WORLD METEOROLOGICAL ORGANIZATION

EXECUTIVE COUNCIL WG ON WIGOS-WIS
SUB-GROUP ON THE WMO INTEGRATED OBSERVING SYSTEMS (SG-WIGOS)

First Session

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LEVELS OF INTEGRATION OF WIGOS

Standardization of instruments and methods of observation (Instruments and Methods of Observation Level)

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Summary and Purpose of Document

This document provides basic information that should be taken into account when discussing the first level of integration of WIGOS.

ACTION PROPOSED

The session is invited to discuss and start the detailed elaboration of the three levels of integration of WIGOS including standard practices to be applied at the different levels of WIGOS integration process.

References: 1. Abridged final report of the EC-LX (WMO-No. 1032)
2. Final report of the first session of the EC WG WIGOS-WIS

Standardization of instruments and methods of observation
Instruments and methods of observation integration level

1. Introduction

1.1 As stated in Article 2 of the WMO Convention, WMO has a requirement to:

(a) Facilitate worldwide cooperation in the establishment of networks of stations for the making of meteorological observations as well as hydrological and other geophysical observations related to meteorology, and to promote the establishment and maintenance of centers charged with the provision of meteorological and related services;

(b) Promote the establishment and maintenance of systems for the rapid exchange of meteorological and related information;

(c) Promote standardization of meteorological and related observations and to ensure the uniform publication of observations and statistics;

(d) Further the application of meteorology to aviation, shipping, water problems, agriculture and other human activities;

(e) Promote activities in operational hydrology and to further close cooperation between Meteorological and Hydrological Services; and

(f) Encourage research and training in meteorology and, as appropriate, in related fields and to assist in coordinating the international aspects of such research and training.

1.2 The international standardization of meteorological instruments and related measurements and observations is seen as a precondition for accurate and reliable data sets. Moreover, the development of new sensors and instruments, including instruments that are inexpensive, durable and utilize new automated observing techniques must be goals of WIGOS and its constituents. As members of WIGOS it is essential for managers of national observing networks and instrument specialists to have a clear vision of WIGOS expectations and to be able to ensure effective operation and maintenance of their national networks.

1.3 The rate of technological change has been unprecedented, with wide-ranging implications for managers of observing networks, and for the development of new instruments and observing techniques. The addition of weak economic conditions will make it difficult to support costly upgrades of instruments and equipment and procurement of consumables. For its part, WMO will continue to explore ways and means of closely involving manufacturers of meteorological, hydrological, and geophysical instruments through the work of CIMO and its constituent partners in providing recommendations and guidelines concerning standardization of instruments and methods of observation as well as the interoperability of instruments and systems.

1.4 For WIGOS to reach its desired goals its Subgroup must work toward developing an optimal end-to-end system of systems which is sustainable and embraces the concepts of homogeneity, interoperability, and compatibility of observations from its constituent observing systems. The approach used to reach its desired result should be based on sound guidance and studies; resulting in agreed to recommendations on instrument standards and methods of observation including instrument testing, calibration, maintenance, traceability, and inter-comparison.

2. Standardization

2.1 Standardization is the process of developing and agreeing upon technical standards. A standard is a document that establishes uniform engineering or technical specifications, criteria, methods, processes, or practices. Some standards are mandatory while others may be voluntary.

2.2 Standards can be:

- De facto standards are those which are followed by informal convention or dominant usage.

- De jure standards are those which are part of legally binding contracts, laws or regulations.
- Voluntary standards are those which are published and available for consideration and use.

2.3 Technical standards can be viewed as a formal means used for calibration.

2.4 Reference Standards and certified reference materials have an assigned value through direct comparison with an accepted reference base.

2.5 Technical standards may be developed privately or unilaterally, for example by a regulatory body. Standards can also be developed by groups such as trade unions, and trade associations. Standards organizations often have more diverse input and usually develop voluntary standards; these might become mandatory for example if adopted by a government.

