World Meteorological Organization

Commission for Basic Systems

Technical Conference

Geneva, Switzerland, 26 - 29 March, 2018

CBS TECO 2018/Inf. 5(1)

Submitted by:
Chair OPAG ISS

9.Mar.2018

DRAFT 1

IMPLEMENTATION OF WIS 2.0

(Submitted by Chair OPAG ISS)

SUMMARY OF DOCUMENT

The document contains the March 2018 draft of the approach to implementing WIS 2.0.

Draft WIS 2.0 implementation approach

INTRODUCTION

The WMO Information System (WIS) 2.0 strategy[1] was endorsed by Recommendation 35 (CBS-16) and subsequently endorsed by Resolution 8 (EC-69). Resolution 20 (Cg-17decided that the Commission for Basic Systems (CBS) is responsible for leading the technical implementation and operation of WIS.

This paper provides a management-level overview of WIS 2.0 and the proposed approach for its implementation– including timescales and risks. While seeking to be informative, this paper does not provide the information on the detailed activities necessary to establish a fully operational updated WMO Information System by 2025. Further documentation will be developed.

WHAT IS WIS?

The WMO Information System (WIS) connects demand for authoritative weather, water and climate information with supply from approved Centres. WIS is intended to support all WMO programmes and all participants in the "global weather enterprise" – NMHS, wider government, non-governmental organisations (NGO), academia, research institutions, private sector, and citizens.

WIS enables discovery of, and access to, authoritative meteorological and hydrological data, and supports the collection of data and its exchange between WMO Centres and their users. WIS provides a catalogue (the "WIS Catalogue") that describes the data and products available within WMO and also incorporates the Global Telecommunication System (GTS), that is operated by national meteorological and hydrological services (NMHS) and collaborating organisations for routine collection and dissemination of time- and operation-critical data and products.

Please refer to Annex 1: A short introduction to the WMO Information System (WIS) and the Global Telecommunication System (GTS) for a more in-depth introduction to WIS.

WHY WIS NEEDS CHANGING

WIS continues to be necessary to support the WMO community: data is an ineffable connection between every Member of WMO and is the essential commodity that we each need to do our work.

Yet WIS has not met all of its aspirations – in part due to the focus on the World Weather Watch (WWW) programme. Data exchanged using the GTS in support of WWW are largely invisible or inaccessible to all but institutional NMHS users. Discovery of data through WIS is far from easy; the WIS Catalogue is disproportionately populated by tens of thousands of records describing GTS bulletins, and GISCs lack effective filtering in their search offering. Even if data matching a user's needs can be found, the majority of users are frustrated by a lack of direct, Web-based access to those data. Where Members provide Web-services to access data, these are rarely registered within WIS. In summary, when compared to its GTS predecessor, WIS has neither significantly improved the discovery nor accessibility of weather, water and climate information.

[1] http://wis.wmo.int/WIS2

Consequently, the value of WIS over and above the GTS is not universally understood, leading to poor adoption within the WMO community.

The UN global agendas[2] on sustainable development, climate change and disaster risk reduction are all dependent upon actionable, accessible and authoritative weather, water and climate information.

The draft WMO Strategic Plan (2020-2023) outlines the long term goals and strategic objectives for WMO. Many of these (listed in Annex 2: WMO long term goals and strategic objectives relating to data and information) relate to the accessibility and use of data and information. Furthermore, the draft Plan states that: "*Technological advances and the increasing demand for more and more diverse services from increasingly sophisticated and capable users changes rapidly the service delivery and business models in many parts of the world. Trends like 'big data' and 'crowd sourcing', the appearance of commercial observing networks, data and service providers, and the affordability of digital technology are game changers that require rapid adaptation and changing behaviours from NMHSs and the private sector.*"

The CBS-led review on emerging data issues (CBSLR-EDI) commissioned by Cg-17 identifies that cloud computing, Web services, data analytics, machine learning and other technologies present new operating concepts that will improve operational efficiency, information sharing and service delivery, and enable users to more effectively exploit data. While a full discussion of these technology trends and the associated benefits arising from their use is not in the scope of this document, readers should note that WIS 2.0 strategy is well aligned with CBSLREDI findings.

In summary, WIS needs to change because:

(1) Weather, water and climate data and information must be made more easily discoverable and accessible to meet many of WMOs strategic objectives and enable WMO to effectively contribute to the UN global agendas; and

(2) Technology advances are leading to massive increases in data volumes and complexity for which many Members are ill-prepared, changing the way in which users seek to consume and use data, and provide opportunities to improve operational efficiency.

WIS 2.0 TARGET

Vision statement

WIS 2.0 is a collaborative system of systems using Web-architecture and open standards to provide simple, timely and seamless sharing of trusted weather, water and climate data and information through services.

This vision statement is described in further in Annex 3: WIS 2.0 vision statement.

[2] 2030 Agenda for Sustainable Development, the Paris Agreement on climate change and the Sendai Framework for Disaster Risk Reduction.

Operating model

The functions of WIS, as defined in the Manual on WIS (WMO-No. 1060), remain largely unchanged[3] – it is the manner in which those functions are delivered which is changing.

WIS remains a 'system of systems' whereby centres operated by Members and partner organizations that provide the services, data and information required to meet the needs of the WMO community are categorized as National Centres (NC) or Data Collection and Production Centres (DCPC).

NCs and DCPCs will still be required to publish descriptions, or metadata, about their services and data for inclusion in the WIS Catalogue. WIS 2.0 will provide a clear and simple process for registering services and data. The format and encoding of this discovery metadata will be reviewed during the WIS 2.0 implementation.

Nevertheless WIS 2.0 embodies a fundamental shift in the approach used for data sharing: from data-oriented GTS distribution to service-oriented access via the Web.

Services may include (among others) simple bulk-download of a complete dataset, real-time data or notification streams to which users can subscribe, Web-based Application Program Interfaces (API) with query or processing capabilities, or hosted data-management and processing platforms for bespoke product generation. Many NMHSs have already adopted (or are planning to adopt) these approaches to meet their national mandates or WMO programme needs.

Global Information System Centres (GISC) will continue to provide the core services required to coordinate the WMO Information System:

- providing access to a portal and catalogue within which Member's services and associated data can be discovered;
- operating the procedures for registering Member's services, and;
- monitoring the operation of the WIS and its components.

With the retirement of legacy message switching operations, GISCs will also take an increasing role in coordinating the real-time distribution of data.

GISCs will continue to work with affiliated NCs and DCPCs to enable them to participate effectively within WIS, in providing services and in leveraging the services provided by others. Within WIS 2.0, the role of a GISC will have a much greater focus on capacity building and coordination within its area of responsibility.

Real-time distribution of data and products between centres will continue – albeit using different mechanisms. Minimal impact to core operations of NMHS is expected.

Key goals for WIS 2.0 and supporting architecture concepts

The evolution of WIS, through which authoritative weather, water and climate information is made available and Members collectively harness advancements in technology, will support the strategic objectives of both WMO and Members.

[3] The WIS Functional Architecture will be updated in respect of WIS 2.0; the functional changes will be clearly identified.

