W O R L D M E T E O R O L O G I C A L O R G A N I Z A T I O N

COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION

OPAG ON REMOTE SENSING TECHNOLOGIES

and

COMMISSION FOR BASIC SYSTEMS

OPAG ON INTEGRATED OBSERVING SYSTEMS

JOINT MEETING OF THE

CIMO EXPERT TEAM ON OPERATIONAL REMOTE-SENSING TECHNOLOGIES

(First Session)

and

CBS EXPERT TEAM ON SURFACE BASED OBSERVATIONS

(Second Session)

Tokyo, Japan

5 to 8 October 2015

FINAL REPORT

DISCLAIMER

Regulation 42

Recommendations of working groups shall have no status within the Organization until they have been approved by the responsible constituent body. In the case of joint working groups the recommendations must be concurred with by the presidents of the constituent bodies concerned before being submitted to the designated constituent body.

Regulation 43

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CONTENTS

EXECUTIVE SUMMARY

The joint meeting of the First Session of the CIMO Expert Team on Operational Remote Sensing Technologies (ET-ORST) and the Second Session of the CBS Expert Team on Surface Based Observing Systems (ET-SBO) was held over 5 to 8 October 2015, at the headquarters of the Japan Meteorological Agency (JMA), Tokyo, Japan, at the kind invitation of Mr Noritake Nishide, the Permanent Representative of Japan with WMO.

This joint meeting of CBS and CIMO teams continues the process of ensuring that there is collaboration between WMO technical commissions and that Member expertise is coordinated and used as efficiently as possible. ET-SBO and ET-ORST currently have several areas of mutual interest in operational remote-sensing systems and the joint meeting was an opportunity to discuss and clarify this in relation to the respective work plans of the teams. Additionally the important concept of the international and inter-commission coordination of weather radar systems was addressed and the teams jointly composed a recommendation for the terms of reference for such a team or group.

While ET-ORST was undertaking its first face-to-face meeting of the CIMO inter-sessional period and seeking to clarify and establish its work plan, ET-SBO sought to finalise its work plan for the coming twelve months in the lead up to the next CBS session in 2016.

Both teams have undertaken work plans which place a strong emphasis on the development and update of WMO regulatory and guidance materials, which is in keeping with the priorities for the WIGOS Pre-operational Phase that have been established by Congress. ET-SBO also reported on and revised its activities associated with a range of areas, including the WIGOS Framework Implementation Plan, OSCAR and WIR development, progress on the Implementation Plan for Evolution of the GOS and quality monitoring.

All participants agreed that the meeting had been highly successful and fruitful. The Chairs and session participants warmly and sincerely thanked JMA and its meeting coordination team for their generous and excellent hospitality.

AGENDA

1. ORGANIZATION OF THE SESSION

1.1 Opening of the Session
1.2 Adoption of the Agenda
1.3 Working Arrangements of the Session

2. CHAIRS' REPORTS

2.1 Report of the Chair of ET-ORST
2.2 Report of the Chair of ET-SBO

3. WIGOS IMPLEMENTATION STATUS & FUTURE DEVELOPMENT

3.1 Outcomes from Cg-17 and EC-67
3.2 OSCAR Development
3.3 Regulatory and Guidance Material
3.4 Data and Metadata Exchange
3.5 Quality Management
3.6 Inter-Commission Teams & Coordination

4. RADAR WIND PROFILERS

4.1 Guidance Material on Operational Systems
4.2 New Developments in Technology

5. WEATHER RADARS

5.1 Dual Polarization
5.2 Algorithm Intercomparison (RQQI)
5.3 New Developments
5.4 Operation in Mountainous Terrain
5.5 Operational Calibration
5.6 Collaborative Mode Operations
5.7 Coordination Mechanism for Weather Radars

6. LIGHTNING DETECTION SYSTEMS

6.1 Guidance Material (performance assessment)
6.2 Testbed and Intercomparison

7. SURFACE-BASED IN SITU OBSERVING SYSTEMS

7.1 AWS
7.2 Manual Observations
7.3 Radiosonde

8. INTEGRATION OF OBSERVATIONS

8.1 Rainfall Data

9. COLLABORATION WITH ISO

9.1 Weather Radar Standard
9.2 Wind Profiler Standard

10. REVIEW AND REVISION OF WORK PLANS AND SCHEDULES

10.1 Review and revision of work plan and schedule of ET-SBO
10.2 Review and revision of work plan and schedule of ET-ORST

11. DRAFT REPORT OF THE SESSION

12. CLOSURE OF THE SESSION

GENERAL SUMMARY

1. ORGANIZATION OF THE SESSION

1.1 Opening of the Session

1.1.1 The joint meeting of the First Session of the CIMO Expert Team on Operational Remote Sensing Technologies (ET-ORST) and the Second Session of the CBS Expert Team on Surface Based Observing Systems (ET-SBO) was opened at 09:30 am on Monday, 5 October 2015, at the headquarters of the Japan Meteorological Agency, Tokyo, Japan, where the meeting was held at the kind invitation of Mr Noritake Nishide, the Permanent Representative of Japan with WMO.

1.1.2 Mr Ishida provided the opening address, in which he expressed appreciation to WMO for providing the opportunity to host the joint session in Japan. He stressed the importance of the meeting, in view of WMO's and Japan's common dedicated goal of promoting improved data quality and integration for WIGOS, and noted that a successful meeting would contribute significantly to the success of the WIGOS pre-operational phase. Mr Nishide reminded the session that Japan is particularly prone to the occurrence of various extreme events, such as typhoon, earthquake and tsunami, and that this provides a great driving force for the improvement of its meteorological services which depend so critically on the availability of high quality observations. He suggested that the occasion of the joint session provided a wonderful opportunity to contribute to improvements in this area, and that he expected the participants to capitalise on the opportunity for discussion between JMA's experts and those from other countries participating in the session. In closing, Mr Nishide wished the participants a successful meeting and an enjoyable and fulfilling time in Tokyo.

1.1.3 Mr Dean Lockett next welcomed the participants to the joint session on behalf of the Secretary General of WMO. He expressed his honour and pleasure to have the meeting held in Tokyo. He commended Japan for its wonderful hospitality, and its excellent observing technology and systems, suggesting that together these make Japan an ideal location for such a joint session. Mr Lockett reminded the participants that the two expert teams were meeting together to capitalise on the opportunity to address a number of commonalities between the two, particularly their mutual interest in radar technologies, and expressed his confident expectation of a very successful meeting which would see the two teams refine priorities and increase efficiencies, which is the essence of WIGOS. In closing, Mr Lockett reiterated his thanks to the hosts at JMA, and wished the participants well for a successful joint session.

1.1.4 Mr Volker Lehmann, chair of ET-ORST, next welcomed the participants. He expressed his delight that the meeting was taking place in Tokyo, given the advanced state of remote sensing technologies in Japan. He expressed his best wishes to the participants for a busy and productive meeting, and added his thanks to JMA for generously agreeing to host the meeting.

1.1.5 Mr Stuart Goldstraw, chair of ET-SBO, welcomed the participants and stressed to them the vital importance of delivering a fully operational WIGOS by 2019. He noted that while 2019 may seem a long way away, it will be with us very soon. He noted that there is much work to do before then and beyond: that we will face increasing challenges over the next few decades, in regard to the expected level of available resourcing in the face of increasing demand for services. With a projected global population of 9 billion by 2040, and with most of those living in areas vulnerable to hazardous weather it is our job to ensure that the WMO Integrated Global Observing System is in best position to provide the services needed. Mr Goldstraw noted the wide range of expertise present at the joint session, and recommended that all participants make the most of this opportunity to share ideas. In closing, he added his best wishes to the participants for a successful meeting. The list of participants is at Annex I.

1.2 Adoption of the Agenda

1.2.1 The agenda for the session was adopted.

1.3 Working Arrangements of the Session

1.3.1 The Meeting agreed on arrangements for the organization of its work, including working hours. The documentation and meeting was conducted in English only. The two teams agreed to meet in plenary for the first two days of the session to consider matters of mutual interest, then separate into individual teams for the remaining agenda items, coming together once more on the last day to conclude the work.

2. CHAIRS' REPORTS

2.1 Report of the Chair of ET-ORST

2.1.1 Mr Lehmann, chairman of ET-ORST, reminded the session of CIMO's objective of facilitating the availability of high quality, globally compatible and standardized WIGOS observations. Recognizing the growing importance of surface-based remote sensing observations, CIMO-16 had decided to retain its Expert Team on Operational Remote-Sensing Technologies, with Terms of Reference focusing exclusively on operational weather radars, radar wind profilers and lightning detection systems. Mr Lehmann noted that most of the team's twelve activities, as described in its Work Plan, are concerned with the preparation of updated material for the CIMO Guide and that documented guidelines are available for this and should be followed closely when preparing such draft guidance material.

2.1.2 Mr Lehmann advised the session that, since the commencement of its new term in July 2014, the team had held four teleconferences to commence and progress its work leading up to the current joint session. He noted that the major goal of the joint session would be to discuss and achieve further progress on each of its Work Plan tasks.

2.1.3 He expressed his concern about the inconsistent terminology used to describe weather radars and radar wind profilers, and requested the participants to agree to standardize and simiplify the vocabulary, to avoid ambiguity and potential misunderstanding by non-experts.

2.1.4 Mr Lehmann concluded his brief report by expressing his appreciation of the work already performed by the expert team in the short time since CIMO-16, and his hope that it would continue with such good progress in the months to come.

2.2 Report of the Chair of ET-SBO

2.2.1 Mr Goldstraw, chairman of ET-SBO provided a summary of the progress that ET-SBO had made since the first session of ET-SBO held in July 2013 and outlined the key activities to be progressed by the team in the lead up to Sixteenth Session of the Commission for Basic Systems, expected to be held in the 4th quarter of 2016.

2.2.2 Mr Goldstraw expressed satisfaction that some activities of the work plan had progressed well, while others had unfortunately not done so as a result of limited capacity of team members to contribute their time and also because the team membership had changed during the period.

2.2.3 The team had been requested to contribute to the work of several other CBS and WIGOS teams in the form of advice and participation in meetings. In particular the chair and vice-chair had attended the Eighth Session of ICT-IOS (April 2014) where it was reinforced that ET-SBO should give attention to the matter of the optimisation of the upper air network as a component of action G10 of the Implementation Plan for the Evolution of the GOS. ET-SBO has also contributed expertise to the meeting and workshops associated with the Inter-Programme Expert Team on Observing System Design and Evolution (IPET-OSDE), for which ET-SBO has related activities in its work plan, including progress on the implementation of the EGOS-IP.

2.2.4 The team had made good progress on the development of draft regulatory material for the Manual on the GOS for three technology areas: weather radar, radar wind profilers and AWS. This had been advanced chiefly through the holding of a meeting of the team Sub-group on Regulatory Material in December 2014 in Geneva but required significant work in order to meet the timeline for finalisation and subsequent approval by CBS-16. The team may also need to consider the requirement for additional or updated regulations or guidance in relation to various matters including radiosonde network optimisation, non-reporting of snow cover and mercury disposal.

2.2.5 An activity that ET-SBO had also taken the lead on and progressed was that related to the revision and update of the WMO data quality monitoring system under the WIGOS Framework Implementation Plan. This was advanced through the holding of the Workshop on Data Quality Monitoring and Incident Management (WDQM&IM) in December 2014 in Geneva.

2.2.6 The team also was expected to contribute to the work of the Inter Programme Expert Team on WIGOS Framework Implementation and its Sub Group on OSCAR Development, with particular emphasis on the complex task of migrating to the new process of reporting of Volume A metadata via OSCAR.

2.2.7 Under item 10.1 of the agenda, ET-SBO members would be expected to formulate plans and actions to advance these and other related activities within the work plan and also report on progress made through ICT-IOS in the first half of 2016.

3. WIGOS IMPLEMENTATION STATUS

3.1 Outcomes from Cg-17

3.1.1 The session was informed of the key outcomes, of relevance to the work of ET-ORST and ET-SBO, of the Seventeenth Session of the World Meteorological Congress (Cg-17), which was held in Geneva from 25 May to 12 June 2015. These included Cg-17's reaffirmation of the importance of the GOS as one of the core components of WIGOS, and its reaffirmation of the importance to WIGOS of the Instruments and Methods of Observation programme.

3.1.2 Congress noted with appreciation, the work and contribution by the Turkish State Meteorological Service (TSMS) in establishing the WMO Weather Radar Database (WRD) and undertaking to maintain this facility for the benefit of all Members.

3.1.3 Congress also acknowledged the important contributions that CBS and other technical commissions provided in support of the WMO polar and high mountain activities and for the development of the Global Cryosphere Watch (GCW), noting that an immediate priority for GCW is to establish the core standardized network of GCW surface-based measurement sites referred to as "CryoNet".

3.1.4 Congress decided that the development of WIGOS will continue during its Pre-Operational Phase in the seventeenth financial period (2016-2019) building upon and adding to those key building blocks of the WIGOS Framework that have already been implemented. The highest priorities for the WIGOS Pre-operational Phase will be:

(a) National WIGOS implementation;
(b) WIGOS Regulatory Material complemented with necessary guidance material to assist Members with the implementation of the WIGOS technical regulations;
(c) Further development of the WIGOS Information Resource (WIR), with special emphasis on the operational deployment of the OSCAR databases;
(d) Development and implementation of the WIGOS Data Quality Monitoring System; and
(e) Concept development and initial establishment of Regional WIGOS Centres.

