**Guidance to the Executive Council WG/SOP**

**Subgroup on Structure, Planning, and Budget**

**from the**

**Presidents of Technical Commissions**

***SWOT and Flexibility Analysis***

**February 2017**

**The Current Executive Council Review**

The current review of the structure of WMO Technical Commissions, Regional Associations, and the Secretariat by the EC WG/SOP Subgroup on Structure, Planning, and Budget is consistent with long-standing practices of Congress and Executive Council (see Annex 1 for a detailed history). It is also worth noting that the current structure of the Technical Commissions, which was last adjusted in 1999, is the result of a long evolutionary history. Its form was deemed to be the most efficient and fit-for-purpose given the issues and priorities addressed by Congress during the 1990s and early 2000s. That said, it is significant that the history of change in the Technical Commissions prior to 1999 was dominated by changes in names, rather than in core functions. The question now is whether or not this inveterate structure remains efficient and fit-for-purpose to address the issues, functions and priorities being developed within the strategic and operating plans for the 2020-2023 financial period that will be adopted by Congress 18 in 2019.

To answer this question, the EC WG/SOP Subgroup has solicited input from the Technical Commissions in accordance with its Terms of Reference as follows:

1. To work with the TCs, RAs and the Secretariat to review the current structure of Constituent Bodies including programmes, and activities of RAs, TCs and co-sponsored programmes, and propose improvements, which should include reorienting the TCs to major theme areas of the Organization;
2. To work with the TCs, RAs and the Secretariat to review the scope of the mandates/ToRs of RAs and TCs, and develop their ToRs and tasks for the next financial period, based on major theme areas of the Organization, for consideration by EC and recommendation to Cg-18; and
3. To work with the TCs, RAs and the Secretariat to propose to EC the TCs that Cg-18 should continue, establish or terminate;

This report addresses issues related to the effectiveness and efficiency of the existing TC structure. This is done through an analysis of the strengths, weaknesses, opportunities and threats for each Commission, and includes a synthesis of those characteristics that are common to all Commissions. It then provides an assessment of how well the current TCs have supported the changing priorities of WMO during recent financial periods in order to evaluate the flexibility and adaptability of the existing structure. It concludes with a review of each Commission’s essential activities and emerging essential activities. We begin our assessment with a synthesis of the SWOT analysis, the full details of which are provided in Annex 2.

**Synthesis of Technical Commission SWOT Analyses**

Given the diversity of issues and topics addressed by the WMO Technical Commissions, it is not surprising that they have broad and varied strengths and weaknesses. This is apparent in the SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis for each TC (Annex 2). However, inasmuch as the Commissions serve as the *technical* engine of WMO, they also have a number of strengths and weaknesses in common. The following synthesis focuses on these shared characteristics of the TCs and, in so doing, provides an insight into the collective value of the Commissions to WMO.

***Generic TC Strengths***

* One of the strengths common to nearly all Technical Commissions is an **efficient structure**; both in terms of management and project execution. Generally speaking, TC management groups or advisory working groups tend to be sized proportionately to the scope of their mission activities. Indeed, most are relatively small given the number of tasks they address which, increasingly, come from requests to support WMO priorities such as WIGOS/WIS, the Global Framework for Climate Service, Disaster Risk Reduction, etc.
* Another vital strength of the TCs is a **strong and committed volunteer workforce**. Because TCs have a discipline focus, and the volunteers supporting each Commission see themselves as representatives of those disciplines, there is a synergy of interests between the Commissions and their volunteer experts. WMO has traditionally been viewed as a high-level scientific organization composed of core hydro-meteorological specialties, and specialists feel an identity with, and commitment to WMO as a result.
* Nearly all Technical Commissions operate within a **framework of** **standards, protocols, and compliance**. TC work programmes, objectives, and implementation pathways are firmly embedded in the WMO regulatory framework. Again, this is an intrinsic feature of TCs reflecting specialized hydro-meteorological disciplines.
* A strength of the Commissions that is frequently overlooked is that they have **key partnerships in place.** Often, these arrangements have a very long history and reflect a belief among partners that WMO is a credible, trusted, and valuable partner for them. Partners include other UN and related agencies, research and academic institutions, and numerous non-governmental organizations. Importantly, these arrangements strongly indicate the ability of TCs to address issues that do not always come from Commission members.
* All TC Presidents are recognized experts in their TC’s subject area and personally and uniquely dedicated to ensuring their Commissions productivity and success.

***Generic TC Weaknesses***

* For many (though not all) Technical Commissions, **relationships with Regional Associations** are weak. Structures for taking global-level guidance, from the expert team level through to Regional and National levels are poor.
* **Relationships with other Technical Commissions** have lacked fruitful horizontal linkages to expert teams and Open Panels of Experts. Historical focus on weather means that links to Commissions such at CHy and CCl are not as strong as they could be; it also creates a potential for duplication of effort with CIMO. Steps have, however, already been taken to strengthen these weaknesses.
* For several TCs, **WMO has relatively low visibility** in its support for members. This is particularly true for JCOMM, CHy, and CAgM, where there are significant constituencies that are not associated with a National Meteorological Service.
* A major gap exists in the **relationship between Executive Council and the TCs**. Often there exists an apparent overlap in the EC, its Working Groups, and the work of the Commissions. Similarly, there is a lack of horizontal linkage between the Open Panel/Expert Team structures in the Commissions and the Working Group structures of EC.

***Generic TC Opportunities***

* **Strategic relationships** with other world-wide organizations can be strengthened and expanded (e.g., UNESCO, IOC, Future Earth, IAEA, GEO, World Bank, Insurance sector, etc.), particularly in the framework of global programs such as SDG, GFCS, the UNFCCC agreement, and the Post-Sendai Framework.
* Expanded **cooperation with developers of technical innovations**, particularly in terms of low-cost monitoring, apps for aviation (and other sector) safety, artificial intelligence, cloud computing and storage, high performance computing, crowd-sourcing, etc. This also extends to framework integration for third party and inter-disciplinary data.
* **Simplification** of the decision-making processes at Congress and Executive Council would facilitate the further exploitation of TC benefits.
* The development of **Regional and Global solutions for data services by TCs** would alleviate the difficulties created by financial pressures at the national level.

***Generic TC Threats***

* All organizations that address environmental issues are in a **global competition** for funding from the same donors.
* The magnitude of **funding constraints** within WMO, and the tendency for a decrease in funding for NMHSs at the national level, represents a double threat by limiting the availability of experts from NMHSs and in constraining the ability of Members to implement upgrades and improvements to their systems and service delivery.
* The **difficulty in providing services** other than through the traditional national and regional structures than are global or regional in nature. WMO itself cannot be operational, and the lack of coordinating mechanisms at a regional level mean that organizations with global or regional needs must go to the academic or private sector to have their needs addressed.

**Recent Performance in Addressing WMO Priority Themes**

To provide further insight into how effectively and efficiently the existing Technical Commissions address major WMO priorities, we consider TC engagement with three priority activities of the current financial period (2016-2019) including the WMO Integrated Global Observing System (WIGOS), Disaster Risk Reduction (DRR), and the Global Framework for Climate Services (GFCS).

Regardless of the topics that become priorities during the next financial period, the question in need of an answer is this: Are the Technical Commissions, as currently constituted, the best organizational structure for addressing the strategic priorities? Although it is easy to answer this question with a simple (and non-informative) *yes* or *no*, a more informative answer requires looking at how well the Technical Commissions have done in addressing past and present priorities. Have they (at least those having a nominal linkage to such priorities), for example, contributed to the programmatic effort implemented within the Organization? Did they have to adapt their own priorities, or terms of reference, to do so? Were they efficient and effective in their efforts to contribute to accomplishing the goals of the priorities?

 Each TC has a track record of performance in this regard that can be considered in answering these questions. What follows is a brief assessment of the role played by Technical Commissions in leading, supporting and promoting the activities, objectives, and successful implementation of three WMO priority themes. It is not intended to be an exhaustive or complete accounting of Commission contributions and does not, therefore, include material for every TC. It is, nonetheless, representative of the involvement and contributions that Technical Commissions generically afford WMO. Also, to simplify the presentation, material is provided in bulleted form highlighting major actions and tasks, rather than as a narrative.

Consider, for example, ***WIGOS***.

