

WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS

OPAG ON INTEGRATED OBSERVING SYSTEMS

**WMO/ICAO WORKSHOP ON FUTURE REQUIREMENTS FOR
METEOROLOGICAL AIRCRAFT OBSERVATIONS**

Geneva, Switzerland, 28-29 October

FINAL REPORT

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GENERAL SUMMARY

1. WORKSHOP OPENING

- 1.1. The WMO/ICAO Workshop on Future Requirements for Meteorological Aircraft Observations was opened by the Chair of the Commission for Basic Systems (CBS), Expert Team on Aircraft-Based Observing Systems (ET-ABO), Mr Frank Grooters, the Netherlands, at 9:30 am on 28 October 2015. Mr Grooters welcomed participants to the workshop and briefly outlined the purpose and objectives for it, which he expected should be a relatively informal meeting of representatives from WMO and ICAO experts and representatives of ICAO World Area Forecast Centres (WAFC). He explained to the participants that the workshop was the result of a work plan task of ET-ABO to seek collaboration with the (as of recently, former) Meteorological Section within the International Civil Aviation Organization (ICAO) and the ICAO World Area Forecast Centres (WAFC) regarding the future requirements for ICAO Aircraft Observations by ICAO, as defined in ICAO Annex 3, Meteorological Services for International Air Navigation (also contained in WMO No. 49, Volume II) and their relationship with the WMO Aircraft Meteorological DATA Relay (AMDAR) programme and other sources of aircraft based observations (ABO) of the WMO Global Observing System (GOS). Mr Grooters suggested that the workshop was an opportunity for participants to openly share ideas and explore issues associated with Aircraft Observations and ABO, particularly concerning such concepts as data policy, quality, sharing and ownership and intellectual property rights. The workshop offered an opportunity to explore how the two organizations might work together and collaborate in the future on ABO with a view to satisfying requirements for upper air meteorological data for the mutual benefit of both the aviation industry and the meteorological community. Mr Grooters mentioned that some of the particular areas of interest and discussion that were expected to be discussed during the workshop included, current and future WAFC requirements for Aircraft Observations through ICAO and WMO Members access to these data, quality control of meteorological data derived from ICAO Air-reports (AIREPs) and Automatic Dependent Surveillance Contract (ADS-C) messages and also the possibility of WMO Member access to meteorological data derived from ICAO AirATC related systems such as Mode-S messaging in Aviation Traffic Management (ATM) Secondary Surveillance Radar (SSR) format.
- 1.2. Mr Dean Lockett from the WMO Secretariat then welcomed participants on behalf of the Secretary General to WMO and thanked them for attending the workshop. Mr Lockett suggested to the participants that the workshop was a timely event for a number of reasons but particularly because WMO Members were becoming increasingly interested in the significant positive impacts and benefits of ABO and the possibility of gaining greater access to higher resolution data in support of Numerical Weather Prediction (NWP) and nowcasting applications. Additionally, ET-ABO was currently in the process of developing new guidance on ABO and the AMDAR system and the workshop provided an opportunity to clarify regulations and acceptable practices in relation to access to and use of such data that is able to be derived from ICAO systems. Mr Lockett also provided some logistical information regarding the programme and schedule for the workshop and the facilities offered by WMO.
- 1.3. The participants agreed to adopt the tentative programme and schedule proposed for the workshop as provided in [Annex I](#). A [list of participants](#) is also provided in Annex I.

