transmit aircraft data. (Example would be average innovations from previous 7-days, which would in principle imply very little added latency). For aircraft

### **APPENDIX III**

#### **Reports of Workshop Breakout Sessions**

observation this could work with the proposed DCP concept (as the DCP would have access to the required monitoring information). But until the DCPs are in place, this may be difficult to implement depending on the actual infrastructure in place.

- Suggested activity: Investigate if a demonstration (or trial) study could be done at one or more actual AMDAR programme, with data in a parallel stream (not on the GTS). Some evaluation process for the usefulness or improvement would be needed from associated monitoring centres.

## APPENDIX IV

### Survey Results on AMDAR Programme Data Policy Status

#### Questions

1. How many airlines are participating in your AMDAR Programme?
2. With how many of these airlines do you have a formal contract or agreement with for the operation of the programme?
3. How many of these contracts or agreements specifically address the issue of data ownership or data use?
4. How many of the airlines in your programme do NOT allow or provide compliance\* with WMO Resolution 40 (See below for Res. 40 details)?
5. With how many of the airlines in your programme does the contract or agreement formally establish compliance with WMO Resolution 40 (See below for Res. 40 details)?
6. For those airlines for which data derived does not comply with Resolution 40, what are the restrictions?
7. Estimate the daily volume (number of observations) and percentage of data produced by your programme that is not compliant with Resolution 40.
8. Estimate the daily volume (number of observations) and percentage of data produced by your programme that is potentially not compliant with Resolution 40 (i.e. not formally established by a formal contract or agreement).
9. Please provide any comments or additional information of relevance to this issue in relation to aircraft observations.
10. Would the current Data Policy of your AMDAR Programme allow archival of Aircraft Observations/AMDAR data in a permanent and publicly available global archive or database? Please explain any issues.

## APPENDIX IV

### Survey Results on AMDAR Programme Data Policy Status

#### Responses

Question	Australia	New Zealand	Canada	E-AMDAR	USA	China
1	6	1	1	12	7	3
2	Contract for all in place or will be in place.	1	1	12	7 (via ARINC)	0
3	6	0	1	No response	7	0
4	0	0	0	0	0	0
5	6	0	0	12	7	0
6	No restrictions imposed.	No restrictions imposed.	No restrictions in terms of use for public purpose except Commercial Exploitation in Competition with the Contractor	No restrictions imposed.	Data to be used in "research mode" or for forecasting use only by government agencies.	No restrictions imposed.
7	0%	0%	0%	0%	0%	0%
8	40% until agreements activated.	100%	100%	0%	0%	100%
9	Nil	Contract to be updated in next 12 months.	Liability versus 3rd party user is a significant issue for the airline/contractor. It is a barrier in establishing a contract between government and airlines. There is nothing in international laws we could refer to but it would help if we could reference to a statement from WMO on 3rd party data use. TAMDAR is another case of high concern	Nil	Currently, the wind and temperature reports tied to the WVSS-II data are not available for distribution because a stand-alone file has yet to be established for this purpose.	China AMDAR Programme doesn't have a formal contract or agreement with the airlines that participate in the programme for the operating of the programme hence there is no formal agreement on the issue of compliance with WMO Resolution 40.