3.1.5 Congress approved Volume I, Part I – WIGOS, of the WMO Technical Regulations (WMO-No. 49) and its Annex - Manual on WIGOS, with effect from 1 July 2016. It also recognized the urgent need for accelerating the development of corresponding WIGOS guidelines and guidance

material to facilitate the implementation of WIGOS technical regulations as specified in Volume I, Part I and the Manual on WIGOS by Members (i.e. development of an initial Guide to WIGOS by 1 July 2016).

3.1.6 Congress noted with appreciation the successful development and implementation of the OSCAR databases. Congress further recognized that the remaining parts of the WIGOS Information Resource yet to be fully developed, e.g. the portal and the "Standardization of Observations" Reference Tool (SORT), are also important for WIGOS and will require substantial resources for their development and subsequent operation.

3.1.7 Congress affirmed that a key principle of WIGOS is an inclusive approach to the integration of observations from a diverse range of observing systems, both NMHS and non-NMHS owned, into a composite set of observations to help Members improve their services across all WMO application areas. Recognizing the need for assistance to Members concerning the establishment of partnerships and formal agreements with different data providers, Congress requested that guidance material on this matter be developed and included in the Guide to WIGOS.

3.1.8 Congress noted the growing conflict between the operation of wind turbines and weather radar systems and requested CIMO to coordinate scientific studies and work on more specific recommendations on the separation between wind turbines and weather radar systems.

3.1.9 Congress agreed to the need for a single international coordination mechanism for weather radar systems and their data and products, that utilizes existing bodies as far as possible, to achieve global weather radar data consistency. Congress requested CIMO to establish a CIMO/CBS-led international coordination initiative for standardization of practices and procedures for weather radar systems, which should include all Members, partners and entities operating weather radar networks, capitalize on the positive experience achieved within regional cooperation mechanisms, such as OPERA and BALTRAD in Europe, and include a strong focus on capacity development to ensure coordinated weather radar data quality across regions.

3.1.10 Congress also requested CIMO to explore options for improving standardization of other surface-based observing systems and techniques, particularly for remote-sensing systems such as radar wind profilers.

3.1.11 With regard to the impending impact of the Minimata Convention on Mercury, Congress requested CIMO to support Members by developing appropriate guidance material and supporting the identification of appropriate replacement instruments.

3.1.12 Congress recognized that common WMO-ISO standards should be considered when both WMO and ISO have a topic of common interest and similar goals. Congress requested CIMO to monitor and, if appropriate, contribute to the development of the weather radar standard that ISO has decided to develop.

3.1.13 Congress urged Members to ensure sustainable operation of GOS and encourage activities with respect to the optimization of observing elements and development and deployment of the advanced composite system, with priority given to projects in the following order:

a) Projects aiming at restoring and improving the existing sites, as well as building the new upper-air observational capabilities of the Regional Basic Networks, with emphasis on GSN/GUAN stations, especially to fill the gaps over data-sparse areas;

(b) Projects aiming at expansion and enhancement of aircraft-based observations, with special attention to developing countries to supplement scarce upper-air observations or to provide a cost-effective alternative to countries that cannot afford costly upper-air sounding systems;

(c) Projects related to the improvement of data quality, regularity and coverage of surface observations of the Regional Basic Networks;

(d) Projects related to the use of new observing equipment and systems including, where cost-effective, surface-based remote-sensing systems (weather radars, wind, temperature and humidity profiles and lightning systems), automatic weather stations, Automatic Meteorological DAta Relay (AMDAR), the Automated Shipboard Aerological Programme and drifting buoys;

(e) Projects related to increasing the synergies between space-based and surface-based observing systems, and the integration of in situ and satellite data.

3.1.14 With regard to §3.1.8 above, the session discussed the current material in the CIMO Guide (Annex 9.A) on mitigation of the impact of wind turbines on weather radars. It agreed that the current guidance material is in need of expansion, and discussed how this might best be done.

3.1.15 Mr Lehmann provided a brief presentation on the impacts of wind farms on C-band (5 cm) radar operations, especially on automated applications. The session agreed that there are two possible approaches that can be taken: prevention and mitigation.

3.1.16 It was agreed that effective prevention requires pro-active engagement with wind farm planners and government regulators, where this is possible, long before plans are developed for the establishment of a particular wind farm. Targeted publicity campaigns espousing the benefits to the community of weather radar-based services can help to increase public perception of the importance of effective weather radar coverage, leading to more public support for maintenance of unobstructed operations, rather than the public sympathy enjoyed in many countries by renewable energy initiatives. Detailed modelling of a radar's beam propagation using high resolution topographic data can assist in identifying those sectors of a radar's coverage which are most susceptible to obstruction by wind turbines. It was unanimously agreed by the session that prevention is the only fully effective solution, but it was noted that in many countries this is simply not possible, owing to strong support for the establishment of wind farms as a renewable energy source.

3.1.17 In regard to mitigation, the session agreed that there is no technique available for eliminating obstruction to radar data, especially reflectivity and wind fields due to the proximity of a wind farm but that this is not well-understood by the general community. The session agreed that detailed guidance material on the various effects of wind farms on weather radars, with an explanation of why no 'cure' is available for each, is needed. This might then assist Members to better understand why this is such a serious issue and why prevention is so important.

3.1.18 Mr Lehmann informed the session that an activity is currently underway within DWD to further investigate this issue, and that he will request DWD to share any resulting publications for use in preparation of more comprehensive WMO guidance material. It was also noted that a similar activity is currently underway for OPERA, and that access to the results can be requested for the same purpose.

3.1.19 The session noted, however, that the timescale for completion of these two activities is beyong WMO control, so, given the urgency of the need, ET-ORST should commence development of its own guidance material. Mr Lehmann proposed that, during the next ET-ORST teleconference, he would request Mr Paul Hettrick to draft some text on prevention, and Mr Cook and/or Mr Urban to draft some material on mitigation. It was agreed that this should be apriority agenda item for the next teleconference of the team. An additional task was added to the ET-ORST Work Plan to address this matter.

3.2 OSCAR Development

OSCAR Development Status

3.2.1 Mr Lockett provided a presentation to the session on the current status of the OSCAR system and the plans for its further development. The key aspects of the presentation were:

- OSCAR is the Observing Systems Capability Analysis and Review Tool and is a component of the WIGOS Information Resource. The WIGOS Information Resource (WIR) comprises three major elements, of which the other two are the WIR Portal and the Standardization of Observations Reference Tool (SORT).
- The OSCAR system was developed originally to fulfill a requirement to be able to record the current and future expected capabilities of the satellite observing system and its ability to meet the requirements of data users. The current development of OSCAR underway is chiefly concerned with implementing extension of the system to be able to store and determine the capabilities of the surface based observing systems.
- A key element of the development would be for the system to be able to store or have access to the full metadata set defined by the WIGOS metadata profile, including the storage of metadata pertaining to WMO Volume A.
- A second major element of the development would be the tools and applications to facilitate the analysis and review of the observing system capabilities in comparison with the user requirements of the WMO Application Areas.
- The two-phased project was underway and being progressed through a WMO partnership with MeteoSwiss and its subcontractors.
- A prototype system was successfully demonstrated at Cg-17 and many members and experts have provided feedback on a beta version of OSCAR throughout July 2015.
- It was expected that some components of the system would become operational in October 2015 with the integration of several phase 1 metadata sets including, GAWSIS, Volume A, Marine elements of the GOS / GOOS and weather radars.

3.2.2 The presentation was followed by discussion in which several important questions were asked. A concern was raised regarding what would be the consequence if members were unable to provide the full set of metadata elements. Mr Monnik responded that the metadata elements would be introduced in three phases over 2016 to 2019, which should give time and make it easier for Members to comply with the more difficult elements. A question was also raised regarding the governance and regulations and guidance relating to the metadata and how this would be managed. It was agreed that these really should be in place before the system is made operational so Members were aware of both what they should comply with and how they should do so.

Observing System Capabilities of Weather Radar

3.2.3 Mr Michelson, Canada, provided a presentation on the development of a model for determining the capabilities of weather radar systems for use in OSCAR. The model provides a concrete practical example of how capabilities of a complex observing system can be formulated for OSCAR, in a way that challenges but still conforms with the way OSCAR works. Radar's native observing geometry, the native observable radar reflectivity factor, data quality issues, are all addressed in this first version of the capabilities methodology. An example of applying the method is provided for the Swiss radar on Monte Lema, demonstrating that the method can be transformed into a real working application. Based on this model, it was also noted that the fundamental metadata required to use the methodology are all available in the WRD. This version of the methodology is a baseline that can be elaborated if and when required.

Development of the WIGOS Information Resource and Discussion Forums

3.2.4 The Chairman of ET-SBO, Mr Goldstraw, provided document 3.2(2) and discussed the relevant activity of ET-SBO to assist in development of the WIGOS Information Resource, particularly focusing on the capacity to share guidance and best practice materials quickly and

efficiently. However this is one of the activities that had not progressed, although it was pointed out that there was still the possibility to make some progress over the next 12 months.

3.2.5 The meeting was also informed that the Secretariat had established the WMO GOS Observing Systems Forum using the WMO Google Groups client and this would allow Members to share information about observing systems practices and issues by email. The online forum for the group would provide a sorted historical record of the emails exchanged. The two groups involved in the meeting had already been added to the forum and it was expected that other teams and focal point might be added in the future. A similar email group forum had been established for numerical weather prediction centers to facilitate discussion on observations issues and had been generating quite a bit of discussion and exchange of information.

3.3 Regulatory and Guidance Material

Status of WIGOS Regulatory Material

3.3.1 Mr Lockett provided a summary of document 3.3(1), regarding the status of WMO regulatory material relating to the establishment and operation of WIGOS. The following key points were made:

- Cg-17 (Resolution 25) had approved an update to the WMO Technical Regulations defining WIGOS as an entity and also the Manual on WIGOS, which was developed by the ICG-WIOGS Task Team on WIGOS Regulatory Material in consultation with various WMO technical commissions and teams.
- Cg-17 had also requested that the WMO Secretary General should oversee the development of the Guide to WIGOS by July 2015 and its further development and expansion over the coming inter-sessional period as a key activity during the WIGOS Pre-operational Phase.
- The new guidance material should focus on three key aspects associated with the Manual on WIGOS, informing members as to “why” and “how” they should comply with the regulations and also provide reference to other manuals, guides, specifications and relevant reports and documents.
- The guidance materials should serve two chief purposes: to preserve historical provisions that were still relevant; and to develop new provisions to facilitate new aspects of the WIGOS framework.
- A draft outline of the Guide to WIGOS had been submitted to the second session of the ICG-WIGOS Task Team on Plan for the WIGOS Pre-operational Phase (TT-PWPP).
- The session was invited to consider the approach and steps used for the development of the initial draft Guide to WIGOS.

3.3.2 There was agreement that there was a need for ET-SBO to consider the development of the Guide to WIGOS in any future endeavours to develop guidance material and that, in particular, the work on the development and finalisation of guidance on AWS should be carefully considered in the context of work being coordinated by the WIGOS Project Office.

AWS Guidance Material

3.3.3 Mr Lockett also provided a summary of the material submitted within document 3.3(2), which outlines the initial work undertaken by the WIGOS Project Office in developing a new and consolidated set of WIGOS guidance on Automatic Weather Systems (AWS). The meeting was informed that this initiative had commenced as a response to a request by Members for WMO to increase the guidance and training provided for the establishment and operation of AWS networks, particularly for developing countries. The development of a consolidated and complete set of guidance materials for AWS was seen as a necessary precursor to the provision of effective

workshops and training, providing the material upon which these activities would be based. A content structure for the WIGOS AWS guidance that also referenced existing relevant materials was presented within the document.

3.3.4 The meeting agreed that ET-SBO should play a significant role in both the development and revision of the material developed for AWS and that this should be considered further and actions proposed under item 10.1 relating to the ET-SBO work plan.

Regulatory Material Developed by ET-SBO

3.3.5 Mr Goldstraw informed the joint meeting of the activity that ET-SBO had undertaken to develop new regulations for three technology areas: weather radar, radar wind profilers and AWS and described the timeline and process that it would be necessary to meet in order to obtain their eventual approval by CBS later in 2016. It was agreed that the material would have to be finalized by the team by mid-February 2016, after which the resulting material would then be considered by IPET-WIFI and then submitted to the ICT-IOS session in April 2016. The three team members responsible for leading this work within ET-SBO then provided brief presentations outlining the content and status of the draft materials.

3.3.6 It was agreed that an important component of the new regulations would be to provide direction to available supporting guidance materials, most particularly including references to the CIMO Guide. This could be facilitated by the addition of notes within the regulations. In addition to providing a direction to relevant guidance materials, the process of adding these might also highlight requirements for new additional guidance material to be developed in the future.

3.3.7 Other points raised in discussion relating to this matter were:

- The manual aspects of observations in the context of the manuals and guides required careful consideration and it was important that these are not lost or neglected.
- There was a clear requirement for guidance on network design and particularly covering the issue of the development and operation of integrated multi-system automatic networks.
- There was a need to develop guidance on dual polarised radar systems and their maintenance and operation as they become the more common operational weather radar system. WMO could play a role in helping Members to achieve best practice in their operation and use including the promotion of open source applications and tools.
- Both the CIMO RQQI and CBS weather radar data exchange activities need to take into account requirements and considerations relating to dual polarised systems implementation.
- While there are many similarities and synergies between weather radar and radar wind profiler systems, it was agreed that the structuring of the regulations should consider the fact that readers might prefer not to have to follow too many cross-references to common provisions. Although, it was recognized that a future electronic version of manuals and guides (e.g. in a future SORT) might provide a way to electronically compile common regulations and provisions in a reader-friendly format. Certainly these technologies should be grouped together in the manual.
- It was identified that there was a need for guidance for Members on how to choose the right radar systems (i.e. technology type and model) for their applications, taking into account location, topography, climate, products required, etc.

