

WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION

**CIMO EXPERT TEAM ON
UPGRADING THE GLOBAL RADIOSONDE NETWORK
First Session**

Geneva, Switzerland

3-7 November 2003

FINAL REPORT



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EXECUTIVE SUMMARY

This report provides a summary of the meeting on the first session of the CIMO Expert Team on Upgrading the Global Radiosonde Network, ET-UGRN. The ET, in response to the need for greater collaboration, both from within and outside of the WMO, requested participation by stakeholders in instruments and methods of observation. Participants included representatives of the Hydro-Meteorological Equipment Industry (HMEI) Association, the Global Climate Observation System (GCOS), and the AMDAR Panel.

The ET was tasked by CIMO Members to review the GUAN architecture from the perspective of international goals, including its structured process for the collection, documentation, data verification, and validation of user requirements. This process is needed to reconcile the mission of the GUAN with all other activities and operations within the WMO. Only through cross Commission review and discussion can requirements and resulting systems or system upgrades and solutions to be evaluated in terms of cost and effectiveness.

The first step to ensuring success is in the validation of operational and research requirements. Both the Climate community and the AMDAR Panel expressed a need for CIMO assistance in establishing sensor accuracies and to investigate how different tropospheric monitoring systems may be used in a complimentary fashion. Such an approach would help in filling data gaps and eliminating duplication, while reducing costs through greater efficiencies in operation.

GENERAL SUMMARY

1. ORGANIZATION OF THE SESSION

1.1 Opening of Session

- 1.1.1 The first session of the Expert Team on Upgrading the Global Radiosonde Network (ET on UGRN) was held in Geneva, Switzerland, 3-7 November 2003. The session was opened by Mr Rainer Dombrowsky, ET UGRN Chairman. The list of participants is given in [ANNEX I](#).
- 1.1.2 Following the opening of the session, Prof. Hong YAN, Assistant Secretary-General, welcomed the participants to Geneva. In his statement to the ET UGRN he pointed out the importance of their work and wished them a productive meeting and an enjoyable stay in Geneva.
- 1.1.3 Mr Dombrowsky welcomed the participants. He thanked the participants for coming and wished everyone a fruitful and productive meeting.

1.2 Adoption of the Agenda

- 1.2.1 The ET adopted the [agenda](#) for the meeting, which is reproduced at the beginning of this report.

1.3 Working Arrangements for the Session

- 1.3.1 The working hours and tentative timetable for the meeting were agreed upon.

2. REPORT OF THE CHAIRMAN

3. DISCUSSIONS & MEMBER PRESENTATIONS ON HIGH PRIORITY ISSUES

3.1 Status of reference radiosondes

3.1.1 For many years groups have attempted to develop reference radiosonde systems. The reference radiosonde is defined as a radiosonde that can be flown on its own to provide reference measurements for other radiosonde systems. The development of such a fully capable radiosonde has not been successfully achieved. This is because all radiosonde systems need to be flown on a regular basis to eliminate the many types of data contamination occurring across a wide range of weather conditions. Earlier comparisons conducted during the 1960's and 1970's between reference radiosonde designs could not produce agreement between temperature measurements. Modern operational radiosonde can now provide better agreement in temperature measurements at night.

3.1.2 It is proposed that a designation of “**higher quality radiosonde**” be adopted for the best new generation of operational radiosondes and for systems being developed by the research community. Once developed it would be necessary to indicate the accuracy achievable by the different systems and also the limitations of the different systems. Users would then be able to identify suitable combinations of systems to provide the measurement quality required.

3.1.3 For research quality reference work, it is recommended that the best quality operational radiosondes be used in conjunction with the high quality scientific sensors.

3.1.4 In discussing the issue of reference radiosondes, the ET attempted to address the question of whether high quality operational radiosondes should be used as working references or do we need higher quality, much more expensive reference radiosondes; and whether there are enough independent high quality radiosonde systems that can provide a plausible working reference for test and evaluation of network performance.

3.1.5 The ET discussed the requirements for reference radiosondes and their associated problems. It was agreed that the manufacturers need to concentrate on:

- (a) Addressing the issue of correcting for solar heating of the temperature sensor during radiosonde ascents and to reference daytime measurements to nighttime measurements, especially at pressures lower than 30 hPa.
- (b) Develop a relative humidity/water vapour sensor that can reliably reference daytime measurements to nighttime measurements. This may require the attaching of a temperature sensor to the surface of the polymer sensor.
- (c) Address the problems of data contamination while ascending through low level clouds or at temperatures between -40 and -60 °C in the tropics.
- (d) Consistency of measurements between satellites and ground based systems.

Relative humidity will require more work by the scientific community, manufacturers and the operational community before a high quality operational radiosonde can be flown on a regular basis.