2. DAY 1 PRESENTATIONS AND DISCUSSION

WMO ABO & AMDAR Status, Requirements & Issues

- 2.1. Mr Grooters made a presentation to the workshop providing the current status of WMO aircraft-based observations (ABO) and describing the basis for the requirements for ABO by WMO Members and the various issues relating to future developments and ABO programme expansion.
- 2.2. The following key points were made in the presentation:

- The AMDAR programme continued to grow but growth in recent years had been predominantly in areas where coverage was already good and chiefly due to expansion within the USA programme. Recent significant enhancements were the addition of Alaska Airways providing coverage over the Northwest of the Americas, the implementation of the Mexico AMDAR programme and the strong expansion of the water vapour measurement programme in the USA and its consolidation as a small component of the E-AMDAR programme.
- There is a small amount of Automatic Dependent Surveillance – Contract (ADS-C) data on the GTS but this was not well controlled for both process and quality, with data generally put on the GTS directly by WMO Members in collaboration with national ATS rather than according to ICAO requirements (ICAO doc. 4444, 4.12.6) via the WAFCs.
- Additional ABO data was being derived from ICAO AIREPs and also from USA “Aircraft Reports”, although the quality, formats and structure in which these data are made available varies considerably and it is difficult to trace their source.
- ADS-B can likely not be considered as a potential source for ABO data because of the limited (and fixed) size of the data block within the ADS-B message.
- While Annex 3 makes provision for ICAO Contracted States to provide Aircraft Observations, both for aircraft on ascent and en-route and at defined frequencies of reporting, it was evident that this requirement was not being widely complied with and it was suggested that very few, if any ATMs had established systems specifically for the purposes of meeting this requirement.
- WMO Members were increasingly interested in and were actively investigating the potential to take advantage of, ICAO Aircraft Observations, with both the Netherlands and the UK having researched and undertaken pilot projects on the derivation of meteorological data from messages provided by the selective interrogation type Mode-S system.
- WMO requirements for ABO are well defined for a range of Application Areas and expressed within the Observing Systems Capabilities Analysis and Review (OSCAR) as a range of technology independent performance metrics (i.e. coverage and performance), with three levels of capability provision. Generally, upper air requirements, particularly for vertical profiles of key parameters, are not well met and ABO offers a high-quality solution to at least partially meet these requirements. The requirements recommended actions for development of ABO are well defined within the CBS document, Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP, WIGOS Technical Report No. 2013-4).
- While WMO ABO are defined under WMO Resolution 40 as Basic Data for distribution on the GTS, it is clear and there is confusion among WMO Members and experts in relation the extent to which ICAO Aircraft Observations can and should be distributed under this resolution and also meet with requirements for compliance with ICAO regulations.
- While there are existing character and binary based codes for distribution of AMDAR and other ABO data on the GTS, there was clearly confusion and non-compliance with provisions and inadequate guidance regarding their use. Particular issues include:

- A lack of regulations and guidance for transmission of AIREPs and ADS-C data on the ICAO AFS and/or WMO GTS.
- Unavailability of a unique aircraft identifier for AIREPs and ADS-C data;
- Inadequate data quality control for ICAO derived ABO.
- It was noted that: At the ICAO/WAFSOP/7 (2012), the working paper titled “The Quality management of ADS reports relating to meteorological information” was discussed and the following conclusion 7/19 was made: *that the Secretary investigate issues concerning the QM of ADS reports relating to meteorological information and provide a report in time for WAFSOPSG/8 (2013)*. At ICAO/WAFSOPS/8 it was reported that: *with regard to Conclusion 7/19, the group noted that the investigation by the Secretariat on issues concerning quality management of automatic dependent surveillance (ADS) meteorological reports was on-going*.
- Mis-use of header and code elements.
- Inconsistency within some WMO manuals and guides on the definition of “Aircraft Identification” and on the process for putting data on the ICAO AFS and/or WMO GTS.