## APPENDIX V

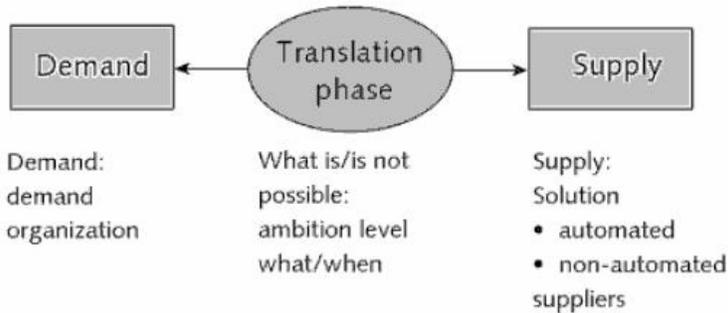
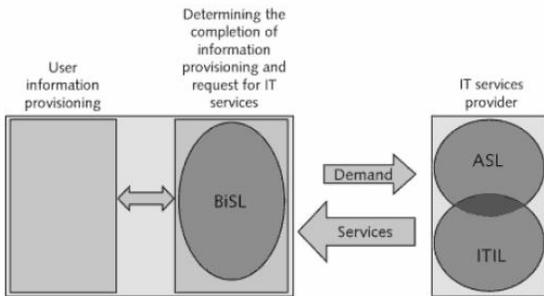
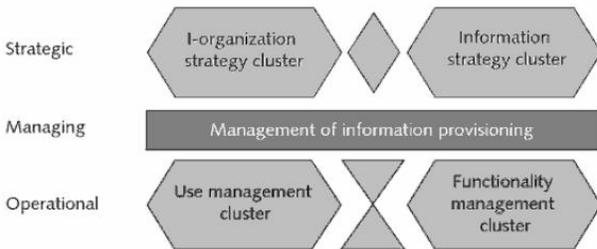
### Outline for the Definition of the Global AO DM Framework

#### Introduction

- Explanatory remarks
- History (ref. WWW/DM [old]; ISS/DM [t.b.c. ?])
- Typical AMDAR DM topics
- Relation with WMO DM developmental activities, like QMF

#### General

- Statements on the need for DM policy as part of Business structure of a Service
- DM policy requirement for national AMDAR data involved bodies
- DM policy requirement for international AMDAR data involved bodies
- DM policy for 3<sup>rd</sup> party data delivery bodies/partners
- Quality assessment, relation with QMF[ISO9000 standards], incl. documentation



Functional	Applications	Technical
Strategic management	Strategic management	Strategic management

## APPENDIX V

### Outline for the Definition of the Global AO DM Framework

Tactical management <ul style="list-style-type: none"> <li>• technical component</li> <li>• personal component</li> <li>• overall component</li> </ul> Operational management <ul style="list-style-type: none"> <li>• on use and practices</li> <li>• functional maintenance</li> </ul>	Tactical management <ul style="list-style-type: none"> <li>• technical component</li> <li>• personal component</li> <li>• overall component</li> </ul> Operational management <ul style="list-style-type: none"> <li>• on applications</li> </ul>	Tactical management <ul style="list-style-type: none"> <li>• technical component</li> <li>• personal component</li> <li>• overall component</li> </ul> Operational management <ul style="list-style-type: none"> <li>• Operational steering (P)</li> <li>• Maintenance infrastructure (IT) Technical support and service, helpdesk</li> </ul>
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#### Various aspects of AO data processes