3.1.6 In addressing the requirement for reference radiosondes, the ET suggest that:

- (a) Reference radiosondes need to be reasonably priced before they can be used routinely. Only through regular use can error characteristics be understood and rectified.
- (b) Systems must be small and light enough to be used operationally minimizing the risk to the local population and the environment.
- (c) Reference systems must be sustained by a facility or the manufacturer long-term high quality support. Short-term designs assembled without consideration for future obsolescence issues may not prove to be cost-effective.
- (d) Traceability to accepted standards is required. This implies a level of investment in referencing which is significantly higher than the best manufacturers currently provide.

3.1.7 ET agreed on the following recommendations:

- (a) ET members should encourage national meteorological services to pursue developments of high quality daytime temperature and water vapour measuring systems;
- (b) GCOS should use new generation radiosondes with high quality sensing systems coupled with additional sensor packages (three thermistor references, hygrometer) using additional channels available in the radiosonde as required;
- (c) The next WMO Radiosonde Comparison should evaluate the performance of new generation high quality radiosondes;
- (d) CIMO should explore the possibility to perform overlap tests between new radiosondes and current operational radiosondes in Regional Instrument Centers.

3.1.8 Mr Diamond stressed the fact that GUAN is comprised of a variety of radiosonde systems. To ensure data comparability and permit the accurate calibration of remote sensing systems such as satellite sounders and GPS Meteorology, he encouraged the ET on UGRN to work closely with

the radiosonde manufacturers in developing a reference radiosonde to be used by a subset of the GUAN stations, an Upper-air Reference Network.

3.2 Satellite calibration using radiosondes

3.2.1 At the Workshop to Improve the Usefulness of Operational Radiosonde Data, Asheville, North Carolina, U.S.A. (2003), several groups from the satellite passive sounding community requested improved quality of radiosonde measurements coupled with a move from ascents made at a fixed time of day to ascents collocated closely in time with the overpass of the satellite sounding system.

3.2.2 The request for flexible launch times may be readily adopted at some stations, but may have significant cost and labor implications. Automatic launch systems provide greater flexibility when this type of operation is required.

3.2.3 Some participants expressed concern with the climatological requirement for observations to be taken at a consistent time. Retaining a consistent time is desirable for climatological purposes, however, there are significant diurnal and semidiurnal temperature tides at most locations. This use may require additional flights at locations currently functioning as part of the GCOS network resulting in higher costs due to the need for additional resources.

3.2.4 In terms of satisfying the requirements for measurement accuracy, it is important that the height to which the measurement accuracy is required is clearly specified. Using the example of temperature, high accuracy is obtainable in the troposphere, however in the middle stratosphere, the sensor design and exposure becomes much more critical and some radiosonde types are unsuitable.

3.2.5 Clear requirements for relative humidity accuracy, as a function of height, in the troposphere are also required before optimum technical solutions can be proposed.

3.2.6 The expert team noted that the advent of high quality radiosondes is expected to eliminate the uncertainty in height assignment at upper levels that have limited the accuracy of radiosonde temperature measurements in the past.

3.2.7 The expert team agreed to support efforts to identify suitable equipment for optimum use at sites where satellite calibration will be attempted.

3.2.8 The expert team agreed that to satellite operators must identify those radiosonde stations deemed essential for the calibration of satellite sounding systems.

3.3 Member briefings on current national upper-air activities

3.3.1 Members of the ET presented current and planned activities in their respective countries. They also provided their personal background to assist the Chair in assigning the ET's tasks. Members presentations will be made available on the CIMO/IMOP website.

3.4 How to solicit agreement on BUFR code table and descriptors for International use; including a discussion on radiosonde/sounding system used in WMO messages

3.4.1 Identification of radiosondes is required in the observations reported via WMO messages. Two code forms are used for this, the legacy character based codes TEMP and PILOT, and the new table driven codes BUFR and CREX. BUFR is binary and CREX is character based. The team recognized there have been significant recent changes in radiosonde and ground systems designs for which there is no defined way of reporting. Additionally, there are needs being brought to surface for metadata, quality control, higher precision data, higher resolution profiles and other

additional information which today are not currently being reported in either one or both of these code forms.

3.4.2 Recognizing that Congress has directed the legacy character based codes be migrated to the new table driven formats, CIMO requested CBS to provide further guidance to Members as relates to TEMP/PILOT codes. The secretariat prepared a discussion paper addressing the limitation of the TEMP/PILOT codes and outlined the work done so far to support BUFR encoding of upper air observations. The paper also provided a synopsis of the code migration schedule. Fred Branski introduced the paper with a discussion of the two codes forms, their differences, the limitation of TEMP/PILOT and the need and schedule for migration.