* Commission for Basic Systems
	+ Provides one of the two co-chairpersons of WIGOS
	+ Terms of reference have been updated at CBS XVI in November 2016 to explicitly reference “*Observational systems, facilities and networks (land, sea, air, and space) as decided by Members including, in particular, all technical aspects of the WMO Integrated Global Observing System, particularly the global observing systems.”*
* Commission for Climatology
	+ Initiated low cost volunteer rain observing network in the Bahamas as an alternative observing paradigm
	+ Provided guidance on creation of reference quality surface stations
	+ Coordinates data rescue
	+ Guides climate data management
* Commission for Hydrology
	+ Developed WHOS has the hydrological component of WIGOS
* Commission for Atmospheric Sciences
	+ GAW is part of the core systems in WIGOS
	+ OSCAR is developed based on the experience from GAWSIS which was developed as the data base for station, instrument and observational records’ information in GAW. MeteoSwiss is a vital partner in WIGOS, built on the evolution of its expertise in support of GAW.
	+ Through GAW, WIGOS covers important domains of the environmental sector which often is covered by national environmental agencies or independent research institutes rather than NMHSs, and in this way WIGOS serves a broader audience than NMHSs.
* Commission for Commission for Agricultural Meteorology
	+ Deployment of simple rain gauges in RA I, similar to CCl’s in the Bahamas, with intercomparisons among diverse raingauge types for their calibrations in terms of accuracy through the collaborations with CIMO (CNR, Italy)
	+ Supplementing new key observation elements under WIGOS: 1) Phenology – collaboration with Phenolonogy Commission of ISB (Int’l Society of BioMeteorology) as a part of GAPON (Global Alliance of Phenology Observation Network) implementation (Joint EG under discussion), 2) Soil Moisture – TT established, and will join Global Soil Moisture Network initiatives together with SMAP-VAX, and 3) GHG Flux – TT established, close collaborations with CAS through joint EG and Occasions
	+ Reconstruction/Downscaling skill development through special TT on WAMIS II for missing and low resolution data, respectively, to meeting emerging requirements for high resolustion data from user community in space, time, and elements, especially to through a global technology consortium on downscaling skills.
* JCOMM
	+ Is developing implementation targets and performance metrics aligned with the Rolling Review of Requirements;
	+ Established a Vice-Chair within its Observations Coordination Group with specific responsibility for coordination (C-Mar) with WIGOS;
	+ Provides guidance to partner (i.e. non JCOMM-owned) ocean observing networks on WMO/WIGOS standards and best practices;
	+ Is promoting more open access to WIS to partner organizations;
	+ The JCOMM *in situ* Observations Programme Support centre (JCOMMOPS) provides a single consolidated interface for marine/ocean observing related information (e.g. metadata) to be provided to WIGOS and is the main conduit between JCOMM and its partner observing networks and WIGOS;
	+ The (Tropical Pacific Observing System) TPOS2020 project, which cuts across sustained and experimental observations, research and operational stakeholders/funders, and the regional coordination constructs of WMO and IOC, has been endorsed as a WIGOS Pilot Project under JCOMM.
* Commission for Instruments and Methods of Observation
	+ Collaborates with all users and providers of measurements
	+ Develops and promotes the implementation of good measurement practices
	+ Develops, and provides effective access to, standards and guidance material
	+ Coordinates the transition from new science and technology to operational implementation
	+ Characterizes the traceability that can be achieved from emerging alternative technologies.

Consider ***Disaster Risk Reduction***

* Commission for Basic Systems
	+ Established a dedicated Coordinator for DRR as part of the Management Group at its XIVth session held in Croatia in 2010, by doing so CBS was the first Technical Commissions to explicitely recognized support to DRR as one of its cross-cutting activities
	+ Spearheaded the efforts leading to the establishment of the DRR Focal Points of Technical Commissions, Technical Programs and Regional Association
	+ Ensuring that observing systems (OPAG IOS), communication and dissemination systems (OPAG ISS), processing and forecasting systems (OPAG DPFS) and best practices in public weather alerting services (OPAG PWS) are maintained and further developed is an essential to DRR and constitutes the basic support of the WMO to the Sendai goals and deliverables
	+ Establish, maintain and further develop the regulations required and the global network of systems supporting high impact weather, water and climate warning and alerting systems
* Commission for Climatology
	+ Providing climate focal points for DRR
	+ Providing guidance on climate risk management.
* Commission for Hydrology
	+ Flood Forecasting Initiative (FFI): strengthening cooperation between NMSs and NHSs through, for example, improving flood forecasting capabilities and ensuring that all major projects under FFI (CIFDP, FFGS, SWFDP) include the requirements and reflect best practices for effective and sustainable flood forecasting;
	+ Provides focal points for DRR working groups and contribute to the development of identifiers for cataloguing of hazardous events (promote hydrological perspective);
	+ Preparing manuals for use by NHS, such as the Manual on Flood Forecasting and Warning and the Manual on Flood Risk Mapping, including investigating the applicability of Common Alerting Protocols (CAP) for use in provision of hydrological warnings;
	+ Founding Member and spearheaded the WMO/GWP Associated Programme on Flood Management (APFM) and member on its Advisory Committee and Management Committee;
	+ APFM: preparing guidelines on how to formulate numerical weather prediction information for use in flood forecasting, consistent with the FFI-AG Work Plan of 2016-2019;
	+ Implement Strategy for the End-to-End Early Warning Systems (E2E EWS) for flood forecasting (using the Community of Practice approach):
		- Developing assessment guidelines for NHSs to evaluate their E2E EWS for flood forecasting,
		- Developing access to the interoperable technologies including platforms and models for use in flood forecasting;
		- Providing access to training and guidance material through the APFM HelpDesk
* Commission for Atmospheric Sciences
	+ Through WWRP the High Impact Weather project is set up with considerable R&D support from many NMHSs in order to develop high-resolution forecasting and observational skills to reduce risks related to high impact weather.
	+ Has supported the development of the forecasting capabilities at the sand and dust storm forecasting centres now in operation worldwide
	+ Through GURME in GAW provided R&D for observations and modelling in support of the forecasting of severe pollution events in urban areas in many major cities worldwide
* Commission for Commission for Agricultural Meteorology
	+ Close collaboration with CHy in implementing APFM and IDMP, including membership on the Advisory Committees, Technical support team, Help Desk, etc.
	+ Designation of Focal Point to DRR (Chair of Focus Area 3 on Natural Hazards and Climate Change)
* JCOMM
	+ Provides the focus for the provision (under the UN SOLAS convention) of mandatory meteorological Maritime Safety Information (MSI), through the network of Metarea Coordinators;
	+ Acts as a focal point for partners, including IOC, and other providers of MSI, such as the International Hydrographic Office (IHO) and the International Maritime Organization (IMO);
	+ Maintains regulatory manuals in respect of the provision of marine services, particularly WMO-Nos. 558, 471 and 702, and acts as the guardian of meteorological inputs to international manuals such as the Joint IMO/WMO/IHO Manual on Maritime Safety Information;
	+ Coordinates surveys and feedback on the quality & accessibility of services from users of MSI;
	+ Is implementing a Marine Competency Framework, endorsed by WMO Members, to ensure consistency amongst marine weather forecasters; this is being introduced alongside Quality Management within marine forecasting services;
	+ Is developing backup guidelines to ensure resilience in the production and dissemination systems for the World Wide Metocean Information & Warning Service (WWMIWS);
	+ Continues to progress to define standards for S-412 charts and information, to ensure alignment with IMO development of their. E-navigation strategy;
	+ Is reviewing the requirements for, and provision of, metocean support in the event of Marine Environmental Emergencies, including events related to oil and other spills, release of radionuclides and search & rescue. This involves building relationships with a number of global authorities to ensure a consistent level of support and undertaking, where necessary, capacity development within Members to ensure appropriate capability is available;
	+ Has expanded the series of Ice Charting Workshops, which have set a standard in this area of work, to the southern hemisphere;
	+ In the context of Waves and Coastal Hazards, has managed an increasing number of “Coastal inundation & Flooding Demonstration Projects” and is currently developing the methodology to move these to an operational phase.
* Commission for Instruments and Methods of Observation
	+ Collaborates with all users and providers of robust measurement system
	+ Develops and promotes the implementation of good practices for sustained measurements
	+ Develops, and provides effective access to, standards and guidance material.