Traceability of Radar Wind Profiler Data

3.3.8 Mr Lehmann provided the session with a presentation on his recent investigation into possible approaches to establishing the traceability of RWP data (See Annex II). He commenced with a review of the available WMO and other documentation on this subject. He next discussed

the principal difficulties in the 'direct calibration' approach for remote-sensing instruments and then described a proposed 'indirect calibration' approach. The session agreed to consider Mr Lehmann's document further under Agenda Item 4.

3.4 Data and Metadata Exchange

Status of the WIGOS Metadata Profile & Metadata Integration in WIGOS

3.4.1 Mr Monnik made a presentation to the session on the recent progress and current status of the development of the WIGOS metadata profile, which is related to the development of the metadata database and observing system capabilities of OSCAR.

3.4.2 The ICG-WIGOS Task Team on WIGOS Metadata (TT-WMD) had undertaken a consultative approach across Technical Commissions to develop the initial requirements for observations metadata, with TT-WMD composed of members who represent CBS, CAS, CIMO, JCOMM, CCl, CAeM, CHy, and GCOS. This process had led to the development of the WIGOS Metadata Standard (WMDS) that was approved by Cg-17. The technical implementation of the WMDS has been assigned jointly to TT-WMD and the OPAG-ISS Inter-Programme Expert Team on Metadata and Data Representation Development (IPET-MDRD). A draft model has been developed and this is currently being evaluated by the team. Work had also begun in 2015 on the process of migrating Volume A to the OSCAR system and a beta-version had been released in July 2015 for testing by various Member and expert team representatives.

3.4.3 At the August 2015 meeting of IPET-MDRD (Melbourne, Australia) the process of developing a generic data model for the WMDS commenced, which is the precursor to designing an application schema. The data model was based on the WMDS and expands upon the 10 over-arching metadata categories to define 65 elements, which are expected to be implemented by Members in three phases over 2016 to 2019. Each element is classified as either mandatory (M), conditional (C), or optional (O) in accordance with the International Organization for Standardization (ISO).

3.4.4 Future work required to be undertaken included the further development of code tables for metadata models, the writing of guidance to support the requirement for Members to comply with metadata delivery, the development and implementation of machine-to-machine interface specifications to allow automated delivery of metadata and the establishment of interfaces to OSCAR with existing metadata sources such as the WMO Radar Database.

3.4.5 The joint meeting agreed that there would be a role for both expert teams to provide assistance and advice in both the development and revision of metadata models and also the compilation of related regulations and guidance.

WMO Radar Database

3.4.6 Based on the document submitted by Mr Sireci (Turkey) in his absence, Mr Goldstraw provided the session with a brief summary of the recent developments and current status of the WMO Radar Database (WRD) that is operated and maintained by the Turkish State Meteorological Service (TSMS) on behalf of WMO. The WRD has been operational since 2012 and now contains the metadata for 874 radars, which is comprised of 852 active, 5 passive, 8 removed and 9 planned (to be installed) radars. The metadata are maintained by 50 member focal points that are requested to check and update the database on at least a 3-monthly basis. The WRD is used as a source of radar metadata for both the WMO Country Profile Database and OSCAR.

3.4.7 TSMS recently upgraded the database to enable several additional functions including, providing a historical dimension to metadata records, allowing the recording of planned, passive and removed radars, the recording of significant events or changes including calibrations and upgrades, the addition of fields to record the status of international data exchange and also the

ability to make changes directly to the database rather than indirectly with intervention by the database operators.

3.4.8 Given the importance of the WRD as a source of radar metadata supporting various databases as well as its link with the work of WMO to protect and justify radio-frequency allocation, it was agreed that WMO should be urged to maintain efforts to ensure all Members provided their metadata to the WRD.

Radar Wind Profiler Metadata

3.4.9 The session was informed by Mr Ruffieux, Switzerland, regarding the ET-SBO activity related to Member utilisation, plans and collection of associated metadata in the operation of radar wind profiler (RWP) systems. This activity had commenced with a survey of WMO Members undertaken over late 2013 to early 2014 on their use or intended use of RWP now and in the future, which had elicited a response from 45 countries. The results of the survey were compiled by Mr Ruffieux and published as WIGOS Technical Report 2014-03. While only a few member responses provided the requested metadata, ET-SBO had not pursued this further as clarification was required regarding expectations for how these data should be sourced and submitted by Members for future compliance with OSCAR. Mr Ruffieux also presented the results of a comparison of the ET-SBO metdata list with the WIGOS Metadata Standard, which had suggested that 90% of the fields appear to be consistent.

3.4.10 The Secretariat raised the issue that there was a requirement of ET-SBO to develop and provide a model for the determination of RWP capabilities based on the metadata profile for this system. It was agreed that the Secretariat should arrange for a meeting with the OSCAR project development team to facilitate a better understanding of what is required of ET-SBO in relation to RWP metadata and the observing system capabilities.

3.4.11 Also raised in relation to RWP, was that the CBS Inter-Programme Expert Team on Metadata and Data Representation Development (IPET-MDRD) at its meeting in Melbourne (June 2015), had received a request to undertake to approve a unified BUFR Template for WPR based on the submission by RWP operators led by EUMETNET. It was agreed that ET-SBO should contact IPET-MDRD regarding the status of this activity and any requirements for the team to assist with the process.

Weather Radar Data Exchange

3.4.12 Mr Michelson, Canada, presented a summary of document 3.4(4) that includes the Terms of Reference of the CBS Task Team on Weather Radar Data Exchange (TT-WRDE), its Work Plan, and a short status of activities undertaken. TT-WRDE is focused on data representation and information modelling, in support of data exchange as a response to G48 of the CBS Implementation Plan for Evolution of the GOS. The strategic aim to work towards achieving a single standard for weather radar has been defined (D2.1), although it is also recognized that a single standard may not be achievable. Work has been delayed due to the absence of the Chair, but it is expected that the activities will soon be commenced. The TT-WRDE membership currently consists of a small group of nominated experts, however given the delay in commencement of the work of the team and the possible reorganization of WMO coordination of weather radar activities (see item 3.6 below), there may be a requirement to review the team membership to ensure adequate and suitable representation of key countries and regions.

JMA's contribution to improvement of radar data quality and development of a radar composite in Southeast Asia

3.4.13 Mr Akihito Umehara made a presentation to the session on the efforts of JMA working towards a radar composite for Southeast Asia in collaboration with other members of WMO regions II and V. The meeting was informed that, while most of the NMHSs in Southeast Asia operate weather radars, many of them cannot utilize the full capabilities of their radars due to a lack of

technical expertise or skills, resources and/or experience. Mr. Umehara stressed that such practical technology transfer is an essential precursor to achieving the aim of the regional exchange of weather radar data and a high-quality radar composite map covering Southeast Asian. Therefore it is necessary to provide support to those NMHSs that require it, so as to improve their capacity, particularly in the area of radar data processing and quality control. For that reason, JMA is actively seeking to assist Members in Southeast Asia through a contribution to the WMO RA II WIGOS Project No. III-2, Capacity Building in Radar Techniques in the Southeast Asia. Some of the recent achievements contributed to by JMA in relation to this project include:

- Thailand succeeded in improving quality of radar data using JMA's software and developed nation-wide composite images.
- Malaysia succeeded in converting its radar data into a common format (GRIB2) and is ready to take steps towards improving the quality of radar data and developing composite images.

3.4.14 The meeting agreed that it was important that ET-SBO and WMO encouraged and helped in the coordination of international and regional efforts to improve radar technical capabilities of Members and the exchange weather radar data in support of both regional requirements for severe weather monitoring and prediction and also the requirements of all data users and applications areas including NWP.

3.5 Quality Management

3.5.1 Mr Stuart Goldstraw presented document 3.5 to the session, summarising the involvement of ET-SBO in the WIGOS activity related to quality management and, in particular, the revision and modernisation of the WMO quality monitoring practices and procedures associated with the land surface systems of the GOS. The meeting was informed that, while this activity was a component of the WIGOS Implementation Plan Key Activity on Quality Management, it forms the initial work in this area that is later expected to be extended to encompass the wider WIGOS Data Quality Monitoring System (WDQMS). The activity commenced initially as initiative of ECMWF to seek EUMETNET and WMO input into the revision of its own quality monitoring practices, which was discussed at a workshop held at ECMWF in May 2013. The activity is also linked to the revision of the Manual on the GDPFS, which contains the requirements for the monitoring procedures of regional monitoring centers. These procedures are being revised as an activity of the OPAG-ISS/Implementation and Coordination Team on Data Processing and Forecasting System and later expected to be integrated into the WIGOS regulatory material. As part of its own work plan, ET-SBO had organised and held the Workshop on Data Quality Monitoring and Incident Management in December 2014 (Geneva, Switzerland). Based on the outcomes of this workshop, ET-SBO and TT-WQM had proposed a series of work activities and pilot projects to assist in developing a revised and modernised quality monitoring framework for the land surface component of the GOS. This would incorporate close to real-time monitoring of observing systems and a new incident management system designed to more quickly discover, report and rectify station faults and outages.

3.5.2 The joint meeting agreed that WMO quality management was in need of revision and modernisation and discussed various issues, including the critical issue of resourcing of centers that undertake a role in providing quality monitoring and incident management services to members. It was also pointed out that quality monitoring needed to be seen in the context of a 3-tiered structure comprising the national, regional and international or global aspects.

3.5.3 The teams also discussed the initial work which ET-SBO was leading, including the establishment of the Incident Management Pilot Project. Mr Karanja, Kenya, informed the session that Kenya was willing to play a leading role in the pilot project, which might be undertaken in conjunction with the participation of other countries in the African sub-region. This was discussed in more detail under item 10.1.

3.6 Inter-Commission Teams & Coordination

3.6.1 Mr Lockett, WMO Secretariat, presented document 3.6 to the session, which outlines a proposal to establish a WMO inter-commission and inter-programme coordination group on weather radar systems. This concept has been raised in a number of forums, most recently at Cg-17 (see Section 3.1 above) and previously as a recommendation at the CIMO/WIGOS Exploratory Workshop on Improving Surface-based Data Quality through Improved Standardization of Procedures, December 2014, Langen, Germany, (Recommendation 5). Further informal discussion and exchange of ideas on the matter had recently taken place between the Secretariat and members of the CBS and CIMO Management Groups with firm agreement on the need for the coordination mechanism and some initial ideas on a possible solution. It had been suggested that the group might initially be formed from the existing radar experts within the various expert teams of CIMO and CBS and given responsibility for the international coordination of weather radar activities and tasks under the joint management of CIMO and CBS. Later the group should be expanded to ensure representation from other technical commissions and programmatic areas to ensure a wider coordination under the WIGOS framework.

3.6.2 The joint meeting firmly agreed with the proposal for the establishment of the WMO weather radar coordination group, citing the increasing complexity of weather radar systems compared to most other observing systems and the pressing requirements to increase standardisation in support of improved operation, data quality and data exchange in particular. It was also agreed that the successful WMO AMDAR Panel, later transitioning to the WMO Aircraft-Based Observations programme, was an example of the international coordination concept being envisaged and on which the team might be modelled. The session also discussed possible risks associated with the formation of such a technology-specific team, such as the potential to overlook or reduce the emphasis on integration and inter-operability of observing systems. It was agreed that such risks could be mitigated by ensuring a focus on such aspects within the terms of reference and work plan of the team. Given the widely acknowledged need for such a coordination mechanism and the position adopted by Cg-17 recommending its establishment, the session recommended that, if it was possible, the formation should not be delayed until future technical commission sessions but should be addressed jointly by the respective management groups of CIMO and CBS with a view to agreeing on a joint governance mechanism under agreed terms of reference and the formation of the team as soon as possible.

3.6.3 The joint meeting requested a sub-group of participants with representatives from both expert teams to compile a proposed set of terms of reference for a WMO coordination group on weather radar systems to be presented later in the session for discussion and revision. The revised and agreed final version of the proposed terms of reference, along with some recommendations in relation to membership and key activities and tasks, are provided within Annex III.

4. RADAR WIND PROFILERS

4.1 Guidance Material on Operational Systems

4.1.1 Mr Lehmann briefly summarized an input document addressing Task 1 of the ET-ORST Work Plan: the preparation of integrated guidance material on RWPs for WMO Members. He suggested that it should be the purpose of the WMO guidance material to provide both an accessible basic overview of the theory of radar wind profiling as well as to give a comprehensive discussion of practically relevant information. He briefly reviewed the existing guidance material on RWPs that is included in a number of IOM reports and the CIMO Guide. He drew attention to a lack of global standardization in both the terminology used for RWPs and in the names of the frequency bands at which they operate, citing both the IEEE and ITU norms, suggesting that it would reduce confusion if a single standard was adopted. He reviewed the content of the existing WMO guidance material, with particular focus on the CIMO Guide, identifying those parts of the text in particular need of updating or correcting.

4.1.2 Mr Lehmann concluded his presentation by noting that the current CIMO Guide text dealing with RWPs is inadequate and proposed a plan for addressing the shortcomings. A draft table of

contents for the new guidance material proposed by Mr Lehmann is at Annex IV. It includes an initial section on the theoretical aspects of RWPs, then covers a number of practical aspects, including spectrum allocation, siting considerations, the technical components of a RWP system, system configuration, data management, quality control and monitoring, and maintenance. It concludes with a section containing examples of different RWP systems.

