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| **World Meteorological Organization**  **Commission for Instruments and Methods of Observation**  **CIMO Management Group**  **Fifteenth Session** Geneva, Switzerland, 26 – 29 March 2018 | **CIMO/MG-15/Doc. 3.2** |
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**CIMO ACTIVITIES in the evolving context of wmo, and collaboration with international organizations**

**Review of the Vision for the future of environmental measurements,**

**the current status of the WIGOS vision,**

**and of relevant decisions of the WMO Executive Council**

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| **Summary and purpose of document**  This document provides the “Mission, vision, outcomes and strategies for the future of environmental measurements within WIGOS” as finalized by CIMO Strategic Management meeting in 2017. It also provides information on the draft “Vision for WIGOS in 2040” and summarizes some IMOP- and WIGOS- related decisions and resolutions of the WMO Executive Council 68th and 69th sessions. |

**Action proposed**

The Meeting is invited:

1. to review the document “Mission, vision, outcomes and strategies for the future of environmental measurements within WIGOS”, available in the Appendix.
2. to ensure this document is complementary to the Vision for WIGOS in 2040, and also ensuring that both visions are not conveying any contradictory messages.
3. to decide on further actions towards approval of the “Mission, vision, outcomes and strategies for the future of environmental measurements within WIGOS” at the CIMO-17 session.
4. to note the Executive Council decisions and resolutions listed in the document and decide on any action that is needed to support them.

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**Appendix:** [Vision for the future of environmental measurements](#Appendix1)

**References:** [Link to the CBS TECO 2018 Doc.6(2) on Vision for WIGOS in 2040 (Draft 1.3, February 14, 2018).](http://meetings.wmo.int/cbs-teco-2018/English/CBS-TECO-2018-Doc-6(2)-WIGOS-Vision-2040-Draft1.docx?Web=1)

[68th session of the WMO Executive Council – Abridged final report with resolutions and decisions](https://library.wmo.int/opac/doc_num.php?explnum_id=3166).

[69th session of the WMO Executive Council – Abridged final report with resolutions and decisions](https://library.wmo.int/opac/doc_num.php?explnum_id=3645).

**EXECUTIVE SUMMARY**

***Mission, vision, outcomes and strategies for the future of environmental measurements within WIGOS***

1. The document “Mission, vision, outcomes and strategies for the future of environmental measurements within WIGOS” was drafted by the CIMO Management Group, at its fourteenth session (Offenbach, Germany, 4-8 April 2016), implementing an agnostic approach to how the vision could be implemented structurally, and aiming at overall enhancement of collaboration and cooperation in promoting the role of measurements.
2. The vision was presented to CIMO TECO-2016 (Madrid, Spain) and also shared with the presidents of other WMO Technical Commissions, Regional Associations and with the participants of the [Workshop on the Vision for WIGOS in 2040](http://www.wmo.int/pages/prog/www/WIGOS-WIS/meetings/WIGOS-VisionSurface-2040/WIGOS-Vision-Surface-2040.html) (18-20 October 2016, Geneva). Lately, the vision was thoroughly revised and updated at the CIMO Strategic Management meeting in Geneva in June 2017, taking into account comments received from the presidents of technical commissions, the WIGOS vision document and the context of the WMO constituent body reform. The most recent version of the vision, as agreed at the CIMO Strategic Management meeting, is available in [Appendix](#Appendix1).
3. The meeting is invited to review the vision in a way that it is complementary to the WIGOS vision, and that both visions are not conveying any contradictory messages, and adequately support the WMO strategic planning. The meeting is further invited to decide on actions needed towards approval of the “Mission, vision, outcomes and strategies for the future of environmental measurements within WIGOS” at the CIMO-17 session.

