WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS

FIFTH MEETING OF THE INTER-PROGRAMME TASK TEAM ON THE FUTURE WMO INFORMATION SYSTEM

FINAL REPORT

KUALA LUMPUR, MALAYSIA, 20-24 OCTOBER 2003

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Regulation 42

Recommendations of working groups shall have no status within the Organization until they have been approved by the responsible constituent body. In the case of joint working groups the recommendations must be concurred with by the presidents of the constituent bodies concerned before being submitted to the designated constituent body.

Regulation 43

In the case of a recommendation made by a working group between sessions of the responsible constituent body, either in a session of a working group or by correspondence, the president of the body may, as an exceptional measure, approve the recommendation on behalf of the constituent body when the matter is, in his opinion, urgent, and does not appear to imply new obligations for Members. He may then submit this recommendation for adoption by the Executive Council or to the President of the Organization for action in accordance with Regulation 9(5).

CONTENTS

AGENDA

1. ORGANIZATION OF THE MEETING

- 1.1 Opening remarks
- 1.2 Adoption of the agenda
- 1.3 Working arrangements

2. REVIEW OF RELEVANT DECISIONS OF Cg-XIV AND EC-LV

3. INFORMATION EXCHANGE REQUIREMENTS OF WMO PROGRAMMES

4. REPORTS ON PILOT PROJECTS

5. REFINEMENT AND CONSOLIDATION OF THE FWIS CONCEPT

6. OUTLOOK OF DESIGN AND IMPLEMENTATION PHASES, INCLUDING TRANSITION

7. FUTURE WORK PROGRAMME

Executive Summary

The fifth meeting of the Inter-programme Task Team on the Future WMO Information System was held 20-24 October 2003 in Kuala Lumpur, Malaysia.

The team considered the data management and communication structures and plans of other WMO Programmes and related Technical Commissions, and developed an information and queries document for collecting information and joining efforts with a view to integrating all WMO Programmes requirements into the common FWIS.

The team reviewed pilot projects relevant to the development of the Future WMO Information System (FWIS), including the WMO Core Metadata Standard, the Virtual (distributed) Global Information System Centre (VGISC) in RA VI, the Earth System GRID, the Community Data Portal, the EUMETNET UNIDART project, the Roshydromet CliWare project and the Korean Meteorological Administration project. It also reviewed the status and development trends of the GTS and its Improved MTN.

Taking into consideration the directives of Congress, Executive Council and CBS, the team reviewed the FWIS vision that had been developed at the previous meeting. It consequently refined and consolidated the FWIS concept.

The team strongly felt that the success of FWIS would depend upon volunteering Members actively supporting and contributing to pilot projects that have the potential to initiate the implementation of the FWIS. It emphasized the crucial importance of metadata and data catalogue, and agreed that a workshop on this topic should be held in 2004.

1. ORGANIZATION OF THE MEETING

1.1 Opening remarks

1.1.1 The fifth meeting of the Inter-programme Task Team on the Future WMO Information System (ITT-FWIS) opened on Monday 20 October 2003 at the Malaysian Meteorological Service in Kuala Lumpur, Malaysia. Prof. G-R. Hoffmann (Germany), chair of the team, opened the meeting and outlined the principal tasks facing the team. Dr Chow Kok Kee, Permanent Representative of Malaysia with WMO welcomed the task team to Malaysia. He recalled that Congress and the Executive Council endorsed the FWIS concept, and that they requested CBS to pursue the further development of the FWIS towards the refinement and consolidation of the concept and then the design and implementation planning phases. He pointed out the benefits of modern ICTs for meteorological and related operations, as well as the challenges of implementing a new system.

1.2 Adoption of the agenda

1.2.1 The meeting adopted the agenda as reproduced in the beginning of this report.

1.3 Working arrangements

1.3.1 The meeting agreed upon its working hours and work plan.

2. REVIEW OF RELEVANT DECISIONS OF Cg-XIV AND EC-LV

2.1 The ITT-FWIS noted with particular attention the decisions and directives of the XIV WMO Congress and EC LV relevant to FWIS. Congress supported the views and conclusions of CBS on the FWIS vision, and requested CBS to pursue the further development of the FWIS towards the refinement and consolidation of the concept and then the design and implementation planning phases. The ITT-FWIS took note of the directives of Cg and EC, and in particular the following:

- Comprehensive requirements of all WMO Programmes as regards information types and volumes, timeliness, sources and users, security, etc., needed to be taken into account to consolidate the FWIS concept, and to develop design and implementation plans;
- All WMO Programmes should actively participate and contribute their own expertise and resources in all phases of the development of the FWIS. The support and involvement of many members of the WMO community, including especially regional associations and technical commissions, was needed, as early as possible, in all phases of the FWIS development in order to ensure a full and shared ownership of the project, and its effective implementation;
- The implementation of FWIS should build upon the most successful components of existing WMO information systems in an evolutionary process. In particular, the FWIS would build upon the GTS with respect to the requirements for highly reliable delivery of time-critical data and products, and the Improved MTN would be the basis for the core communication network;
- The FWIS development should pay special attention to a smooth and coordinated transition.