Consider the ***Global Framework for Climate Services***

* Commission for Basic Systems
	+ Standards ensuring global exchange, interoperability and intercomparability is one of the pillar of the GFCS
	+ In cooperation with CCL, the OPAG DPFS established the Joint CBS-CCl Expert Team on Operational Predictions from Sub-seasonal to Longer-time Scales (ET-OPSLS), whose work had led to the establishment of a Global Network of Producing Centres which will feed the Climate Service Information System
	+ As part of the evolution of the seamless Global Data Processing and Forecasting System, the inclusion of the Climate Services Information Systems will provide a solid basis for the delivery of data, products and services under the GFCS
* Commission for Climatology
	+ Nearly everything CCl’s over 20 teams accomplish can be viewed as contributions to the GFCS.
	+ Especially education and training activities
	+ Guidance on national climate monitoring.
* Commission for Hydrology
	+ Supports Observations and Monitoring through WHOS, WHYCOS, and the Global Hydrometry Support Facility (GHSF)
	+ Supports the Climate Services Information System with WHOS, APFM, Flood Forecasting Initiative (FFI), Extended Hydrological Prediction (EHP), and the GHSF
	+ Supports Research, Modeling and Prediction with the Flash Flood Guidance System (FFGS), EHP, and the GHSF
	+ Supports Capacity Development through WHOS, WHYCOS, GHSF, FFI, EHP, APFM, Integrated Drought Management Programme (IDMP), and QMF-Hydrology
	+ Supports the User Interface Platform with APFM, EHP, and IDMP.
* Commission for Atmospheric Sciences
	+ Promoted the seamless modelling approach through the WWRP Implementation and Action Plans and through the applications part of the GAW Implementation plan.
	+ WWRP together with WCRP is in charge of the subseasonal to seasonal project (S2S) which in some ways is the successor of the THORPEX project
	+ Developed the Integrated global greenhouse gas information system (IG3IS) to become a major framework for supporting individual countries in a top-down technical approach in their national greenhouse gas emission assessment. IG3IS is attracting substantial interest from international funding mechanisms and at COP 21 in Paris.
	+ GAW is in charge of the greenhouse gas bulletin, a major WMO outreach activity
	+ GAW is in charge of the Ozone Bulletin, another major WMO outreach activity
* Commission for Agricultural Meteorology
	+ Since the very early stage of GFCS (2009), CAgM has proactively engaged in GFCS implementations, especially through GIAM (Global Initiatives in AgroMeteorology) that has corresponding components to GFCS pillars, being based on existing/legacy CAgM resources/programmes (GAMOS, GAMPP, GCREAM, GFAMS, WAMIS II)
	+ Potential core Climate Services, e.g. daily long-range forecasts with high spatial resolution, has been under development under cloud computing environment for operational services including an interface with Agricultural applications such as Crop simulation models. (WMO made MoU with KISTI, Korea in 2016 for sharable ICT infrastructure)
	+ Under Seamless GDPFS (CBS), CAgM is proposing a dedicated AgMet early warning and outlook service centers at global and regional levels to facilitate better Climate Services to global user community.
* JCOMM
	+ Is developing ocean observing implementation targets and performance metrics aligned with the Global Climate Observing System;
	+ Is establishing the Marine Climate Data System (MCDS) with 2020 Vision as one of JCOMM contribution to GFCS. MCDS builds on existing facilities with modernized functionalities and products and services provided through Marine Meteorological and Oceanographic Climate Centres (CMOCs);
	+ Is promoting facilitated and integrated access to real-time and near-real-time ocean observations using new technologies such as ERDAP;
	+ Is promoting better integration of ocean data systems with WIS through new JCOMM Cross-cutting Task Team for Integrated Marine Meteorology and Oceanographic services within WIS (TT-MOWIS).
* Commission for Instruments and Methods of Observation
	+ Collaborates with all users and providers of measurements
	+ Develops and promotes the implementation of good measurement practices
	+ Develops, and provides effective access to, standards and guidance material
	+ Characterizes the traceability that can be achieved from emerging alternative technologies.

**Current and Emerging Essential Activities**

Each of the eight Technical Commissions delivers “essential activities” in support of WMO and our members and partners. These are the functions that members and partners expect and depend upon WMO to provide, and that are intrinsic to the core mission of the Organization. They must be delivered without regard to transient strategic priorities or to the structure of Technical Commissions. Enumerating these activities is, therefore, critical for Executive Council to consider

will not have the concrete and succinct information to assess the risks and consequences of any new organizational structure.

**Commission for Aeronautical Meteorology**

***Essential Activities***

* Application of meteorology to aviation taking into account relevant developments in science and technology and the study of aeronautical meteorological requirements;
* International standardization of methods and techniques for the provision of aeronautical meteorological services;
* Improvement of observations, forecasts and warning in the airport terminal area;
* Initiation of specific studies aimed at improving forecasting accuracy;
* Consideration of requirements for basic and climatological data, observations and specialized instruments;
* Updating regulatory and guidance material such as WMO Technical Regulations;
* Implementation of the World Area Forecast System (WAFS) jointly with ICAO;
* Improvement of forecasts on en-route weather hazards such as turbulence, icing and volcanic ash and tropical cyclones;
* Studies on the impact of aviation and on the environment and;
* Training of personnel in aeronautical meteorology.

***Emerging Essential Activities***

The current meteorological services for international air navigation, regulated through ICAO Annex 3 and WMO Technical Regulations Volume 2, have been provided for several decades without significant changes in the scope and service delivery methodology. Most of the main information products provided to users are based on technology from the second half of the 20th century. The implementation of the ICAO Global Air Navigation Plan and supporting Aviation System Block Upgrade (ASBU) methodology will require significant changes in the service delivery philosophy and methodology with these scheduled for implementation in the ASBU time blocks by 2028 and beyond. The main changes envisaged include:

* Service delivery shift from product-centric to data/information-centric
* Further regionalization and globalization of all (including MET) aspects of aviation service delivery whilst ensuring underpinning MET infrastructures are adequately supported, developed and maintained
* Full implementation of System Wide Information Management – use of “cloud”, digital data technologies and new and evolving modes of data delivery and discovery
* Provision of high resolution information for decision-making through collaborative decision making to support the trajectory-based operations
* Full integration of weather information in the Air Traffic Management ‘value chain’
* Provision of near-real-time information directly to aircraft in flight for near-term (0-20 min) decision-making
* Climate change and its impact on aviation operations

**Commission for Hydrology**

***Essential Activities***

* Advisory activity in hydrology and water resources, including, but not limited to:
	+ The measurement of basic variables characterizing the quantity and quality of water and sediment in the hydrological cycle;
	+ The acquisition of other related characteristics describing the properties of basins, rivers, and the inland water bodies;
	+ The collection, transmission, processing, storage, quality control - archiving, retrieval and dissemination of data and information;
	+ Hydrological forecasts and warnings, both under natural and accidental conditions;
	+ The development and improvement of methods and technology required for the items above;
	+ The application of water-related data and information to the assessment, effective management, and sustainable development of water resources and to the protection of society from hydrological hazards;
* Promoting and facilitating the international exchange of experience, transfer of technology, research uptake, education, and training and development to meet the needs of national Hydrological Services or other organizations fulfilling the functions of such Services including programme management and public awareness (e.g. through HOMS and other mechanisms);
* Promoting and facilitating the international exchange and dissemination of information, terminology, data, standards, forecasts and warnings;
* Promoting the collaboration and linkages among hydrology, meteorology, and environmental management;
* Raising awareness in the wider community of the social, economic and environmental significance of water, and promoting the role of hydrology in the mitigation of hydrological hazards and in the development and management of water;
* Supporting cooperation between WMO, IHP of UNESCO, IAHS and other governmental and non-governmental organizations on matters related to hydrology and water resources;
* Supporting and, where appropriate, taking the lead in, coordinating within WMO terrestrial water-related matters, including the activities of the regional associations' working group on hydrology.

***Emerging Essential Activities***

* Coordinating the sharing of near real-time hydrologic data through the WMO Hydrological Observing System (WHOS);
* Promoting and facilitating the use of new advances in measurement, modeling, and visualization to address problems associated with water scarcity, environmental degradation, and water‐related natural hazards;
* Participation in the Global Data Processing and Forecasting System to ensure that hydrological process models are fully integrated and that hydrological outputs and services meet the needs of Members, the GFCS, and DRR.

**Commission for Climatology**

***Essential Activities***

* Global climate monitoring, For example, all leads of the annual WMO State of the Climate publication are from the Commission for Climatology.
* Guiding and facilitating national climate monitoring.
* Implementation of the Climate Services Information System.
* Guiding and advising Climate Data Management Systems (CDMS).
* Coordinating and advising international data rescue.
* Guiding and coordinating climate change detection and indices used to assess how climate extremes are changing.
* Evaluating and guiding climate data homogenization.
* Advising and coordinating the ongoing creation of World Weather Records, which is a WMO climate data set initiated in the 1920s whose updates are still crucial for global climate change analysis.
* Assessing, reviewing and guiding WMO Regional Climate Centers.
* Coordinating and guiding operational predictions from sub-seasonal to longer-time scales.
* Coordinating the global seasonal climate updates.
* Initiating, reviewing and guiding the Regional Climate Outlook Forums (RCOFs).
* Creating sector-specific, such as human health or agriculture focused, climate indices.
* Providing guidance on climate risk assessment.
* Updating the *Guide to Climatological Practices* a WMO mandatory publication.
* Creating guidance on Quality Management.
* Providing guidance on NMHS infrastructural and institutional capabilities for providing climate services.
* Advising on education and training aspects of capacity development in climatology and further developing competency standards for core job-tasks in climate services.