2.3. The following discussion points were made and conclusions reached:

- Mr Neil Halsey, ICAO, clarified that ICAO regulations and provisions indicate the following relating to the provision and use of ICAO Aircraft Observations:
 - ICAO aviation data that can be considered as contributing to meeting the provisions for ICAO Aircraft Observations are AIREPs, ADS-C and Mode-S data.
 - Provisions for Aircraft Observations as defined in Annex 3, are based on the requirements for such data by ICAO WAFCs for the support of forecasts and other services to aviation.
 - ICAO Members should exchange messages only in the format in which they are received (ICAO, Annex3, App 4,3.4).
 - These data are produced for the use of ICAO Members for ICAO purposes but should be made available to WMO Members and placed on the GTS under the arrangements set out in ICAO doc. 8896, 7.7.1 and 7.7.3, which stipulates that *Air-reports exchanged beyond WAFCs are considered as basic meteorological data and therefore their further dissemination is subject to WMO provisions*.
- Mr Halsey pointed out that, in the future, all aviation data is likely to be required by ICAO in XML format.

ICAO Position on Aircraft Observations

2.4. Mr Halsey provided some background information and comments on the matter of ICAO Aircraft Observations, making the following key points:

- Pilot Reports (PIREPs) are not defined or regulated by ICAO and are not considered ICAO Aircraft Observations since they are a national product provided primarily by the United States.
- The Meteorological Section in ICAO has been dissolved as a result of a recent ICAO reorganisation and the chief forum for interaction between ICAO and WMO now is the ICAO Meteorology Panel - <http://www.icao.int/airnavigation/METP/Pages/default.aspx>. The Panel has four Working Groups, of which the one most relevant to Aircraft Observations might be the Meteorological Information and Service Development group. The ABO programme should work with the WMO Aeronautical Meteorology Division to interface with the Meteorology Panel and its work groups.
- While data derived from ICAO Aircraft Observations can be utilised by WMO Members under the regulations within Annex 3, the extent to which these arrangements are valid are limited to the requirements for Aircraft Observations as specified in ICAO Annex 3. Above and beyond these requirements, arrangements for the reception or utilisation of additional data from these ICAO data sources would be a matter for member states and their respective national organizations. In this regard, access by NMHS to high resolution Mode-S data from SSR would be subject to this understanding.
- AMDAR data is considered by ICAO to be an arrangement either between WMO Member NMHS and airlines directly or, in some cases WMO Member NMHS and national civil aviation authorities. These have the same status with ICAO as do other Basic Data and would be subject to the same cost-sharing arrangements as established under ICAO and as described in the ICAO Manual on Air Navigation Services Economics (Doc 9161).

EUMETNET Developments & Expectations for ADD

2.5. Mr Siebren de Haan made a presentation to the workshop on the Mode-S Enhanced Surveillance System (EHS): *EUMETNET Developments & Expectations for Aircraft Derived Data (ADD)*, describing the progress that various EUMETNET members have made in investigating the validity and utility of aircraft-based observations derived from the Mode-S EHS system.

2.6. Mr de Haan made the following key points in his presentation:

- ADS-B and Mode-S data sources had been studied by various EUMETNET members, including the Netherlands, for some years now and have concluded that data from the Mode-S systems, in particular the Mode-S EHS system, in combination with some ADS-B parameters, offers a great opportunity for meteorological services to obtain good quality high resolution upper air data from the aircraft platform. The various system sources of ADD are shown in the table below along with the potential for obtaining meteorological data from them (Figure 1).
- The quality of Mode-S ADD wind data, once corrected and quality controlled is equivalent to that of AMDAR wind data, while the ADD temperature data is useful but lower quality than AMDAR temperature data, chiefly owing to the lack of precision reported in the aircraft Mach Number.
- Mode-S EHS derived meteorological information is available in high resolution and in time for assimilation and derived meteorological information has a positive impact on initializing NWP model and improves the forecast of wind up to 12 hours into the forecast. Current and potential reporting resolution are shown in Figure 2 below.

- The derived upper air observations from Mode-S EHS are semi operationally being provided by KNMI to the several European meteorological data users free of charge based on a Non-Disclosure Agreement.
- ADD, while not available over oceanic areas, are seen as a low-cost source of upper air data and supplementary to AMDAR data. They may offer the opportunity to reconfigure and re-optimize the AMDAR observing system over Europe.