3.4.3 Mr. Branski drew the team's attention to the fact the existing capability for new radiosondes to be described in TEMP code was limited to twenty six without deleting existing entries in the code table. This could be done since there were some entries that had never been used. The same existing table in BUFR has over 150 new possibilities available. Additional BUFR tables can be added to support as many additional entries as needed. The TEMP code cannot support further expansion without a change to the code format. This is also true for the addition of any information that is not already included in the code. Any change of this nature would require every decoder, encoder, data assimilator or display software using TEMP code worldwide to be changed. This cost cannot be justified especially since the TEMP still would not meet all existing requirements. The nature of the TEMP code would require software changes every time a modification to it was needed to support future needs. BUFR is designed to allow changes to and addition of parameters and tables without significant software or hardware costs each time. Recognizing this, Congress agreed no changes should be made to TEMP or other legacy codes and directed migration to the table driven code forms of BUFR, CREX and GRIB.

3.4.4 The team reviewed the information presented and endorsed the need to migrate to BUFR as soon as feasible, but not later than the dates provided for in the migration plan developed by CBS and approved by Congress. The team endorsed the following recommendations:

1. Member countries should ensure that procurement specifications for future radiosonde systems contain the requirement to have the equipment report its data in the BUFR code.
2. ET on UGRN should review the BUFR code tables applicable to the radiosonde network and recommend suitable changes, namely:
 - (a) Identify additional radiosonde/system identification requirements and coordinate these with the CBS Expert Team on Data Representation and Codes (ET/DRC). Until BUFR migration has been completed any additions must have a one to one correlation with TEMP code table entries.
 - (b) Identify any additional data encoding requirements and provide the list to the ET/DRC for incorporation into BUFR tables.
 - (c) Identify and coordinate code migration issues with the CBS ET on Migration to Table Driven Code Forms (ET/MTDCF).

3.4.5 The team also considered that there may be a need to track some additional metadata information which cannot be incorporated into TEMP codes prior to it's availability in BUFR. If this is determined to be so, this information should be incorporated, as much as possible, into the on-line database maintained by the Rapporteur on Radiosonde compatibility.

3.4.6 **Mr E. Järvinen** indicated his interest to participate in the work aimed at practical proposal about what "household" information from radiosonde observation data should be included in the BUFR message; for example, quality indicators, sounding system parameters etc.

3.5 How to monitor and integrate AMDAR measurements into upper-air database

3.5.1 The ET noted the report on the status of implementation of the Aircraft Meteorological Data Relay (AMDAR) observing system presented by the AMDAR Panel Technical Coordinator (Mr J. Stickland). He pointed out the worldwide growing interest in AMDAR and the increasing membership of the AMDAR Panel. AMDAR currently has 20 Member countries. In addition to the 9 Member countries with mature operational AMDAR programmes there has been an increase in the number of countries either developing or testing new national AMDAR programmes including Canada, Saudi Arabia, Japan, China, the Republic of Korea, Hong Kong China and Chile. Furthermore, the ET was informed that a number of countries continued to express interest in developing national AMDAR programmes including Morocco, the Russian Federation, United Arab Emirates, Oman, Argentina, India, Finland and a group of Central and Eastern European countries. Significant effort was therefore being deployed in developing AMDAR to provide upper air data into those well-recognized data sparse areas of the world.

3.5.2 The ET was informed of a system established to closely monitor and control the quality of AMDAR data. The goal of the system is to minimize the number of unacceptable observations exchanged on the GTS. The success of this system can only be achieved through the close collaboration with participating airlines. The ET was further informed of the need to minimize the volume of redundant data and to ensure the required level of spatial and temporal coverage. The AMDAR Panel is addressing this requirement by supporting the development and implementation of data optimization systems.

3.5.3 The ET noted the recent directives from Congress and Executive Council to CAeM and CBS to more fully integrate AMDAR into the WWW global observing system. Consequently, the Panel focusing its attention on this activity. It was further recognized that collaboration with CIMO is of equal importance. A number of steps have been taken to satisfy this need starting with the completion of AMDAR guidance material, the development of new regional AMDAR bulletin headers and extended code forms to improve the distribution and exchange of AMDAR data. The Panel continues to be more involved in the various relevant OPAGs and Expert Teams of CBS, CAeM, CIMO, and other related groups. The Panel is addressing the need for AMDAR familiarization and training. In this regard, a successful technical training workshop was conducted in Dakar, Senegal in 2002 for ASECNA and 4 more such workshops are being planned for South America, Eastern Europe, China and Morocco. Interest for such training has also been expressed by the Russian Federation, Saudi Arabia and Oman.

3.5.4 The ET noted interest in activities being carried out for the development of a reliable humidity sensor in the U.S., Germany and the UK. Several trials are planned over the next 18 months with sensor installations scheduled for research aircraft. In addition, operational trials are planned for commercial aircraft in the U.S.

3.5.5 Work continues on the development of alternative AMDAR systems in the U.S., Canada and Australia. Of particular interest is the Tropospheric Airborne Meteorological Data Relay (TAMDAR) system that will undergo an operational trial on more than 60 aircraft in the US and separate trials planned in Canada and France.