4.1.3 The joint session expressed its appreciation for Mr Lehmann's two input documents on RWPs. Further development of the two documents into a single comprehensive IOM report was briefly considered, but Mr Lehmann advised his inability to commit to the drafting of it, given the time required, and suggested instead that he commence work immediately on updating the relevant sections of the CIMO Guide, including new material on uncertainty calculation. The session agreed to Mr Lehmann's proposal. It noted that the latest edition of the CIMO Guide contains just a few somewhat outdated pages of guidance material as part of its chapter on Special Profiling Techniques for the Boundary Layer and the Troposphere (Part II, Chapter 5, §5.2.2) and requested Mr Lehmann to update this existing guidance text, to provide some additional text on the traceability topic, some new guidance on procurement considerations, and include an introductory section on the uses of RWPs: their advantages and disadvantages in comparison with other observing system solutions. Mr Thomas Kane agreed to assist Mr Lehmann by drafting a corresponding section of text on RWP Spaced Array mode configuration, which is used operationally in Australia. It was envisaged by the session that, dependent on its final volume, the resulting documentation might potentially be proposed as a new stand-alone chapter of the CIMO Guide. Mr Lehmann agreed to take the lead on this task, with its description in the ET-ORST Work Plan to be modified accordingly.

4.2 New Developments in Technology

4.2.1 Mr Lehmann advised the session that there were no new RWP technological developments to report under this topic.

5. WEATHER RADARS

5.1 Dual Polarization

5.1.1 Mr Lehmann informed the meeting of the progress achieved to date by Mr Richard Ice in gathering information on the current status of the use of dual polarization radars (the principles, QC, QPF applications, use, costs, benefits, advantages of C-band versus X-band, etcetera). Mr Lehmann presented a draft document submitted by Mr Ice which is proposed to comprise the basis of a guidance document for WMO Members on the use of dual polarization radar. The session expressed its appreciation to Mr Ice for this valuable contribution, which provided a sound basis for further development. In view of his recent advice that he would soon be retiring and was no longer able to contribute to the work of ET-ORST, Mr Lehmann agreed to contact Mr Kevin Cook, Mr Ice's replacement on ET-ORST, and request him to continue the development of the document.

5.1.2 In considering how to integrate the new material on polarimetric radars into the existing new chapter on weather radars in the CIMO Guide, a number of points requiring attention in the latter material were noted by the session. Mr Pekka Utela (HMEI) agreed to examine each of the points made and propose changes to the text of the CIMO Guide chapter to take them into account, then to circulate that document amongst the team members for their agreement. The session proposed that Mr Lehmann should then urge Mr Cook to examine the amended CIMO Guide chapter and integrate the completed section on polarimetric radars into it. It was also suggested that a section be included in the document on the operational calibration of polarimetric radars, based on the information contained in the session input document from CMA on this topic (see §5.5 below).

5.1.3 Mr Naoki Tsukamoto informed the session that JMA had recently developed a guidance document (in Japanese) which comprises a technical review of JMA's operational radar systems. He offered to arrange for that document to be translated so that ET-ORST can use it, also, to provide further input for the CIMO Guide chapter on weather radars. The joint session expressed its appreciation for this offer by JMA, and suggested the document, once translated, could be

submitted for publication in the CIMO IOM report series. The table of contents of the JMA document is provided for information at Annex V.

5.1.4 With respect to the use of polarimetric radars, the session raised the matter of the use of predefined echo/hydrometeor classifications, noting that there may be significant differences in practice from region to region, and that it has been argued by some that these should not be used at all. Mr Lehmann agreed to circulate a paper which recommends against the use of echo/hydrometeor classification. Mr Kong agreed to draft some text on the matter, for inclusion in the CIMO Guide.

5.2 Algorithm Intercomparison (RQQI)

5.2.1 Mr Tom Kane provided the session with an update on the status of the Radar Quality Control and Quantitative Precipitation Intercomparison (RQQI) and emerging plans for its completion during the current intersessional period of CIMO.

5.2.2 Mr Kane advised the session that the intercomparison stalled in 2013 due to the lack of availability of key participants. That situation has now been addressed. Mr Daniel Michelson will take over from Mr Paul Joe as project leader. The previous participants will all be contacted to ascertain their willingness to continue their contributions and additional participants will be recruited to replace any who are no longer available. It is anticipated that this process should be concluded by the end of 2015 so that the intercomparison can resume early in 2016. It is then expected that the intercomparison itself could be completed by the end of 2016, with the final report available in 2017.

5.3 New Developments

5.3.1 The joint session considered an input document from CMA on the development and use within CMA of millimetre wave radars (cloud radars). The joint session thanked Ms Pei Chong for the excellent document, but noted that its subject fell outside the scope of ET-ORST, and recommended its submission to the Chair of the CIMO Expert Team on New Remote Sensing Technologies, which has responsibility for the development of guidance material on cloud radars.

5.4 Operation in Mountainous Terrain

5.4.1 Mr Wai Kong presented the session with a draft document that he has prepared on the topic of radar operation in mountainous areas. It includes discussion and examples of particular challenges confronting the operation of radars in areas of high terrain. Mr Kong noted that further work is required on the document but requested feedback on its suitability from the session. The session agreed that the structure of the document is excellent and its intention good. It was noted that the use of differential phase information for pixel correction, as discussed in the document, is a technique that works effectively for liquid precipitation but may not be as effective for snow. It was also suggested that the document include some discussion of the accessibility problems that can accompany the siting of radars in mountainous terrain. Mr Kong was also requested to consider including some discussion on health and safety issues associated with human exposure to the microwave radiation in the near field of weather radars. An additional problem experienced with alpine radars is the accumulation of ice or snow on the radome: it was agreed that some discussion of this issue would also be useful.

5.4.2 To gather additional material from other countries faced by the same challenges, Mr Kong had prepared a draft questionnaire to send to relevant experts. He requested feedback from the participants on the content of the questionnaire and asked for assistance in identifying experts to send the questionnaire to. Mr Dominique Ruffieux agreed to pass the questionnaire to a relevant colleague in Meteoswiss for input on Swiss practice. Mr Bernard Urban of Meteo France was suggested as an additional point of contact on this topic. The WMO secretariat agreed to contact Mr Oguzhan Sireci of TSMS and request him to provide a list of focal points for radar networks in countries with mountainous terrain and send this list to Mr Kong.

5.4.3 Ms Pei Chong then presented a CMA document on the same issue which described the practices used in China to overcome some of the difficulties. Mr Kong agreed to incorporate this material into his guidance document.

5.5 Operational Calibration

5.5.1 Ms Pei presented her input document on CMA's operational calibration practices for dual polarization radars. The session was informed of the work carried out by CMA in researching cross calibration technology and automatic correction methods in weather radar networks and the investigation of an operational calibration method for dual polarization weather radar, especially online calibration and compensation of differential reflectivity, which indicates consistency in horizontal and vertical channels. The session expressed its appreciation to Ms Pei for this contribution, noting the importance of the topic, and requested that this information be included as appropriate in the section on dual polarization of the updated CIMO Guide chapter on weather radars (see §5.1 above).

5.5.2 Mr Tsukamoto noted that additional CIMO guidance material on operational calibration of single polarization radars would also be very useful for Members.

5.6 Collaborative Mode Operations

5.6.1 Ms Pei Chong informed the session of the progress made by CMA in investigating the use of collaborative adaptive observation mode of weather radars, focusing on temporal and spatial synchronization, as well as echo consistency and product comparability in radar networks. She described the use of three separate modes of operation of CMA's radars: an alarm mode, a self-calibration mode and a collaborative/adaptive mode (involving reduced sector, rapid update scans). It was noted that the use of separate modes of operation can interfere with the need for regular and frequent full volumetric mode scanning, which is required for the use of automated applications such as QPE and severe weather warning. It was also noted that collaborative adaptive mode operations would also require the dynamic transmission of associated metadata.

5.7 Coordination Mechanism for Weather Radars

5.7.1 Mr Lehmann noted the detailed discussion on this topic that had taken place under agenda item 3.6. The session agreed that further discussion under the present agenda item was not required.

6. LIGHTNING DETECTION SYSTEMS

6.1.1 The session was informed of the work carried out by Mr Paul Hettrick to date concerning the collection of information on the performance assessment of lightning detection systems. Mr Hettrick has commenced drafting guidance material for inclusion in the CIMO Guide. The session expressed its appreciation to Mr Hettrick for providing a well-structured document that would provide a sound basis to which further detail can be added. Mr Pekka Utela offered to review the document on behalf of HMEI and provide feedback to Mr Hettrick. It was suggested that the document include a section of text on the uses to which lightning location information is put, to provide insight on the functional requirements of detection systems. It was also suggested hat the document would benefit from inclusion of some discussion on the meaning of location accuracy, given that a lightning flash can extend horizontally for considerable distance.

6.1.2 Mr Utela advised that an intensive observation campaign investigation intra-cloud processes had been carried out in Brazil several years ago, which included a lightning detection component (CHUVA: http://chuvaproject.cptec.inpe.br/portal/noticia.ultimas.logic) but that he was unaware whether the final report had been released. The session suggested that Mr Hettrick make enquires to ascertain whether the CIMO guidance material should include relevant results from CHUVA. Mr Lehmann informed the session of the availability of a AGU publication on lightning location

systems: their characteristics and performance validation techniques (Volker, please provide link). He requested Mr Hettrick to include consideration of this publication in his draft text for the CIMO Guide chapter on lightning.

6.1.3 Ms Pei Chong provided a presentation on CMA's lightning detection test bed at Guangzhou. In her presentation she described the layout of the experimental site, the instrumentation and performance assessment techniques used, and the measurement campaigns that CMA has conducted at the site in recent years. The session commended Ms Pei for her excellent contribution and congratulated CMA on the work performed at its lightning testbed. The WMO secretariat agreed to provide Ms Pei with advice on the process for CMA to follow to have the experimental site formally recognized as a CIMO Testbed. The session requested Mr Hettrick to include mention of the CMA site and its capabilities in his draft guidance documentation.

7. SURFACE-BASED IN SITU OBSERVING SYSTEMS

This item was addressed by ET-SBO in the separate team session.

7.1 Automatic Weather Stations

7.1.1 During the separate team session, the ET-SBO participants at the meeting discussed the current status of activities in the WMO technical commissions relating to AWS and agreed that the current focus on developing regulatory material and guidance was an important and significant undertaking that would consume a lot of expert time resource. However it was also agreed that, as for radar systems, AWS technology was a large and significant concern for Members and consideration should be given by the technical commissions to ensuring adequate international and inter-commission coordination.

7.2 Manual Observations

7.2.1 Mr Goldstraw spoke to the ET-SBO participants regarding the fact that manual observations still remained an important element of the GOS and that ET-SBO had a responsibility to maintain a watch on this component and address any issues that arose. It was also important that manual observations were adequately addressed in the WMO regulatory material, both in terms of their continued operation and also in relation to key aspect of the transition from manual to automated observations.

7.2.2 In particular the issue of disposal of mercury relating to the transition away from the use of mercury in glass thermometers and mercury barometers has been raised and Mr Goldstraw suggested that there may be a requirement for additional guidance for Members on how to comply with national and international requirements for mercury disposal. It was agreed that such a requirement for guidance would likely be the responsibility of CIMO and any concerns by ET-SBO members should be conveyed to and coordinated with the CIMO Expert Team on Operational Metrology.

7.3 Radiosonde

7.3.1 Mr Oakley, United Kingdom, made a presentation to the meeting about Radiosonde observations and networks. He provided some statistics on the current global network and his understanding of the operational challenges to Members, primarily from his current experiences as the GCOS network manager. According to statistics from the National Centres for Environmental Prediction (NCEP, USA) there are around 800 stations reporting daily (1260 TEMP's / day), resulting in around 460,000 TEMP's per year. This represents an annual expenditure by WMO Members, for consumables only, of between $70-$100 million (USD). There continues to be a significant number of different radiosonde designs/systems in operational use (8+), and several of those that participated in the last WMO Intercomparison in China (2010) have now been superseded by an updated model.

7.3.2 Mr Oakley then presented in more detail on operational challenges being faced both by the operators and data users, which are summarised as follows:

- Transition to BUFR coding and including high-resolution data.
- Quality monitoring of radiosonde measurements & network coverage.
- Sounding schedules.
- Tiered networks (Reference v Baseline v Comprehensive).
- Environmental impact and disposal.
- Co-ordination group.

7.3.3 The key discussion points and actions following this presentation were:

- The meeting accepted that there were a number of issues with the transition from TEMP to BUFR messages and that many countries were currently performing only a direct translation of the TEMP message to BUFR, which results in no additional information or benefit. This is directly related to one of the actions in the EGCOS-IP for which this expert-team has a responsibility to help deliver. It was agreed that Mr Oakley would work with the other team members to document the status in their countries, and as a first step, coordinate work to ensure these radiosonde networks deliver high resolution data via BUFR.
- Following on from a previous agenda item on quality monitoring, it is evident that there is already a range of products on radiosonde performance (availability and quality), but the statistics and plots provided are inconsistent with each other, sometimes difficult to interpret and not easy to find online. The presentation by Mr Oakley gave examples of monitoring products from NCEP, ECMWF, NCEI and EUMETNET. It was agreed that ET-SBO should work on providing guidance and access to a more coherent monitoring product under the work-plan item on Quality Monitoring. It was agreed that Mr Oakley would work with the Secretariat on improving access and visibility of the currently available monitoring tools and diagnostic, perhaps through a dedicated webpage under the WIGOS Information Resource (WIR).
- Also related to quality monitoring was the question of network coverage and 'silent' stations, again an action under the EGOS-IP for which this team was requested to provide updated information. In terms of the GCOS Upper-Air Network (GUAN) the following statistics were included in the text from GCOS to the WMO Congress in June 2015.