ADD data types and sub-types



<http://mode-s.knmi.nl>

Type	Sub-type	Direct meteorological information	Derived meteorological information	Remarks
Automatic Dependent Surveillance (ADS)	ADS-B	✗	✓	- Only wind - Small number - Poor quality
	ADS-B ES	✗	✓	- Small number - Poor quality
	ADS-C	✓	✓	- Only small portion of messages - Good quality - Data only via ATC or airlines - Data communication costs
Secondary Surveillance Radar (SSR) Mode-S	Mode-S ELS	✗	✗	-
	Mode-S EHS	✗	✓	- Specific dynamic aircraft corrections and quality control required - Good quality wind - Lower quality of temperature - Exceptionally large amounts of observations - Data distribution costs still to be negotiated with ATM community
	Mode-S MRAR	✓	✗	- Small number - Good quality
	Mode-S MET Hazard Report	✗	✗	-
E-AMDAR (for comparison)	E-AMDAR	✓	✗	- Requires on-board AMDAR software - Contract with airlines - Data communication costs - Good quality

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Figure 1.

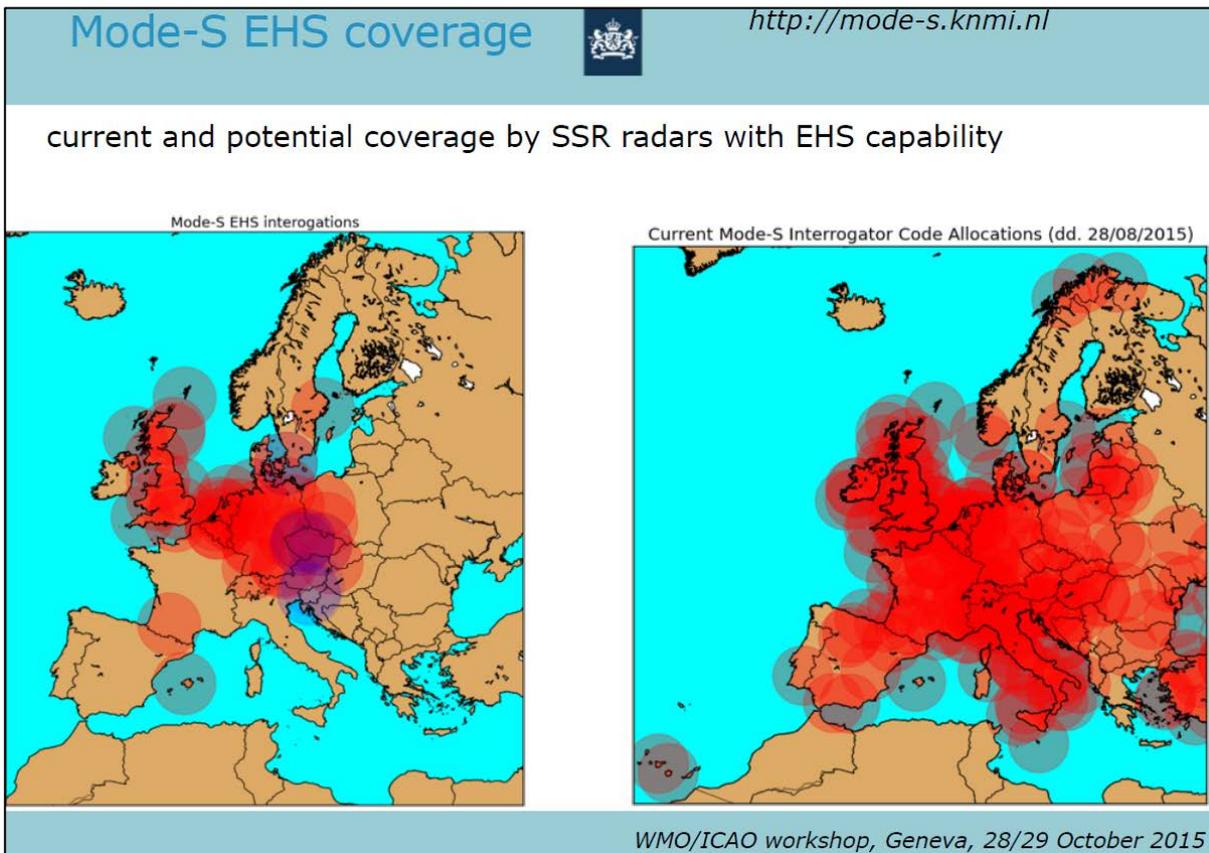


Figure 2.

Use of and requirements for ABO data by WAFCs

2.7. Mr Matt Strahan, USA and Mr Chris Tyson, UK, representing the Washington and London WAFCs respectively, jointly provided some discussion and input on the use of ABO in support of meeting their obligations under ICAO Annex 3 for provision of services to international air navigation. In particular, the following key points were made:

- Several authors had commenced collaboration on a paper on, The Role of Aircraft Based Observations (ABOs) in Modern Weather Forecasting which might form a basis for describing the benefits and defining the requirements for ABO to support aeronautical meteorology forecast applications.
- There was an ICAO Recommendation within the Aviation System Block Upgrades (ASBU) to support the delivery of high resolution icing and turbulence products by the WAFCs. Such forecasts would benefit from high resolution observing and reporting of icing, humidity and turbulence data. Such data would also provide information that could be used to verify the forecasts and to establish climatologies of these parameters. Whilst greatest benefit might be obtained through receipt of such observational data in real or near-real time, it was noted that for verification and climatological purposes data could be utilised for such purposes days or even weeks after the event. It was suggested that WMO might be able to assist in the development of requirements for the provision of non-real-time data sets of these parameters from aircraft platforms, if such an initiative could be supported by AMDAR partner airlines and perhaps IATA.