2.6 Primary standards are usually under the jurisdiction of a national standards body. Secondary, tertiary, check standards and standard materials may be used for reference in a meteorological and other related system. A key requirement in this case is traceability, an unbroken paper trail of calibrations back to the primary standard.

2.7 Some standards are derived from the result of accepted best practices. A Best Practice is an idea asserting that there is a technique, process, activity, incentive or reward that is more effective at delivering a particular outcome than any other technique, method, process, etc. The idea is that with proper processes, checks, and testing, a desired outcome can be delivered with fewer problems and unforeseen complications. Best practices can also be defined as the most efficient and effective way of accomplishing a task, based on repeatable procedures that have proven themselves over time for large numbers of people.

2.8 Despite the need to improve on processes as times change and technology evolves; Best Practice is considered by some as a term used to describe the process of developing and following a standard way of doing things that organizations can use as standards or policy.

2.9 One must be aware the term “Best Practices” can convey different thoughts to the user. A best practice can convey a thought of Finality, Obedience, Authority, and Universality; implying that there is a final answer to the matter in question. The term implies that some recognized authority has come up with a list, and since they are ‘Best Practices’, the authority is the best one in every way and recognized as such. The term also suggests that the practices are ‘Best’ for every situation that involves the task, product or goal involved.

2.10 On the other hand, “Better Practices” can imply continuous quality improvement. It engages the recipient to think about how to apply the practices to his or her specific situation. It encourages the recipient to seek better ways, which may even lead to adjusting the suggested practice to make it even better. It suggests that all of us together can come up with something better than any one of us can arrive at individually, and places authority in the community. The term may also imply that the better practice is not universal and is situation specific. Many of the commissions and programs within WIGOS have documented existing best practices when standards are difficult to develop or achieve consensus.

3. Integration

3.1 A system is an aggregation of subsystems cooperating so that the system is able to deliver the desired over-arching functionality. System integration involves integrating existing and often disparate subsystems. Subsystems will have interfaces. Integration involves joining the subsystems together by their interfaces. If the interfaces don’t directly interlock, they can provide the required mappings. System integration is about determining the appropriate interfaces.

3.2 System integration is also about value-adding to the system, capabilities that are possible because of interactions between various subsystems.

3.3 Methods of Integration:

- *Vertical Integration* is process of integrating subsystems according to their functionality. The benefit of this method is that the integration is performed fast and involving only the necessary vendors, therefore, this method is cheaper in short term. On the other hand, cost-of-ownership can be substantially higher than seen in other methods, since in the case of new or enhanced functionality, the only possible way to implement would be by implementing another silo. Reusing subsystems to create functionality is not possible under this integration method.

- *Star Integration*, the process of integration of the systems where each system is interconnected to each of the remaining subsystems. The cost of this method of integration can vary from the interfaces which subsystems are exporting. In the case in which the subsystems are exporting vendor-specific interfaces, the integration cost can substantially rise. Time and costs needed to integrate the systems increases exponentially by adding additional subsystems. From the perspective of implementing new features, this method is preferable since provides extreme flexibility to reuse the functionalities from existing subsystem into new system.

- *Horizontal Integration* is a method in which a specialized subsystem (BUS) is added to the system which is dedicated to communicate with other subsystems. This allows cutting the number of connections (interfaces) to only one per subsystem which will connect directly to the BUS. The BUS is capable to translate the interface into another interface. This allows cutting the costs of integration and provides greater flexibility.

3.4 The WIGOS Subgroup will need to examine the various approaches to integration and determine which process will best meet the goals of WIGOS.

4. Interoperability

4.1 The practice and purpose of monitoring has changed considerably over the past 50 years. The increase in the number, scale, and diversity of today's systems has evolved to a point where successful operation often requires a number of steps between measurement and the end user.