Table 1 presents the key goals of WIS 2.0 and their supporting architecture concepts. Further details on each concept are provided in annexes.

Key goal	Supporting architecture concept
A. Increase the discoverability and accessibility of authoritative weather, water and climate data and information beyond the traditional institutional NMHS user base to include wider government, NGOs, academia, research institutions, private sector and citizens.	WIS 2.0 will focus on providing access to authoritative weather, water and climate data and information via the Web. WIS 2.0 takes a 'service-oriented' approach to providing access to data and information. Users, whether humans or software agents, interact with data and information through services: whether to view, download or invoke some other process. Service providers should publish the descriptions of their service(s) and data holdings (i.e. metadata) for ingestion into others' catalogues and for indexing by commercial search engines. See Annex 4: Web-centric
	WIS 2.0 will comprise of services contributed by Members and cooperating international organisations (WIS 2.0 will be an 'ecosystem' of services). WIS 2.0 will promote the use of open standards for data exchange – particularly from the Internet Engineering Task Force (IETF), the International Organization for Standardization (ISO), the World Wide Web Consortium (W3C) and the Open Geospatial Consortium (OGC). WIS 2.0 will support a wide-range of commonly used open standards, thereby enabling Members to leverage investments in data sharing solutions that are designed to meet national or WMO programme needs. See Annex 5: Ecosystem approach

Key goal	Supporting architecture concept
B. Ensure that the WMO community is equipped to derive benefit from the explosion in data volumes resulting from continued investment in earth-system modelling and observing systems.	Adoption of cloud technologies is an essential response to the challenge of Big Data. WIS Centres are encouraged to assess the use of cloud technologies when implementing services in WIS 2.0 to support wide-spread exploitation of data and information by all Members. WIS 2.0 will not provide cloud hosting as a core service – nor will WMO recommend a specific solution or commercial vendor. Use of cloud, and the choice of implementation, is a local decision for each WIS Centre. WIS 2.0 Core services are likely to use cloud technologies to enable the delivery of globally scalable shared services. Guidance material on selection and use of cloud technologies will be provided. See Annex 6: Into the clouds
C. Cost reduction for WIS Centres from retirement of the legacy systems and infrastructure, and consolidation of how core WIS functions are provided.	Where service-levels can continue to be met, replace private networks with Internet connections for GTS network links. Adopt commodity, open standard, messaging solutions for real-time data distribution. Cease operationally intensive message switching activities. See Annex 7: Real-time data distribution

Key goal	Supporting architecture concept
	WIS 2.0 will provide a consolidated WIS catalogue and real-time data cache within a cloud environment, plus centralised Web-services (e.g. search, registration etc.) that each GISC can integrate into locale-specific portals for particular user communities. These components would be designed to meet service level requirements (including availability and request latency) and likely implemented as multiple, redundant systems . Synchronisation of data and metadata between GISCs will no longer be necessary. Real-time data distribution will be incorporated as an additional core function managed by GISCs. Costs from operating the shared service will be distributed among GISCs. See Annex 8: GISC infrastructure consolidation
D. Improve access to data and services in developing countries and, through regional and global cooperation, strengthen the capacity of Members to provide meteorological, hydrological, marine and climate services.	Goal D is not directly supported by an architecture concept – although adoption of cloud technologies may help. Please refer to Outreach, capacity building and pilot projects for further information on how Goal D is supported.

Table 1: mapping between WIS 2.0 goals and architecture concepts

A measurement framework will be developed as part of the implementation plan to enable the delivery of these goals to be assessed.

Policy landscape

Global sharing of data was the fundamental basis for the establishment of the World Weather Watch (WWW) and has been articulated more specifically over the last 20-years in Resolutions 40 (Cg-XII), 25 (Cg-XIII) and 60 (Cg-17). This free and open approach to data sharing is a unique international hallmark of WMO and is the envy of many other global organisations.

WIS 2.0 will continue to promote free and open data sharing, encouraging the release of data and information in accordance with Resolutions 40, 25 and 60, or other open data licenses as appropriate.

Data and services published within WIS 2.0 are considered authoritative: as is existing technical regulations, centres that are registered as WIS centres must be endorsed by the Permanent Representative (PR) of the Member country or territory within which they are located. Furthermore, WIS centres will subject to initial and periodic audit to demonstrate

compliance with the new provisions for Quality Management, WMO-No. 49 Volume I. Part VII – as amended in Resolution 20 (EC-69).

Where the criteria are met, registration as a WIS centre should be open to all participants in the global weather enterprise: NMHS and other government agencies, non-governmental organisations (NGO), academia, research institutions and private sector organisations.

WIS 2.0 will require WIS centres to comply with the new provisions on data and information management – WIS Part C: Information Management.

In addition to data policy, WIS 2.0 will provide guidance on service usage policy and cost recovery. Issues to consider include:

- Who can use a service and for which purpose(s)?
- Can licensing restrictions be applied to the outputs from the service?
- Is it appropriate to charge for the use of the service or apply usage quotas?

In accordance with emerging principles from WMO, WIS 2.0 should provide a level playing field for both public and private sectors to operate, with sufficient flexibility to accommodate different business models and data licensing approaches.

WIS 2.0 will support a wide-range of open-standards commonly used for data exchange. Where necessary, sub-communities may choose to restrict the set open standards that their WIS centres and applications support. These 'conventions' will improve interoperability within their community (data and services will be more uniform) at the expense of making it more difficult to participate because specific standards or standards-profiles must be supported. Sub-communities must clearly publish details of such additional restrictions. For example, WIS centres participating in the World Weather Watch may restrict their choice of data formats to those listed in the Manual on Codes (WMO-No. 306).

WIS 2.0 IMPLEMENTATION PROGRAMME

Governance and programme management

The WIS 2.0 implementation programme will adopt an industry-recognised approach to project, programme and portfolio management (P3M), establishing the necessary structures and accountabilities to ensure effective governance of the WIS 2.0 implementation.

Building on experience from the original implementation of WIS, a Project Office with a full-time programme manager should be established within the Secretariat to coordinate the WIS 2.0 implementation and support all WIS 2.0 implementation activities.

The Project Office will:

- ensure that WIS 2.0 is aligned with the long-term goals and strategic objectives outlines in the WMO Strategic Plan;
- have responsibility for developing and monitoring the WIS benefits framework;
- support all WIS 2.0 implementation activities, including coordination with ITT-WIS, participants to the programme and contributing members;

- ensure that the resource requirements to support the implementation are understood by Members, and considered in the WMO budgeting and planning process; and

- coordinate WIS 2.0 implementation with the different WMO Programmes and the WMO Secretariat department.

The Intercommission Task Team on WIS (ITT-WIS), that provides a channel for technical commission input into the operation and development of WIS, will help the Implementation Coordination Team of the Open Programme Area Group on Information Systems and Services (ICT-ISS) manage the WIS 2.0 implementation, advising on the interests of the Regional Associations and Technical Commissions. This will include the support required for capacity development and implementation, as well as providing oversight of the WIS 2.0 implementation to ensure that benefits are delivered as planned. ITT-WIS will also gather input from key organisations that are not affiliated to WMO.