2.8. The workshop participants discussed the requirements for Aircraft Observations in support of WAFC operations and whether these might require review by the WAFCs, particularly in light

of the capability of aircraft to reliably measure humidity and the future requirements for icing and turbulence products by aviation.

3. DAY 2 DISCUSSION AND CONCLUSIONS

Discussion on Key Topics

Requirements for Upper Air Data and ABO

- 3.1. The workshop participants discussed the respective requirements of WMO and ICAO members for provision of and access to ABO in support of the various meteorological and other WMO Application Areas, including Aeronautical Meteorology (AeM). It was suggested that the WAFC requirements for upper air data should be consistent with and perhaps even contained within the AeM Statement of Guidance which supports the WMO Rolling Review of Requirements process. It was agreed that Mr Strahan and Mr Tyson would review the current AeM SoG in order to assess the document's relevance to WAFC operations and, in collaboration with ICAO, report back to ET-ABO.
- 3.2. The workshop agreed that it was clear that the ICAO regulations in relation to the specification of requirements for ICAO Aircraft Observations were in part to support the operation of the WAFCs. Any revisions to the requirements to support these operations would be subject to ICAO Member approval. Mr Strahan and Mr Tyson agreed to review the needs of WAFCs for Aircraft Observations, in consultation with WAFC colleagues and report back to WMO ET-ABO accordingly. It was suggested that the paper mentioned in section 2.7 above might provide useful analysis and support for this and it was agreed that the various technical reports and guidance on ABO data impacts and benefits already produced by the WMO ABO programme might be a good source of reference and input for this document. The needs of VAACs, TCAs and MWOs would require the involvement and input from other stakeholders and then identified and approved for inclusion in the ICAO requirements.