4.2 Current trends suggest an evolution from passive operational observing, where after instrument deployment the data are simply collected, archived, and displayed, to active research or societal driven observing, which requires a form of dynamic feedback. Such an approach better supports the need for long-term, extreme short term, and large scale (global) monitoring in order to better understand things as trends in climate change, the propagation of storms and tsunamis. For WIGOS to fulfill these needs it will need to deploy or integrate and sustain thousands of instrument/systems throughout the globe. Systems required for such a capability are incredibly complex.

4.3 Interoperability requires the automation of some tasks due to sheer numbers and complexity of instruments and instrument suites, human resource issues and the need for a certain level of autonomous operation for such things as system maintenance, diagnostics, event response, and coordination between instruments.

4.4 For complete interoperability, instruments that use different methods to measure the same variables should return identical answers. This should be achievable without disrupting other elements of interoperability, requiring hardware modification, or the manual installation of instrument software. This approach will require a significant outlay of resources which may impact the progress of WIGOS implementation.

4.5 The WIGOS Subgroup will need to examine the various approaches to integration and then determine whether integration or interoperability would best serve WIGOS in meeting its goals.

5. Relationship of WIGOS to the Global System of Systems (GEOSS)?

5.1 WIGOS will be one of the many systems which will be incorporated into the Global Earth Observing System of Systems (GEOSS). The member companies, government agencies and universities that make up the GEOSS Open Geospatial Consortium (OGC) are working to create open standards for sharing geospatial data and services across different systems and platforms worldwide. It is this interoperability that will be instrumental in making (GEOSS) a reality and WIGOS needs to follow a similar path.

5.2 The Earth itself is viewed as an integrated system, and all the processes that influence its conditions, whether ecological, biological, climatologically or geological, are linked. So it makes sense that interoperability standards should be developed to make it easy for practitioners from any discipline to access the multiple datasets created from space, air, land and ocean-based earth observing systems.

5.3 According to GEOSS/GEO information, there are a vast number of data buoys floating in the ocean, tens of thousands of land-based environmental stations, and more than 50 environmental satellites orbiting in space. All this technology is creating millions of data sets and most of these are incompatible, making integrated analyses impossible. By solving the issues related to integration and interoperability on a global scale, more accurate monitoring of changes in land use, air quality and other environmental parameters. Through the development of a standardized process of for the implementation of interoperability we will be able to collect, analyze and understand more data from around the globe than ever before and do it all in real-time or near real-time.

5.4 The Subgroup needs to define WIGOS roles and responsibilities within the larger GEOSS Framework.

6. What needs to be done?

6.1 As the Subgroup begins examining instruments, systems and networks which will make up WIGOS, it will likely find great disparity between instrument performances, instrument siting, and data quality. This does not mean that the data being provided is necessarily bad, but that the data is likely of a different quality level. It must be noted that networks are constructed to meet specific purposes and needs of the network operator and the various user communities. As WIGOS is constructed the Subgroup may have to change how it views each of the systems and networks providing data. To gain a firm understanding of each instrument, system, and network we will have to identify the physical and logical attributes of the hardware and data produced by it. The Subgroup will need to address:

- o What does this instrument do? (Data products)
- o Where is it located? (physical location and ownership)
- o How does it work? (functional model of the hardware)
- o How do we use it? (access as network service)

6.2 In addition to answering the questions above, we will need to document instrument/system specific metadata, as well as, the hardware life-cycle:

- o Instrument/network siting,
- o Calibration, validation, faults, and maintenance.

6.3 All of the bullets above lead to acquiring a better knowledge of the instrument or system. By collecting and making such knowledge available to the end user it then becomes the responsibility of the end user to determine whether a particular segment of the greater WIGOS monitoring system is suitable for their use; this is of particular importance when one considers the variety of divergent disciplines requiring similar datasets. This approach places the burden on the end user and not the network operator, allowing the network to continue to operate without having to unnecessarily upgrade their instruments or systems when such upgrades are not feasible due to budgetary constraints.