***Vision for WIGOS in 2040***

1. The “Vision for the Global Observing System in 2025” was adopted at 61st session of the WMO Executive Council in 2009. A need for updating this document initiated in 2015 the development of vision for satellite component and, one year later, a vision for the surface-based component of WIGOS. A drafting group led by the ICG-WIGOS Co-Chairs and supported by the lead authors of the surface- and space-based contributions, integrated both visions into an overall draft “Vision for WIGOS in 2040”. The draft document of the WIGOS vision has been constantly improved, aiming at is final approval by the 18th World Meteorological Congress in 2019.
2. The current version of [Vision for WIGOS in 2040 (Draft 1.3, February 14, 2018)](http://meetings.wmo.int/cbs-teco-2018/English/CBS-TECO-2018-Doc-6(2)-WIGOS-Vision-2040-Draft1.docx?Web=1) consists of three chapters:
3. Introduction, purpose and scope;
4. The space-based observing system components of WIGOS in 2040;
5. The surface-based observing system components of WIGOS in 2040.
6. The meeting is invited to take into consideration the WIGOS Vision while reviewing the “Mission, vision, outcomes and strategies for the future of environmental measurements within WIGOS” and indicate if any parts of WIGOS Vision are contradictory or convey any message that might be inappropriate to CIMO.

***The WMO Executive Council decisions and resolutions***

1. The paragraphs below summarize decisions and resolutions of the 68th and 69th session of the WMO Executive Council that are relevant to CIMO. The meeting is invited to note them and decide on any actions that might be needed to support their implementation.

***The WMO Executive Council – 68th session***

1. The sixty-eighth session of the WMO Executive Council (EC-68) was held from 15 to 24 June 2016, in Geneva, Switzerland. A short summary of the adopted decisions relevant to the Instruments and Methods of Observation Programme is provided below:
2. Decision 34 (EC-68) – Approval of the new edition of the International Cloud Atlas (WMO-No. 407)

EC authorizes the President of WMO to approve the draft text of the revised Atlas on behalf of the Council, subject to no objections to the draft text being expressed by Members by the time of expiry of the review period.

1. Decision 35 (EC-68) – Inter-programme Expert Team on Operational Weather Radars

EC authorizes the president of CIMO to establish, in consultation with the president of CBS, an Inter-Programme Expert Team on Operational Weather Radars.

EC requests CIMO to collaborate with CBS in the selection of the chairperson and members of the Inter-Programme Expert Team and in the establishment of its workplan. EC calls on all technical commissions to ensure that the Inter-Programme Expert Team is aware of their priorities concerning weather radar standardization requirements, as appropriate.

Terms of Reference of the WMO Inter-programme Expert Team on Operational Weather Radars are presented in the Annex to Decision 35 (EC-68).

***The WMO Executive Council – 69th session***

1. The sixty-ninth session of the WMO Executive Council (EC-69) was held from 10 to 17 May 2017, in Geneva, Switzerland. A short summary of the adopted decisions and resolutions, relevant to the Instruments and Methods of Observation Programme and to the WMO Integrated Global Observing System, is provided in the following text.

***IMOP –related decisions:***

1. Decision 5.1(3)/1 – Translation of the International Cloud Atlas

The new edition of the *International Cloud Atlas – Manual on the observation of clouds and other meteors* (WMO-No-407) was released in the form of a website ([www.wmocloudatlas.org](http://www.wmocloudatlas.org)) on the occasion of the World Meteorological Day 2017. The Secretary-General is requested to arrange for translation of the Atlas into official WMO languages.

1. Decision 5.1(3)/2 – Update of the Guide to Meteorological Instruments and Methods of Observation

WMO and ISO have developed second common WMO/ISO standard: Ground-based remote sensing of wind by heterodyne pulsed Doppler lidar. The Secretary-General is requested to publish the CIMO Guide, updated with this standard, in all official WMO languages.

1. Decision 5.1(3)/3 – Discontinuation of the concept of Regional Standard Barometer Cloud Atlas

The traceability of atmospheric pressure measurements to the International System of Units (SI) should be ensured through accredited RICs, or other laboratories that are either accredited or designated by National Metrology Institutes. WMO Members hosting Regional Standard Barometers supported the above-mentioned concept of traceability assurance and agreed that maintaining the RSB concept, in addition to the RIC concept, creates a duplication of work and is uneconomical and inappropriate. They also supported the discontinuation of the RSB concept. EC-69 agreed to discontinue the concept of Regional Standard Barometer and requested CIMO to update the CIMO Guide and other relevant WMO guidance and regulatory documents, ensuring their consistency.