3.5.6 The ET agreed on the following recommendations:

- (d) Assistance from CIMO and manufacturers is required to assess the quality of humidity data reported through the operational AMDAR programme;
- (e) Technical guidance is required from CIMO on operational performance standards for all meteorological elements reported by AMDAR;
- (f) Information and support on relevant ET activities should be provided by the AMDAR Panel as required.

3.6 How to determine the quality and consistency of data processing radiosonde algorithms for TEMP messages

3.6.1 The ET recognizes that there is a problem due to the incompatibility between the coding algorithms used by different operators for encoding the upper-air TEMP messages. This problem should be largely resolved for future data once the migration to BUFR code has been achieved. The ET noted, however, that because no change will be made to TEMP message format the problem will always exist for those using TEMP message data.

3.6.2 The ET invited manufacturers of upper-air equipment and Members, who develop their own coding software, to provide information about details of implementation of coding algorithms. The consistency of algorithms then could be studied both by expertise of those description and by simulation experiments, performed by developers of software, using testing data set in plain ASCII test format. Relevant report will be provided to ET and user community.

3.7 Other issues

3.7.1 Procedures to improve, correct and validate different radiosondes

3.7.1.1 Mr Järvinen emphasized that:

- (a) When using operational radiosondes one should try to maximize the achieved accuracy of the (PTU) observation, using available operationally simple and reliable methods;
- (b) Quality of operational observations should be a "HIGH PRIORITY ISSUE", The radiosonde network requires considerable attention to insure the accuracy of the RS observations;
- (c) Technical specifications of Radiosonde performance must be defined by manufacturers against traceable methods.

3.7.2 Reference humidity measuring methods

3.7.2.1 Dr Leiterer explained the scientific background of the reference humidity measuring method used at Lindenberg. This so-called "FN method" will be tested during the LAUTLOS Validation Experiment in Sodankylä, Finland early next year.

3.7.2.2 Dr Leiterer informed the ET meeting that the Lindenberg upper-air reference site station is ready to organize a highly sophisticated upper air sensor campaign in March 2006 or March 2007 with the aim of addressing the humidity measuring problems in the atmosphere from the surface to 5 hPa. It is provisionally planned that during this campaign some 60 synchronous/parallel soundings will be launched during the day and night over a 30-day period. The following reference instruments will be used:

- (a) Reference balloon borne systems (lightweight systems, max. 4000 g like FN-sonde, snow-white SRS34, CAO-Flash, NOAA frost-point hygrometer);
- (b) Operational radiosondes from different producers;
- (c) The remote observing systems at Lindenberg reference site, e.g. Microwave-profilers, GPS and optical (sun and star-photometer) water vapour column measuring systems, Lidar, Ceilometer, cloud radar, wind profiler (RASS).

3.7.3 Presentation of the status and needs of GUAN Network

3.7.3.1 The meeting agreed that there is a need for improved coordination with the Climate Community on the requirements for high quality (e.g., research quality) reference radiosondes for improved climate observations for the Global Climate Observing System Upper Air Network

(GUAN) in order to begin addressing deficiencies in upper air observations noted in the 2nd GCOS Adequacy Report.

3.7.3.2 It was recommended that the CIMO ETs on UGRN and ET on Upper-air Systems Intercomparison invite formal participation in the work of the ETs from CCI, the GCOS Atmospheric Observations Panel for Climate (AOPC), the World Climate Research Program, and others (university community) as appropriate. Better information on the use and performance of operational radiosondes needs to be disseminated from the experts in the field to the climate community.

3.7.3.3 The provision of a forum for the exchange of information between the climate community (requirements) and radiosonde community (capabilities) in order to develop a better understanding on the needs for a high quality upper air approach to better measurements of water vapor should be investigated. This should include the provision of the latest test information on the abilities of next generation operational radiosondes so that they can be considered for use in higher quality climate upper air observations.

3.7.4 Presentation of the radiosonde EUMETNET Network

3.7.4.1 Mr Oakley presented information on EUMETNET Observational Programs with a focus on programs related to Radiosonde and WINPROF Projects. ET agreed to maintain links with the EUMETNET programmes to facilitate the exchange of information and collaborate, where necessary, with related issues.

3.7.5 Introduction of new “universal” upper-air systems

3.7.5.1 Dr Bhandari was asked by the ET to present India’s experience with the “universal” upper-air systems. In his view, the lifespan of a typical radiosonde receiver today commonly exceeds 15 years, while the radiosondes designed to be employed with these systems tend to last on much shorter timescales. Incompatibility between these newer sondes and the older receivers can then render the expensive ground equipment obsolete long before its planned replacement date, leading to prohibitive overall increases in the cost of maintaining upper air programs for some users. This premature obsolescence can be avoided by the use of “universal” upper-air systems which are more versatile, open and modular in design. Such “universal” systems can also enable overall savings to be achieved in low budget situations where a particular operator wishes to employ cheaper sondes produced by an alternative supplier. This latter consideration also promotes a more competitive marketplace, ultimately enabling further economies to be achieved by program operators.