  Table below is the 2014 summary for the GCOS Upper-Air Network (GUAN) monitoring against the GCOS minimum requirements (25 daily soundings to 30hPa per month) for each region, according to the monthly statistics provided by NCEP. In brackets are the same statistics for 2013, 2012 and 2011. For 2012 and 2011 these are based on availability only according to NCDC.

Region	**Number of GUAN stations**	**%** meeting minimum GCOS requirements in 2014 (% for 2013, 2012 and 2011)
RA-I	23	**39%** (46%, 48%, 57%)
RA-II	32	**87%** (87%, 87%, 87%)
RA-III	18	**72%** (67%, 89%, 78%)
RA-IV	24	**83%** (75%, 83%, 87%)
RA-V	38	**76%** (74%, 84%, 87%)
RA-VI	24	**87%** (83%, 92%, 87%)
Antarctica	12	**58%** (58%, 83%, 83%)

In terms of non-reporting stations, 3 of the GUAN stations (2%) were 'Silent' (zero reported TEMP observations) during 2014, which was the same as in 2013. In 2012 there were 4 'Silent' stations and 5 in 2011. Currently for 2015, up to September, we have 7 'Silent' stations.

- According to TEMP availability statistics for 05/10/15, provided by ECMWF, there were 684 soundings at 00utc, 30 at 06utc, 637 at 12utc and 44 at 18utc, with this scheduling being what we would expect given that the regulations in the GOS manual, stipulates that Members should undertake 2 soundings per day at 00 and 12utc. However, one of the actions in the EGOS-IP is to harmonize the network coverage, both in space and time, working towards the stated RRR for all applications. One of the tasks of ET-SBO is produce a proposal for a more adaptive radiosonde programme, being both efficient and delivering against the requirements. It was agreed that ET-SBO would work towards the update of WMO No.544 to make provisions for adaptive and optimised radiosonde synoptic reporting operations in WIGOS.
- It was agreed that the Chair should report to ICT-IOS that there is a perceived lack of coordination of radiosonde issues at the global level and that ET-SBO does not currently have the member resource to cover it.

8. INTEGRATION OF OBSERVATIONS

8.1.1 Mr Lehmann presented a draft document on behalf of Mr Bernard Urban on the integration of rainfall data obtained by different measurement techniques (raingauge, weather radar, satellite). The document describes the main methods of rainfall measurement/detection, and discusses the issues associated with each, most of which are related to the use of indirect techniques of measurement. The draft document then considers the techniques that have been used to date to integrate the information from multiple systems to provide improved precipitation products. Mr Urban sought advice from the session on how to develop the document further so that it would comprise useful guidance information for WMO Members.

8.1.2 The session noted that this task, as specified by the CIMO Management Group, requests ET-ORST to summarise the current methods used and to describe best practice for Members (CIMO Guide update if required), so the next step for Mr Urban to take is to examine existing guidance material in the CIMO Guide and propose updates as required, based on most recent understanding, e.g., the QPE practices currently employed at different NMHSs, the strengths and weaknesses of each and what constitutes best practice). It was suggested that the guidance material should consider both realtime and non-realtime analysis/processing. In view of Mr Urban's absence from the session, Mr Lehmann suggested that this item should be discussed further with Mr Urban during the team's next teleconference.

9. COLLABORATION WITH ISO

9.1.1 The session was informed about the current status of WMO collaboration with the International Organization for Standardization (ISO) on weather radar and wind profiler technology standards.

9.1.2 Mr Lehmann advised the session that he had received an email in 2014 from ISO regarding their interest in developing a ISO standard on radar wind profilers, accompanied by a draft based on an existing, somewhat dated, German standard. In the email ISO requested Mr Lehmann to take the lead on using the German document as the basis for preparation of a draft ISO standard. Mr Lehmann informed the session that he has reviewed the document, and is of the view that it requires substantial change: it is too detailed, too specific and outdated (e.g. it is concerned with analogue receiver RWP systems). Mr Lehmann advised that his concern is that the document requires so much change it will require considerable investment in time to develop the draft ISO document. Mr Lehmann informed the session that his quandary is whether to perform an extensive modification of the German standard or draft a completely new document 'from scratch'. The

session advised that the resulting standard should be high level, generic and not too detailed, to avoid locking RWP technology into its current state. After detailed discussion, Mr Lehmann agreed to draft a high level generic standard, with details only in the commentary, and then circulate it amongst the team members for comments and suggestions.

9.1.3 Mr Atkinson then described a parallel process underway within ISO Technical Committee 146, Sub-Group 5 (TC146/SG5) to develop a weather radar standard. He advised the session that WMO is currently represented on the drafting group by Mr Marco Gabella (of Meteoswiss) and himself. Although CIMO MG does not consider the establishment of this standard to be a high priority for WMO, it considers it important for WMO to engage with ISO to ensure the resulting standard is acceptable to WMO. At the outset, the draft ISO standard (based on a German national standard and promoted by the German hydrological engineering community) was very detailed and aimed at standardizing radar hardware and data processing techniques (e.g., QPE algorithms). This was seen as a concern to WMO, because it risked stifling future development of radar technology and applications (before, e.g., the completion of RQQI, which is expected to provide much greater insight into global best practice with respect to radar algorithms). At a meeting of the ISO drafting group hosted by Meteoswiss in Locarno in 2014, agreement was reached to separate the standard into two parts: the first part will be a joint WMO/ISO high level standard that consider only radar hardware and configuration and will exclude consideration of algorithms for applications. The second part concerning QPE and possible other applications, should it go ahead, would be dealt with after the completion of the first part, and may not involve WMO participation. The next meeting of the drafting group is to be held in Dusseldorf in mid-October. Mr Atkinson agreed to provide an update to ET-ORST at the conclusion of that meeting.

10. REVIEW AND REVISION OF WORK PLANS AND SCHEDULES

Each team independently reviewed and revised its respective work plan and schedule to take into account the discussions during the session and the progress made prior to the session.

10.1 Review and revision of work plan and schedule of ET-SBO

10.1.1 Given that the CBS inter-sessional period ends in 2016, it is necessary that ET-SBO participants fully revised their work plan in the context both of completing as much of the work plans as possible over the coming 12 months and also of reporting to the CBS Implementation-Coordination Team on Integrated Observing System (ICT-IOS).

Revision of the ET-SBO Work Plan

10.1.2 The issue of ET-SBO input to the development of OSCAR, metadata and observing system capabilities was discussed in detail. It was agreed that for both weather radar and radar wind profiler systems, there was a need for ET-SBO leads to contact the OSCAR project team and seek clarification on the expectations of ET-SBO experts to contribute. In particular there was a need to clarify if more was required to describe the respective models to determine the observing system capabilities for these sytems and also the expectation for member provision of radar wind profiler metadata to OSCAR. There was also a concern raised that the OSCAR system should provide suitable explanations and appropriate disclaimers regarding the way in which capabilities for particular systems were derived, how they might be used and perceived. Mr Goldstraw also advised that there were several matters raised at the recent session of the IPET-WIF Sub-Group on OSCAR Development that required clarification by ET-SBO. While it was acknowledged that ET-SBO had been requested to undertake a revision of Volume A with respect to transition to its maintenance within OSCAR, the team had been unable to commit resources to this task. In this regard the following specific actions were requested:

- Mr Ruffieux to contact SG-OD regarding clarification on RWP related matters.
- Mr Ruffieux and the Secretariat to contact the OSCAR project team and SG-OD and arrange a meeting as soon as possible to discuss requirements for RWP.

- ET-SBO to contact SG-OD regarding the matter of explanations and disclaimers relating to observing system capabilities.
- Mr Monnik to circulate the OSCAR Transition Plan for Volume A to team members.
- ET-SBO to seek clarification from SG-OD on requirements for ET-SBO involvement in the transition to maintenance of Volume A within OSCAR.

10.1.3 In relation to ET-SBO involvement in the WIGOS Data Quality Monitoring System (WDQMS) it was agreed that ET-SBO would make a formal approach to the Kenya Meteorological Service regarding their participation in the pilot project (see Item 3.5 above). Initially, ET-SBO would approach other countries in the region informally to gauge the possibility of their participation in the pilot and later follow up formally as appropriate. Additionally, ET-SBO would improve the formulation of the scope and requirements for the pilot project, most particularly including the requirements for quality monitoring reports and diagnostics to be made available to participating countries.

Review of Implementation Plan for the Evolution of the Global Observing System (EGOS-IP)

10.1.4 The actions assigned to ET-SBO in the EGOS-IP were reviewed and leads for assessing the current status of various actions agreed. It was also noted that CIMO were identified as the lead TC for some actions and it was agreed the Secretariat would highlight this requirement to the relevant CIMO ETs.

10.1.5 The updated Work Plan of ET-SBO is provided in Annex VI.

ET-SBO Reporting to ICT-IOS

10.1.6 Mr Goldstraw discussed with ET-SBO participants the various issues and aspects of the team's performance and work plan that should be brought to the attention of ICT-IOS to address. The team members generally agreed that the focus of ET-SBO is perhaps too wide and that it is difficult therefore to ensure expertise across all the areas that the team is expected to cover. Based on discussion within other agenda items, it was clear that some technology areas require the attention of a specifically focussed team or group, for example weather radars and possibly also AWS. The participants also agreed that, while there was a requirement for specific technology focus, it was also important that observing system inter-operability and observing network design was addressed adequately. It was also suggested that many members and experts were confused about the respective roles and responsibilities of CBS and CIMO in the WIGOS framework and there appeared to be a requirement to stream line the teams and their various activities and tasks across technical commissions to ensure the best use of the time and work of experts. The issue of the availability of time resources of member experts was raised and the difficulty acknowledged in progressing the work plan of the expert team. Mr Goldstraw also suggested that the process of assigning tasks by one expert team or group to another should be clarified and stream lined by ICT-IOS. Given the expectation that a coordination group on weather radar systems would be formed, this and the above issues should be taken into account by ICT-IOS when making a recommendation relating to the structure of OPAG-IOS teams and activities for the next inter-sessional period. The terms of reference for ET-SBO or its successor team would require significant revision.

10.2 Review and revision of work plan and schedule of ET-ORST

10.2.1 The updated work plan of ET-ORST is provide in Annex VII.

11. DRAFT REPORT OF THE SESSION

11.1 The session agreed to finalise its report by correspondence.

12. CLOSURE OF THE SESSION

12.1 The session concluded at around 5pm on 8 October, 2015.

ANNEX I

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ANNEX II

Traceability for surface-based remote sensing methods – Radar Wind Profilers

1. Introduction

The mission of WMO CIMO is to promote high-quality and world-wide compatible observational data. For this purpose it is mandatory to define the right technical standards and proper calibration methods, to help manufacturers and system operators achieving these goals.

WMO held a CIMO-WIGOS Exploratory Workshop in Langen (Germany) from December 03-05, 2014. This workshop was focussed on improving surface-based data quality through an improved standardization of procedures. Among other things, the needs for standardization for remote sensing technologies were extensively discussed. As the main result of this workshop, the participants have prepared 11 recommendations for CIMO. In particular, recommendation 6 stresses *that high priority is assigned to tasks examining the traceability and quality improvement of the more mature remote sensing products, for example, vertical wind profiles (from radar wind profilers and weather radars), and develop guidance material for inclusion in the CIMO Guide and other relevant material.*

This document discusses the problems related to achieving the goal of traceability for radar wind profilers (RWP), which are already successfully used in an operational setting by several WMO members.

2. Review of currently existing WMO documents and other material

The problem of achieving traceability for remote sensing systems is clearly non-trivial due to the very nature of the indirect measurement process. Of course, remote sensing systems also aim at achieving accurate measurements with properly estimated uncertainties, which have then value for the user.

Quoting from Quinn and Kovalevsky (2005):

Accurate (or 'absolute') measurements are those made in terms of units firmly linked to fundamental physics so that they are repeatable in the long term and consistent with measurements made in other areas of science and technology.

Traceability of measurement results means that a given result is obtained in terms of measurement units that are linked by an unbroken chain of calibrations or comparisons to national measurement standards – in practical terms – to SI units. (…) In this way a proper uncertainty of the final measurement in terms of SI units can be given.

However, this is more complicated to achieve for remote sensing systems since the measurement methods employed are fairly complex and may even not always be fully understood. Meteorological parameters, like the wind vector, are often retrieved instead of directly measured and in this case, the quality of the retrieval is depending on the unknown properties of the turbulent atmosphere, not only on the instrument itself.

Previous WMO documents have addressed the calibration problem for wind profilers, notably CIMO/ET-NTTB-1/Doc. 10(2) "Reliability and consistency of wind measurements by wind profilers towards the development of an ISO-WMO standard". Due to the size and measurement range of the RWP it is obvious that a classical calibration in a fully controlled environment, like a laboratory wind tunnel, is utterly impossible.

The proposal made in the above referenced document is a direct comparison of horizontal wind components derived from RWP with in-situ sensors on either masts/towers, tethered balloons or unmanned aircraft.