***WIGOS–related decisions:***

1. Decision 5.1(1)/1 (EC-69) — *Regional Basic Observing Network;*

The Regional Basic Observing Network (RBON) concept was endorsed by EC-69 and Members are requested to actively participate in the further development of this concept. Members are invited to propose inclusion of additional surface-based observing stations, such as weather radars, wind profiler systems, lightning detection systems, data buoys, voluntary observing ships and aircraft, in the Pilot RBON established by the regional association.

1. Decision 5.1(1)/2 (EC-69) — *Vision for the WMO Integrated Global Observing System in 2040;*

A draft Vision for WIGOS in 2040 was presented to EC-69. EC-69 provided guidance towards its finalization and decided that ICG-WIGOS takes ownership of the further development of the Vision, with a view to have it approved by the Eighteenth World Meteorological Congress in 2019.

(c) Decision 5.1(1)/3 (EC-69) — *Standardization of observing systems installed on ships;*

Members are invited to collaborate in the European and others efforts, to facilitate standardization of AWS systems and their observations installed on ships as well as the maintenance of such systems by port meteorological officers (PMOs).

(d) Decision 5.1(1)/7 (EC-69) — *Developing the WIGOS “Standardization of Observations” Reference Tool (SORT);*

Standardization of Observations Reference Tool (SORT) is being a tool to electronically navigate complex regulatory and guidance material with multiple cross references. As it would address an overall need for the Organization, the Secretary-General is requested to make the development of SORT an Organization-wide activity rather than something unique to WIGOS;

(e) Decision 5.1(1)/10 (EC-69) — *Guidance on establishing Regional WIGOS Centres (RWCs) in Pilot Phase;*

EC-69endorsed the Guidance on establishing a WMO Regional WIGOS Centre (RWC) in a pilot phase (RWC guidance) as technical guidance to regional associations for establishing a RWC and its implementation arrangements. Regional associationsare requestedto support the establishment of RWC(s) in their Region, while the presidents of regional associations are authorized to approve the pilot RWC(s). EC-69 urged Members to familiarize themselves with the RWC guidance and to actively participate, together with regional partner organizations, in the implementation of RWC. The Secretary-General is requested to provide the necessary assistance and Secretariat support for the establishment of RWCs in the WMO Regions.

(f) Decision 5.1(1)/11 (EC-69) — *Indicators for monitoring the progress in the WIGOS national implementation;*

Addressing the need for a regular assessment of the progress achieved in the national implementation of the WIGOS by Members, ICG-WIGOS has developed: Guidance on the National WIGOS Implementation and Guidance on WIGOS Data Partnerships. The material should assist Members with the implementation of the WIGOS technical regulations. EC-69 endorsed the indicators of monitoring the progress of the WIGOS national implementation as an initial version of the Key Readiness Indicators to assist Members with a regular assessment of the progress achieved in the national WIGOS implementation. ICG-WIGOS is requested to further develop this monitoring tool to be used by Members. The Secretary-General is requested to assist Members with a regular assessment of the progress achieved in the national implementation of the WIGOS, while Members are urged to collaborate with the Secretary-General in this assessment.

(g) Decision 5.1(1)/12 (EC-69) — *Way forward for transitioning WIGOS from the current project structure into the WMO programmatic structure;*

WIGOS, as an operational system which supports all WMO Programmes and activities, will assist in improving the integrated operations of Members and in building productive partnerships to sustain and improve their ability to provide weather, climate, water and other relevant environmental services. The unique nature of WIGOS as a cross-cutting infrastructure will require well-developed collaboration and coordination mechanism between regional and technical working structures. EC-69 recognized the need to start planning for the future of WIGOS after the current project phase, which is scheduled to end in 2019, and requested ICG-WIGOS to develop a proposal for WIGOS in the WMO programmatic structure. The Secretary-General is requested to coordinate collaboration with partners responsible for co-sponsored and non-WMO observing systems in the development of the proposal, in order to address their requirements.