**Commission for Atmospheric Sciences**

***Essential Activities***

* Promoting the Science for service and the value chain concept in the implementation plans for WWRP and GAW
* R&D to develop seamless modelling capability across space and time scales
* Responsibility for the High Impact Weather, polar prediction project PPP (including YOPP) and subseasonal to seasonal predictions project (S2S) (all in WWRP)
* Focusing on high impact weather prediction, predicting the water cycle, environmental effects of urbanization, emerging technologies (like using unconventional observations, high performance computing etc)
* Providing through WWRP the expert infrastructure for nowcasting and mesoscale weather forecasting, tropical meteorology, predictability, dynamics and ensemble systems, data assimilation and observational systems, verification, social and economic research (SERA)
* In GAW there is focus on High Quality Long Term Data which Enables Global Assessments and Analysis
* GAW focuses on the theme - Atmospheric Composition Matters - to human health, & weather forecasting, climate, terrestrial and aquatic ecosystems, agricultural productivity, aeronautical operations, renewable energy production, and more (GHGs, aerosols, reactive gases)
* GAW has established a new Science Advisory Group (“GAW-Applications”) focused on the objective “to demonstrate usefulness of exchanging chemical observational data in NRT in support of monitoring and forecasting applications” targeting applications that use NRT data delivery on scales larger than urban
* GAW provides R&D in climate change; high-impact weather and events; urban meteorology, air quality and health; ecosystems; and conventions and treaties. Cross cutting issues are aerosols, GHG tracking (IG3IS), health
* GAW focus on enhancing data management architectures to facilitate improved metadata exchange and interoperability, data discovery and analysis, and to promote and facilitate the near-real time delivery of data

***Emerging Essential Activities***

* Seamless model development across the atmosphere, land surface, oceans, ice, environment and biogeochemical cycles for NWP, ocean forecasting, environmental forecasting, hydrology and climate
* Together with CBS move seamless GDPFS forward
* Improve science for service and value chain concepts to bridge the gap between R&D and operations in order exploit the potential inherent in observations, modelling, It includes high performance computing and standardized data management

**Commission for Agricultural Meteorology**

***Essential Activities***

* Proactively engaged in GFCS, DRR, WIS/WIGOS implementations, especially through GIAM (Global Initiatives in AgroMeteorology) (GAMOS, GAMPP, GCREAM, GFAMS, WAMIS II) including ICO through GRIAM.
* Enhancing Climate Services, especially daily long-range forecasts with high spatial resolution for Crop simulation models
* Establishment of Cloud/GRID computing environment for AgroMeteorological services as sharable ICT infrastructure, especially for LDC and SIDS
* Establishment of a dedicated AgMet early warning and outlook service centers at global and regional levels to facilitate better Climate Services to global user community. Mobilization of financial resources from external donor agencies by proposing grand research projects, e.g. IKI, GCF.
* Provide essential (science-based) operational knowledge to NMHSs and farmer extensions to support productivity and resilience.
* Implement the offer and the understanding of climate-weather based information and of their value in agricultural sectors (value chain)

***Emerging Essential Activities***

* Create sustainable and climate resilient agricultural production systems for food security: (Protect and enhance food security- Promote climate smart management to support adaptation, sustainability, resilience)
* Mitigate climate change by adapting weather-climate respectful management.
* Preserve the earth’s heritage: protect and maintain landscape and rural areas

(land use, social, economics ,traditions, environmental and multifunctional issues).

* Favor food-water-energy nexus
* Proactive engagement in assessing sustainable development goals for AgroEcosystems, in terms of mitigation and adaptation

**Commission for Basic Systems**

***Essential Activities***

CBS is responsible for matters relating to:

* Cooperation with Members, other technical commissions, regional associations and relevant bodies in the development and operation of integrated systems for observing, data processing, forecasting, telecommunications, and data management. These activities shall be in response to requirements and in support of all WMO Programmes, particularly contributing to disaster risk reduction, and taking advantage of opportunities provided by technological developments;
* The assessment of opportunities for, and the provision of, a common infrastructure to meet the requirements defined by technical commissions and regional associations, as well as by organizations with whom WMO has relations, taking into account new applications of meteorology, hydrology, oceanography, and related environmental sciences;
* Continued development and modernization of the World Weather Watch (WWW);
* Further development and implementation of the Public Weather Services Programme, with particular attention to the implementation of the WMO strategy for service delivery, including impact-based forecasting and risk-based warnings, to ensure end-to-end service delivery;
* Further development and implementation of the WMO Space Programme;
* Contribution to the development and implementation of the Global Framework for Climate Services;
* Further development and implementation of processing, storage and retrieval of basic data for meteorological and related purposes including, in particular, the organization of the seamless Global Data-processing and Forecasting System of the WWW;
* Further development and application of systems and techniques to meet user requirements including those of operational weather analysis and forecasting and of services for environmental emergency authorities;
* Provision of operational technical support to Disaster Risk Reduction and humanitarian activities, in particular the multi-hazard early warning system and service delivery;
* Observational systems, facilities and networks (land, sea, air, and space) as decided by Members including, in particular, all technical aspects of the WMO Integrated Global Observing System, particularly the global observing systems;
* Telecommunication networks, radio-frequency allocation and facilities for operational, research and applications purposes including, in particular, the organization of the WMO Information System, including the Global Telecommunication System of the World Weather Watch;
* The development and application of operational procedures, schedules, and arrangements for the exchange of and access to weather, climate and water information (data and, products), including warnings, required by all WMO Programmes, in particular~~,~~ through the WMO Information System;
* The development and application of data management principles and procedures including monitoring and evaluation of the common infrastructure, in particular, of the World Weather Watch;
* Promote assessment of social and economic benefits of meteorological and hydrological services, including a more systematic basis for prioritizing the use of available resources for infrastructure.

***Emerging Essential Activities***

* Through the seamless Global Data Processing and Forecasting System and the Climate Services Information System, the Technical Commissions will provide Members with products, data and services on past, present and future weather, water, climate and air quality supporting the WWW and the GFCS.
* Emerging data issues is seen as an essential activities, and as such, the Commission has established the proper leadership and work arrangements to support this activity.
* Broader engagement of academia, other scientific organizations and the private sector in the activities of the Commission

**JCOMM**

***Essential Activities***

* Managing the provision of MSI, under the auspices of the WWMIWS, through the network of Metarea Coordinators;
* Ensuring consistency in the delivery of services, both as routine safety services and also support tom appropriate authorities in the event of marine environmental emergencies;
* Continuing to manage regulatory documentation applicable to the provision of marine weather services and MSI;
* Enhance engagement with Regional Associations and GOOS Regional Alliances to ensure a more consistent understanding of the requirements for marine information and services;
* Continued collaboration with the IOC and the Ocean Research community towards implementation of a sustained ocean observing system relevant to hydrological forecasting;
* Continuation and sustainability of JCOMMOPS to assure monitoring of the ocean observing networks and promotion of data sharing;
* Development of a robust Marine Climate Data System (MCDS) with higher quality control and added value ECV/EOV based marine climate products and services;
* Promotion of enhanced and new partnerships to access more ocean data in support of WMO Applications

***Emerging Essential Activities***

* Enhancing the collaboration and partnering with an increasing range of bodies at both global and regional level engaged in the delivery and use of marine services. These may be removed from the traditional users and include bodies such as marine insurers;
* Ensuring that WMO/NMHS are seen as the authoritative voice with regard to issues involving marine meteorology and oceanography;
* Working with partners to develop a method of cost recovery for marine services that enables increased investment in services by NMHS;
* Engaging with partners, particularly IMO, with metocean implications within the Polar Code;
* Develop a more consistent approach to capacity development activities across the marine sector, possibly in collaboration with other MSI providers (IHO & IMO);
* Use of new cost-effective observing technology using GPS for wave observations;
* TPOS-2020 project to develop the Tropical Pacific Observing System for the next decade;
* Use of ERDAP for integrated access to real-time and near-real-time ocean observations;
* Use of citizen science for ocean data rescue.

These examples provide solid evidence that the Technical Commissions, as currently constituted, serve the Organization effectively and efficiently, and in a manner consistent with the desires of Congress and their original design. At least with respect to their performance in addressing past and present WMO priorities, the Technical Commissions have demonstrated few critical deficiencies. What now remains to be assessed is whether or not this historically fit-for-purpose design can continue to be successfully utilized in addressing the Organization’s future major priorities. We will consider that concern in Part 2, after EC completes its drafting of proposal priorities for consideration by Congress 18.

**Additional Considerations**

In addition to the SWOT analyses, performance in addressing recent strategic priorities, and their essential activities, some technical commissions have other issues that need to be considered by EC in its restructuring deliberations. JCOMM, for example, is a Commission that is jointly managed by WMO and UNESCO’s Intergovernmental Oceanographic Commission (IOC). As such, any change to the structure of JCOMM requires the agreement of both WMO and UNESCO/IOC.