- [general; relationship with icao; ADS] Develop a **framework for DM** of ICAO data.
- [ADS issue, 3<sup>rd</sup> party, external data; **AI**: cleanup the regulation: ICAO/Airep @ ATS, to go via WAFc] Define issues to be directed **to ICAO** for the DMF for **ADS** data.
- [archiving, validation, delivery {application}; **AI** TOR Archival Policy] Define the ToR for a AO Global Data **Archival** Centre.
- [quality control; **al**] Define a **Framework** for the **implementation** of **DQFs** by AO.
- [real time data processing] Define a **process for updating data in real-time** as a result of data processing.
- [data volume issue] Consider how the DMF might need to change to cater for **increasing** data volumes through expansion of AMDAR, ADS-B and Mode S.
- [data targeting] Consider how the DMF might need to be **structured to support short and medium term** data targeting.
- [comparison of data validation; NWP centres intercommunication] Consider how the DMF can support a more coordinated approach to access to **NWP comparison information**. Define a **framework to support lodging of NWP** comparison data.
- [data transfer and processing timeliness] Consider in the design of the DMF how to ensure that **data latencies** are not made worse – and preferably made better. [Centralised processing might actually allow improvements in DL.]
- [excluding aircraft; NWP centres intercommunication] Consider how **to store NWP blacklisting of aircraft** centrally for access by other NWP centres and AO Programme Managers.
- [atmospheric composition data in AmDAR data archive] Consider whether data derived from the **IAGOS** program should be integrated with the **AO Data Archive**.
- [turbulence; forecasting; verification of turbulence forecasts] How can the **DMF** support a **turbulence** forecasting, notification and verification system(s)?
- [documentation; data quality information] Consider the documentation of data quality issues in the high level design of the DMF.
- [**priority 1**; data display; data access; data communication] In the design of the DMF, consider how best to handle the fact that data sources from different programs and fleets may require different **data access** arrangements, depending on the contracts in place between NMHSs and 3<sup>rd</sup> parties.
  - Consider proposing 3 models for a AO DPC System as part of the AO DMF with advantages and disadvantages:
    - A single centralized system taking on all functions of reception, QC, redistribution, archival, QC, QM, data targeting, etc.
    - A system of regional DPCs with centralized DPC-functionality for each region only.
    - An improved decentralized system with central archival and QA
  - Consider the best solutions for delivery of global data display for:
    - AO Programme Management (including QC, QM, QA);
- [data display; developing countries] Provision of basic meteorological diagnostic delivery in support of developing countries.
- [QC results stored in archive; archiving] Incorporate into the DMF design, a proposal to include provision and storage of multiple comparison statistics in a AO Centralised Data Archive.
- [**priority 2**; 3<sup>rd</sup> party processed data; QC; data format] As a high priority, design a DMF for ICAO derived AO data. Consider:
  - ICAO requirements for use of ADS data and requirements for WAFcs;
  - How QC should be carried out and where;
  - Centralisation;
  - Future data volumes;
  - Requirements for new formats/templates.
  - Resource requirements.
- [data optimization] interaction NWP and optimization system
- Alerting for QC
- [Metadata]

#### MATRIX overview,

20 points above related with:

- 3<sup>rd</sup> party data
- ADS (ICAO), other new data sources (Mode-S)
- Archiving (data and metadata)
- Delivery (level II data; also profile data for local), relation to time/place resolution)

## APPENDIX V

### Outline for the Definition of the Global AO DM Framework

- *Optimization of obs*
- *data targeting (additional, for applications)*
- *data coverage (global), provision (e.g. Africa); programme extentions*
- *Developing countries, special constraints (data comm. issues)*
- *Data format (incl. resolution)*
- *Code issues (incl. data header)*
- *Data display*
- *Data access*
- *Data transfer*
- *Typical data: Atmosph. Composition data*
- *Phenomena: Icing, Turbulence, use of data (e.g. direct input, verification)*
- *Timeliness (taking into account Q/C processes)*
- *Data checking, filtering, flagging (relation with rules, M.GDPFS)*
- *Excluding aircraft (how to manage)*
- *Quality control: monitoring (availability), technics (NWP), stages (real time, off-line); flagging principles; archiving; logistics; feed back*
- *Metadata (definition, use, archive)*

Current documentation (overview and review for update)

WMO ref Man

WMO regulatory material (TR, incl. Manuals) and Guides

WWW/DM, ISS/DM

QMF documentation

Current status

As documented in AMDAR ref man

Special situation w/r ADS [auto AIREP]