(h) Decision 68 (EC-69) — *WMO Constituent Body Reform*

EC-69 decided to proceed with the development of separate recommendations, for consideration of EC-70 and ultimately the Congress, for restructuring of the Executive Council, the technical commissions and the regional associations with associated terms of references, implementation schedules and other relevant details;

EC Working Group on Strategic and Operational Planning with support from the Secretariat was requested to develop, for consideration by EC-70, a set of recommendations for Cg-18, which address the key issues identified in the current proposal for WMO constituent body reform, including:

* + Prepare separate recommendations pertaining to each of the structures: the Executive Council, the technical commissions and the regional associations, including terms of reference of proposed bodies, step-by-step transition schedules and other relevant details explaining in particular inter-relations between various bodies in a holistic manner;
  + Draft amendments to General Regulations supporting structural changes and updating processes and functionalities to bring them in line with the current realities;
  + Clearly articulate on how the proposed structures would realize opportunities and bring benefits to WMO, the key risks, which could be introduced both during and after the transition period, and issues which will not be resolved by the proposals;
  + Prepare a communication strategy, including consultations with Members and relevant external constituencies, such as IOC/UNESCO, FAO, ICAO;
  + Review the WMO Programmes with the aim of streamlining and better alignment with the key foundational elements of WMO; and
  + Elaborate the transition and change management processes.

***WIGOS-related resolutions:***

1. Resolution 5.1(2)/1 (EC-69) *—* *Manual on the WMO Integrated Global Observing System (WMO-No. 1160), Section 2 and Section 8;*

EC-69 adopted the updated Appendix 2.4 (The WIGOS Metadata Standard) and its attachment, and the updated Section 8 (Attributes specific to the observing component of the Global Cryosphere Watch) of the [*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)](http://library.wmo.int/pmb_ged/wmo_1160_en.pdf) with effect from 1 January 2018. Furthermore, it was decided that the attachment to Appendix 2.4 will be extracted from the Manual and be processed separately as a stand-alone attachment in order to facilitate frequent updating of its technical content. The code tables from the current annex to the attachment to Appendix 2.4 will be removed and included in the [*Manual on Codes* (WMO-No. 306);](https://library.wmo.int/opac/doc_num.php?explnum_id=3361)

1. Resolution 5.1(2)/2 (EC-69) *— Initial Version of the Guide to the WMO Integrated Global Observing System;*

EC-69 adopted the initial version of the [*Guide to the WMO Integrated Global Observing System*](http://www.wmo.int/pages/prog/www/wigos/WGM.html) with effect from 1 July 2018. ICG-WIGOS is requested to finalize the initial version of the Guide with additional guidance material. The Secretary-General is requested: to publish the Guide in all WMO official languages, to ensure the editorial consistency of the relevant documents, to publish the specification of the Binary Universal Form for the Representation (BUFR) of meteorological data code table entries that support WIGOS station identifiers on the WMO website in advance of their formal approval through the fast track procedure, to maintain *Weather Reporting* (WMO-No. 9) and the associated 5-digit WMO station identifiers until the Eighteenth World Meteorological Congress, when Members receive training and have sufficient time to transition to the WIGOS station identifiers.

Members are requested to inform the Secretary-General of the intended date to transition to the WIGOS identifiers with sufficient lead time to enable operational changes by other Members to manage the impact of the change to identifier.

1. Resolution 5.1(2)/3 (EC-69) *— Revised Manual on the Global Observing System (WMO-No. 544) and Guide to the Global Observing System (WMO-No. 488);*

EC-69 decided to amend *Manual on the Global Observing System (WMO-No. 544) and Guide to the Global Observing System (WMO-No. 488)* as proposed by CBS-16.

1. Resolution 5.1(2)/5 (EC-69) *— Guide to Aircraft-Based Observations;*

EC-69 adopted the *Guide to Aircraft-Based Observations* as formal guidance on regulations for Members in replacement of the AMDAR Reference Manual: Aircraft Meteorological Data Relay (WMO-No. 958).

(e) Resolution 5.1(2)/6 (EC-69) *— Establishment and Designation of the WMO Global Data Centre for Aircraft-Based Observations.*

EC-69 decided to designate the Meteorological Assimilation Data Ingest System (MADIS) of the National Centers for Environmental Protection (NCEP) of the National Oceanic and Atmospheric Administration (NOAA) (the United States of America) as the WMO Aircraft-Based Observations Global Data Centre.