3.7.5.2 The ET on UGRN discussed this issue at the meeting, with many experts and manufacturers expressing a range of views. Dr. Bhandari described a three-tier system, in which the sonde-specific component comprised only 10 to 20 percent of the overall cost. He described India’s current “universal” system, for which viable sub-units and software are obtainable from various vendors. Mr. Järvinen, HMEI member, noted that the Vaisala ground equipment is universal in the sense that it can be used with GPS, Loran C or RDF sondes, but cannot accommodate other manufacturers’ sondes. Mr. Parini noted that the InterMet systems were more truly “universal”, with open architecture, tunable receivers (in bandwidth and frequency) and with full capability for processing data from different radiosondes, including their competitors. Dr. Nash, invited expert, noted that these “universal” systems are very difficult and costly to characterize in all possible configurations, so advised caution before implementing the concept.

3.7.5.3 Mr Järvinen explained that cost-effective Vaisala radiosondes do not send the highest quality of meteorological data, but rather signals from which the sounding system processes edited high-quality raw data that is based on the algorithms in the sounding system. The high-quality upper-air messages to GTS and users are thus a combination of the sensor quality in radiosonde and sounding processor performance as a result of design compatibility; neither does it alone. Therefore, Vaisala radiosondes alone are not enough for gaining highest quality of meteorological data. The radiosonde and the sounding system are always designed to match to each other to assure correct observation results.

3.7.5.4 Mr. Järvinen stated that Vaisala has provided "universal" upper-air systems with compatibility to various manufacturers radiosondes in the past, and maintained them with great difficulty, due to the reasons mentioned above. Therefore, well-performing cost-efficient sounding systems need to be an integrated solution. The modern tendency is away from multi-manufacturer systems. Focus should be on both sounding system performance, and cost-efficiency of the life-cycle.

3.7.5.5 Mr. Dockendorff discussed the merit of "universal systems" but noted that it may be difficult to ascertain causes for poor performance and to rectify problems where the radiosonde and ground system suppliers differ. The number of upper air systems presently in use is very small and manufacturers may be reluctant to divulge details of their proprietary software. This may make it difficult to judge the claims of certain manufacturers. It may also result in unnecessary work by a manufacturer just to prove that he is not responsible for identified problems.

3.7.5.6 The ET on UGRN recommends:

- (a) Further discussion of this issue among its members to develop a concept and assess its viability, in order to safeguard the best interests of the meteorological community;
- (b) That GCOS explore the possibility of providing partial funding to assist in development of such a system and for subsequent testing and possible introduction at some of its GUAN stations.
- (c) That these systems not be referred to as "Universal Systems", but "Flexible Systems" to eliminate any misunderstanding as to the capability of the system.

3.7.6 **Report on the outcome of the Workshop to improve the usefulness of operational radiosonde data**

3.7.6.1 The workshop was organized by a combination from the US National Climatic Data Centre and NOAA NESDIS (National Environmental Satellite Data and Information Service). Most of the attendees were users of radiosonde data from both the USA and from a selection of international experts. There were also a limited number of radiosonde experts. Mr Nash, who represented WMO at this meeting, provided a briefing on issues most relevant to the work of the expert team.

3.7.6.2 In the area of specifications for radiosonde accuracy and precision, there was a request to update the CIMO Guide with the aim to possibly customize specifications for different radiosonde applications, such, normal synoptic use, GCOS, satellite collocation (GUAN). In this regard, the UK Met Office volunteered to define those specifications. The workshop put emphasis on improved measurements of relative humidity in the upper troposphere for climate purposes. The uncertainty whether frost-point/ dew-point hygrometers are suitable (and necessary) for large-scale deployment should also be addressed with the assistance from ET on UGRN.

3.7.6.3 In the area of reference operational radiosonde measurements, the workshop suggested that relative humidity measurements be checked by radiometer / GPS water vapour measurements. For the identification of temperature errors three-thermistor radiosonde technique should be used,

rather than “average“ correction algorithms. The assistance is needed from the ET on how much testing is required and whether new radiosonde designs should allow extra sensors to be attached to verify measurement quality periodically, should operational pressure / height measurements be checked. It was also recognized that some tests may be of poor standard and may lead to confusion rather than clarification of system performance. The ET addressed those issues in [Agenda Item 3.1](#).

3.7.6.4 As for the operational procedures the level of preflight checking of radiosondes that is beneficial to in-flight performance should be addressed. More guidance material on this issue is required as well as more instructions on record keeping and data archiving required for radiosonde stations to improve traceability of radiosonde performance and to improve knowledge of local staff about quality issues.