A similar proposal for lidar (wind) profilers has been made by Gottschall et.al. (2011), where traceability was obtained through a meticulously arranged direct comparison of the lidar data with calibrated in-situ reference sensors mounted on a mast at various heights. The authors argued that there is currently no alternative to the presented procedure for achieving traceability, but also mention that the arrangement is principally no fair comparison due to the very different measurement principle and due to sampling / colocation issues. The latter is perhaps the key difficulty, since the lidar derived wind values are, at least in the monostatic setup, retrievals and not direct measurements, as the wind vector is *recovered from the set of radial speeds obtained for different azimuth positions*. Of course, the retrieval results always depend on the (unknown) state of the atmosphere. The authors also state: *The values measured by the lidar and the reference sensor are comparable only under specific requirements, e.g. for flat terrain and long enough averaging times.* In other words, these conditions are assumed to assure a horizontal homogeneity of the wind field sampled by the lidar which is required for a good agreement between a local in-situ (point-measurement) sensor and a remote sensing instrument (volume-measurement).

3. Principal difficulties of the direct calibration approach for remote sensing

A calibration is essentially a comparison of a measurement instrument with a standard, i.e. a reference instrument with known accuracy. Such a calibration is usually made in a controlled environment like a laboratory. This methodology is well established for in-situ sensors: Anemometers are put in the controlled environment of a wind tunnel and compared against a working standard, like a laser Doppler anemometer, see Holstein-Rathlou et.al. (2014) or Shinder et.al. (2015).

However, a direct application of this approach for remote sensing systems is difficult, if not impossible: Active remote sensing instruments used in meteorology perform indirect measurements by sending out acoustic or electromagnetic waves in a defined direction. The waves are scattered in the atmospheric volume sampled and all the information is obtained from those parts of the scattered waves that are received at the position of the instrument (usually backscattering). To achieve a fully controlled environment, the whole instrument and the sampled volume would thus have to be placed in a closed space. This might indeed be possible for short range instruments, like a CW lidar with a high spatial resolution, but it is physically impossible for an instrument like a 400 MHz RWP, which is designed with the goal of providing a vertical profile of the horizontal wind vector throughout the troposphere. In that case, the measured volume extends over a range of the order of 10 km with a range resolution of about 100 m. For such an instrument, the only option has been to do an outdoor comparison with an appropriate reference instrument.

Such a comparison must be aiming at

- a perfect match in space and time of the (atmospheric) measurement volume sampled – otherwise natural fluctuations in the quantities to be measured will necessarily lead to differences

- no interaction between the propagating waves and the instrument of a reference remote sensing system (e.g. it will be impossible to place two radars using the same wavelength side-by-side without suffering from RF interference)

- no interaction between the propagating wave and any in-situ sensors placed in the sampled volume (a tethered balloon will always be a detectable target for the remote sensing system)

It is obvious that this cannot be exactly achieved by any combination of in-situ and/or remote sensing instruments, so any attempt will remain a compromise. This is not to say that such comparisons are useless, see e.g. the cross-technology comparison of Päschke et.al. (2015). It is probably possible to improve such comparisons further, but using this direct comparison methodology for achieving a comprehensive calibration appears to be not feasible in practice.

4. A proposal for an indirect calibration approach

For a monostatic pulsed RWP, the following presuppositions must be met for an accurate measurement:

1. Correct position, orientation and shape of the measurement volume generated by the antenna radiation pattern and the range weighting function defined by the envelope of the transmit pulse and the receiver filter properties.

2. Correct determination of the scattering process generating the receiver voltage signal, to assure that the scattered waves can indeed be used for inferring air motion (wind).

3. Correct determination of the Doppler shift and other properties of the received voltage signal generated by the backscattered electromagnetic wave.

4. Correct assessment of the validity of the assumptions which are implicitly used in the wind retrieval algorithm, like (statistical) horizontal homogeneity and stationarity.

Any failure to meet these requirements will result in erroneous measurements of the wind vector. It is no principal problem to verify presuppositions 1 and 3 with well-defined test measurements, using calibrated RF instruments, since these tests are employed to verify the correct operation of the radar hardware. In contrast, presuppositions 2 and 4 depend on the availability of validated algorithms, to correctly estimate the a-priori unknown state of the atmosphere.

So instead of thinking about a full calibration of a RWP as a wind measuring instrument, whereby the whole RWP is treated as a “black box”, it might be useful to consider a simplified approach to verify the correct performance of the instrument. This rather indirect calibration procedure borrows ideas from acceptance testing which is usually performed after system installation and ensures that the instrument is performing according to the specifications.

As a first step it should be relatively easy to fully test the correct functioning of the complete radar hardware without the antenna in a controlled environment. Such a test would include transmitter, receiver and signal processor. In a second and more difficult step, the correct functioning of the antenna would need to be verified. If these components are comprehensively tested using calibrated RF measurement instruments, the RWP could be said to be indirectly calibrated in a sense that it would provide accurate and traceable raw measurements of the backscattered electromagnetic wave. It is clear that this is a necessary, but not a sufficient condition for an accurate wind measurement.

Antenna: The critical property that needs to be correct for high-quality measurements is the antenna radiation pattern. For the typically employed phased-array antennas, the radiation pattern depends on the array pattern and the individual element pattern. The latter can be verified on an antenna test range. The whole antenna pattern can be verified using artificial or natural RF sources (satellites, sun, radio stars – depending on wavelength). After a correct installation of the array it is sufficient to ensure a correct excitation (amplitude and phase) and operation of the individual

antenna elements, see e.g. Law et.al. (1997). This can be done through special antenna testing and monitoring of antenna parameters like the VSWR.

Transmitter: The properties of the transmitted signal can be directly measured using calibrated RF measurement instruments like a digital oscilloscope and a (peak) power meter. For frequency compliance it is important to make sure that the occupied spectrum is within the limits of authorization. The short and long time frequency stability of the oscillator can be verified using well-established methods.

Receiver: The sensitivity of the receiver can be checked using a calibrated signal source, the determination of the signal frequency change relative to the transmit signal can also be verified using a calibrated signal generator. A precise determination of the radar systems group delay, which is important for correct ranging, is possible with a calibrated delay line. In fact, this test setup can also be used to determine the range resolution function and to verify the Doppler processor simultaneously.

Signal processing software

The software employed in a RWP for controlling the radar and for processing the received signals is complex and comprehensive. Especially critical is the correct implementation of the – hopefully validated - signal processing algorithms used. This can be verified using methods for software system testing. It should also possible to generate test data sets with known properties to verify the signal processing software, see e.g. Zrnic (1975).

Data processing and quality control software

The meteorological products are always derived from these raw measurements, but the quality of this retrieval is of course depending on the acting scattering process and the flow state of the atmosphere in the volume sampled by the RWP. Both conditions are outside the direct control of the experimentalist, but need to be assessed on the basis of the raw data using well-established and tested algorithms (clutter filtering, homogeneity tests, etc.). Further theoretical work is very much desired to identify the relationships between the RWP signals and the turbulent atmospheric field in the radar resolution volume for clear air scattering. A theory based on first-principles was established by Muschinski (2004), but the consequences of, for example, a possible bias due to a non-vanishing covariance between clear air reflectivity and wind velocity for operational wind profiling needs to be further investigated, see Muschinski and Sullivan (2013).

Data processing and quality control software can be verified through simulations and field campaign comparisons (cross-sensor validation). It is also possible to compare the final data products against NWP model output through monitoring statistics.

5. Summary

For complex remote sensing instruments like a RWP it is suggested to discriminate between a calibration of the essential hardware components antenna, receiver and transmitter, a testing of the control and processing software and finally, a verification of the full system by a multi-sensor comparison, e.g. against a Doppler lidar.

ANNEX III

Proposed Terms of Reference for WMO Coordination Group on Operational Weather Radars

1) Under the governance of CIMO and the joint management of CIMO and CBS, act as the WMO primary coordination group and focal point for all operational meteorological radar (S, C and X band) matters and related WMO activities, including:
    a. WIGOS framework and operational development and implementation;
    b. Standardization of, and regulations and guidance on, systems requirements and specifications, quality control, maintenance and operation, data processing algorithms, data products and data quality monitoring;
    c. Radio-frequency allocation and protection;
    d. Methods, models and formats for the international exchange of meteorological radar data and metadata;
    e. Response to requirements of data users; and
    f. Training and capacity development.
2) Maintain an active watch and report on potential operational developing and emerging meteorological radar research and technologies;
3) Liaise and coordinate activities, as appropriate and as directed, with other international and regional organizations on relevant matters, particularly including international standards organizations and research bodies and associations.
4) Liaise with and respond to the various requests of WMO bodies and Technical Commissions and their associated work teams and groups on mutual and relevant matters of responsibility.
5) Develop and document strategies and plans for the activities of the CG-OWR under the direction of and subject to the approval of the management board.
6) Report on issues, activities and progress to the governing Technical Commissions through the CIMO OPAG on Remote-Sensing Technologies, and the CBS OPAG on Integrated Observing Systems.

Membership

Recommended that the initial membership of CG-OWR should

- include experts on meteorological radars in CIMO/ET-ORST and CBS/ET-SBO and TT-WRDE;
- have geographical representation across WMO regions; and
- include representation of the countries and regional organizations with large and advanced radar networks.

As soon as possible, membership should include representation from:

- CHy
- CCL
- CAeM
- CAS

Possible Priority Tasks and Work Plan Activities

a) CIMO RQQI activity.
b) CBS weather radar data exchange activity.
c) Assistance and advice on WMO coordination with ISO on radar matters.

d) Development of integrated rainfall products.
e) In consultation with relevant WMO Members and WMO Education and Training Branch, development of training curriculum and associated materials in support of WMO international training courses and workshops on operational meteorological radar systems.
f) Attend and publish technical reports on relevant aspects of key international meteorological radar conferences, particularly including AMS Radar Conference and ERAD (2 members to attend).
g) Coordination of/assistance with international training courses, e.g. TSMS and KMA.
h) Development of functional requirements and specifications of Regional WIGOS Centers on Meteorological Radar Operation and Maintenance.
i) Organisation of WMO international conferences on meteorological radar systems (e.g. every 2-4 years) in collaboration with AMS and/or ERAD.
j) Development of an operational plan for CG-OWR.

ANNEX IV

Proposed table of contents for CIMO Guide Material on Radar Wind Profilers

1. Theoretical aspects – physical and mathematical basics
    a. Scattering processes
        i. Clear air scattering
        ii. Particle scattering
        iii. Clutter
    b. Atmospheric properties and profiler performance
        i. Refractive index turbulence
        ii. Clouds and precipitation
    c. Signal processing
        i. Estimation of Doppler spectrum
        ii. Clutter suppression methods
    d. Methods for wind determination
        i. Doppler method
        ii. Spaced antenna method

2. Practical aspects
    a. Frequency and spectrum allocation
        i. Carrier frequency selection: 50, 400, 1000 MHz
        ii. RF interference and its mitigation
        iii. Instrument selection
    b. Siting considerations
        i. Ambient RF spectrum
        ii. Potential clutter targets
    c. Technical components of a Doppler RWP
        i. Transmitter
        ii. Antenna
        iii. Receiver
        iv. Signal processor
        v. Ancillary components: UPS, A/C, IT, COMMS
    d. System configuration - sampling aspects
        i. in space – number of beam directions
        ii. in range – PRF, max. unambiguous range and aliasing, minimum range
        iii. in time – integration and averaging
        iv. in frequency – PRF and Nyquist frequency, Doppler spectrum resolution
    e. System configuration – processing aspects
        i. Signal processing – algorithms and parameters
        ii. Data processing
    f. Data management
        i. Product levels
        ii. WMO BUFR template
    g. Quality control and system monitoring
        i. Internal data consistency
        ii. NWP monitoring
    h. Maintenance

3. Example systems
    a. 50 MHz
    b. 400 MHz
    c. 1 GHz

ANNEX V

Technical Review of JMA's Radar Systems: Table of Contents

WORK PLAN FOR THE ET-SBO FOR THE PERIOD 2013 – 2016
VERSION 1.5

Includes updates from review during ET-SBO-2 in Tokyo Japan October 2015.