Data Policy and WMO Resolution 40

- 3.3. Mr Halsey suggested that the issues of data policy, data ownership and intellectual property rights in relation to aviation and meteorological data was a growing concern for ICAO and WMO Members and that there was a need to carefully consider these aspects of the organization's respective operations, particularly in light of the movement towards greater and wider exchange of data globally in support of future ATI management systems being envisaged by entities such as SESAR and NextGen.

Wider WMO Member Access to Aircraft Observations

- 3.4. The workshop discussed the availability of meteorological data from ICAO Aircraft Observations and in particular how greater compliance with existing ICAO Annex 3 requirements for their provision by ATCs and airlines might be attained. Mr Halsey agreed to investigate possible ICAO forums and means for addressing this issue and report back to ET-ABO on any progress made. It was also agreed that ET-ABO should consult with IATA contacts regarding possible collaboration with IATA and their Members on this issue.

Quality Management of Meteorological Information Derived from Aircraft Observations

- 3.5. The workshop participants recognized the concerns regarding the quality of message formats and of meteorological data derived from ICAO Aircraft Observations on the GTS and the need to be able to uniquely identify aircraft that report poor quality data so as to be able to blacklist such aircraft from GTS transmission until such issues have been resolved. It was also agreed that, while such a data QC process was clearly a WMO requirement, it was not currently recognized as a requirement for, or responsibility of, the WAFCs. At the current time, any resource requirements for the development and operation of such QC functionality would be attributable to WMO Members. The workshop agreed that a possible solution would be to more actively enforce ICAO requirements for management of ICAO Aircraft Observations and for WAFCs to each "pass" the data to a WMO designated center for QC prior to GTS transmission. Whether or not the issue of unique aircraft identification could be resolved would require further analysis. It was agreed that:

- 1) ET-ABO would investigate further the possibility to put in place and regulate a WMO data processing centre to be associated with each WAFC and to provide QC functionality for meteorological data derived from ICAO Aircraft Observations as provided by the WAFCs; and
- 2) Mr Strahan and Mr Tyson would investigate whether there might be a benefit for WAFCs to receive quality controlled meteorological data derived from ICAO Aircraft Observations.

3.6. The workshop participants agreed that a remote conference meeting of workshop participants should be held around March 2016, arranged by the WMO Secretariat, so as to discuss progress on the above agreed actions from the workshop.

4. CLOSE OF THE WORKSHOP

The workshop participants unanimously agreed that the workshop had been very beneficial, both to the participants and to the organizations represented and that such a face to face meeting or workshop should be considered again in the future to discuss progress and issues related to ABO.

The Chair thanked all participants and the meeting closed at around 3pm on 29 October 2015.

ANNEX I - WMO/ICAO Workshop on Future Requirements for Meteorological Aircraft Observations

[Purpose](#)

[Venue & Dates](#)

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PURPOSE

At the 2014 ICAO Meteorology Divisional Meeting (in part conjointly with the Fifteenth Session of the WMO Commission for Aeronautical Meteorology (CAeM) including Technical Conference), WMO submitted an Information Document entitled: Current status of aircraft-based observations and plans for expansion of the AMDAR programme - IP.21-INF.21¹.

This paper describes the current status of WMO AMDAR observations and their significant positive impact on meteorological applications and, through those applications, to aviation services. It also discusses meteorological data that are currently available and potentially more widely available from ICAO aircraft observations. These meteorological data can be derived from several ICAO sources and systems including automated and special Aircraft Reports (AIREPs) and Automatic Dependent Surveillance (Contract and Broadcast - ADS-C and ADS-B). Currently WMO receives more than 15,000 aircraft-based meteorological observations per day from ICAO aircraft observations and there is an expectation among WMO Members that such data will become more widely and abundantly available in the future. Meteorological services of countries such as The Netherlands and the United Kingdom are currently investigating the potential benefits of winds and temperature via interception of ADS-B information transmitted from aircraft fitted with Mode-S transponders communicating with national Air Traffic Management systems.