3.7.6.5 In the above regards, the expert team suggested:

- (a) To expand the regional radiosonde workshop training programme as a follow-up of the Botswana Workshop on Upper-air Observations.
- (b) To improve the level of identifying and resolving deficiencies in the global radiosonde network through new Rapporteur on radiosonde compatibility.
- (c) Better co-ordination between radiosonde monitoring centers, and the supply of data to other parties such as the climatological community or the operators/ manufacturers.

3.7.7 Radiosonde compatibility report

3.7.7.1 Mr Oakley presented the latest report of Mr John Elms, the outgoing rapporteur on radiosonde compatibility, containing monitoring results summarized for the succeeding period 1998 to 2001, including some references to statistics in 2002.

3.7.7.2 The ET agreed that the final report from the previous rapporteur (John Elms) should be ready for publication by CIMO by the end of Nov 2003.

3.7.7.3 The ET recommended that:

- (a) The Rapporteur maintains a catalogue of upper-air stations and radiosonde types/systems in use. This catalogue should be updated regularly and made available via the WMO web site. Where possible more detailed metadata should be included with the catalogue (i.e. operating radio frequency, radiation correction)
- (b) The Rapporteur continues to monitor the “long term” performance of radiosonde networks & designs using the ECMWF “OB-FG” Statistics. These statistics to be made available on an annual basis, in tabular format, with a final report being submitted to CIMO at the end of the session.
- (c) The Rapporteur prepares recommendations for the use of the ECMWF statistics to monitor the wind measurement performance of global systems.
- (d) The Rapporteur will act as a liaison between the ET Members, HMEI & WMO Permanent Representatives for the exchange of information (metadata & monitoring statistics) and for informing/resolving system & network issues

4. WORK PLAN

The outcome of the discussion on the above agenda items were recast into a detailed Work Plan that specifies actions and deliverables for all tasks that were put forward to the team by CIMO-XIII and CIMO-MG. The Work Plan is in [ANNEX II](#).

5. ANY OTHER BUSINESS

5.1 Water Vapour Validation Project

5.1.1 More accurate PTU-values, in particular humidity data, mainly in the 30 to 5 hPa (relevant to GUAN network) are needed. Precise humidity measurements are closely connected with good temperature data (better than + 0.1 °K). For this reason a radiation correction has to be applied.

5.1.2 Dr Leiterer informed the meeting that the above-mentioned problems will be addressed by the LAUTLOS Validation Experiment is planned in February 2004 in Sodankylä, Finland. A new reference humidity measuring method "FN Method" will be introduced in this during this campaign. Comparison with different radiosondes/hygrometers are planned, namely: NOAA Frost-point Hygrometer, Russian Central Aerological Observatory's Flash Hygrometer, Snow-white CR34 System, RS92(GPS), RS80 A Humicap and FN sondes (modified RS90).

5.1.3 It is expected that for the LAUTLOS data evaluation an official updated version of the RSKOMP software would be used. In this regard, the ET recommended that CIMO makes available RSKOMP software for official use for the next WMO upper-air systems intercomparisons and tests.

5.1.4 Mr Leiterer will provide a final report to ET members.

5.2 Radiosonde frequency issues

5.2.1 Radiosonde frequency issues were presented by David Franc and discussed by the by the ET. The International Telecommunications Union (ITU) is the international agency responsible for international regulation of radio spectrum use. The ITU maintains the International Radio Regulations that prescribe how radio system operators can use the radio spectrum. The frequency bands used for radiosonde operations have been considered for use by other radio services since 1992 and proposals have been made to change the International Radio Regulations to remove spectrum from radiosonde use. The radiosonde bands are used consistently worldwide and are below 3 GHz, which makes them prime bands for use by other radio systems, in particular where worldwide access to spectrum is required by the radio service. Another factor that has put access to the current radiosonde spectrum at risk are the poor RF characteristics of current radiosonde systems. There are a number of tasks that the ET can undertake that will assist members and the WMO in defending the frequency allocations in the proceedings of the ITU in the future. Proposed activities of the ET are:

- (a) Develop, in consultation with the CBS Steering Group on Radio Frequency Coordination (SG-RFC) and HMEI, objectives for spectrally efficient radiosonde transmitters and receivers. The objectives should balance the need to improve spectrum efficiency with the need for an economically viable radiosonde, and should take into account existing systems and the needs of all countries. Failure to improve radiosonde spectrum efficiency could lead to forced reduction of spectrum by the ITU, with a magnitude and a schedule that would not allow continued operation of the global radiosonde network.
- (b) Contribute to the work of the CBS SG-RFC by providing information on radiosonde system radio frequency characteristics, operational practices, future equipment trends and future spectrum requirements. This information will be forwarded by the SG-RFC to the ITU in the form of information documents and revisions to existing ITU Recommendations on radiosonde systems and operations. The current ITU documentation has detailed information, though dated, on systems and operations in North America and Europe. Information on system characteristics and operational practices is missing for the balance of the world. Several options exist for collecting this information, which include inputs from other ET members, requested input from WMO Member upper air contacts, and input from HMEI. The introduction of new radiosonde systems may also create the need for

additional testing which could be accomplished through the activities of the ET on Radiosonde Intercomparison.