Additional information added to plan to improve clarity

No.	Task	Deliverable/Activity	Due	Responsible	Status	Comment
1.	**Helping WIGOS Succeed** Original Text: Contribute to the implementation of WIGOS by undertaking those tasks assigned to it by the OPAG IOS Chair from the WIGOS Framework Implementation Plan [ToR a] Informally, as discussed at ET-SBO-1 and ET-SBO-2, this ToR has become: "Contribute to the implementation of WIGOS by undertaking those tasks assigned to it by the CBS/IOS IPET WIFI Chair and other relevant groups" In 2015/6 the focus will be on developing the Quality Management and Incident Management Function as discussed at the December 2014 QM Workshop. The proposal will be presented to CBS in 2016 for approval. This task includes work taken from work plan item 6 to simplify the reporting of tasks.	Address relevant items of WIGOS Implementation Activities assigned to ET-SBO, details to be forthcoming during work plan period, see individual task sheets for more detail.	Ongoing	**Co-ordination Lead:** Chair ET-SBO for overall delivery with lead and contributors for each task identified	On track	100 days provisionally assigned to this work plan item. *SJG 21/10/15: At ET-sBO-2 it was highlighted that other tasks would come to ET-SBO for review from WIGOS Task Teams. However they would not all be explicitly included in the work plan.*
1.1		**Regulatory Material** Review the following sections of the Manual on the GOS: Part III (surface-based sub-system) except 2.5 and 2.7. See Annex III Breakout Group 1 information for more detail.	October 2013	**Task Lead and Contributors:** See the detailed attachment on pages 3 to 5 of Annex III.	Complete	Significant task requiring ~20 days of effort in total. *SJG 19/12: Report submitted to TT-WRM before November meeting, suggest task complete.*
1.2		**Metadata** Use several specific surface-based observing systems to road-test the draft WIGOS metadata core profile. After road tests review the lessons learnt	November 2013	**Task Lead and Contributors:** See the details in the report of Break out group 1 on page 2 for details.	Complete	Significant task requiring ~20 days of effort in total. *SJG 19/12: Review of Profile complete and top level feedback given to TT-WMD, suggest task complete.*
1.3		**Quality Management** Improve quality monitoring of WMO / CBS / GOS surface-based observations exchanged globally by: Review the operation of the current centres; Develop the proposed role and terms of reference of a global 'WMO Lead Centre for Quality Monitoring of Land Surface Observations'; Develop an Incident Monitoring framework for land Surface Observations;	Complete by Q1 2016 Done at December Workshop Q3 2015 Q2 2015	**Task Lead**: Stuart Goldstraw Contributors: Henry Karanja and others yet to be identified. Joint with IPET-WIFI SG-QM Support TT-WQM	Good Progress, workshop held Dec 2014 Some progress by Dean Lockett. Stefan developing	Significant task requiring ~20 days of effort in total. *SJG21/10/15: Dean Lockett has invested considerable effort in developing the concept of the WMO Lead Centre for QM of land surface obs. Hentry Karanja has suggested a list of countries that could be included in the East African Pilot Project.Next Webex to be held on 27th October to discuss next steps. Stefan Klink is developing the functional and technical specifications for the Incident Monitoring System.*

No.	Task	Deliverable/Activity	Due	Responsible	Status	Comment
		Undertake pilot projects to demonstrate the value of the quality monitoring and fault monitoring system. See December 2014 Workshop report for action details.	Q3 & Q4 2015	Stuart & Henry jointly	Specs Not yet started	
2.	**<u>Improving Technical Documents</u>** Develop and update relevant elements of the Manual and the Guide on the GOS in the context of WIGOS, with initial priority on weather radar and AWSs [ToR b] In 2015 the focus will be to finish the draft material prepared in the November 2015 Sub Group meeting and hold a mini Sub Group meeting to draft revised material for the Radiosonde component in the Manual of the GOS.	Review and update the technical content on Weather Radars, AWS and other high priority systems in SBOs area of responsibility currently held in Manual and Guide for the GOS, noting a new technical document structure may be implemented during the period.	March 2014 & March 2016	**Co-ordination Lead:** Islam Ameen	On Track	60 days provisionally allocated, 110 days recorded below. *SJG 21/10/15; Excellent progress made by SG teams on AWS, RWP & WxR. Actions for Chair to review material and propose, where possible, unified wording for consideration by IPET-WIFI in January 2015.*
2.1		**Weather Radar Review** Update WMO No.544 to reflect the importance of Weather Radar operations in WIGOS. Details in break out group 4 report.	November 2014 plus additional work thereafter	**Task Lead:** Daniel Michelson **Task Contributors:** Al Wissman, Aki Umehara & Tom Kane (Nov workshop)	On Track	50 days of effort from ET members but others will be engaged SJG 21/10: Unified task comments from SJG by mid November is the next step before wider circulation.
2.2		**Wind Profiler Review** Update WMO No.544 to reflect the importance of Wind Profiler operations in WIGOS. Details in break out group 4 report.	November 2014 plus additional work thereafter	**Task Lead:** Dominique Ruffieux **Task Contributors:**Al Wissman, Volker Lehman, Aki Umehara & Tom Kane	On Track	Effort required to be assessed after Wind Profiler Survey comment. # SJG 21/10: Unified task comments from SJG by mid November is the next step before wider circulation.
2.3		**Upper air synoptic stations** Update WMO No.544 to reflect the current status of operational radiosonde synoptic reporting operations in WIGOS. Reference to the need for operational data from GRUAN also needs to be considered.	2015, as a follow on to success of SG meeting in November 2014.	**Task Lead:** Tim Oakley**Task Contributors:** Rongkang Yany	Not yet started	30 days of effort from ET members but others will be engaged. SJG 21/10; Tim Oakley has agreed to review some text. An informal meeting will be arranged in Geneva when Tim and SJG are next in WMO headquarters to agree next steps. New ET member Rongkang Yang from CMA has agreed to join this mini team.

No.	Task	Deliverable/Activity	Due	Responsible	Status	Comment
2.4		**Surface synoptic stations** Update WMO No.544 to reflect the current status of surface land reporting operations in WIGOS. Details in break out group 4 report.	November 2014 plus additional work thereafter	**Task Lead:** Karl Monnik **Task Contributors:** Henry Karanja, Islam Ameen & Charles Paterson.	On Track	30 days of effort from ET members SJG 21/10: Unified task comments from SJG by mid November is the next step before wider circulation.
2.5		**AWS Technical Manual** Create an AWS technical manual from all material generated by ET-AWS over the past 7 meetings and publish as a technical document under new WIGOS banner. (Suggest task is superseded by WIGOS initiative)	November 2014 plus additional work thereafter?	**Task Lead:** Karl Monnik **Task Contributors:** Henry Karanja, Islam Ameen & Charles Paterson.	Replaced by WIGOS led task	Details of resources required to be confirmed by Karl. SJG 26/02/15: Karl is happy that material can be turned into WIGOS technical reports, following review, which will meet this action. Next steps to finalise draft and send to ET-SBO as a whole for feedback. SJG 21/10: This task has now been superseded by the work to generate a WIGOS led AWS Manual. Close working relationship between ET-SBO & WIGOS is expected.
3.	**Status of Implementation** Monitor and assess the status of planned and operational surface-based observing systems and ensure this is adequately described in Volume A and metadata database(s) of Members' observing system capabilities [ToR c] The focus in 2015 will be to continue the evolution of the WMO Radar Metadata Database, hosted by TMS, and to identify where Wind Profiling Radar metadata should be held in the future.	Complete the outstanding actions associated with the Wind Profiler Questionnaire including results analysis. Review content of WMO No.9 Vol A including R/S catalogue and ensure it is fit for purpose and up to date, noting any future plans for changes in light of WIGOS and in particular the WIGOS Information Resource	Ongoing / Annual review	**Co-ordination Lead** To be confirmed	On track	60 days provisionally allocated. *SJG 26/02/2015: Excellent progress being made. Task 3.4 deleted as very similar to task 5.1*
3.1		**WMO Radar Metadata Database** Maintenance and improvement of the WMO Radar Database, specifically the improved functionality identified at the WMO WxR Data Exchange Workshop, under recommendation 11.	Ongoing + annual report	**Task Lead:** Oguzhan Sireci **Task Contributors:** To be identified	On track	*SJG 26/02/2015: Excellent progress being made by Oguzhan and TMS with historical metadata function and planned stations function being added to WMO RMD.* *Next steps to add the radar exchange tracking function.*

No.	Task	Deliverable/Activity	Due	Responsible	Status	Comment
3.2		**Wind Profiling Radar Survey** Complete the outstanding actions associated with the Wind Profiler Questionnaire including results analysis. See Breakout report for details but main focus is the metadata hosting question.	April 2014	**Task Lead:** Dominique Ruffieux **Task Contributors:** Dean Lockett, OSCAR working group	On track	*SJG 26/02/15: Excellent progress with take with only the outstanding issue of metadata collection and storage remaining. Plans for this need to be considered in 2015. Current discussion to harmonize the questionnaire to be OSCAR compatible.*
3.3		**Validation of 'Vol A' metadata** Details of task to become clear once proposals for migration of Vol A to new framework completed.	2015?	**Task Lead and Contributor:** N/A	Superseded by IPET_WIFI led task.	Needs close liaison with IPET-OSDE and IPET WiFI needed. *SJG 26/02/12015: Careful consideration of this task and its link to other groups included OSCAR oversight team potentially undertaking the same task needed. SJG 21/10: IPET-WIFI SG-OD now leading on Vol A issues and so this task is no longer needed, although support from ET-SBO may be required?*
4.	**Meeting User Requirements** In collaboration with IPET-OSDE, assess the contribution of current and planned SBO systems to meeting user requirements for all Application Areas [ToR d] The main focus of this work plan item is to provide Expert Team input to IPET-OSDE led meetings, workshops and other initiatives.	Provide reports to IPET-OSDE on the suitability of each observing system in meeting each Application areas requirement	Ongoing	Co-ordination Lead still to be to be identified currently being undertaken by Stuart & Dean	Responding to requests as raised.	*SJG 26/02/2015: Good progress with IPET-OSDE engagement as part of Observing System Design Workshops. An outstanding task is the review of the status of the EGOS-IP actions. SJG 21/10: EGOS-IP review triggered at ET-SBO-2, feedback expected over next few weeks. Many team members have contributed to other task, such as the development of OSND Principles.*
5.	**Delivering the EGOS-IP** Facilitate the delivery of those EGOS-IP actions identified as priorities for OPAG-IOS [ToR E] The main focus here is for ET-SBO to	Undertake Radar Data Exchange Workshop and ensure follow up actions triggered. Review EGOS-IP and proposed priority actions for consideration to ICT-IOS. Undertake agreed follow up actions		**Co-ordination Lead: TBD**	Some progress being made	SJG 26/02/2015: Need to identify a co-ordination lead. Good progress being made with Wx Radar exchange tasks. Next steps to review EGOS-IP to identify actions ET-SBO can really assist with. Task 5.3 removed until task 5.2 is completed.

No.	Task	Deliverable/Activity	Due	Responsible	Status	Comment
5.1	have suitable oversight and monitoring of progress with EGOS-IP actions assigned to it for review and to undertake the specific tasks associated with G48.	**Next steps with Weather Radar Data Exchange Action G48** WxR Data Exchange Task Team – details of ToR and work plan for TT to be found in final report in annex III pages 6 to 12.	March 2016 & beyond.	**Task Lead:** Daniel Michelson **Task Contributors:** See TT membership	On track	*SJG 23/07/14: TT formed and work plan made available by Chair.* *SJG 21/10: Daniel and team hoping to have first TT meeting in Q1 2016.*
5.2		**Identify EGOS-IP Actions for ET-SBO** Analyze existing EGOS-IP actions using methodology defined by ET-SBO-1 Breakout Group 6 and recommend actions to be supported by ET-SBO to ET Members. Task replaced with task identified by ICT-IOS – develop options for implementing G10 Optimising R/S programmes to take account of the complementary nature of AMDAR	November 2013	**Task Lead:** TBD **Task Contributors:** Jean-Luc Cheze & Tom Szynborski **Task Lead:** Tim Oakley **Task Contributors:** RongKang Yang	Superceded On Track	Approximately 10 days in total should be assigned to this task. *SJG 21/10: Tim and Yang sent outline ideas on how to develop the proposal following ET-SBO-2. An informal meeting will be set up in Geneva to progress this work in Q4 2015 and Q1 2016.*
6.	**<u>Promoting Best Practice</u>** Monitor the status of operational networks of SBO systems, promote best practice among WMO Members and provide advice on operational matters [ToR F] The focus here is to develop a web page within the WIR that contains useful technical documents that ET-SBO members believe would be useful for WMO operational observing managers to have access to. A WebEx will be arranged with Henry and others to agree how to proceed with this work plan item.	Establish an improved source for technical advice documents "SBO Portal" as part of the WIGOS Information Resource. Populate Portal with national best practice documents. Respond to requests for advice from members	2014 for Portal then ongoing for other actions	Co-ordination lead: **Henry Karanja** as Vice Chair SBO All members will support this activity.	Progress Delayed	*SJG 23/07/14: Some progress has been made with this task but predominantly by Dean Lockett.* *SJG 26/02/2015: A task specific WebEx is required to kick start this task.* *SJG 21/10: Lots of discussion at Et-SBO-2 on this matter but actions from meeting report will provde clear guidance as to next steps. It is not clear how much work will be undertaken by ET-SBO in next 6 months.*
6.2		**Best Practice Portal** Create an observing networks operations best practice portal, described and linked from the WIGOS Information Resource (WIR) under Operations & Maintenance topic.	November 2014	**Task Lead:** Edmundo Lucas	Progress Delayed	Suggested 10 days are associated with this task. SJG 23/07/14: Requires a review of the plan *SJG 26/02/2015: A task specific WebEx is required to kick start this task.* *SJG 21/10: lots of encouragement from Chair to keep this task simple. Actions from ET-sBO-2 will identify next steps.*