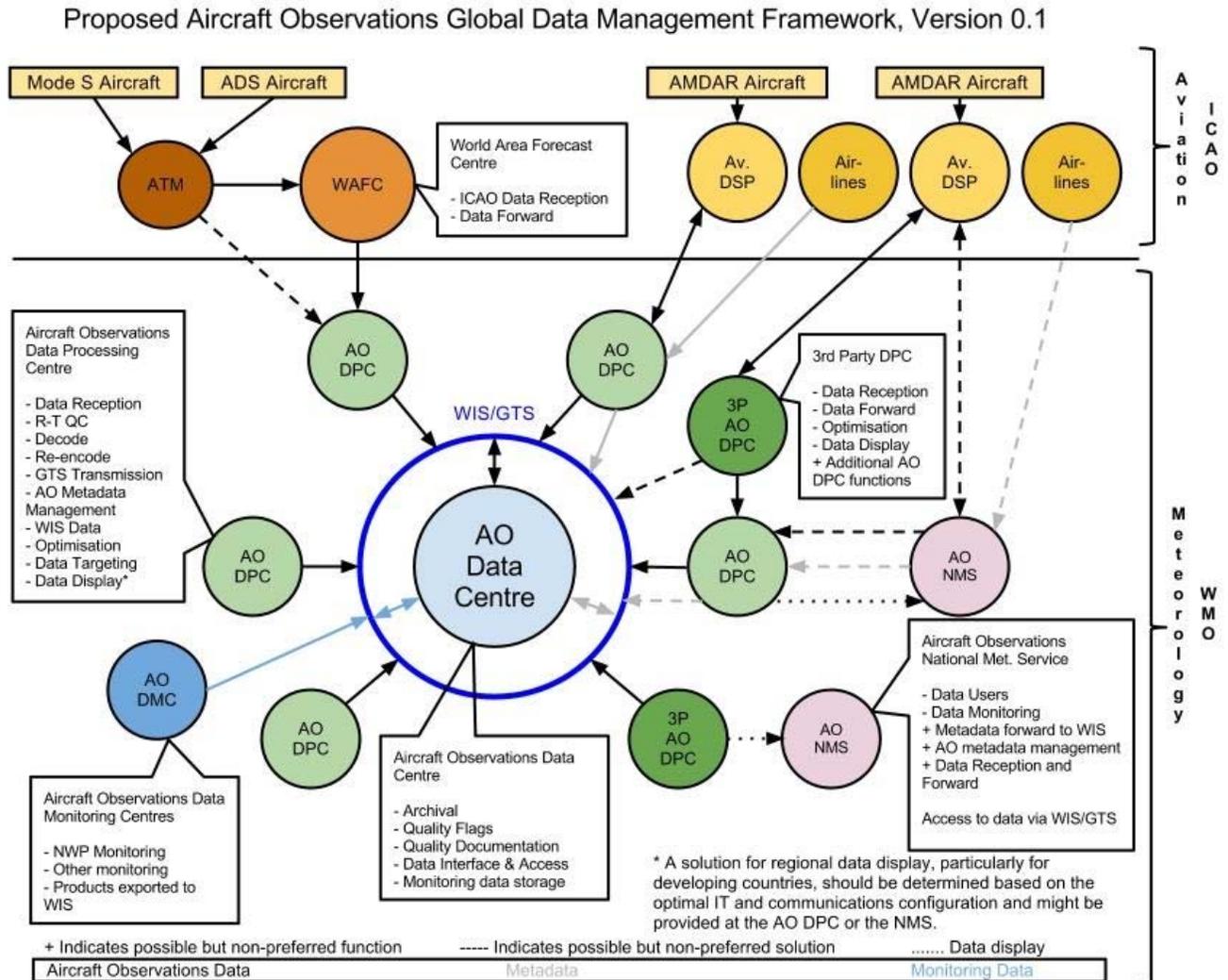
Q/C and feed back

## APPENDIX V

### Outline for the Definition of the Global AO DM Framework

#### Recommended Framework

Philosophical aspects on how to structure, taking into account the recommended position of DPC, DMC etc; centralization, distributed regional centres.  
Relation to the WIS [DCPCs].



#### Recommended Activities

- Recommendation on the implementation of DM policy/strategy at national level
- Recommendation w/r proposed activities (see Matrix)
- Recommendation on change of WMO policy/strategy, e.g. on checking/filtering data before transmission over GTS; integration of DM policy (other WMO programmes involved)
- Recommendation on new regulatory doc; to replace [?] WMO docs. and/or indicating status:
  - WWW/DM document
  - ISS/DM documents, with proposed strategy

## **APPENDIX V**

### **Outline for the Definition of the Global AO DM Framework**

Stimulate research on QEV tasks (impact of quality on use of AMDAR data), incl. feed back and co-operation; uniformity (standardization) in Q/C processes, appropriate definition of NWP data = reference practices

Recommendation on development of user feed back mechanisms (communications)