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**Mission, Vision, Outcomes and Strategies**

**Future of environmental measurements WITHIN WIGOS**

(a proposal from the CIMO MG to WIGOS)

Under the vision for the WIGOS community and the environmental measurements it seeks to achieve:

**Mission:**

Fit-for-purpose environmental measurements through leadership, standards and guidance.

**Vision:**

The WIGOS measurement community is the recognized source of information and guidance on performing measurements for environmental intelligence.

**Desired Outcomes:**

1. The WIGOS measurement community are esteemed experts that gather and disseminate knowledge on measurements.
2. Users and providers understand measurement quality and how fit-for-purpose measurements are achieved.
3. Users and providers understand the importance of the measurement process in developing environmental intelligence.
4. Users and providers of Essential Climate Variables are committed to measurement traceability.
5. The potential, quality and performance characteristics of emerging measurement technologies and their products are documented in guidance material.

**Strategies to achieve the Mission and Vision:**

1. Collaborate effectively with users and providers of measurements;
2. Develop and promote the implementation of recognized measurement practices;
3. Develop and provide effective standards and guidance material;
4. Provide guidance for the implementation of new measurement technology; and
5. Identify and characterize the potential of emerging measurements.

**Shaping the Vision and Mission**

Several new drivers are impacting on WMO and particularly WIGOS, including the opportunity and challenges of Big Data and its myriad of sources, the Minamata Convention, new generation satellites, and the pressing need to be more agile, innovative and informative. The CIMO MG meeting at Offenbach, in April 2016, provided an opportunity to discuss and then formulate the draft of a long term vision and mission of the measurement components of WIGOS. A concise vision, mission, desired outcomes and principle strategies on a page was the result.

At that CIMO MG meeting it was decided to take an agnostic approach to how the mission could be implemented structurally, but whatever structure came to pass it must enhance collaboration and cooperation and promote the role of measurements as an output.

At CIMO TECO 2016 in Madrid in September 2016, with wide representation from a number of other Commissions and Programmes, there was also an opportunity to have a two hour open forum to discuss the vision and mission on a page. There was a general consensus from those present that it had the right form but that it needed some expansion on the drivers and activities that should be pursued to achieve the desired outcomes.

At the CIMO Strategic Planning Meeting in Geneva in June 2017, the draft vision and mission “Future of environmental measurements within WIGOS” was thoroughly revised and updated, taking into account comments received from the presidents of technical commissions, the WIGOS vision document and the current context of the WMO constituent body reform.

**Form of the Vision and Mission**

This vision and mission is for nearly 25 years (2040) hence is necessarily limited in detail on planning, tactics, goals and concrete data forms, but does focus on ensuring the key elements of achieving fit-for-purpose measurements as a foundation element of environmental intelligence regardless of what the future brings. The concise language was designed to be relatively easy to use as a litmus test for any future work for those developing, enhancing and encouraging measurement practises in support of environmental intelligence.

The foundation of any organization with the aim to be an effective high-quality environmental information service is access to a community of esteemed experts with a fundamental understanding of the science and application of the processes of measurement and its ultimate output: fit-for-purpose data. In the current organizational context of WMO and its priority WIGOS, CIMO is but one of the current Commissions and Programmes involved in developing processes of measurement for the environmental monitoring elements. So under the framework of WIGOS where does the user go for information to find out if a data stream is fit for their purpose? This vision, mission and strategy is not focused on the future of CIMO and is agnostic to there being a CIMO in the future. Rather it is a vision and mission for a strong, vital, agile and integrated cadre, the WIGOS measurement community, to further the aims of, and be the source of information on all WIGOS measurement data streams.

Hence the vision, mission and strategies stated at the start of this document cannot be just for the existing CIMO community, but should be for the WIGOS measurement community made up of all the relevant current Commissions and partner programmes (GAW, GCW, WCRP, WHYCOS, etc.). **Overarching new and existing drivers**

Change of focus: Methods to Outputs

The time when a meteorological measurement[[1]](#footnote-1) is primarily a measurement through observation by a human observer is now consigned to history. As has the time when one meteorological datum can be a representative of a quantity with assumed characteristics of assumed quality. Instead, the majority of the measurements used for environmental intelligence are automated, from numerous sources made up of multiple component and processes, and a diverse range of measurement methods and technologies. Furthermore, it is now understood by many that meta data associated with a datum is critical to the understanding of the information.