The purpose of this workshop is to:

- 1) Present the current status of meteorological aircraft observations, including both the WMO Aircraft Meteorological Data Relay (AMDAR) program and ICAO aircraft observations;
- 2) Present and discuss the potential for and benefits of wider and improved future access to ICAO aircraft observations by World Area Forecast Centers (WAFCs) and WMO Members; and
- 3) Initiate high level discussion with ICAO and other stakeholders towards a more coordinated approach to the derivation of meteorological data from ICAO aircraft observations in support of improved weather services.

VENUE & DATES

Venue: Proposed: WMO Secretariat, Geneva, Switzerland.

¹ <http://www.icao.int/Meetings/METDIV14/Information%20Papers/IP.21-INF.21.pdf>

Schedule and Dates: 28-29 October - Workshop will commence at 9:30 am and we expect to conclude business at or before 4pm on the 29th October.

Meeting Room: WMO Headquarters, Meeting Room 8 Jura (Level 8, Exit lifts to right and proceed to end of corridor.)

Information on WMO and Geneva: http://www.wmo.int/pages/visitors/index_en.html

Nearby hotels:

- Mon Repos
- The Eden

Security: An entry badge will be provided by the reception desk on the first morning - please bring photographic ID.

TOPICS

It is expected that the following topics will be covered:

- Future requirements for upper air data.
- Status & future of the AMDAR Program.
- Status & future of ICAO aircraft observations.
- Aircraft tracking systems.
- WMO Member access to ICAO aircraft observations.
- Policy, ownership and liability issues.
- Requirements for data management and quality control.
- Cost/benefit and resourcing.

OUTCOMES

The following outcomes are expected:

- 1) Better understanding of the current and future availability of aircraft observations to WMO Members.
- 2) Better understanding of ICAO objectives for the availability, use and management of aircraft observations.
- 3) Development of plans for future collaboration between ICAO and WMO on aircraft observations access and management.

TENTATIVE PROGRAM**Day 1**

Item	Title/Topic	Description	Presenter
1	WMO ABO & AMDAR Status, Requirements & Issues	<ul style="list-style-type: none"> • Global Status of ABO, AMDAR • Requirements for ABO by WMO Members and User Applications Areas • WMO regulations & guidance on ABO • Current issues with ADS data 	Frank Grooters
2	ICAO Position on Aircraft Observations	<ul style="list-style-type: none"> • ICAO evolving and future approach to meteorology and meteorological data • ICAO expectations regarding future of ADS & Aircraft Tracking • ICAO position on AMDAR and Aircraft Derived Data (ADD) and relation to WMO Res. 40 • Future of Annex 3 & regulations on Aircraft Observations 	Neil Halsey
3	EUMETNET Developments & Expectations for ADD	<ul style="list-style-type: none"> • Developments in acquisition of ADD in Europe • Expected development of ADD by EUMETNET members 	Siebren de Haan
4	Use of and requirements for ABO data by WAFC London	Use of and requirements for ABO data by WAFC London	Chris Tyson
5	Use of and requirements for ABO data by WAFC Washington	Use of and requirements for ABO data by WAFC Washington	Matt Strahan

Day 2

Item	Title/Topic	Description	Moderator
1	Discussion on key topics	<ol style="list-style-type: none"> 1. What are the requirements for Upper Air data & ABO by WAFCs in support of ATI? 2. How much of requirements for Upper Air data can/should be provided by ICAO? 3. How would cost be attributed/recovered? 4. Are there issues with WMO Res. 40. 5. How can availability of ADS data be improved and extended in the future? 6. What are requirements for QC and management of ICAO ABO and how can required QC of data be achieve? 	Frank Grooters
2	Conclusions, Recommendations, Actions	<ul style="list-style-type: none"> • Workshop to derive a set of conclusions, recommendations and actions arising from the meeting. 	
3	Report	<ul style="list-style-type: none"> • Agreement on how to report to WMO members on the outcomes of the workshop. 	

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