### **References**

**APPENDIX VI**  
**Recommendations and Actions**

Item	Workshop Agenda Item	Topic	Recommendation	Actions	Responsibility
1	2.2	AO Data Management Framework	A data management framework, in line with WMO's QMF and WIS policies and in line with the AMDAR reference manual, shall be further developed to such extent that implementation in national and regional bodies can be carried out. Such a framework may have a generic structure.	1. Incorporate into planning at Panel-15	AMDAR Panel & ET-AIR
2	2.2	AO Data Management Framework	Universal procedures shall be developed for standard practices to [1] check and flag data in real-time before dissemination over the GTS, and [2] to monitor and evaluate data. Results of these practices should be in a standard format, to be use as metadata, capable for archiving purposes. Moreover these procedures shall be inclusive of feed back practices.	2. Incorporate into planning at Panel-15	AMDAR Panel & ET-AIR
3	2.2	AO Data Management Framework	New guidance material on data management for WWW practices shall be developed to replace to current Guide on Data Management (WMO-No. 788), which is out of date.	3. Incorporate into planning at Panel-15	AMDAR Panel & ET-AIR
4	2.3	WMO QMF	The AO DMF design, structure and implementation should take into account the requirements of the WMO QMF		AMDAR Panel & ET-AIR
5	2.5	EGOS-IP Requirements	The AO DMF must take into account the objectives and aims for AO of the CBS Implementation Plan for the Evolution of the GOS: <ol style="list-style-type: none"> <li>1. Handle expected increases in data volume;</li> <li>2. Cater for optimization requirements;</li> <li>3. Cater for data targeting;</li> <li>3. Manage data associated with new variables such as humidity, turbulence and icing; and,</li> <li>4. Cater for development of AMDAR capability and implementation of GA aircraft and associated data volume increases.</li> </ol>		AMDAR Panel & ET-AIR
6	2.5	WIGOS Requirements	The DMF for the Aircraft Observing System should be developed and structured in such a way that is compatible with the plans for the implementation of WIGOS and for the evolution of the GOS.		AMDAR Panel & ET-AIR

## APPENDIX VI

### Recommendations and Actions

7	3.1	NWP Requirements	<ol style="list-style-type: none"> <li>1. Effort should be made to expand the AOS to smaller regional carriers;</li> <li>2. Quality Control and Quality Assurance should be improved as much as possible prior to data delivery without compromising current data latency levels;</li> <li>3. A system should be developed for the exchange of global monitoring data and information in support of improved data quality management of the AOS.</li> <li>4. Additional observed quantities should be incorporated and/or expanded as elements of the AMDAR Observing System, including humidity, turbulence and icing;</li> <li>5. The system for management and handling of metadata requirements to support both NWP data monitoring and temperature bias correction should be developed;</li> <li>6. Centralisation of AOS data processing should be given consideration and may benefit NWP by providing a single source for access to AO data;</li> <li>7. NWP would benefit from access to a long-term archival of AO data in support of NWP reanalysis and observing system experiments.</li> </ol>	<ol style="list-style-type: none"> <li>1. Incorporate into planning at Panel-15</li> <li>2. QC and QA procedures to be revised and improved;</li> <li>3. Panel and ET-AIR to work with the Lead Centre and DMCs to develop a centralized storage for NWP monitoring data.</li> </ol>	AMDAR Panel & ET-AIR
8	3.2	Services & Data Users Requirements	<ol style="list-style-type: none"> <li>1. In order to improve forecasting and verification of turbulence and icing forecast products and services, there is a requirement for increased coverage of both turbulence and icing observations;</li> <li>2. Investigate how AO data (and possibility other upper-air observations) can be displayed to forecasters, either by a COTS AO display system or the development of an inexpensive software tool;</li> <li>3. Investigate a method for forecasters and/or users to flag suspect AO data to a responsible network/program manager.</li> </ol>	<ol style="list-style-type: none"> <li>1. Continue developments in area of monitoring of turbulence and icing.</li> <li>2. Ensure data display is a component of the DMF;</li> <li>3. Incorporate into design of DMF;</li> </ol>	AMDAR Panel & ET-AIR
9	3.4	Data Policy for AO	<ol style="list-style-type: none"> <li>1. Future new and updated agreements with airlines are more carefully negotiated so as to specifically ensure compliance with Resolution 40.</li> <li>2. Take into account varying data policies among AMDAR Programmes in the design and establishment of any</li> </ol>	<ol style="list-style-type: none"> <li>1. AMDAR Panel &amp; CBS to assist Members with</li> </ol>	AMDAR Panel & ET-AIR