Implementation activities will be organised into coherent tranches of work. Each tranche of will be organised to minimise interdependencies between tranches, to support phased migration toward WIS 2.0, and enable early validation and testing prior to widespread rollout. Where possible, work will be organised to support release of interim benefits.

Implementation timescales

WIS 2.0 implementation is planned to start in 2019 – following approval of the implementation plan by Cg-18. Implementation is expected to be complete, and WIS 2.0 'fully operational', in 2025.

The Design and development phase will continue until at least the end of 2019 in order to consolidate project participants and contributing stakeholders.

Initial implementation activities will start in mid-2019 with the Cache in the Cloud (CitC) project that can be considered as the first step in this implementation plan. By facilitating the exchange of data and metadata between GISCs, this will enable the creation of a cloud based central data repository, one of the WIS 2.0 core services (i.e. the cache service).

By 2025, the core services required for the operation of WIS (portal, catalogue, cache, real-time data distribution, notification / messaging and monitoring) will be fully operational. At this time, legacy message switching operations will be decommissioned – the GTS as it works today will be phased out.

The WIS 2.0 implementation plan will help Members understand when the transition to WIS 2.0 begins, when services and capability are available for use, when the transition period is expected to be complete.

Readers should note that WIS 2.0 implementation is expected to be evolutionary. As capability is made available, Members will be able to begin their migration: Members do not need to wait until 2025 before beginning their migration to WIS 2.0. Furthermore, some elements of the WIS 2.0 architecture (e.g. use of Internet for GTS links, deployment of Web-services, use of cloud environments) are compatible with the current WIS technical regulations. Members are encouraged to plan implementation of these aspects on timescales that suit their local needs. The WIS 2.0 implementation programme, in cooperation with the Regional Associations, will incorporate such changes into the programme plan.

Key Activities for WIS 2.0 implementation

Standards, regulation and guidance

The technologies required to implement WIS 2.0 are understood. However, given that technologies, standards, protocols, and the ecosystem itself, are evolving, the design of WIS 2.0 will, wherever possible, be modular to allow improvements resulting from new approaches to be incorporated. Work is required to identify the standards[4] and define best practices that will best enable interoperability within the WIS 2.0 ecosystem while ensuring adequate cyber security measures are in place. Initial focus will be given to the most commonly used data exchange standards and implementation patterns, and to those relating to the Core services of WIS 2.0. As the ecosystem grows and new approaches are adopted, good practices will be catalogued and published as guidance in an aim to harmonise implementation approaches.

Given that use of cloud-environments will be new to many Members, developing policies relating to use of cloud environments, and the access to and usage of services deployed therein, is considered to be a priority. Guidance will be shared regarding how to users may exploit cloud-hosted services effectively, as these may present quite a different operational model that may not be obvious to all Members.

Complementing those technical aspects, guidance material will be developed regarding data licensing, service usage, and cost recovery. Initial deliverables will include an assessment of the existing WMO policy landscape, to determine what is already in place and what is missing. Where gaps are identified, the WIS 2.0 implementation programme will work through CBS to determine the appropriate approach. Any policy recommendations must be sensitive to the emerging outcomes from the debate on public-private engagement.

Updates to Technical Regulation and Guides will also be required – noting specifically the need to update the WIS Functional Architecture and review the audit and certification criteria for WIS Centres.

As regulation, policies and guidance are developed and published, the skills gap between current WIS implementation and WIS 2.0 will be assessed. This information will be shared with Members and Regional Training Centres so that the training requirements to support WIS 2.0 adoption can be determined.

CBS Expert Teams will lead these tasks, coordinating with regional associations to collate best practices employed by Members.

Core services

A minimum set of services that are required for WIS 2.0 to be considered viable, known as "core services," will include:

- Portal and catalogue – enabling users to discover data, information and services, and for WIS Centres to manage information about their service contributions;
- Real-time data, notifications / messaging and a cache of globally distributed data;
- Monitoring of WIS ecosystem and its constituent services; and
- Identity management, authentication and access control.

[4] WIS 2.0 will promote the use of open standards for data exchange, e.g. from IETF, W3C and OGC.

Design of these core services will be led by CBS Expert teams in collaboration with the Project Office and relevant WIS Centres – particularly GISCs. Implementation will be the responsibility of WIS Centres; once again, with the GISCs expected to provide the majority of effort.

Where existing capability is to be phased out or replaced, parallel running of old and new capability will be used to reduce disruption to operations; enabling Members to switch at a mutually convenient time. Switch over periods will be communicated well in advance, to allow Members time for their planning. Furthermore, all services will initially be deployed in a 'pre-operational' mode to allow Members to identify issues and to test the functions in accordance with the acceptance test criteria defined by the WIS 2.0 Project Office.

Portal, catalogue and monitoring

The WIS Portal and Catalogue will be redesigned and implemented as a shared service, hosted within a cloud environment. Cloud hosting is anticipated to provide the elastic scalability and global presence required to meet the needs of Members in all regions. The shared service will be implemented in a way that avoids single points of failure.

Re-development of the WIS Portal and Catalogue, along with the necessary services to monitor the health of WIS, will be led by the GISCs (coordinated through CBS Task Team on GISCs) with guidance from CBS Expert Teams. The activity will include development of the management and cost-allocation models for the shared service.

Refactoring the WIS Portal and Catalogue for cloud hosting presents an opportunity to review the portal and catalogue functions; e.g. user experience, metadata management and collection, service registration etc. Expert review has indicated that there is a significant overlap between WIS requirements and those of other data exchange ecosystems – particularly the Global Earth Observing System of Systems[5] (GEOSS) developed by the Group on Earth Observations (GEO).

The WIS 2.0 implementation will leverage relevant industry best-practice in redeveloping the WIS Portal and Catalogue. Given the strong alignment in goals and vision of WIS 2.0 and GEOSS, the WIS 2.0 implementation programme will work with the GEOSS Common Infrastructure (GCI) Operations Team to assess reuse of GCI solutions for WIS. If deemed mutually beneficial, a shared technical roadmap will be developed enabling WIS and GEOSS to share future solution development costs and for both to benefit from a wider pool of engineering talent.

Readers should note that WIS will remain a distinct entity from GEOSS and will continue to operate independent infrastructure to meet the operational needs of the WMO community.

Real-time data distribution, notifications / messaging and cache

Implementation of the real-time data distribution service using open standard, commodity message technology will build on the work of the existing Cache in the Cloud (CitC) project being led by CBS in collaboration with GISC operators.

CitC Intial Phase, expected to be operational in 2021, will connect GISCs to a cloud-hosted cache service (for globally distributed data) using the protocols specified in existing technical regulation. This initial phase will determine how to provision and implement cloud-hosted shared services. CitC Evolution Phase (2021 onward) will add new standards-based messaging protocols and extend connectivity to all WIS Centres. This new capability will form the basis of the real-time data distribution service, and will incorporate both messaging / notification and a

[5] https://www.earthobservations.org/geoss.php

persistent cache that is required to meet the WIS functional requirements for delayed access to real-time data.