**Annex 1**

**A Brief History of WMO Technical Commissions**

The WMO Convention (WMO-No. 15) recognized the need for Technical Commissions in Part IX, Article 19 as follows:

*1) Commissions consisting of technical experts may be established by Congress to study and make recommendations to Congress and the Executive Council on any subject within the purpose of the Organization;*

*2) Members of the Organization have the right to be represented on the technical commissions;*

*3) Each technical commission shall elect its president and vice-president; and*

*4) Presidents of technical commissions may participate without vote in the meetings of Congress and of the Executive Council.*

More specific guidance regarding Technical Commission membership, duties of the president, sessions, session agenda, quorum, and assistance by the Secretariat was described in Chapter V of the General Regulations (WMO-No. 15). As specified under Regulation 182, “(t)he main purpose of a commission is to study and make recommendations to Congress and the Executive Council on subjects within its terms of reference and in particular on matters directly referred to the commission by Congress and the Executive Council.”

The first WMO Congress (1951) established eight Technical Commissions (WMO-No. 721):

• Commission for Bibliography and Publications (CBP)

• Commission for Instruments and Methods of Observation (CIMO)

• Commission for Aerology (CAe)

• Commission for Climatology (CCI)

• Commission for Agricultural Meteorology (CAgM)

• Commission for Maritime Meteorology (CMM)

• Commission for Synoptic Meteorology (CSM)

• Commission for Aeronautical Meteorology (CAeM)

The first Congress also defined the terms of reference for the Commissions, except for CAeM, for which it was decided that the terms of reference would be finalized after negotiations between WMO and ICAO were concluded. The terms of reference of CAeM were subsequently finalized and approved by the second Congress in1955.

Each successive Congress reviewed the structure and terms of reference of the Technical Commissions, and adjustments were adopted as necessary; so the current review is not unique. Indeed, as the following paragraphs indicate, there have been numerous changes and adjustments made to the Technical Commissions on a continual basis since the inception of the Organization. Notably, however, many, if not most of these changes have been to Commission names rather than to Commission functions.

Congress III (1959), for example, decided to discontinue the Commission for Bibliography and Publications (CPB) and to replace it by a panel of experts as much of the work that had been undertaken by CBP was completed. This Congress also established a new Commission for Hydrological Meteorology (CHM) in response to concerns in the Regional Associations and the broader international community that hydrologic issues were not being adequately addressed within WMO. The fourth Congress (1963) completely revised the terms of reference of CHM and renamed it the Commission for Hydrometeorology (CHM). The terms of reference of the other technical Commissions were also amended at that time.

Congress V (1967) requested Executive Council to arrange for a comprehensive study of how the scientific and technical work of WMO was organized, and laid down extensive guidelines for this study. In the interim Congress expanded the terms of reference of CSM to enable it to be more closely associated with the activities of the World Weather Watch. The same Congress also changed the name of the Commission for Aerology (CAe) to the Commission for Atmospheric Sciences (CAS). Congress VI (1971) then made an extensive review of the system of Technical Commissions based on the EC study carried out at the request of the fifth Congress, and classified the Commissions as either "Basic Commissions" or "Applications Commissions". Furthermore, the Commissions for Synoptic Meteorology, Maritime Meteorology, Hydrometeorology, and Climatology were renamed respectively as the Commission for Basic Systems (CBS), Commission for Marine Meteorology (CMM), Commission for Hydrology (CHy) and Commission for Special Applications of Meteorology and Climatology (CoSAMC). CBS, CIMO and CAS were placed under "Basic Commissions" while CAeM, CAgM, CMM, CHy and CoSAMC were placed under "Applications Commissions". The terms of reference of all the Commissions were also modified.

Congress IX (1983), also considered alternative structures to the system of Technical Commissions that had been proposed by an EC panel established after the eighth Congress (1979). While retaining the existing structure, Congress IX substantially revised each Commission’s terms of reference. Other changes during the period from the seventh to the tenth Congress also occurred. Congress X (1987) moved the Commission for Hydrology (CHy) into the "Basic Commissions". Also, the name of the Commission for Special Applications of Meteorology and Climatology (CoSAMC) was changed twice; first to the Commission for Climatology and Applications of Meteorology (CCAM) by Congress VIII (1979), and subsequently to the Commission for Climatology (CCI) by Congress IX (1983).

Prior to 1999, marine meteorological and oceanographic observations, data management and service provision programmes were internationally coordinated by two separate bodies; the WMO, through its Commission for Marine Meteorology (CMM) and, UNESCO, through it’s Intergovernmental Oceanographic Commission (IOC). The coordination took place through the joint Committee for the Integrated Global Ocean Services System (IGOSS). While enhancing safety at sea remained the primary objective of marine forecasting and warning programmes, requirements for data and services steadily expanded in volume and breadth during the preceding decades. Moreover, many other applications required observational data sets and prognostic products for both the oceans and the overlying atmosphere.

Responding to these interdisciplinary requirements necessitated the development of closer working relationships between oceanographers and marine meteorologists. This was reflected at the global level by growing collaboration between the IOC and the WMO in organizing and coordinating ocean data acquisition, data management, the provision of related services, and associated capacity development needs. The increasingly close relationship between the two agencies' operational ocean activities culminated when the Thirteenth WMO Congress (May 1999) and the 20th IOC Assembly (July 1999) formally established a new IOC/WMO Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM). With the establishment of JCOMM in 1999, the structure of the Technical Commissions took the form that continues to today:

*I. Basic Commissions*

• Commission for Basic Systems (CBS)

• Commission for Instruments and Methods of Observation (CIMO)

• Commission for Hydrology (CHy)

• Commission for Atmospheric Sciences (CAS)

*II. Applications Commissions*

• Commission for Aeronautical Meteorology (CAeM)

• Commission for Agricultural Meteorology (CAgM)

• Joint WMO-IOC Commission for Oceanography and Marine Meteorology (JCOMM)

• Commission for Climatology (CCl)

**Annex 2**

**Analysis of Strengths, Weakness, Opportunities and Threats**

***Commission for Basic Systems***

**Strengths:**

**Efficient Management Structure**: A management group that is organized around the 4 key functions of the World Weather Watch, one coordinator for DRR as a cross cutting priority and one coordinator to focus on emerging issues and WIGOS. Clear objectives, terms of references and work plans for each CBS component

**Collaborative Culture:** The Commission has developed a collaborative and cooperative approach to addressing issues; while this may imply the investment of significant time and effort in achieving solutions, those solutions are then very robust with buy-in from all parties.

**Extensive reach:** The remit of the Commission for the operational aspects of meteorology gives it a reach into all NMHSs who are Members of WMO. Sustained support for and development of the basic, core building blocks of NMHSs

**End to end capability:** The Commission has oversight of the entire chain of operational meteorology from observations through to service delivery, which should make it easier to contribute to sectoral needs (such as the Humanitarian Sector, the surface transport sector etc).

**WIS, WIGOS, GDPFS:** An efficient, robust and reliable cascading research to operations to service delivery infrastructure for weather.

**Global Network of Emergency Response Centres**

**End-to-end visibility:** throughout the entire data and 'basic systems and services' value chains, with strong connections to users and their requirements throughout

**Strong Common Operating Standards and Protocols Culture (Regulation):** Work programme, objectives and implementation pathways for CBS activities and developments firmly embedded in the WMO regulatory framework.

**Committed Volunteer Workforce**: A Global network of experts across all observing system relevant to WMO that istechnically strong and broad, geographically diverse, and fiscally efficient (see Annex 3).

**Weaknesses:**

**Relationships with other Technical Commissions:** The horizontal linkages to Expert Teams and OPAGs in the other Technical Commissions are weak, and therefore cross-Commission working is not as fruitful as it might be. Historical focus on weather means that links to other Commissions (CHy, CCl) are not as strong as they could be. A potential exists for duplication of effort with CIMO.

**Relationships with Regional Associations:** The working arrangements between TCs and RAs are not as strong and robust as they might be, and the structures for taking global-level guidance and expertise from OPAG/ET level through to Regional and National level are weak. No formal CBS MG presence within RA construct.

**Relationships with Executive Council and its constituent bodies:** Often there is apparent overlap of responsibility between the work of EC and its Working Groups and the work of the Commission. A related difficulty is the lack of any horizontal linkage between the OPAG/ET structures in the Commission and the WG structures of EC.

**Unbalanced engagement in Expert Teams:** The engagement of experts from RA1 and RAIII in the work of the Commission is especially weak, and in general the balance of experts from the developed / developing world needs to improve. There are competing demands between engaging those with a high level of expertise (mainly, but not exclusively coming from the more developed countries) and engaging those who fully understand the on-the-ground limitations present in the less-developed NMHSs.

**Over-reliance on a small number of Member states for expertise:**  Perhaps only twelve Members of CBS that contribute the majority of the expertise available to the Commission (US, Canada, UK, France, Germany, Switzerland, Russia, China, Japan, Australia, New Zealand, South Africa). Even in the developed world there is a need to encourage more active engagement from the smaller Member states in CBS work. The benefits that engagement brings back to the home NMHSs need to be more clearly articulated.

**Over-reliance on a small number of Secretariat officers:** The implementation and execution of CBS guidance / decisions falls on the shoulders of a small number of Secretariat officers who, while being individually excellent, are necessarily limited by time and resources in what they can achieve.