## APPENDIX VI

### Recommendations and Actions

			<p>online public archive of AMDAR data and it may be necessary to facilitate delayed release of some data so as to comply with specific programme policies.</p> <p>3. Data archival of the global AO DMF should take into account varying requirements and constraints by individual NMHSs on timeliness and QA.</p>	<p>agreements and contracts</p> <p>2. Incorporate recommendations 2 and 3 in design of the AO DMF.</p>	
10	3.5	AO Data Display	<ol style="list-style-type: none"> <li>1. Contacts in African NMSs should be cultivated, and encouraged to ascertain the potential of AMDAR. If this task is not successful, subsequent tasks should not be pursued;</li> <li>2. Insure that there is useful AMDAR data to be displayed in target African countries;</li> <li>3. Develop and deploy an AMDAR display system tailored to the infrastructure available in the target African countries;</li> <li>4. Develop and implement appropriate training;</li> <li>5. Provide simple AMDAR quality information to forecasters as a part of their display systems;</li> <li>6. Maintain and enhance person-to-person relationships between AO Data Processing Centers and data providers; and,</li> <li>7. Display systems should allow feedback from users to AO data managers.</li> </ol>	<ol style="list-style-type: none"> <li>1. Incorporate into planning at Panel-15</li> <li>2. Investigate and coordinate improved and wider data provision from the existing program over RA I;</li> <li>3. Incorporate into planning at Panel-15</li> <li>4. Incorporate into planning at Panel-15</li> <li>5. Incorporate into design of DMF;</li> <li>6. Incorporate into design of DMF;</li> <li>7. Incorporate into design of DMF.</li> </ol>	AMDAR Panel & ET-AIR
11	5.1	AMDAR Air Temperature Bias	<ol style="list-style-type: none"> <li>1. The global NWP community would benefit from publication of the ECMWF bias correction scheme including the method and units used to estimate aircraft</li> </ol>	<ol style="list-style-type: none"> <li>1. Brad Ballish to request information</li> </ol>	<ol style="list-style-type: none"> <li>1. Brad Ballish/NCEP</li> <li>2. AMDAR Panel &amp; ET-AIR</li> </ol>

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			<p>vertical velocity.</p> <p>2. The AMDAR Panel and the CIMO Leader on Aircraft Measurements should determine a strategy for determining the cause of air temperature bias, which might include approaches to and the involvement of each or any of sensor, avionics and airframe manufacturers.</p>	<p>from ECMWF.</p> <p>2. Incorporate into planning at Panel-15</p>	
12	5.2	Data Quality Management	<p>1. Recognize comparisons of aircraft observations to NWP model background fields as a critical component of AO QC.</p> <p>2. Consider whether or not such comparisons should be done before AO data are exchanged on the GTS.</p> <p>3. Promote and support the development of a universally available (and interactive) AO data monitoring display system, for use by program managers, airlines, NWP centres and other clients.</p> <p>4. Consider more frequent reporting of monitoring reports and reject lists, including a daily report and possibly an alerting mechanism.</p> <p>5. With the concept of an archive of Aircraft Observation being developed as part of the new AO Data Management Framework, consideration should be given to include records of documented aircraft data quality issues and associated corrective action.</p> <p>6. Semi-automatic near real time monitoring information such as data counts, missing data, higher than normal rejects by the assimilation system, etc. should be exchanged regularly (monthly or more frequently as required and agreed to) between designated centres and data managers (and/or producers). This could include and Alarm/Event system.</p> <p>7. Consideration should be given to the designation of centres to carry out international QC of Aircraft Observations (WMO and ICAO), possibly before insertion on the GTS.</p> <p>8. That the data processing model developed as part as the Aircraft Observation Data Management Framework be established in such as way as to accommodate the processing and distribution of WMO and ICAO</p>	<p>1. Incorporate into design of DMF;</p> <p>2. Incorporate into planning at Panel-15;</p> <p>3. Incorporate into planning at Panel-15;</p> <p>4. Incorporate into planning at Panel-15;</p> <p>5. Incorporate into design of DMF;</p> <p>6. Incorporate into design of DMF;</p> <p>7. Incorporate into design of DMF;</p> <p>8. Incorporate into planning at Panel-15;</p> <p>9. Incorporate into planning at Panel-15;</p> <p>10. Incorporate into planning at Panel-15;</p> <p>11. CBS and ET-AIR to</p>	AMDAR Panel & ET-AIR