- (c) Provide guidance to Members on spectrum regulatory activities that may impact upper air measurements and encourage Members to develop a working relationship with their national spectrum regulatory agencies. This will allow members to communicate their spectrum and operational requirements to their radio spectrum regulators that participate in the meetings of the ITU. A working relationship between Members and spectrum regulatory agencies will also provide mechanism where the spectrum regulatory agencies can coordinate proposals that may potentially impact national or global meteorological operations. Guidance on improving radiosonde characteristics and spectrum issues can also be provided to Members through the radiosonde training workshops. Region specific material can be developed and presented by a workshop instructor.
- (d) Develop, in cooperation with the SG-RFC, an approved mechanism that improves the coordination of frequency use between radiosonde and meteorological satellite operators. This mechanism will help eliminate some of the problems experienced in the past where radiosonde operators are unaware of expanded meteorological satellite spectrum use into parts of frequency bands used for radiosonde operations. The expansions have resulted in incompatibility between the two systems.
- (e) If there will be further digital transmitter standards for radiosonde application, they should follow the guidelines of first transmitter standard EN302054, in order to avoid diversification of digital transmitters.
- (f) Analog transmitter standard would implicate to the usability of the cost efficient Loran-C versions of radiosondes.

6. DRAFT REPORT OF THE SESSION

The members of expert team prepared their inputs for the Final Report, a draft of which was subsequently prepared by the Secretariat. The meeting requested Secretariat to send the draft to participants for further evaluation and comments.

7. CLOSURE OF SESSION

The ET meeting was closed at 15:00 on November 7, 2003.

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ANNEX II

WORK PLAN
Expert Team on Upgrading the Global Radiosonde Network
(2003-2006)

No.	Task description	Person responsible	Action	Deadline	Deliverables	Deadline
1	Improve the global radiosonde network					
1 a)	Develop techniques and report annually on the performance of radiosonde types in the GOS	T. OAKLEY	1. Continue to monitor & develop the technique as required, the performance of the radiosonde Geopotential height measurements.	Ongoing	<ul style="list-style-type: none"> • Produce monitoring statistics on a quarterly basis. Liaise with members, HMEI & Permanent Representatives on performance issues. • Produce annual summary tables & catalogue revisions for CIMO web site. • Report to CBS ET • Report to CIMO OPAG • Produce plan for implementation of new monitoring techniques. 	Ongoing
		T. OAKLEY	2. Provide a summary report of the monitoring results in conjunction with the revision of the upper-air catalogue.	Ongoing		Yearly
		T. OAKLEY	3. Review the status of the sonde-type table used in the TEMP code.	Dec.03		Dec.03
		D. DOCKENDORFF	4. Survey members on the current techniques used to monitor the performance of upper-air wind & humidity measurements.	Nov 04		Dec.04
		R. ATKINSON	5. Investigate the possible techniques to monitor the performance of radiosonde wind and humidity measurements.	Nov 05		Dec.05

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1 b)	In coordination with HMEI solicit agreement on BUFR code table and descriptors for international use	A. KATS F. BRANSKI T. OAKLEY	1. Recommend the code table and descriptors for international use	Feb.04	• Report on agreement achieved on BUFR code table and descriptors	Apr.04
		A. KATS F. BRANSKI	2. Solicit agreement on recommended code table and descriptors	Mar.04	• Report to CBS ET/DRC for approval by CBS	Apr.04
		A. KATS F. BRANSKI	3. Identify additional data encoding requirements	Mar.04	• Report to CBS ET/DRC for approval by CBS	Apr.04
1 c)	Migration strategy towards the binary codes	A. KATS S. EI-FOULY S. BHANDARI F. BRANSKI	1. Identify and coordinate code migration issues with CBS ET on MTDCF	Mar.04	• Report to CBS ET	Apr.04
1 d)	Investigate measures for reducing the cost of upper-air operation cost	S. EI-FOULY S. BHANDARI	1. Prepare a report on progress on measures for reducing the upper-air operation cost	May.04	• Final report	Jun.04
2	Coordination between CIMO and AMDAR Panel					
1 a)	Coordinate between CIMO and AMDAR Panel on technical issues	J. STICKLAND R. ATKINSON	1. Collaborate on introduction of AMDAR measurements into upper-air database	Dec.05	• Implementation plan • Final report • Annual progress reports on AMDAR	Dec.04 Jan.06 Yearly
2 b)	Monitor and assist in the introduction of humidity measurements in AMDAR Systems	J. STICKLAND R. ATKINSON	1. Review the status of humidity measurements in AMDAR systems	Mar.04	• IOM Report on the Status of humidity measurements in AMDAR systems	Sep.04
		J. STICKLAND R. ATKINSON U. LEITERER	2. Assist in evaluation of AMDAR humidity measurements	Jun.04	• IOM Report on evaluation of AMDAR humidity measurements	Dec.04
		J. STICKLAND R. ATKINSON U. LEITERER	3. Prepare a summary of all national water vapour sensor evaluations	May.06	• IOM Report on water vapour assessment	May.06