**Systems-led approach dominates without a corresponding understanding of social sciences:** The topics of Impact-based forecasting, Service Delivery, Big Data among others requires some understanding of how users interact with weather services, and indeed even how the “human” elements within our own increasingly automated systems behave. This understanding will best come from the Social Sciences but the interactions between the Social Science community and the CBS community are not very strong.

**Nimbleness and Adaptability:** The cost of being robust.

**Opportunities**:

**Strategic Relationships**: Linkage with other worldwide organizations can be strengthened and expanded (UNESCO, IOC, Future Earth, IAEA, GEO, World Bank, Insurance Sector, etc), especially in the framework of global programs such as SDG, GFCS, the UNFCCC agreement, and the Post-Sendai framework.

**Increasing trend toward inter-Commission joint planning and work:** Building better cross-Commission linkages via the promotion of Service Delivery. CBS has been asked to take a lead in the promotion of Service Delivery across all the activities of WMO. This provides a mechanism for improved collaboration with other TCs and with RAs, but will require significant effort on our behalf.

**Seeking expertise beyond the NMHS community:** Some of the other Commissions (CHy, CAeM, CAgM) have better links outside the traditional NMHS community than does CBS. There should be opportunities to engage a broader range of expertise into the work of the Commission if we actively try to promote involvement from partner agencies to NMHSs.

**Other modes of Expert engagement:** The primary work of most experts active within the Commission is to contribute to the work of Expert Teams in developing regulations, protocols, guidelines etc. We should also examine how experts might be used to augment the role of Secretariat staff in providing direct support to Members and regional groups of Members through involvement in training courses, capacity building, mentoring etc.

**Technical Innovations** – Artificial Intelligence, cloud computing and storage, evolving HPC capability, Internet of Things, crowdsourcing, social media means, integration framework for third party and inter-disciplinary data.

**Emergence of the private sector –** new sources ofobservations and expertise; collaboration and increased value for all, based on unique strengths of private and public sectors.

**WIS 2.0, WIGOS 2040, Future Seamless GDPFS:** Building on the data integration, fusion, processing and dissemination we have in place to broaden the services to climate, water, air quality and broader environmental community.

**Threats**:

**Emergence of the private sector:** Private companies offering services which were previously the domain of NMHSs; ill-prepared Members exploited by more nimble private sector operators (e.g., purchasing arrangements for observations, IT infrastructure); Increasing gap in capabilities between advanced and developing NMHSs.

**NMHs commitments to CBS programs and standards**: Financial pressures are preventing Members from investing in or maintaining observing systems.

**WMO and NMHS funding constraints:** The level of funding constraints within WMO and the tendency for a decrease in funding for NMHSs at a national level represents a double threat – both to the availability of expertise from NMHSs to CBS and in constraining the ability of Members to implement upgrades and improvements to their systems and service delivery.

**Global Competition**: Every international organization involved in environmental issues is looking for funding from the same donors.

**Division between Systems and Services aspects:** While the presence of both systems and services aspects within the one Commission is a strength, these two aspects do not always sit easily together and there is a threat of the Commission essentially functioning as two distinct halves, which would not be optimal.

**Development / duplication of traditional CBS systems and services in the non-NMHS sector:** We have seen the development of parallel observation systems and duplicate NWP forecasting systems by some Members and Regions. While these non-NMHS systems can add a lot to the overall global meteorological enterprise, there is a threat that the oversight / guidance of CBS could well be weakened if the owners/operators of these systems perceive that CBS and WMO are not relevant to their needs.

**Difficulties in providing services other than through the traditional national / regional structures:** As had been seen in our interactions with the Humanitarian Community, there are significant difficulties in the provision of services other than through NMHSs and especially weather services that are global or regional in nature. The fact that WMO itself cannot be operational in nature and the lack of coordinating mechanisms at a regional level mean that organisations (even within the UN system!) with global or regional needs must go to the academic or private meteorological sector to have their needs addressed. This inability to provide services to meet the needs of users represents a threat to the relevance of CBS / WMO.

**Plans to revamp the TC structures in WMO:** See Opportunities above. If CBS is not willing and able to adapt to new circumstances and morph into new structures, it may become increasingly irrelevant. It would not be good for CBS to be seen within WMO as a block to development and progress.

**Changing nature of media:** Not so many years ago, there was a meeting between representatives of CBS/PWS and representatives of CNN and the BBC. At that time these two channels provided the great bulk of globally focused and globally-available weather broadcasting. Now the multiplicity of channels, websites, apps, social media sites etc., which provide global level data, means that it would be impossible for the Commission to meaningfully engage with even a small percentage of the service providers. This point illustrates the huge challenge faced by the WMO community in remaining relevant to consumers of weather services and challenges us to consider how we can best use the scant resources available to us in this regard.

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***Commission for Hydrology***

**Strengths:**

**Efficient Structure**: A single advisory working group comprised of relatively few experts each having unique technical capabilities and diverse regional experience.

**Strong Regional Linkage**: A Working Group on Hydrology exists in every WMO Region, with a Regional Hydrological Advisor who advises the President of the Regional Association, and who interacts closely with the President of CHy.

**Critical Societal Issue**: Addresses the monitoring and forecasting of the world’s most essential natural resource (water), as well as assessing and mitigating the adverse impacts associated with hazardous water-related events.

**Committed Volunteer Workforce**: A technically strong, geographically diverse, and fiscally efficient means of accomplishing the mission (see Annex 3).

**Flexible Strategic Character**: Strong, engineering-oriented approach to problem solving makes it easy to adapt to new priorities.

**Weaknesses:**

**Perceived as an Outsider**: Not seen as an equal priority area within WMO community, and not well represented in WMO governance.

**Complex Hydrology and Water Resources Landscape**: Many different global actors, and the Commission is not seen as the key player.

**Perceived Focus on Surface Water Quantity Exclusively**: CHy is not considered to be a key partner with respect to groundwater and water quality.

**Lack of Visibility and Trust**: Many National Hydrological Services are in decline, with low visibility, low budget, low level of performance, and low visibility.

**Opportunities**:

**Strategic Relationships**: Linkage with other worldwide water-oriented organizations can be strengthened and expanded (UN-Water, UNESCO, IAHS, IAHR, ISO, GWP, IAEA, GEO, World Bank,), especially in the framework of global programs such as SDG, GFCS, the UNFCCC agreement, and the Post-Sendai framework.

**Technical Innovations**: Expand cooperation with developers of innovative and low-cost solutions to monitoring water quantity and quality.

**Providing Information on the Water Cycle Globally**: Expand expertise in, and collaboration with, scientific disciplines addressing the different components of the water cycle.

**Hydrological Forecast Clearinghouse:** Provide guidance and benchmarking for flood and drought forecasting/warning.

**Threats**:

**Disconnectedness**: The poor interaction between many National Hydrological Services and their respective National Meteorological Services often impedes effective and timely communication.

**Global Competition**: Every international organization involved in water is looking for funding from the same donors.

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***Commission for Atmospheric Sciences***

**Strengths:**

The value chain thinking: «Science for service» evaluated by its quality, relevance and impact, is a strength. The value chain is not stronger than its weakest element, and where R&D needs to invested.

Another strength is the user interactions which are inherent in «science for service» forces exploration of «What works». This often leads to monetary and social innovation.

The quality of NWP, climate projections and reanalysis, the observational basis and its incorporation into R&D and operations, has grown steadily over several decades, as judged for instance by the forecast quality of the 500hPa geopotential height of the ECMWF global model.

CAS has two main branches, WWRP and GAW. Both these branches work according to implementation plans written by the relevant science community and use the science for service value chain thinking. The WWRP structure addresses four challenges (high impact weather, predicting the water cycle, urbanization and emerging technologies), concentrates on the three legacy projects sub-seasonal to seasonal prediction (joint with WCRP), polar prediction in collaboration with WCRP and high Impact weather. WWRP has working groups and their main topics are nowcasting and mesoscale; tropical meteorology; predictability, dynamics and ensemble forecasting; data assimilation and observing systems; verification; and social and economic research.

In GAW there is a similar thinking with main objectives, underpinning projects and organizational structures, including a science advisory group on near real time applications and the IG3IS initiative (Integrated Global Greenhouse Gas Information System) in particular in demand after COP21 in Paris. The observational legacy of GAW is vital to the understanding of global atmospheric change (greenhouse gas and aerosol composition records over time and space).

**Weaknesses:**

The weaknesses inherent in CAS are shared with the rest of the WMO structures: The final goal is to provide adequate data and information on for instance all the issues in the central box of the figure below. To provide optimal services, all the surrounding boxes need to function and be balanced in close understanding with the needs and issues in the central box. This is the challenge for WMO, and WMO is not alone in this service field (see box in the upper right corner).