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			<p>observations.</p> <p>9. That distribution of ICAO automated aircraft observations on the GTS be done using WMO approved format (BUFR) with an appropriate template (similar to the AMDAR ones) for clear identification of the source of the data (ADS, MODE-S, Aircraft ID, etc.).</p> <p>10. The AMDAR Panel and ET-AIR to work with CBS OPAG-ISS and IPET-DRC to investigate changes necessary to the GTS headers for FM94 in order to readily distinguish AMDAR BUFR data from ADS BUFR data.</p> <p>11. Ideally, the AO data processing model would be agreed to by ICAO.</p> <p>12. Further experience and studies with data quality aspects from smaller airplanes and regional carriers are needed. Current AMDAR programmes could be encouraged to perform (as permitted) trials with smaller airplanes and regional carriers. Sharing of this experience between AMDAR programmes is very important.</p>	<p>communicate with ICAO re policy;</p> <p>12. Incorporate into planning at Panel-15;</p>	
13	6	AO DMF Design & Strategy	<p>1. Further consider the proposed DMF (Appendix III, Reports of Workshop Breakout Sessions, Session 1, Group 1) structural design and its implications;</p> <p>2. The DMF structural design, once approved and adopted, is incorporated into the documentation of the DMF and the QMS for the Aircraft Observing System within the appropriate WMO regulatory material.</p>	Incorporate into planning at Panel-15.	AMDAR Panel & ET-AIR
14	6	Metadata Management	<p>1. Review the metadata dataset and ensure that it meets the requirements of WMO WIS as well as considering the needs of AMDAR, NWP, Climate and NWS communities,</p> <p>2. Population of the Metadata dataset(s) to be the remit of the Regional and National AMDAR Programme,</p> <p>3. Consider infrastructure of developing countries with regards to accessing AMDAR Metadata dataset,</p> <p>4. Consider development of a Historical Records/Event Log, to be used to track events relative to AMDAR Metadata.</p>	Incorporate into planning at Panel-15.	AMDAR Panel & ET-AIR
15	6	QC & QA Data Processing	<p>1. A system for near-real-time QC monitoring and alerting, possible email-based, should be considered for development and implementation;</p> <p>2. The existing QC flags in the BUFR format should be</p>	<p>Incorporate into the DMF for AO.</p> <p>Incorporate into</p>	AMDAR Panel & ET-AIR

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			utilized for flagging data quality by data processing and monitoring centres, including 3 <sup>rd</sup> parties.	planning at Panel-15.	
16	6	Quality Monitoring & Reporting	<ol style="list-style-type: none"> <li>1. Determine the designation process and requirements for the AO DPCs, considering the monitoring activities as well.</li> <li>2. Further elaborate the split responsibilities for the quality monitoring between the Lead Centre and the DPCs</li> <li>3. Establish a list of potential candidate centres that could host and perform the activities of the AO data archival centre. Investigate what sort of designation would be required for a centre to accept responsibility and begin activities.</li> <li>4. Document and develop the concept of gridded AO quality statistics, and get a few (2 or 3 initially) monitoring centres to begin generation and exchange of this information initially on a monthly basis, including the Lead Centre. Expand into more frequent reporting as agreed to by the contributing monitoring centres. After some trial period, make this information widely available (web sites, etc), and also expand the number of contributors (eventually to all DPCs).</li> <li>5. Monitoring centres should consider including more frequently updated monitoring statistics and reject list (in addition to the current monthly lists). Proposal should be made by the Lead Centre to contributing monitoring centres. Suggestion: initially start with weekly updates.</li> <li>6. Consider adding multi-day statistical monitoring information to AO data that goes onto the GTS/WIS.</li> <li>7. Set up a google (or other) forum to which people can post AMDAR-related messages and select a set of AMDAR data managers to moderate this forum (i.e., approve posts) and respond to messages.</li> <li>8. A fault event logging system, both for operational issues as well as data quality issues should be part of the operational responsibilities of the AO DPCs.</li> <li>9. Issues about aircraft data biases to be included in the fault logging system.</li> <li>10. Convert the E-AMDAR (EUCOS) fault log spreadsheet</li> </ol>	Incorporate into planning at Panel-15.	AMDAR Panel & ET-AIR