The transitional phase, where GTS point to point circuits will be gradually replaced by Internet-based communications, should be planned and implemented by the Regional Associations as owners of the regional telecommunications networks, supported by CBS as necessary with coordination being provided by the WIS 2.0 Project Office.

Once the real-time data distribution service has been approved as operational, the WIS 2.0 implementation programme, working closely with the Regional Associations, will begin to migrate WIS Centres from legacy message switching to the new service. Given that real-time data distribution is an essential operation for many WIS Centres, migration will be carefully planned and communicated to minimise disruption. A selection of WIS Centres will be invited to participate in a commissioning phase for the new data distribution service to identify and resolve any unforeseen issues.

The WIS 2.0 implementation programme anticipates a period where legacy messaging switching is run in parallel with the new data distribution service. The legacy point-to-point messaging switching infrastructure will be decommissioned from 2025 onwards. Options such as providing a limited-duration gateway between existing message switching systems and the new data distribution system may be considered where resource constraints impede timely migration.

Finally, in an effort to streamline the migration and reduce the impact of change to Members, the WIS 2.0 implementation programme will seek support from vendors of message switching systems (through HMEI) to implement support for the new data distribution service within their products.

Ecosystem development

Three of the architectural concepts that WIS 2.0 is premised upon are:

1. Provision of access to authoritative weather, water and climate data via the Web;

2. Use of Web services; and

3. Adoption of cloud technologies where appropriate.

Successful implementation of WIS 2.0 relies on DCPCs and NCs, the contributors of data and services into the WIS 2.0 ecosystem, applying these concepts – and for the consumers of weather, water and climate data being able to use those services effectively.

Already within the current WIS framework, there are examples where Web services are used to provide access to data and information. Similarly, many NMHS and cooperating international organisations are already working towards provision of operational services hosted within cloud environments. Web and cloud technology is already reasonably mature – but is not uniformly understood by Members.

Registration of Web- and cloud-based services is already permissible within the current WIS technical regulations. Similarly, techniques to improve the discoverability of data and information via commercial search engines, and via GISC catalogues can also be implemented now.

The WIS 2.0 Project Office will prioritise the provision of guidance for WIS centres on implementation of Web-services, how to support improved discoverability, indexing by commercial search engines and how to register these services within the existing WIS

framework, thereby enabling WIS centres to develop and deploy services independently throughout the WIS 2.0 implementation period, taking into account their local operating constraints.

In cooperation with the Regional Associations, the WIS 2.0 Project Office will work with Members to identify when such services will be made available in WIS 2.0, establishing a roadmap for availability of these services. The Project Office will provide regular communication to Members regarding progress within the roadmap, successful deployments, exemplars and availability of training and guidance materials.

The new portal and catalogue Core services will be designed to streamline the transition from the existing WIS framework to WIS 2.0, simplifying the procedure for registering data and services within WIS 2.0. Service registration (and de-registration) processes and accompanying guidance will be published for WIS centres.

Outreach, capacity building and pilot projects

Successful implementation of WIS 2.0 is dependent on effective engagement with Members so that:

- Once approved by Congress, all Members understand what activity is required and the benefits of doing so;
- The WIS 2.0 implementation approach can be developed, validated and refined in response to regional and national needs.

The WIS 2.0 implementation programme promotes and supports the role of Regional Associations in developing regional plans to support WIS 2.0 implementation. In particular, the WIS 2.0 implementation plan will work through Regional Associations to:

- Identify how best to engage Members;
- Raise awareness about WIS 2.0;
- Gather and disseminate feedback on WIS 2.0 implementation progress;
- Understand and, where possible, mitigate the operational, technical, political, financial and cultural challenges and perceived risks concerning the adoption and exploitation of WIS 2.0;
- Identify any region-specific requirements;
- Determine opportunities for pilot projects to inform, evolve, validate and refine the concepts and implementation approach of WIS 2.0;
- Coordinate information sharing about WIS 2.0 pilot projects and their outcomes.

The WIS 2.0 implementation programme will learn from and apply the experience of other organisations establishing global data-sharing ecosystems.

Members are encouraged to establish and participate in WIS 2.0 pilot projects; engaging partners across NMHS, academia, research institutions and private sector, and sharing knowledge, technology and expertise from these projects to support widespread adoption of WIS 2.0. The WIS 2.0 Project Office aims to identify and, where possible, support pilot projects in all regions covering requirements from all Technical Commissions. Use of the WMO/CBS Affiliated Projects framework, as outlined in Decision 15 (CBS-16), is recommended.

The draft WMO Strategic Plan (2020-2023) states that "*Service performance of Member's NMHSs continues to be uneven and many are facing significant development needs and capability gaps in providing weather-, climate- and water-related information and services required by their economies and societies. The typical challenges are around maintaining a sustainable infrastructure, financial and human resources and the lack of ability to benefit from the advances in science and technology. [...] Narrowing the capacity gaps through international cooperation and focused assistance is more important than ever [...]*". In this regard, the WIS 2.0 implementation programme will actively pursue pilot projects that explore how WIS 2.0 can support service delivery in Least Developed Countries (LDC) and Small Island Developing States (SIDS).

To further support capacity building, the WIS 2.0 implementation programme will work with Regional Associations and Regional Training Centres to develop skills assessments and training plans in support of Member's WIS 2.0 implementation activities. In particular, the WIS 2.0 implementation programme will work with key centres in each region who are adopting cloud in order to support Members in developing their understanding of cloud technologies and how these can be effectively exploited to deliver services in support of their national mandates.

Where Members or cooperating organisations have already implemented, or plan to implement, services that conform to the WIS 2.0 architecture (e.g. use of Web services and/or cloud), the WIS 2.0 Project Office will work with these early adopters to incorporate their services within WIS.

The WIS 2.0 Project Office will also actively engage with projects supporting flagship WMO initiatives: seamless GDPFS, GMAS, CSIS, ODIS, WHOS phase 2 etc.

Effective communication is an essential element of the WIS 2.0 implementation approach. The WIS 2.0 implementation programme will communicate the programme work plan to all Members providing a clear understanding of the planned and pending changes, the benefits arising from those changes and the implications anticipated to arise from implementation – especially implementation activities are expected to be resource intensive. Routine and regular information updates will be provided, describing progress, pending activities and tasks that Members should complete. Additional communication channels to support WIS 2.0 implementation, e.g. provision of a WIS help-desk to respond to Member's queries, will be considered.

COSTS AND FINANCIAL MODEL

At this time, it is too early to provide cost estimates for WIS 2.0 implementation. However, the proposed funding model and the mechanisms used to determine costs are provided below. Readers should note that, where possible, WIS 2.0 implementation activities will be grouped into coherent, largely independent tranches of work that can proceed independently; each with a phased approach intended to release benefits incrementally. The WIS 2.0 strategy, as endorsed by Executive Council[6], sets the direction for WIS; the implementation will be organised so that activities build upon each other in accordance with the approved direction. Financial commitment will be sought for discrete phases of activity, each delivering associated benefits, rather than for the entire change programme. In this way, the WIS 2.0 implementation programme can adapt in response to the needs of Members.