Another weakness is the complex mixture of ambition directions in WMO, se box in the lower right hand corner. Should WMO address the member states’ needs of today, or should it literally follow the letter of the WMO Convention? How can the needs of both developing MSs and more advanced MSs be satisfied simultaneously? How can WMO move from a “frontend” focus (forecaster’s role and capability) to a backend role, which is becoming more and more the requirement (expert data streams through a backend data node, followed by expert advice in periods). This is a challenge for WMO and for CAS.



**Opportunities :**

The Societal challenges that CAS has set for the next 10 years are a real opportunity for CAS.

* High Impact Weather and its socio-economic effects in the context of global change
* Water: Modelling and predicting the water cycle for improved DRR and resource management
* Integrated GHG Information System: Serving society and supporting policy
* Aerosols: Impacts on air quality, weather and climate
* Urbanization: Research and services for megacities and large urban complexes
* Evolving Technologies: Their impact on science and its use

Elements here are seamlessness in modelling across time and space scales and earth system components, together with a unified vision of super computing and sustainable, distributed, metadata governed, multioperational, IPR-conserving data management structure.

**Threats:**

Lack of willingness to realise that the gap between R&D and operations is closing rapidly.

* Lack of understanding that weather forecasts for the general public make up only 50% or less of the money income stream in modern NMHSs. Does this correspond to the strategic focus of most NMHSs including WMO?
* And that cost-benefit ratios can be very favourable for public (and private) sector investments in «weather-R&D»
* Lack of understanding that to enhance the benefit for each societal sector as well as for the NMHS, the relationship needs to be R&D driven, getting to know intimately the «weather» dependence of the sector, leading to evolution of postprocessing models, new observations or use of observations, and backend data stream delivery into sectoral decision systems.
* Lack of understanding that the traditional NMHS dominance is vanishing. NMHSs’ R&D needs to further build interdependencies with academia and private sector R&D and funding capabilities to feed the quality and variety of the «science to service»-value chains in the NMHSs. This is quite advanced in CAS. (46% of experts in WWRP from outside of NMHSs; 65% in GAW; many experts bring in teams or institutions).
* A threat to the sustainability of NMHSs is the dominance of routine, rule-driven operations static over long time periods with little new feedback to and from R&D (iterations) in their core activities, with an ever increasing gap to R&D (which also includes scientific programming, which may reside in IT-departments with too strict «entry rules» (IT fundamentalism in a geo-legacy structure)).
* Lack of ability to understand that the future GDPFS needs to cut across the «R&D to operations» gap.

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***Commission for Aviation Meteorology***

**Strengths:**

**AeM services critical to NMHSs**

**User focused and services oriented**

**Services highly regulated (compliance)**

**Leader in quality management, personnel competency**

**Highly efficient, but small structure**

**Close links with ICAO, especially conjoint intergovernmental meetings**

**Strong international networks of centres**

**Weaknesses:**

**Heavy workload:** Due to rapid SARPs update cycle and paradigm shift

**Few experts and overloaded meetings**

**Inadequate linkages to regions and providers outside NMHSs**

**Opportunities:**

**Air traffic growth**: Meteorology is a key enabler for air traffic management

**New service needs (GANP/ASBU)**: Impact / risk based, nowcast R&D enhancing services (e.g. AvRDP)

**Opportunities for innovation**: Electronic Flight Bag app, use of big data (downlink)

**Increasing role of CAeM with respect to ICAO:** Service development informed by science technique / guidance dev

**Threats:**

**Industry drive for lower costs**: Deregulation trend, competition from private providers

**Uncertainties in global / regional automation trend**

**Lack of governance / Internet Protocol rights of data and service of NMHSs**

**Increasing gaps in capacity development**

**Inadequate resources (especially within ICAO)**

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***Joint Commission for Oceanography and Marine Meteorology***

|  |  |
| --- | --- |
| **Strengths** | **Weaknesses** |
| * JCOMM ETMSS group to coordinate WWMIWS and liaise with IHO,IMO on Joint MSI provision.
* High compliance with SOLAS regulations within WWMIWS NMHS;
* Successful implementation of projects related to WWMIWS, such as Arctic MetArea’s.
* New relationships developed with NAVAREA issuing authorities as well as national authorities for the promulgation of MSI
* JCOMM ETSI group providing leadership on ice information service provision and development of new standards.
* Establishment of pilot projects to improve capability in coastal hazard warnings.
* Availability of global, regional and sub-regional centres to help enhance product quality.
* NMHSs own and operate the basic MET-Ocean observing systems according to international standards, which when exchanged, yield the information required for global, regional and national understanding of weather
* Well-established governance structures, and information sharing networks and protocols.
* Key partnerships in place
* With extremely limited resources providing excellent Met-Ocean services and coordinated Met-Ocean infrastructure where GOOS, GCOS and NWP requirements taken into account
* Extremely efficient and coordinated JCOMMOPS centre where all members and WMO benefit from
* CIFDP and WAVES successes
* Robust and long term historical Marine Climate Summaries Scheme (MCSS) for delayed mode Voluntary Observing Ship (VOS) data
* Modernization of MCDS well underway with the Marine Climate Data System (MCDS) to take into account additional sources of data
* Effective International Comprehensive Ocean-Atmosphere Data-Set (ICOADS) as a trusted and comprehensive source of historical marine meteorological data
* Effective World Ocean Database (WOD) as a trusted and comprehensive source of historical oceanographic data
* Efficient Global Data Assembly/Acquisition Centres (GDACs) for Argo, OceanSITEs, GOSUD, GTSPP etc. making data and metadata available in real-time and delayed mode
 | * Marine not part of the WMO Strategic Plan.
* No Marine National Focal Points to interact with capable countries and develop marine services beyond the WWMIWS MetArea NMHS.
* Static resourcing levels in WMO to support the increasing requirements from partners and stakeholders, and the activities of JCOMM.
* Not all NMHS have mandate or capability to provide marine activities for their countries coastline and citizens.
* Low funding of NMHSs from government and the development partners for development and maintenance of infrastructure, Met-Ocean observing systems, forecasting tools, staff competencies, and service delivery mechanisms;
* Low capacity of NMHSs to undertake the continuous modernization resulting from rapid advances in the science and technology;
* Limited recognition of the socio-economic value of NMHSs and their services
* Limited capacity to focus on facilitating and leveraging key partnerships
* Low visibility of WMO in providing authoritative voice on marine service matters and in supporting all marine NMHS members.
* Less ship time/financial resources for expanding and maintenance of Met—-Ocean infrastructure
* In-Situ Satelite data not well documented
* Poor Coordinated CD
 |
| **Opportunities** | **Threats** |
| * Increased need by industry for tailored services to address increasing vulnerability to marine and coastal hazard risks.
* With additional resources and focus on Marine in WMO one could develop products and services for marine industry and successful implement cost recovery this in turn may see NMHS invest more in Met-Ocean services
* Increased capabilities of weather and wave computer model guidance.
* Additional satellite provider on GMDSS may enable better coverage in polar areas, and potentially improve monitoring compliance for Issuing Services
* New ice information standards (now part of WMO No 558 and No 471) have been developed.
* Implementation of the WMO Quality Management Framework and Marine Forecaster Competencies in marine NMHS;
* UN focus on LDC, SIDS.
* Greater involvement of METAREA Coordinators and establishment of Marine National Focal Points in activities of the Experts Teams (ETSI and ETMSS).
* Defining a Marine GDPFS to coordinate service provision across a number of marine service frameworks.
* Existence of development partners and funding agencies as a potential source of resources;
* Growing awareness of the public and the decision makers on the value added of and growing demand for marine and coastal hazard services;
* Climate change is a high level political and developmental issue at national, regional and international levels;
* Existence of regional and sub-regional institutions to strengthen partnerships and coordination;
* New platforms such as marine Mammels, H F Radars and Gliders
 | * Additional satellite provider on GMDSS may present additional costs to Issuing Services.
* Expectation of IMO to commence routine provision of E-navigation services within WWMIWS.
* Continued lack of visibility and inadequate financial support from governments;
* Globalisation of meteorological data
* Increasing commoditisation of marine weather services.
* Poor service delivery by some NMHS, and increasing service provision capability by commercial meteorological companies.
* Globalization of weather issues through international media and research institutions without proper attention to national or local requirements;
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***Commission for Climatology***

**Strengths:**

**Clear and Unique Mandate:**  That is widely viewed both inside and outside WMO as being critical to societal and economic needs.

**Strong, volunteer, results-oriented culture:**  That focuses squarely on helping NMHS’s (see Annex 3).

**Weaknesses:**

**Extra-budgetary resources required for success of some projects:** For example, this year our team on national climate monitoring products will release software that will enable NMHS’s to monitor their climate every month. Routine climate monitoring will raise the visibility of the NMHS and educate the country’s population on how their climate is changing. But in order to get NMHS’s started will require training workshops be held in multiple places around the world.