Most importantly there is now a rapid acceleration and divergence in the measurement technologies (instrumentation, data dissemination and amalgamation to provide other measurements, etc.) that explicitly requires all involved in the data and information value chain to re-evaluate the methods of standardization from a measurement being represented by instrumentation (e.g. satellite, AWS, radar, ceilometer) to the quantity as an output (e.g. vertical temperature, vertical wind, temperature and humidity, rainfall, cloud base or aerosol profile).

Quality and fit-for-purpose

The assignment of the quality of a measurement has always been dependent on being fit for a user’s requirements. In the past the focus on making all measurements fit for climate analysis has dominated the measurement regime. That is no longer the case with tiering of networks (e.g. climate, weather, aviation), 3rd party data availability, and crowd sourcing. As the methods and sources of the same measurement, for example, ‘temperature’, become more heterogeneous there is a temptation to use an instrumental method (if known) to estimate the quality through assumptions, rather than finding a quantitative measure based on the facts of the process of measurements. One solution to replacing belief with knowledge for some quantities is traceability[[2]](#footnote-2) where there is a framework of physics and chemistry metrology. However, some existing measurements and new measurements being integrated into the WIGOS framework either require a significant amount of work to achieve traceability (e.g. satellite radiances), or have yet to consider traceability (e.g. 3rd party data), or where traceability is impracticable (e.g. crowd sourcing, camera imagery). A potential substitute where traceability is not feasible, is a combination of meta data and ancillary co-located reference measurements that can be used without human interpretation. As a result, to serve the user community, a clear and readily visible source material must be available to provide assurance for the user that the datum or data series they use is fit-for-purpose and will indeed serve their needs.

Big Data - opportunities and issues

The meteorological community has been at the forefront in contributing to ‘Big Data’ initially through its rapid take up of space and surface-based remote sensing, and now is actively pursuing 3rd party data sources and crowd sourcing. The volumes are increasing exponentially and have a velocity (speed and direction) unheard of in the past, ultimately providing opportunities for greater insight into the nature of environmental phenomena in increasingly small scales in space and time. However, the down sides are inconsistency in the information content, and particularly how they impact the data quality on information extraction. Perhaps, the most significant issue for the environmental measurement community is to use belief and assumptions rather than understanding and knowledge, largely because the data are loosely related to meta data that provides only a partial description of the measurand, leading to an increase in false conclusions. A mitigation of the risk in some cases can be provided by making sure all the requirements for traceability accompany what was in the past a single datum (e.g. a relative humidity value in a SYNOP message). However, in doing so would in turn expand the volume of data for the most basic of quantities by a factor of three as traceability mandates including uncertainty and degrees of freedom.

The language and integration

Given the focus on integration in WIGOS, does the distribution of activities on measurement standardization and guidance through a number of Commissions and associated agencies make sense for the future? While the CIMO Guide provides a focal point on measurement characteristics and methods, the large number of Commissions tends to lead to well-intentioned duplication and may not be efficiently using the available expertize. Furthermore, linkages between Commissions may not be as effective for communicating user requirements, as each Commission has developed its own vocabulary on processes for measurement. Integration in WIGOS cannot succeed unless all the relevant communities use the same vocabulary with the same semantic intent, and can communicate effectively with the innovators, industry and users. It is of little value, if Commissions’ processes of measurement are translated by the CIMO Editorial Board into the international recognized standard vocabulary that remains outside the comprehension of the source community (e.g. is it accuracy or uncertainty?). Hence in continuing the implementation of WIGOS there is considerable work to do in standardization of the language of measurement.

**Strategic elements**

The key strategic elements to achieve the Mission and Vision are elaborated in the following paragraphs taking as examples CIMO activities.

1. **Collaborate effectively with users and providers of measurements**

The current method of providing focal points for communication and collaboration between the Commissions and Programmes will continue.