[6] Resolution 8 (EC-69)

Opportunities for external funding will be pursued by the WIS 2.0 Project Office; for example, seeking financial support from international development organisations to develop the WIS 2.0 platform in, and for, developing countries.

The WIS 2.0 funding model assumes continuity of funding from Members to support the WIS Centres they have committed to operate.

Implementation of Web-services to provide access to weather, water and climate data will obviously incur costs for DCPCs and NCs. However, not only do many WIS Centres already expose (or plan to expose) their data in this way, it is anticipated that benefits from adopting this Web-centric approach to data sharing will outweigh the implementation costs. Such details cannot be provided here, but the WIS 2.0 Project Office, in cooperation with Regional associations, will work with Members to help them understand the benefits and develop implementation plans as appropriate (see above).

Also note that the WIS 2.0 implementation programme will encourage the provision of open source software solutions that DCPCs and NCs can employ in an effort to reduce any implementation costs.

Cost models associated with use of cloud environments – either as a service provider or service consumer – are not widely understood within WMO. Emerging experience from those WIS Centres already working with cloud technologies will be captured and shared as guidance for Members.

Investment will be needed to fund the development of the Core services. As these functions are (largely) the remit of GISCs, it is anticipated that costs will be shared among the GISCs. However, given the infrastructure consolidation involved, the change is anticipated to be better than cost-neutral.

The financial model to be used for allocation of costs from shared services – particularly those hosted within cloud-environments – it yet to be determined. The Cache in the Cloud (CitC) project Initial Phase (2018-2021) will explore this aspect further, building on the concepts used for RMDCN where a shared solution is procured and operated on behalf of several Members.

Migration from legacy message switching to the new data distribution service will also incur costs for all WIS Centres. However, these costs should be more than offset by a move from dedicated private networks to Internet connectivity and simplification of operations. It is also hoped that such changes can be incorporated into planned update cycles for message switching systems (MSS) to further reduce costs.

Following the model adopted for the original implementation of WIS, funding will be requested to supplement training activities and to support the WIS 2.0 Project Office (including a full-time programme manager).

IMPLEMENTATION RISKS

WIS 2.0 implementation, like any complex programme of activity is subject to risk. Risks will be proactively managed within the WIS 2.0 implementation Project Office as per industry good practice.

A full risk assessment is yet to be undertaken. Annex 9: Risks and proposed mitigation approaches lists risks (and proposed mitigations) identified to date. These are grouped into the following categories:

- Unknown or excessive cost of implementation or operation;
- Missing dependencies;
- Incomplete adoption;
- Lack of basic infrastructure;
- Operational disruption;
- Ineffective policy, and.
- Lack of resources.

NEXT STEPS

The CBS Task Team on the evolution of WIS (TT-eWIS) will continue development of the WIS 2.0 implementation plan. The plan will be shared for consultation with Members in November 2018, and approval sought from Congress in 2019 (Cg-18).

Executive Council (EC-70) will be requested to:

- Endorse the WIS 2.0 implementation approach;
- Note the development of the WIS 2.0 implementation plan; and
- Decide that it will be presented to Cg-18 for consideration.

Input will be sought from Regional Associations and Technical Commissions during the further development of the implementation plan. Where possible, TT-eWIS will present at the intergovernmental sessions planned for 2018 to share insight into the WIS 2.0 implementation plan and to gather input.

ANNEX 1: A SHORT INTRODUCTION TO THE WMO INFORMATION SYSTEM (WIS) AND THE GLOBAL TELECOMMUNICATION SYSTEM (GTS)

The WMO Information System (WIS) enables discovery of authoritative meteorological and hydrological data, and supports the collection of data and its exchange between WMO Centres and their users. It is operated and governed according to rules ("technical regulations") defined by WMO, published in the Manual on WIS (WMO-No. 1060)[7].

WIS provides a catalogue (the "WIS Catalogue") that describes the data and products available within WMO. Data and products are registered with the WIS by submitting a metadata record to the WIS Catalogue that describes the content, structure and access mechanisms for the associated data or product.

The majority of data and products publicised through the WIS catalogue are provided as files; made available via FTP servers or distributed using the Global Telecommunication System (GTS) for regional or global exchange between collaborating Centres. The use of Web services to deliver data on the WIS is becoming increasingly common.

Centres participating in the WIS ("WIS Centres") responsible for publishing data are designated either as a National Centre (NC) or a Data Collection and Production Centre (DCPC). In reality, both types of Centres are similar, but the latter are affiliated with a WMO Programme rather than a national activity.

There are also Global Information System Centres (GISCs). These are the hubs in the global network; with each NC and DCPC being affiliated with one GISC. GISCs manage the registration of data and products into the WIS from affiliated NCs and DCPCs, maintain synchronized copies of the WIS Catalogue, provide a portal to search the WIS Catalogue, maintain a short-term cache of data and products exchanged between operational centres, and offer mechanisms to download or subscribe to data and products within the cache. It is important to note that this "global cache" represents a very small subset of the data that is discoverable on the WIS.

WIS Centres must be approved by the Permanent Representative to WMO of the country (or 'Member') within which the Centre is located. Furthermore, GISCs and DCPCs are required to demonstrate through independent audit their capability to meet the relevant WMO technical regulations. These constraints ensure that WIS remains an authoritative source of meteorological and hydrological data. The list of approved WIS Centres is published in Appendix B of the Manual on WIS (WMO-No. 1060): Approved WIS Centres.

WIS also incorporates the Global Telecommunication System (GTS), which is the communications network operated by national meteorological and hydrological services (NMHS) and collaborating organisations for routine collection and dissemination of time- and operation-critical data and products. Relevant technical regulations are published in the Manual on the GTS (WMO-No. 386)[8].

Technically, the GTS is based on point-to-point routeing of messages (e.g. the data and products) between centres according to pre-arranged agreements. It has been the mainstay of operational data exchange in WMO for decades. It is robust and resilient but band-width constrained as it uses high-availability dedicated links and network clouds to ensure a guaranteed quality of service.

---

[7] https://library.wmo.int/opac/index.php?lvl=notice_display&id=9254

[8] https://library.wmo.int/opac/index.php?lvl=notice_display&id=10728

In some circumstances, the Internet may be used as an underlying technology for components of the GTS (e.g. when acceptable levels of service and adequate security measures are provided in a cost-effective manner) - particularly for less time-critical requirements and for distribution of larger volumes of data.

Distribution of data using the GTS must be through a registered WIS centre. FTP and SFTP are the two data exchange methods that can be used on the GTS. SFTP is preferred on the Internet.