No.	Task	Deliverable/Activity	Due	Responsible	Status	Comment
6.3		**Quality Monitoring Portal** Specify structure, review current best practice and implement a QM portal within the WIR	November 2014	**Task Lead:** Tim Oakley?	Limited Progress	Suggested 10 days are associated with this task. SJG 23/07/14: Requires a review of the plan *SJG 26/02/2015: A task specific WebEx is required to kick start this task.* *SJG 21/10: Tim Oakley provided links to a number f monitoring sites. This will provide the starting point for developing this portal of useful links.*
7.	**Purposeful Horizon Scanning** Assess the potential contribution of new and emerging SBO technologies in meeting the Vision for the GOS in 2025, in collaboration with CIMO [ToR G] The focus here is to co-ordinate the efforts of ET-SBO members in the gathering of intelligence about the evolving state of observing system technology and the likelihood of it being suitable for operational implementation at some point in the future. A WebEx will be arranged with Richard and others to discuss how to best progress this item.	Report on the suitability of new and emerging technologies for operational network implementation. Propose updates to the Vision for the GOS. Ensure close collaboration with relevant CIMO ETs & other working groups.	20014 2015, 2016	Co-ordination Lead: **Richard Ice** with all members of ET acting as contributors.	Limited Progress	*SJG 26/02/15: A specific WebEx is required to discuss how best to progress this task.* *SJG 21/10: Richard Ice has retired and a lead for this task has not been forthcoming. Co-ordinating this task in the context of all the work being undertaken by CIMO is key.A new task may trigger an improved activity within ET-SBO.*
7.1		CIMO Teams identified where close co-ordination and review of their meeting reports is required: *CIMO OPAG-S&I ET-A2 New In-situ Technologies;* *CIMO OPAG-RSNT ET-B1 Operational Remote Sensing;* *CIMO OPAG-RSNT ET-B2 New Technology and Test Beds;* *Note CIMO ET team names changed since CIMO Commission session. It is assumed the work of all CIMO ETs is relevant and so outcomes of all meetings need to be reviewed.*		**Task leads:** to be identified.	Task delayed	Report from each meeting is ~2 days of effort *SJG 26/02/2015: It is proposed to hold a joint session with ET-ORS in October 2015.* *SJG 21/10: Little progress with this item.*
7.2		*In addition a review of papers submitted to major scientific and technical conferences, such as: AMS2014, EMS, ERAD, ISTP, others to be added.*	Dates tbc	**Task leads:** to be identified.	Limited Progress	Report from each meeting is ~2 days of effort. *SJG 19/12: Daniels's report provides good style to follow.* *SJG 23/07/14: No additional visit reports produced.* *SJG 21/10: no additional visit reports*

No.	Task	Deliverable/Activity	Due	Responsible	Status	Comment
7.3		Produce Annual Report for ET-SBO members. Annual report is a synthesis of likely future operational observing systems and their potential in meeting stated requirements.	March 2014, March 2015,/ March 2016	Task Lead: Richard Ice	Not undertaken	Annual report is ~2 days of effort per year. SJG 23/07/14: No annual report mechanism put in place to date but Richard is developing a report on emerging remote sensing technology. A follow up WebEx to support Richard is required.
7.4		Provide input to the new Vision for the GOS in 2040, considering the current and likely evolution of R&D observing capabilities	March 2016	Task Lead: TBD	On track	SJG 21/10: This was triggered by an action from ET-SBO-2 and will be the de-facto outcome of the tasks originally considered important in 7.1 to 7.3 above.
8.	**Reporting Progress to ICT-IOS** Provide advice and support to the Chairperson of OPAG-IOS on the implementation of the WIGOS framework and its operational aspects [ToR H]	Deliver progress reports and recommendations for changes to operating practices, technical documents and guidance to ICT-IOS during inter-sessional period.	2014 and 2016	**Task Lead: Chair ET-SBO**	On track	*SJG 26/02/15: Reporting on track. Resource commitments the major issue.*
8.1		Generate report of work for ICT-IOS-8. Requires input from all ET Members.	April 2014 (tbc)	Chair ET-SBO with review of report by all members.	Complete	
8.2		Attend ICT-IOS-8, report progress with work plan activities and provide feedback to ET Members	April 2014	Chair ET-SBO	Complete	Chair 5 days
8.3		Generate report of work for ICT-IOS-9. Requires input from all ET Members.	April 2016 (tbc)	Chair ET-SBO with review of report by all members.	On track	
8.4		Attend ICT-IOS-8, report progress with work plan activities and provide feedback to ET Members	May 2016 (tbc)	Chair ET-SBO	On track	

ANNEX VII

Updated Workplan of the CIMO Expert Team on Operational Remote-Sensing Technologies (2014-2018)
CIMO-16, §5.2
(ET-ORS deals with **all aspects** of radar wind profilers, weather radars and lightning detection systems)
(Version: as approved by CIMO-MG-13 in Dec. 2014, updated 8 October 2015)

No.	Task description	Person responsible	Action	Deliverable	Deadline for deliv.	Status [%]	Comments
1.	**Radar wind profiler operations, including:** **a) profiler selection** **b) siting considerations** **c) networking considerations** **d) integration with other systems** **e) data quality control** **f) uncertainty and traceability of output data** **g) Sustainability and resource requirements.**	**Lehmann** Boers Kane	1. Review available national and international documentation on the operational use of radar wind profilers, including that available from Testbeds. 2. Based on the existing information, prepare guidance material (CIMO Guide) on all aspects of the operation of radar wind profilers 3. Update the CIMO Guide information on radar wind profilers	2. Draft CIMO Guide material on the operations of wind profilers 3. Finalise update of CIMO Guide (possibly new chapter).	1.) 02/2015 2. 12/2016 3. 12/2017	100% 20% 0%	CIMO-16 §5.12, 5.13 Liaise with CBS ET-SBO Note information contained in IOM Report No 110 and http://www.wmo.int/pages/prog/www/OSY/Meetings/ET-SBRSO_ET-RSO-2011/DocPlan/5.1(1)_Profiler_Regional_National_Status.pdf See presentations from TECO 2014 on profiler selection (Scott McLaughlin) and from MMC 2014 (Alexander Haefele) on traceability
2.	**New and emerging radar wind profiler technologies**	**Cook** Lehmann	1. Review current developments in radar wind profiler technology.	1) Report on new and emerging wind profiler technologies, if appropriate.	As available	ongoing	Contact manufacturers through HMEI Rep. (Vaisala, Detect Inc., ATRAD, Degreane, Scintec,…)
3.	**Dual polarization**	**Cook**	1. Collect information on the		1.	Ongoi	Refer to CIMO-16, §5.6

No.	Task description	Person responsible	Action	Deliverable	Deadline for deliv.	Status [%]	Comments
	weather radar	Kong Tsukamoto Urban Sireci	current status of use of dual polarization radars (principles, QC, QPF applications, use, costs, benefits of dual polarization technology, C-band vs. X-band). 2. Review material currently available in CIMO Guide 3. Update CIMO Guide Ch 9	 3a) Draft Updated CIMO Guide section on the use of dual polarization radars 3b) Finalise material for CIMO Guide	Ongoing 2. 12/2015 3a) 12/2016 3b) 12/2017	ng 20% 20% 0%	http://www.wmo.int/pages/prog/www/OSY/Meetings/ET-SBRSO_ET-RSO-2011/DocPlan/3.3.1_Development_of_Polarization_Technology.pdf http://www.wmo.int/pages/prog/www/OSY/Meetings/ET-SBRSO_ET-RSO-2011/DocPlan/INF.3.3.1_Dual_polarization_Meteo_France.pdf Include output from Task 4
~~**4.**~~	~~**Operational calibration of weather radars**~~	~~**Pei Chong** Cook~~	~~1. Research on cross calibration technology and automatic correction methods in weather radar networks.~~ ~~2. Research on operational calibration method for dual polarization weather radar, especially online calibration and compensation of differential reflectivity, which indicates consistency in horizontal and vertical~~	~~1) Document on the research results of cross calibration technology in weather radar networks.~~ ~~2) Document on the research results of operational calibration methods for dual polarization weather radar.~~	~~1.) 12/2016~~ ~~2.) 12/2017~~	~~100%~~ ~~100%~~	~~Contributions from domestic radar producers in China~~ ~~CIMO-16, §5.9~~ ACTION COMPLETE

No.	Task description	Person responsible	Action	Deliverable	Deadline for deliv.	Status [%]	Comments
			~~channels.~~				
5.	**Operation of weather radars in mountainous regions.**	**Kong** Sireci Kane Pei Chong Cook Tsukamoto Waniha	1. Gather information from different countries on strategies employed 2. Synthesize information obtained into general guidance material	2a) Information document (possibly IOM report) on operation of radars in mountainous regions. 2b) New section for CIMO Guide chapter on weather radars, if warranted.	1. 06/2015 2a. 12/2016 2b. 12/2017 (if req)	40% 40% 0%	Note http://www.wmo.int/pages/prog/www/OSY/Meetings/ET-SBRSO_ET-RSO-2011/DocPlan/3.4.2_Radar_at_high_altitude_sites-20111128.pdf CIMO-16, §5.7 CIMO guide contribution TBD Consult with Urs Gehrmann (invited expert, Meteoswiss) Sec to contact Marco Gabella. Request Oguzhan to provide focal points in mountainous countries.
6.	**Weather radar data and metadata exchange**	**Sireci** Kane Cook Urban	1. Contribute CIMO input to the CBS ET-SBO Task Team on Radar Data Exchange 2. Work closely with Turkish Meteorological Service in the design and implementation of the second version of the weather radar metadatabase	1) Input to CBS ET-SBO TT-WRDE 2) Liaison with TMS on requirements for radar metadata, as required	1. As req 2. As req	Ongoing ongoing	CIMO-16, §5.3 Exchange of products (reflectivity, radial Doppler, derived VVP Winds): data exchange studies, collect info about different formats BUFR, HDF5, ODIN CIMO developed radar metadata database, now handled by CBS ET-SBO CIMO input to CBS required Support task for ET-ORST, on request
7.	**Evolution of weather**	**Pei Chong**	1. Review current	1) Report on new and	12/2017	ongoi	Contact manufacturers through HMEI Rep. with

No.	Task description	Person responsible	Action	Deliverable	Deadline for deliv.	Status [%]	Comments
	radar technologies: New developments, resource requirements, spectrum allocation constraints.	Cook	developments in weather radar technology: (e.g. solid state transmitters, phased array antennas, low cost X-band radars, use of radio spectrum and RFI issues, health and safety etc.)	emerging weather radar technologies, if appropriate.		ng	regard to aspects mentioned. Contact with B.3 "Theme leader on Radio-Frequency Protection". CIMO-16 §5.10, 5.11
~~**8.**~~	~~**Collaborative adaptive observation mode of weather radars**~~	~~**Pei Chong** Ice~~	~~1. Research on collaborative adaptive observation mode of weather radars, focusing on temporal and spatial synchronization, as well as echo consistency /product comparability in radar networks.~~	~~1) Document on research results of collaborative adaptive observation mode of weather radars.~~	~~12/2016~~	~~100%~~	~~CIMO-16, §5.8~~ ACTION COMPLETE
9.	**Intercomparisons of weather radar algorithms and products (Radar Quality Control and Quantitive Precipitation Intercomparison (RQQI))**	**Kane** Leijnse	1. Monitor progress of the intercomparison 2. Publish results of the analysis	2.1) IOM report on the results of the intercomparison 2.2) Update CIMO Guide Chapter on weather radar	2.1) 12/2016 2.2) Dec 2017	0% 0%	CIMO-16, §5.5 Invited experts on an opportunity basis: Daniel Michelson, project leader RQQI, communication through WMO Secretariat. Activity depending on RQQI activity, monitoring task for ET-ORST

No.	Task description	Person responsible	Action	Deliverable	Deadline for deliv.	Status [%]	Comments
10.	**Lightning detection systems**	**Hettrick** Pei Chong	1. Assemble existing information and propose improvements to current methods of assessing the detection efficiency and location accuracy of lightning detection networks 2. Review the use of lightning data in integrated observations products.	1a) Report on current status of lightning detection systems 1b) Update CIMO Guide 2) Report on use of lightning data in integrated obs products .	12/2016 6/2017 6/2017	50% 0% 0%	(Leftover from previous task team) Note existing guidance doc from FMI. Search for additional literature / reports Contact HMEI and ask for contacts/input
11.	**Lightning detection systems: Testbed and Intercomparisons**	**Pei Chong** All	1.Assist CMA, on request, regarding the development of a CMA testbed for lightning detection systems 2. Examine the feasibility of a CMA intercomparison of lightning detection systems and provide advice to CMA, if requested, to assist in planning such an intercomparison	1)Guidance doc regarding the establishment of a new CIMO testbed 2)Guidance doc regarding the planning of an intercomparison experiment	1 as req. 2 as req.	50% 0%	CMA expects to submit a proposal late in 2015.
12.	**Integration of observations from different rainfall observation systems**	**Urban** Kane Ice	1. Evaluate issues related to integrating precipitation observations from weather radars, satellites and rain	1-2. Guidance document on integration of rainfall observations from			CIMO-16, §4.9, 4.10, 5.8 Note: in collaboration with ET-OIST Draft based on experience at

No.	Task description	Person responsible	Action	Deliverable	Deadline for deliv.	Status [%]	Comments
			gauges 2. Propose standardized techniques for data integration	different systems. a) Draft b) Final doc	 a) 10/2015 b) 07/2016	 50% 0%	MeteoFrance and within Europe
13.	**Access to publications on wind profilers, radars and lightning detection systems**	**Lehmann** All Secretariat	1. Identify national and other publications on wind profilers, weather radars and lightning detection systems 2. Provide internet access to those publications from the WMO webpages	1. List of publications 2. Webpage providing access to those publications	ASAP	ongoing	CIMO MG-11 CIMO-16, §5.2 Continuous task.
14	**Outcomes of Exploratory Workshop**	**Kane**	Follow-up on outcomes of exploratory workshop Participate in discussion on Inter Program coordination mechansim	1) Assist in development of draft ToR for group	1) 10/15	100%	
15	**Operation of Weather Radar Systems**	**Tsukamoto**	1. Develop report on JMA's current weather radar program	1a) IOM report. 1b) Material integrated into existing CIMO Guide chapter.	2018 2018	10% 0%	NEW ACTION (10/15)
16	**Impact of Wind Turbines on Weather Radars**	**Cook** Hettrick Urban	Develop improved guidance for Members on prevention/mitigation of interference to weather radars from wind turbines.	1) Updated Annex 9-A to CIMO Guide	12/2016	0%	NEW ACTION (10/15)