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			<p>into a google spreadsheet and allow wide access (read mode only).</p> <ol style="list-style-type: none"> <li>11. Consider making the fault log mentioned above editable by users at centers other than the E-AMDAR center.</li> <li>12. Consider use of bugzilla (<a href="http://www.bugzilla.org/about/">http://www.bugzilla.org/about/</a>) or similar system to allow more complete tracking of faults, and more broad participation for adding faults and reporting them fixed.</li> <li>13. Consider more frequent reporting of monitoring reports and reject lists, including a daily report and possibly an alerting mechanism.</li> <li>14. Semi-automatic near real time monitoring information such as data counts, missing data, higher than normal rejects by the assimilation system, etc. should be exchanged regularly (monthly or more frequently as required and agreed to) between designated centres and data managers (and/or producers). This could include and Alarm/Event system.</li> <li>15. Monitoring centres should be encouraged to begin the generation of a daily statistic (e.g. based on last 7-days).</li> </ol>		
17	7.1	Definition of the AO DMF	<ol style="list-style-type: none"> <li>1. The Outline of the Definition of the Global AO DM Framework is further developed and is eventually integrated into appropriate WMO regulatory material as part of the Quality Management System for Aircraft Observations and AMDAR.</li> <li>2. A strategy and plan for the implementation of the AO DMF is developed;</li> <li>3. The 20 points in the Matrix Overview for the DMF are addressed in the strategy and implementation of the DMF (Appendix V);</li> <li>4. A process is put in place to review and make changes as necessary to the WMO policy in relation to QC of data and the use of quality flags for the GTS.</li> </ol>	Incorporate into planning at Panel-15.	AMDAR Panel & ET-AIR
18	7.2	Update of Regulatory Material	<ol style="list-style-type: none"> <li>1. The Guide to the Global Observing System, Edition 2010, needs to be updated to reflect the current status in Aircraft Observations, taking into account the results of the WIGOS Pilot Project for AMDAR, the ET-AIR Workplan and the outcome of the Workshop on Aircraft</li> </ol>	Incorporate into planning at Panel-15.	AMDAR Panel & ET-AIR

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			<p>Observations Data Management;</p> <ol style="list-style-type: none"><li>2. The Manual on the Global Observing System, Volume I, Edition 2011, needs to be updated to reflect the current status in Aircraft Observations, taking into account the results of the WIGOS Pilot Project for AMDAR, the ET-AIR Workplan, the requirements for the AO elements as formulated in the WMO Observing Requirements Database (<a href="http://www.wmo-sat.info/db/requirements">http://www.wmo-sat.info/db/requirements</a>) and the outcome of the Workshop on Aircraft Observations Data Management;</li><li>3. The requirements for AO for the Regional Associations and Antarctica as stated in the Manual on the Global Observing System, Volume II, Edition 2011, need to be updated in accordance with the current status of other observing systems, preferably is support by and cooperation with the Regional Offices, the EC Panel of Experts on Polar Observations and GCW;</li><li>4. Other Technical Commissions (in particular CIMO) should be informed about the need for updating the CIMO Guide in those parts where AO is mentioned;</li><li>5. The necessary update of the CBS Guidance Material should be included in the ET-AIR workplan and recommended for adoption by the ET-AIR in their forthcoming meeting.</li></ol>		
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