The value of TECO and METEOREX/MetExpo in providing a venue to initiate, promote and disseminate methods of measurement has been demonstrated on a number of occasions and must be continued, as well as the partnership with HMEI.

The value in the collaboration with BIPM and associated NMIs has been proven in the last four years and demonstrated at CIMO TECO 2016, and hence the strengthening of the collaboration must be pursued.

The past ECV focus of the CIMO Guide must be re-examined and other user requirements incorporated that enable a user to determine what type of measurement processes are required to achieve a fit-for-purpose result; for example, incorporating aviation requirements and also applications that will achieve fit-for-purpose results from 3rd party and crowd sourced data. These activities would be included in a significant revision of the Annex 1.E in the CIMO Guide, Part I, Chapter 1.

While there is now a significant volume of the CIMO Guide on space-based (satellite) measurements there have been limited advances in integrating satellite and surface-based data to produce new measurements. In particular the bi-directional utility of downward and upward looking microwave radiometers needs to be investigated as there have been significant advances in surface-based microwave technology.

1. **Develop and promote the implementation of recognized** **measurement practices**

The continuation of intercomparisons is essential to address world-wide operational traceability, like the regular 5-yearly IPCs, and to improve knowledge of the components of uncertainty in the process of measurement (e.g. SPICE, screen, ceilometer and radiosonde intercomparisons). Also essential for the sustainment of quality management are the interlaboratory comparisons and training courses for continuing to develop an understanding of the fundamental aspects of good metrology and measurement practise, and they are essential in developing a common vocabulary across measurement disciplines. Promotion of these essential activities needs to be communicated to the highest levels within Member organizations.

Regardless of whether the existing technical commission structures remain or not it is essential that the principles and practices of standardization are promoted by effective liaison, and where required co-development of standards with partner global agencies (ISO, BIPM).

The most recent CIMO TECOs have shown their value in both promoting good measurement practices and introducing new methods for active discussion and dissemination within the measurement community. There is extra benefit from a CIMO TECO when there is participation from other measurement communities (e.g. surface meteorology, air chemistry, marine, hydrology and space weather) as new technologies, both instrumental and algorithmic, become visible, and interaction can be direct and immediate. As an example, exploring synergies between the radar and space weather communities should be advanced. Hence any future TECO for the WIGOS measurement community must allow for diversity in measurement output, all the while promoting traceability in any new or merged measurement stream.

The provision of competencies for the processes of measurement must continue. While the focus in the past, with good outcomes, has been to provide a competency framework at developing levels of NHMS. The focus in the future should insist on a basic level of understanding of what makes a measurement fit-for-purpose and what is required to sustain operations and outputs.

An understanding of the fundamentals of measurement must be imparted to senior leaders in NMHS. The dynamic nature of position rotation in NMHS can lead to incorrect decision making by the use of belief or assumptions rather than being based on a knowledge of measurement fundamentals.

1. **Develop, and provide effective standards and guidance material**

The CIMO Guide and other WIGOS documentation are dynamic documents that need to be updated as knowledge improves. IOM reports (or their equivalent) are an effective way to document investigations, technical findings and new methods of measurements, must remain an integral part of the WIGOS measurement community’s outputs, and in particular, documents that delineate the transition from research to operations for products based on new measurements.

The liaison with BIPM and collaboration with ISO are fundamental pathways to the development of standards and guidance materials and it is essential that collaboration pathways are utilised effectively and strengthen where needed.

As in strategic element (a), the Annex 1.E of the Part I, Chapter 1 of the regular revision of the CIMO Guide (or its equivalent) is a key to access existing and new standards and guidance.

The impact of the future updates to the JCGM 100: Evaluation of measurement data - Guide to the Expression of Uncertainty of Measurement (so called ISO GUM) is of particular concern as the methodology of calculating measurement uncertainties moves from the calculus of variances to a Bayesian probability distribution framework. The environmental measurement community has significantly benefited, including financially, from the introduction of ISO GUM as a key component of good measurement practice. Specific guidance material needs to be developed to ensure that these benefits are not only secured but even enhanced, in spite of the perceived complexities of the new approach for computing measurement uncertainties.