ANNEX 2: WMO LONG TERM GOALS AND STRATEGIC OBJECTIVES RELATING TO DATA AND INFORMATION

The draft WMO Strategic Plan (2020-2023) outlines the following long term goals and strategic objectives for WMO that relate to accessibility and use of data and information:

Long term goals	Strategic objectives
1. Better serve societal needs: delivering authoritative, accessible, user-oriented and fit-for-purpose information and services.	1.1 Weather, water and climate extremes: Build resilience through enhanced services in support of national Multi-Hazard Early Warning Systems (MHEWS): foster regional and global weather hazards awareness through information sharing.
	1.2 Climate services for climate-resilient development: Expand and broaden the provision of policy- and decision-supporting climate information and services at national, regional and global level.
	1.3 Water management for sustainable development: Further develop and operationalise services in support of sustainable water management [through] better access to improved hydrological services and warnings for water resources, drought and flood risk management and planning.
	1.4 Weather-integrated decision making: Enhance and innovate the provision of value-added, decision-supporting weather information and services for weather- and climate-sensitive economic and social activities..
2. Enhance Earth system observations and predictions: strengthening the technical foundation for the future.	2.2 Data exchange and data management: Improve and increase access to, exchange and management of current and past observation data and derived products through the WMO Information System.
	2.3 Data processing: Enable access and use of numerical analysis and prediction products at all temporal and spatial scales from the WMO Global Data Processing and Forecasting System.
4. Close the capacity gap: enhancing service delivery capacity of developing countries to ensure availability of essential information and services.	4.1 Address the needs of developing countries to enable them to provide and utilise essential weather, water and climate services, in particular warnings for impactful events.
	4.3 Scale-up effective partnerships for investment in sustainable and cost-efficient infrastructure and service delivery.

ANNEX 3: WIS 2.0 VISION STATEMENT

WIS 2.0 is a collaborative system of systems using Web-architecture and open standards to provide simple, timely and seamless sharing of trusted weather, water and climate data and information through services.

Collaborative system of systems: is the term used by GEOSS to describe a system built from the contributions of others based on an approach of accommodating their diversity

Web architecture: provides the foundation for WIS 2.0 and should ensure that weather, water and climate information is accessible to the broadest possible user base - WIS 2.0 should be part of the "Web of data".

Open standards: because we want WIS 2.0 to be as inclusive as possible

Simple: indicates that we strive to remove the complexity for both providers and consumers of the information shared through WIS.

Timely: because WIS still needs to meet the operational needs of NMHS and other organisations.

Sharing: covers both provision and use and is a broader concept than *exchange* or *distribution*; we will not always seek to move the data to provide access - hosted processing is increasingly necessary for "big data" .

Trusted: implies both authoritative and secure.

Weather, water and climate: are our domains of interest.

Through services: because WIS 2.0 moves from a data-centric to a service-centric model; data is still part of WIS, but exposed through services - services enable information to be extracted from data (e.g. creating products on-the-fly from complex data sources) and can expose complex processing through simple interfaces.

Seamless: because a single analysis should be able to use data from multiple sources – even where those data are hosted in different cloud environments.

ANNEX 4: WEB-CENTRIC

The most significant change for WIS is a focus on providing access to authoritative weather, water and climate data and information via the Web.

The Web has had a huge impact on how we exchange and access information. The World Wide Web Consortium (W3C), the leading standards development organisation for Web technology standards, says[9]

> *"The Web is the World's most successful vendor neutral distributed information system, enabling people to access applications and services right across the World from their smart phones, tablets, laptops and other computing devices. […]*
>
> *Complementing the Web of pages [as viewed by humans using Web browsers], there is the Web of data which ranges from small amounts of data to vast datasets, and either which are open to all or restricted to a few. Data can be consumed by Web pages, downloaded for local processing, or accessed via network APIs that support remote processing [e.g. Web-services]."*

The 'Web of data' is the only data-sharing platform with truly global participation. Consequently, many NMHS are already investing in delivery of their data and information through Web services to meet their national obligations for public safety, provision of open data and more.

Why publish on the Web? Because it is the path from which the vast majority of users choose to access data and information. Users expect the data and information to be accessible somewhere on the Web – albeit that they may need to authenticate or pay for that access.

By publishing to the Web, NMHSs immediately have the potential to reach a global audience. Not only does this increase the visibility of authoritative weather, water and climate data, it makes this data available for use, licensing and access controls aside, in a multitude of applications ranging from societal benefit and public good to commerce to science to education and more. Likewise, the ubiquity of the Web makes it likely that other sources of data useful for NMHS operations will also be found there: voluntary observing networks, Web-enabled digital sensors (i.e. "Sensor Webs"), third party data, crowd-sourced data etc.

Data is a means to an end – not the end in itself. Through the Web, WIS 2.0 connects data and information to the users who can apply it for societal benefit.

More specifically, WIS 2.0 takes a 'service-oriented' approach to providing access to data and information. Users, whether humans or software agents, interact with data and information through services: whether to view, download or invoke some other process. A well-designed Web service will make it easy for users to interact with data and information; for example, enabling users to download only the data they need for their task – not the entire dataset. In WIS 2.0, the service is considered a first class entity.

WIS remains 'metadata-driven': service providers must publish descriptions of their offerings and data holdings (e.g. provide metadata) that are then indexed. Users search the indexed metadata to find what they need.

---

[9] W3C study of practices and tooling for Web data standardisation, https://www.w3.org/2017/12/odi-study/

WIS will continue to provide a portal that allows users to search for data. However, non-expert users will often begin their search using a commercial search engine: Google, Bing, Yahoo etc.

To support indexing of content by commercial search engines, service providers will be encouraged to publish the descriptions of their service(s) and data holdings using human readable Web-pages that incorporate machine-readable metadata – ready for indexing by search engine's Web-crawlers.

WIS 2.0 will aim to harmonise the machine-readable metadata required for both WIS Portal and commercial search engines to avoid unnecessary duplicated effort.

ANNEX 5: ECOSYSTEM APPROACH

WMO sets the overall framework, technical regulations and guidance within which Members define and deliver their national mandates for weather, water and climate services. Yet the responsibility for delivery of those services, and designing and delivering the requisite underpinning operations and infrastructure, happens at the national level. The CBS-led review of emerging data issues characterises this as "think global, act local".

For comprehensive coverage of operational meteorological service needs, it is probably fair to say that all participants in the global weather enterprise ultimately rely to some degree on the infrastructure and data provided by WMO through its Members – coordinated at a global, regional and national level.

WIS remains a 'system of systems' where Member's contributions, in the form of National Centres (NC) and Data Collection and Production Centres (DCPC), provide the services, data and information required to meet the needs of the WMO community.

The services provided by Members, and the data and information accessed through them, constitute the WIS 2.0 ecosystem – a set of interconnected elements subject to a common operating environment and governance.

Describing the Web of data, the World Wide Web Consortium (W3C) states:

> *"Data is often published without prior coordination with other publishers — let alone with precise modelling or common vocabularies. Standard data exchange formats, models, tools and guidance are needed to facilitate Web-scale data integration and processing."*

WIS 2.0 will promote the use of open standards for data exchange – particularly from the Internet Engineering Task Force (IETF), the International Organization for Standardization (ISO), the World Wide Web Consortium (W3C) and the Open Geospatial Consortium (OGC).

WIS 2.0 will seek to balance the need for standardisation (to enable Member's contributions to function with uniformity) with the need for flexibility (to accommodate diversity in how Members choose to meet their local requirements).