**Opportunities:**

**Partnering arrangements with internal and external groups**: For example, our expert team on data rescue has members representing IEDRO (The International Data Rescue Organization, http://iedro.org/) and ACRE ([Atmospheric Circulation Reconstructions over the Earth](http://www.met-acre.org/), <http://www.met-acre.org/>). This allows the CCl team to coordinate a wide variety of projects, well beyond just WMO projects, through their international data rescue portal (<https://www.idare-portal.org/>) thereby avoiding duplication of effort and improving efficiency.

**Threats**:

**Limitations of a volunteer workforce**: Although volunteers have accomplished a great deal that has directly benefited NMHS’s, much of it is due to the results-oriented, NMHS-focused volunteer culture we have fostered over the last decade. The biggest threat to CCl, therefore, is potential merging with organizations with very different cultures, such as GCOS or WCRP. Creating a larger CCl also raises the potential for CCl to grow beyond what is manageable by part time volunteer leadership (see Annex 3).

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***Commission for Instruments and Methods of Observations***

**Note: In lieu of a conventional SWOT analysis, CIMO decided to utilize a document recently prepared by its Management Group for WIGOS (and presented at the joint PRA-PTC-2017 meeting) to characterize its strengths, weaknesses, opportunities and threats. As CIMO has a unique crosscutting role within WMO, it shares many characteristics with the other Commissions and has indicated that the synthesis of strengths and weaknesses appearing in the section entitled “Synthesis of Technical Commission SWOT Analyses” apply to it as well.**

**Future of environmental measurements**

**(a proposal from the CIMO MG to WIGOS)**

**Mission:**

Members achieve fit-for-purpose environmental measurements through appropriate standards and technologies.

**Vision:**

The WIGOS measurement community is the source of information on the suitability of measurements for specific environmental intelligence (applications).

* Clarifying the place of measurements in the environmental information chain.

**Desired Outcomes:**

1. The WIGOS measurement community is a cadre of the measurement experts in a WMO organizational structure that supports and promotes the gathering and dissemination of knowledge on the quality of relevant environmental measurements and how fit-for-purpose measurements are achieved.
2. Users and providers understand the importance of the measurement process in the environmental information chain.
3. Users and providers are committed to traceability of ECV measurements.
4. The potential quality and uncertainty of emerging measurements are documented in the CIMO Guide and reference material.

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

1. Collaborate effectively with all users and providers of measurements;
2. Develop and promote the implementation of good measurement practices;
3. Develop, and provide effective access to, standards and guidance material;
4. Coordinate the transition from new science and technology to operational implementation;
5. Characterize the traceability that can be achieved from emerging alternative technologies.

**Shaping the Vision and Mission**

Several new drivers are impacting on WMO and particularly WIGOS, including the opportunity and threats 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 principal 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 some expansion on the drivers and activities that should be pursued to achieve the desired outcomes. The following paragraphs address the latter request.

**Form of the Vision and Mission**

This vision and mission 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 effective measurements as one of the foundational elements 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 cadre of people 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 non-weather centric elements of environmental monitoring. 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 WIGOS and be the source of information on all measurement data streams.

**Overarching new and existing drivers**

Change is the only constant

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 measurements used by the environmental community are automated, from numerous sources made up of multiple component and processes, and a diverse range of measurement methods. Furthermore, it is now understood by many that meta data associated with a datum is a critical information component.

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, crowd sourcing, camera imagery). A potential substitute where traceability is not practical, is a combination of meta data and ancillary co-located 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 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 of analysis and information paths) heading in directions 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 assumptions rather than knowledge, largely because the data are only a datum 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 standardization of measurement through a number of Commissions and associated agencies make sense for the future? While the CIMO Guide provides a focal point on quantities and methods of measurement, the large number of Commissions tends to lead to well-intentioned duplication and may not be maximizing 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 their 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.

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, etc.).

**Strategic elements**

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

The current mode of providing focal points for communication between the Commissions and Programmes will continue, as will incorporation into the CIMO Guide chapters provided by JCOMM, CAS, CBS (satellite), space weather and other future contributing entities to WIGOS measurements. 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 should 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 expansion of the collaboration must be pursued with increased vigour.

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 processes of measurement are required to achieve a fit-for-purpose result; for example, incorporating aviation requirements and applications that will achieve fit-for-purpose results from 3rd party and crowd sourced data. These activities should be summarized 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 surface-based microwave technology advances have been rapid.

1. **Develop and promote the implementation of good 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; they are also essential in developing a common vocabulary across measurement disciplines. Promotion of these essential activities needs to be communicated to the highest levels within Members.

Regardless of whether the existing technical Commission structures remain or not it is essential that the principles and practice 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 if there is participation from a heterogeneous collection of measurement sub-communities (e.g. surface meteorology, air chemistry, marine, hydrology and space weather) as new technologies, both instrumental and algorithmic, used in one community 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 the use and dissemination of traceability in any new measurement stream or the merging of existing streams.

The provision of competencies for the processes of measurement must continue and be developed to incorporate an understanding of the fundamentals of measurement to senior leaders in NHMS. The dynamic nature of position rotation in NMHS can be lead to incorrect conclusions regarding organizational priority because of the use of assumptions rather than knowledge. While the focus in the past has been to provide a competency framework for the lower levels of NMHS with good outcomes, the focus in the future should insist on a basic level of understanding of what makes a measurement valuable for all organization levels within an NMHS and what is required to sustain fit-for-purpose operations and outputs.

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

The CIMO Guide, the International Cloud Atlas and other WIGOS documentation are dynamic documents that need to be updated as knowledge improves. IOM reports, 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 pathways from research to operations for new measurement outputs.

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 agile revision of the CIMO Guide 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. Specific guidance material needs to be developed to ensure that the significant benefits, including financial, that have accrued to environmental measurement community since the introduction of the ISO GUM as a key component of good measurement practise, are not lost because of the perceived complexities of a pure Bayesian approach (now preferred in the latest versions of the ISO GUM).

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. 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 must be progressed. Similarly, the standards associated with soil moisture and evaporation will need to be developed and propagated.

The positive effect of short and sharp 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 as the most recent example. 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. **Coordinate the transition from new science and technology to operational implementation**

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 trialled, including inviting external experts to examine the potential measurement methods for operational use. A clear gap at present is an examination of the value of melding in a measurement sense, for example of melding space and surface-based remote streams.

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

1. **Characterize the traceability that can be achieved from emerging alternative technologies**

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 and specific reports are ideal vehicles for dissemination to the measurement community, but meta data bases 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 Vihlo Vaisala Awards, outreach documentation of the Testbeds and Lead Centres, as well as measurement community TECO.

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**Annex 3**

**Volunteers**

**A Fundamental aspect of the Commissions**

Every single person on every WMO Technical Commission is working on a voluntary basis. Almost all get paid for their work, but by their home institution, not WMO.

**Strengths**

As essentially contributions in kind, the volunteer nature of the Commissions is a tremendous financial savings to WMO. It also results in a diverse make up of the Commissions, not only geographic and gender, but also NMHS’s, other government agencies, academia, and other non-governmental agencies.

**Weaknesses**

In order to expect a volunteer to apply his or her time and energy to address a problem, we need to make sure the work they engage in is a win/win/win:

a) A win for the individual. The results must contribute to his or her personal missions and help with their personal or professional development. For an academic, this may mean a peer-reviewed document at the end. For a member of an NMHS, this may mean raising their profiles within their home institutions. For all of them, it usually also means making the world a little better place to live as this is a personal driver for almost all Technical Commission volunteers.

b) A win for the agency paying the volunteer’s salary. For some NMHS’s this may mean capacity development where their employee learns and grows professionally while making this contribution. For some NMHS’s and academia, it may mean essentially bragging rights: That they can point to the accomplishments of the individual and his or her team with pride. That may require peer-review publications or it may just require raising the national or international visibility of their organizations.

c) A win for WMO and that Technical Commission in particular. What this includes varies with the Commission. But it usually involves making concrete contributions towards helping NMHS’s around the world do their jobs better and improving broad themes such as making air travel safer or making the Intergovernmental Panel of Climate Change Assessment Reports more accurately reflect the changes in climate going on throughout the world.

These put limits on the tasks we can ask a volunteer to undertake. It also means that we need the volunteers to guide the development of the precise topics they will undertake because only they can fully weigh these diverse factors. But more than that, it puts limits on how much we can ask an individual to undertake on a voluntary basis.

**Implications for Technical Commissions reorganizations**

This fundamental nature of the Commissions imposes constraints that, by and large, the Presidents of the Technical Commissions view as good:

1. The domains cannot be so large that a part-time volunteer President could not coordinate the work.

2. The domains cannot be so broad that they are beyond the scope of any one individual’s expertise. We need the leadership within each Technical Commission to be dedicated to championing that Commission’s work and they can only be expected to champion work within their areas of expertise as this is the domain they understand and think is important.

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 calibration report of laboratory. [↑](#footnote-ref-2)