The work of the Regional Instrument Centres, both of the atmospheric and marine variants, must continue as should increasing the collaboration on the propagation of traceability with the atmospheric chemistry calibration centres. While likely to be difficult, if a suitable measurement culture exists, the role of the Regional Instrument Centres and their client base should be expanded to include active and passive remote sensing measurements when methods of traceability to SI become available for those measurement types.

Continuing to link an operational measurement to a physical or chemical definition of a quantity needs to continue. For example: one phenomena in particular, clouds, has proven to be difficult; determining physical definitions of cloud base height, cloud amount and type has been started recently to come up with definition to allow traceability and this must be progressed. Similarly, the standards associated with soil moisture and evaporation will need to be developed and propagated.

The positive impact of effective guidance material on the importance of the processes of measurement and supporting infrastructure cannot be underestimated, as shown by the recent initiative of MeteoSwiss on the importance of intercomparisons using the recent International Pyrheliometer Comparison. More visual, concise and to the point material needs to be developed and distributed widely within NMHSs and environmental agencies that are, or will be, providers of 3rd party data. The effectiveness of social media and web-based portals can also assist in providing information to the myriad of potential providers of crowd sourced data.

1. **Provide guidance for the implementation of new measurement technology**

Testbeds, Lead Centres, expert teams and Regional Instrument Centres will continue to play a crucial role in transitioning new science to operations. Intercomparisons’ primary role has been to provide traceability but they also play a role in introduction of new science and methods on the pathway to operation, and should continue to be used, particularly for the rapidly advancing detector science and engineering used in in situ methods, as well as, passive and active remote sensing.

Measurement community TECO-like fora must continue to be a venue that enables visibility of the new science to be considered for operations. The most recent candidates are: use of infrared all-sky imagery combined with ceilometers to provide cloud height, amount and vertical distribution based on physical processes (e.g. radiative transfer), and use of microwave transmissions for communications being used to derive rainfall.

Alternate approaches to increasing the value of new technologies must also be evaluated, including inviting external experts to examine the potential measurement methods for operational use. Benefits can also be expected from a melding in a measurement sense, for example from melding space and surface-based remote streams.

Linkages between WMO agencies and partners that focus on the science behind environmental physical and chemical processes must continue and be strengthened to ensure innovative methods of measurement and associated quantities are developed, and the resultant environmental intelligence can be introduced with confidence by operational service areas. To achieve this the likely attendees of measurement TECO must be expanded further.

1. **Identify and characterize the potential of emerging measurements**

When a new or alternative process of measurement is available, to ensure that its potential integration into the future environmental information chain is effective and efficient, the measurand must be critically assessed to determine if it is a traceable quantity, and at what organizational infrastructure cost is required to be fit for purpose for known applications.

If an emerging measurement technology is not traceable then the user community must be made aware. While the resultant data are of significant value, the risks associated with their use must be available for consideration. IOM reports (or their equivalent) and specific reports are ideal vehicles for dissemination to the measurement community, but meta data databases like OSCAR, and short reference publications and handouts need to be developed. Alternative methods to publish measurement knowledge include sponsoring workshops on emerging technologies for operational use and the invitation of an external experts, from a parallel science stream or the NMI community, to provide a relevant perspective.

Once these emerging technologies are used in operations, the character of the measurements must be added to the CIMO Guide as a matter of cause. Other dissemination vehicles include their promotion through innovative award schemes like the Prof. Dr Vilho Vaisala Awards, outreach documentation of the Testbeds and Lead Centres, as well as measurement community TECO.

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1. **Measurement** - process of experimentally obtaining one or more quantity values that can reasonably be attributed to a quantity.

   Note: The use of the word ‘observation’ or ‘observations’ has been deliberately avoided as it is a WMO re-definition of the term ‘result of a measurement’ and sometimes is equated to measurement.

   **Result of measurement** - set of quantity values being attributed to a measurand together with any other available relevant information.

   **Measurand** - quantity intended to be measured. [↑](#footnote-ref-1)
2. **Traceability** – property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.

   Note: It is important to understand that traceability is the property of the result of a measurement not an instrument or laboratory calibration report. [↑](#footnote-ref-2)