This approach of "diversity management", where a wide range of commonly used standards are supported rather than prescribing a small set, is hoped to encourage wider uptake of WIS than has been previously experienced.

Members should be able to register the services they have created for their domestic needs, or re-use the technology patterns they are familiar with, and thereby leverage their existing investments (and sustainability of funding) instead of being forced to build new systems specifically for integration with WIS.

ANNEX 6: INTO THE CLOUDS

The discussion on emerging data issues at Cg-17 identified that most Members were ill-prepared for the explosion in data volume and the growing diversity of new data sources. Even today, many Members are already unable to effectively exploit the petabytes of data published and made freely available by the weather prediction centres to deliver high-quality services to their citizens.

Th problem lies with the infrastructure requirements for moving, managing and processing these high-volume, rapidly changing datasets: many Members simply cannot afford to make the necessary investments.

Use of cloud computing is seen as an essential response to the challenge of Big Data; where data volumes require significant investment in technical infrastructure to use those data – and, moreover, it is impractical to move the data fast enough to meet operational requirements. Cloud computing provides an opportunity to rethink the 'topology' of data sharing arrangements: it promises to enable data processing to be hosted adjacent to the data – thereby removing the need to operate one's own data management infrastructure. NMHS could exploit such cloud-hosted services in order to deliver high-value, high-quality services to their governments and citizens helping them more effectively meet their national mandates. The WMO mantra that "no Member be left behind" and that "no Member stands alone" can be realised through cooperation between Members, ensuring that all Members have access to the necessary capability.

For example, a modelling centre may offer a cloud-based service that allows users to deploy applications that work with 'Big-data' in-situ (e.g. to predict locations susceptible to natural disasters caused by extreme weather), rather than requiring those users to "download" that data and manage it locally. Such applications may present simple, low-bandwidth user interactions (e.g. Web pages, chat bots [via text message or other IM]) with the data-intensive processing occurring in the remote cloud environment.

Cloud computing technologies are already mature and associated services are becoming financially competitive against in-house solutions. In fact, several large NMHS and cooperating international organisations are already investing in providing cloud-hosted services.

WIS 2.0 will not provide cloud hosting as a core service from which compute and storage can be provisioned for Member's applications. Services operated by Members (and cooperating international organisations) that are registered in WIS 2.0, plus the WIS 2.0 Core services, may use cloud environments where it is deemed appropriate to do so. Members operating such services will need to provide clear policies on who can use such services, for which purposes and whether users of the service will incur costs.

The WIS 2.0 implementation programme will provide guidance on how services provided by WIS Centres can be effectively deployed within cloud environments.

There is no intent to recommend a specific cloud environment for the WMO community. The choice of cloud environment (e.g. public or private cloud, choice of vendor for commercial cloud services etc.) for a given service will depend on the requirements of the service operator. As a result, WIS 2.0 will inevitably adopt a multi-cloud approach.

WIS 2.0 Core services are likely to be deployed within a cloud-environment. Selection of the cloud environment (or environments) for each core service will be depend on the requirements of the service. The due diligence assessment for each selection will be shared (subject to any contractual limitations), but any choice should not be considered an endorsement of a particular cloud environment for use by the entire WMO community.

WIS 2.0 will provide guidance to service operators aiming to prevent different cloud environments becoming silos. WIS 2.0 will be "seamless", enabling a single analysis to use data from multiple sources – even where those data are hosted in different cloud environments.

ANNEX 7: REAL-TIME DATA DISTRIBUTION

The requirement for real-time distribution of data and products is not going away anytime soon: it is a core requirement of the World Weather Watch programme. However, the WWW was established over five decades ago, and the Global Telecommunications System (GTS) which moves data between Members day-in, day-out has been operational since the 1970s – predating the Internet.

Migrating WIS to the Web – and consequently using the Internet as the underlying network – removes the need for WIS Centres to maintain costly dedicated private networks, thereby enabling cost reductions to be found.

The reliability of the Internet has improved in recent years – yet it is still subject to disruption and periodic poor performance. With appropriate 'fault tolerant' design, applications can be made sufficiently robust for use in safety-critical circumstances.

Thus, a quick win is to encourage the adoption of Internet for GTS network links where service-levels can continue to be met. Many NMHS have already adopted the Internet for their GTS connections – plans to amend technical regulation in recognition of improved Internet robustness are already in place and expected to be approved by Cg-18.

Yet further rationalisation of the GTS is possible. The Manual on GTS (WMO-No. 306) describes the GTS as an "integrated network of point-to-point circuits". Use of the Internet, a single, global network, negates the need for point-to-point circuits, thereby removing the requirement for data and products to be retransmitted from GTS node to GTS node. Effectively, this means that the legacy 'message switching' approach, with associated costs from bespoke software and manually intensive operations e.g. maintenance of routine tables and monitoring retransmission of messages, can be decommissioned.

Looking at technology trends, we see that real-time messaging has become a commodity technology, with a choice of several open-standards. The application of such solutions in social media platforms demonstrates the ability of the technology to scale well beyond the needs of the WMO community. Use of open-standard messaging solutions allows us to rethink how real-time data distribution should occur.

Instead of addressing messages with headers or naming files according to specific conventions, used when routing those messages and files between centres, we uniquely identify a 'queue' or channel from which data for a given location and/or domain is published. Users subscribe to the queue, filtering messages based on how the content matches their requirements. This change alone has a significant positive implication for the WIS catalogue: instead of creating metadata records for each bulletin (numbering more than 100,000 records as of today), data publishers focus on describing the scope of data available from a much smaller number of queues – resulting in one, perhaps two, orders of magnitude fewer records in WIS to search through and dramatically reducing the amount of metadata that WIS Centres need to create and maintain.

Messages are send directly to subscribing users. Without the need to retransmit messages to propagate them to users, the latency of data transmission is reduced – which is particularly important for time-critical warnings which have a 2-minute SLA for end-to-end transmission.

With message queues, there is minimal overhead in sending messages; there is no longer any need to wait for the arrival of several smaller data elements to arrive (e.g. from an observing system) before bundling them up into "bulletins". Data can be published on a queue as soon as it arrives. Bulletins, an artefact of legacy technology constraints, are no longer needed.

Finally, by publishing message queues on the Web, the routinely exchanged operational data that is the lifeblood of operational meteorology becomes genuinely accessible to the general population.

In summary: the Global Telecommunication System will continue to occupy a critical role in WMO – albeit 'reborn' with new technology that make it more accessible and more cost-effective than ever. Traditional GTS message switching will be phased out.

The use of commercial cloud offerings from multi-national corporates such as Alibaba, Amazon, Google, IBM and Microsoft provide a cost effective opportunity to operate applications that scale to deliver global reach.

In this way, functions of WIS such as real-time data distribution of observations, as required by the WWW programme and currently implemented via the GTS, can be provided as shared services for use by the entire WMO community.

The WMO "Cache in the Cloud" (CitC) project provides a baseline for assessing how such shared services might be commissioned, funded and operated. CitC initial phase, planned to become operational in 2021, uses like-for-like protocols already supported by GISCs and aims to simplify the data exchange topology among GISCs from many-to-many using dedicated networks to hub-and-spoke via the Internet, where the 'hub' is hosted in the cloud. CitC evolution phase then plans to engage all WIS Centres and introduce message queuing.