3 Standardize data processing radiosonde algorithms						
3 a)	In coordination with HMEI investigate the consistency of Radiosonde algorithms for coding TEMP messages	A. KATS S. BHANDARI	1. Encourage NMSs and manufactures to provide description and details of algorithms for significant level selection	Feb.04	• IOM Report on survey of radiosonde algorithms for TEMP messages coding	Dec.04
		A. KATS S. BHANDARI	2. Study the consistency of automatically coded TEMP messages and make the review on compatibility of radiosonde algorithms	Aug.04	• IOM Report on Compatibility of radiosonde algorithms	Dec.04
4 Development of technical information for support of radio frequency sharing policy for WRC						
4 a)	Improve coordination of radiosonde frequency use with other users of meteorological spectrum	D. FRANC R. ATKINSON	1. Suggest mechanisms for better coordination of radiosonde frequency use with meteorological satellite operators	Mar.04	• Approved mechanisms for coordination of radiosonde frequency use with meteorological satellite operators	Sep.04
		D. FRANC R. ATKINSON	2. Review in cooperation with the HMEI the current and new ground based systems and their frequencies used	Nov.04	• IOM Report on the Current and new systems and their frequencies used	Mar.05
4 b)	In coordination with HMEI, assist the SG-RFC in coordination and protection of radio frequencies for ground-based observing systems	D. FRANC R. ATKINSON	1. Develop proposals for coordination and protection of radio frequencies for ground-based observing systems	May.04	• Recommendations to ITU	Sep.04
		D. FRANC R. ATKINSON	2. Provide input to the SG-RFC on system characteristics, operational practices, future trends and spectrum requirements	Ongoing	• IOM report on coordination and protection of radio frequencies for ground-based observing systems • Information documents submitted to the SG-RFC Meetings	Dec.04 Yearly
4c)	Develop, in consultation with the SG_RFC and HMEI, objectives for spectrally efficient radiosondes	D. FRANC R. ATKINSON	1. Develop radiosonde transmitter and receiver standards to be used as system design objectives by Members and manufacturers	Mar.05	• Document of recommended radiosonde transmitter and receiver RF characteristics	Dec.05

4d)	Provide guidance to Members on spectrum regulatory activities and encourage cooperation with national spectrum regulatory agencies	D. FRANC R. ATKINSON D. FRANC R. ATKINSON	1. Develop guidance document for Members 2. Provide training information for Radiosonde Training Workshops	Jul 04 Ongoing	<ul style="list-style-type: none"> Guidance document to Members Training materials for Radiosonde Training Workshops 	Dec 04 Ongoing
5	Provide advice on Quality Management Systems procedures for instruments and methods of observation					
5 a)	Develop performance measures to demonstrate continuous improvement in the quality of upper-air observations	D. DOCKENDORFF	1. Identify best practices used in quality management of upper-air networks 2. Develop guidelines for documenting quality management procedures of upper-air observations, instrument maintenance, calibration and operational practices 3. Suggest methodology to demonstrate the effectiveness of such procedures	Dec.04 Dec.04 Dec.04	<ul style="list-style-type: none"> IOM Report on Procedures for quality management of upper-air observations, instrument maintenance, calibration and operational practices Report on Methodology to demonstrate the effectiveness of such procedures 	Feb.05 Feb.05
5 b)	Contribute to the review and update of WMO Technical Regulations, Guides and other material related to Quality Management and standardization of upper-air observations	D. DOCKENDORFF	1. Make proposals for update of the relevant part of the CIMO Guide	Dec.04	<ul style="list-style-type: none"> Draft update of the CIMO Guide 	Mar.05

6.	Coordination between CIMO and climate community					
6 a)	Improve coordination with the Climate Community on the requirements for high quality radiosondes.	R. THIGPEN R. DOMBROWSKY	1. Invite formal participation in the CIMO ETs on UGRN and U/A Systems Intercomparison by CCL, GCOS AOPC, WCRP, and others as appropriate.	Jan. 04	<ul style="list-style-type: none"> • Exchange of Letters; designation of representation. 	Mar. 04
		R. THIGPEN R. DOMBROWSKY	2. Provide forum for exchange of information between climate community and CIMO.	Mar. 04	<ul style="list-style-type: none"> • Establishment of a web site to provide a forum for the exchange of information from both communities 	Jan. 05