6.4 Such an approach raises the question as to whether WIGOS integration would require adopting some form of classification ranging from high quality research level data, required in monitoring climate change to lesser quality data sometimes used in short fuse events where data is sparse. These considerations become extremely important as the surrounding environment changes due to shifts in population and other naturally occurring changes. This problem has been noted in efforts to establish national reference networks; the lack of pristine monitoring locations to address difficult issues such as climate change. In addition there is lack of siting standards and/or divergent standards across the diverse disciplines which make up WIGOS.

6.5 To resolve these and other problems the WIGOS Subgroup needs to set observational goals for WIGOS. The following goals have been established by past working groups looking at the issues of enabling integration or interoperability:

- Develop a summary the existing technologies which make up the WIGOS observing/monitoring capability;
- Identify what is needed for instruments/systems to achieve instrument integration and/or interoperability;
- Identify challenges and barriers to WIGOS achieving instrument/system integration and/or interoperability, and
- Develop actions that will overcome identified challenges.

6.6 The following are recommended actions on which past working groups members could agree. The WIGOS Subgroup should consider these recommendations as members review the WIGOS Implementation Plan:

- Prepare a list of recommendations for enabling instrument integration or interoperability and to be shared with instrument developers;
- Develop a recommendation for funding sources to achieve instrument integration and/or interoperability.
- Within each element of the WIGOS program managers should be identified and made to understand that milestones for achieving instrument integration and/or interoperability must include the defining and selection of a methodology for uniquely identifying each instrument, the development of a common protocol for automatic instrument discovery, develop an agreement on uniform methods for measurements (standards), the enablement of end user controlled power cycling, and implementation of a registry component for instrument identifiers and attributes.
- The need for establishing a global observing body that addresses standards for metadata, commands, protocols, processes, exclusivity, and naming authorities.

7. Barriers and Challenges

7.1 The WIGOS Subgroup must consider developing a list and prioritize the list of barriers to instrument integration and/or interoperability. Previous working groups have attempted to address these issues from two major viewpoints, operational and research and the WIGOS Subgroup will have to address its priorities in a similar fashion. The following obstacles were given a high priority and included the lack of:

- *A registry for instruments identification and attributes.* Currently there is no mechanism in place to require or provide accommodations for the registration of an instrument and its associated metadata.
- *Stakeholder engagement,* If only a handful of stakeholders met and tried to address the issue on their own, a number of potentially effective strategies may develop, but the implementation of these ideas across all sectors would be difficult to achieve, and

- o *Funding,* in many arenas there is a lack of funding for meeting even the most basic of requirements that would help even a community small of providers. For example, the replacement/upgrade of analog instruments would require significant up-front costs.

7.2 Additional high priority obstacles from an operational perspective:

- o No standard schema has been established for defining the structure of data and metadata.
- o There is no well-defined discovery process for resolving basic power and communication issues.
- o A significant commitment of time will be required in order to develop instrument standards and to resolve differences in current standards.
- o No standard approach exists for overcoming legacy issues such as analog instruments and manual observations.
- o There is a tremendous disparity in user requirements.

8. Conclusions:

8.1 The WIGOS Subgroup has many formidable challenges it must address in facilitating the implementation of WIGOS. To meet these challenges the Subgroup must initially:

- o Define what the various elements of WIGOS are currently doing so it can identify how it might be better accomplished.
- o Define, understand and support WIGOS constituent requirements and needs to address the broad range of user needs, monitoring system requirements, and sensor requirements.
- o Promote effective communication between WIGOS constituents.
- o Identify current and potential partners, the processes they embrace and the data and products produced.
- o Identify and eliminate redundant processes and data based on spatial and temporal requirements.
- o Conduct planning of improvements which should be cost effective.
- o Define the WIGOS monitoring system concept accounting for end-user requirements, monitoring system requirements, and sensor requirements.