Where Internet connectivity is inadequate satellite distribution mechanisms, such as the WMO Integrated Global Data Distribution Service (IGDDS), provide an extremely useful alternative.

Although the data distribution mechanism will change, there is no evident need to change the data formats agreed for existing data sharing arrangements (e.g. use of GRIB and BUFR for WWW) as specified in technical regulation (and other programmes may have their 'conventions').

ANNEX 8: GISC INFRASTRUCTURE CONSOLIDATION

Within WIS, each of the 15 GISCs operate infrastructure that performs the same functions. Each GISC has a portal, catalogue and real-time data cache, and must synchronise the contents of the catalogue and cache with all other GISCs to ensure they are consistent.

Operating these facilities is a significant expense for each GISC. Furthermore, the catalogue and cache are routinely found to be inconsistent between GISCs.

The CBS-led review on emerging data issues (CBSLR-EDI) commissioned by Cg-17 identifies that cloud computing, Web services, data analytics, machine learning and other technologies present new operating concepts that will improve operational efficiency.

WIS 2.0 will provide a consolidated WIS Catalogue and real-time data cache within a cloud environment, plus centralised Web-services (e.g. search, registration etc.) that each GISC can integrate into locale-specific portals for particular user communities; for example, using the languages commonly used within their area of responsibility. These components would be designed to meet service level requirements (including availability and request latency) and likely implemented as multiple, redundant systems.

Mechanisms such as global server load balancing can be used to distribute user requests to servers in different locations according to criteria (e.g. client IP address, geolocation or server availability).

While the costs of the consolidated, cloud-hosted portal and catalogue may be higher, each GISC will only contribute a fraction of the costs. Synchronisation of data and metadata will no longer be required between each of the 15 GISCs, thereby improved reliability and further reducing costs. This change is expected to be better than cost-neutral for each GISC.

Consolidation also provides the added benefit of agile change. Any changes needed in the Portal and catalogue can be more quickly implemented, due to no longer having to meet the common capabilities across 6 separate GISC software environments, nor having to provide long-lead times for those GISCS to implement a change.

Building on the initial phase of the Cache-in-the-cloud (CitC) project, real-time data distribution, as described above, will become an additional core function managed by GISCs – once again, using a cloud-hosted, shared service approach.

ANNEX 9: RISKS AND PROPOSED MITIGATION APPROACHES

Risk management is an ongoing process that need to be followed during the file of the WIS 2.0 programme. the WIS 2.0 Project Office will follow the WMO Risk Management Policy to identify and manage risks associated to the implementation of WIS 2.0.

Risks identified to date and their proposed mitigation approaches are listed in the table below. Many more risks will be identified once a better understanding of the implementation plan and its constituent activities have been achieved.

Risk	Mitigation
Unknown or excessive cost of implementation or operation	
Costs associated with the use of services hosted in commercial cloud environments may prohibit participation of some Members; e.g. compute costs, data egress costs.	WMO to work with commercial cloud vendors to develop a tariff structure for use of cloud services in support of public safety operations.
In the event that WIS and GEOSS share a technical roadmap, Members are locked into a costly, rapid change cycle because WIS solutions are 'aligned' with GEOSS release cycle.	Apply lifecycle management to operational services; ensuring that Members are given adequate time to respond to any breaking changes.
Additional costs are required to interoperate / integrate with ICAO System Wide Information Management (SWIM) because the technical and policy specifications for ICAO SWIM remain largely unknown.	Through the Commission for Aeronautical Meteorology (CAeM), engage closely with the ICAO Meteorology Panel (METP).
Missing dependencies	
Cache in the Cloud (CitC) Initial Phase, an essential precursor to WIS 2.0, is not approved by EC-70.	Clarify the dependency between WIS 2.0 and the CitC Initial Phase in the decision requested from EC-70.
Incomplete adoption	
Some Members perceive that the costs of migrating to WIS 2.0 are not sufficiently offset by the benefits.	WIS 2.0 will support a wide range of commonly used open standards; Members should be able to register the services they have created for their domestic needs, or re-use the technology patterns they are familiar with, and thereby leverage their existing investments. Application of proven approaches from other organisations to help on-board participants- e.g. the GEOSS Data Providers workshops. GISC role will be more focused on capacity building and supporting their affiliated WIS Centres.
Introduction of new and unfamiliar technology prevents some Members from effectively participating in WIS 2.0.	Develop (and fund) a training programme to address the skills gap.
Members are resistant to change, citing	Where possible, adopt an evolutionary

their previous investments in WIS.	approach; where components registered in the current WIS framework can be migrated to WIS 2.0. Else, clearly articulate the benefits of the change.
Technical Commissions, Regional Associations and Members do not understand what is required of them, or are unwilling to commit resources, leading to gaps in the WIS 2.0 implementation.	The WIS 2.0 Project Office will prioritise communication and outreach activities.
Lack of basic infrastructure	
Lack of adequate Internet connectivity in developing countries prevents Members from effectively exploiting using the proposed real-time distribution services or other cloud-hosted services.	Assess Internet connectivity using pilot projects; work with Development Banks / World Bank and other NGOs to develop the necessary infrastructure.
Cloud platforms are not globally accessible – due to technical, political or legal reasons.	Assess cloud platform accessibility using pilot projects; work with commercial cloud vendors to address issues arising.
Operational disruption	
Migration from legacy message switching operations to the new data distribution services inhibits or disrupts the flow of real-time observations required for the World Weather Watch programme.	Operate legacy message switching and new data distribution service in parallel; with agreed failover procedures to mitigate operational issues. Undertake rigorous validation and commissioning of the new service.
Change to real-time data distribution method forces breaking change that Members are unable to accommodate.	Work with MSS vendors and others to develop software solutions that streamline this change.
Routinely exchanged data that is late or missing cannot be effectively tracked because the expected data delivery schedule, as specified in the MSS routeing tables, is no longer available.	Ensure that the data distribution service includes the capability to detect late or missing data. Technical solutions may include use of analytics and heuristics to detect 'normal' data flow and compare those messages actually published with those expected.
Use of consolidated infrastructure for WIS core services introduces a single point of failure or unacceptable latency.	Mechanisms such as global server load balancing can be used to distribute requests to, for example, https://wis.wmo.int/ to servers located in multiple locations according to specified criteria (e.g. IP address, geo-location or server availability).
Ineffective policy	
In the event that WIS reuses technology or solutions from a third party (e.g. the GEOSS Common Infrastructure), license to use those technologies or solutions may be withdrawn.	Promote the use of open source licenses; otherwise, negotiate a license with a perpetual use clause. Ensure that an 'exit strategy' is in place before becoming dependent on a third-

	party solution.
Lack of resources to manage and execute WIS 2.0 implementation	
resources are available to plan an coordinate the complex set of activities that comprise the WIS 2.0 implementation programme.	Within Secretariat, fund a Project Office with a full-time, highly competent programme manager.