2.2 Congress noted the impact on Members' responsibilities and resources and other policy aspects that were identified by the study on policy-level implications of the FWIS. The ITT-FWIS noted that Congress concluded that the impact of the FWIS on Members' responsibilities and resources appeared to be commensurable with the development that would be anyhow needed to face the general evolution of information and communication technologies and of Members' requirements. Cg and EC requested the CBS as well as the other technical commissions involved in the FWIS development to give particular attention to the impact on Members' responsibilities and resources and the policy aspects. In this regard, the team reviewed and noted the issues that were analysed in the study on policy-level implications of the FWIS.

2.3 The team kept these considerations in mind as it worked to consolidate the FWIS concept.

3. INFORMATION EXCHANGE REQUIREMENTS OF WMO PROGRAMMES

3.1 The team reviewed in detail the data management and exchange structure, mechanisms and requirements of the WMO Programmes that were represented at the meeting. All the presentation were posted on the WMO Web server under http://www.wmo.ch/web/www/FWIS/documents.htm

3.2 Mr D. Thomas (representing JCOMM) noted that the oceanographic and marine community's communication needs had many synergies with the current WWW communication system and that many data flows already make extensive use of this system. However, there are differences in requirements from the atmospheric community in that the marine community also manage as well physical, biological and chemical data. An issue still to be agreed on by JCOMM and IODE is whether the extent of requirements on FWIS should include the physical, biological and chemical data needs or simply focus on those needs that are similar to WWW requirements.

3.3 Metadata is also critical to the marine community and in many cases the amount of metadata is significantly larger than the data itself. There are many metadata management systems and an important component to address in FWIS is the ability to support interoperability between metadata standards. This requirement is highlighted by the marine data and metadata project DMAC (Data Management and Communication), using OPeNDAP (Open Source Project for a Network Data Access Protocol) that faces many similar issues to FWIS.

3.4 An important part of JCOMM's data management strategy is to understand the full life cycle of data and this is being addressed as End-to-End Data Management (E2EDM). The JCOMM representative demonstrated this with an example of the Australian Commonwealth Bureau of Meteorology's "Marine Data End-to-End Data Flow" project. The group noted how effective this project was in increasing their understanding of oceanographic data communication needs, and also highlighted how the present meteorological communications structure is being utilised for collection of oceanographic data. The JCOMM representative highlighted within the data flow analysis how important it will be in FWIS to manage both the real-time data flow as well as the delayed-mode data flow, capturing metadata from QC processes along both paths. This includes QC information from numerical model assimilation and forecast processes.

3.5 The representative for JCOMM also expressed his appreciation for Dr Robert Stanek and Dr Steve Foreman's contributions in identifying FWIS issues from IODE's and JCOMM's perspective, through their participation as CBS/ISS representatives in the Task Team on an IOC Strategy for Oceanographic Data and Information Management, and the JCOMM Expert Team on Data Management Principles respectively. The team noted with interest the respective reports and recommendations, and was pleased that these cross-participations had definitely facilitated a convergence between CBS and JCOMM, and also IOC, on common Information systems.

3.6 Mr John Shortridge (representing CCI) recalled the general requirements of the WCP, which had been identified in previous ITT-FWIS sessions. He emphasised the concept of Regional Climate Centres in the potential framework of FWIS. Considerable work is going into the development of this concept, and there appears to be a clear need to ensure that the concept of Regional Climate Centres remains in harmony with that of the FWIS DCPC concept, as the two concepts are defined in increasing detail. Detailed attention will also need to be given to the metadata aspects of FWIS, to ensure their compatibility with the metadata needs of CCI. The team particularly noted Climate metadata developments in the USA, and it requested that relevant development and experience be submitted to the forthcoming session of the ISS/ET-IDM (December 2003).

3.7 Mr Byong-Lyol Lee (representing CAgM) made a detailed presentation on the strategy and plans of CAgM related to data management and exchange. The current requirements of the programme were quite limited. CAgM is willing to play an increased role of information provider by collecting and disseminating non-synoptic data that are expected from Core AgroMeteorological Stations (CAMS) of CAgM. It will include agronomy data and surface flux data on energy and GHG that will be critical elements for future NWP model development and as RS ground truth information. The team particularly noted future plans for the establishment of network of stations measuring fluxes, which were expected to generate large volumes of raw data. The representative of CAgM also emphasized that FWIS should support WAMIS, the official Web Portal of WMO/CAgM dedicated to Agricultural

Meteorology, by providing multi-directional communications including feedback mechanisms from end-users to service providers at global level.

3.8 Mr Marc Morell (representing CHy) recalled the various components of the WHYCOS, and made a detailed presentation of the MEDHYCOS component as an example of current hydrological data exchange, as well as of the requirements for WWW data. It was noted that most of the current exchange were involving a limited number of countries, at the level of rivers or basins. The representative of CHy focused on the requirements of GTN-H related to data and products at global scale.

3.9 The team agreed that the ITT-FWIS should promote an active interaction with all WMO Programmes in the further development of FWIS. In order to assess the data exchange requirements of WMO Programmes and their integration into a common system, the team developed a questionnaire, (see annex to this paragraph) containing the description of the FWIS concept and seeking information from WMO Technical Commissions about their respective WMO Programmes requirements and systems, at present and for the foreseeable future. The team requested the WMO Secretariat to arrange for the distribution of the questionnaire to the WMO Technical Commissions, and to request replies within four months.

3.10 The team also agreed that the representatives for the WMO Programmes in the FWIS Task Team should normally represent FWIS in the relevant bodies and groups of their respective Commissions. Ad hoc participation of specific experts in meetings could be considered on a case-by-case basis, depending upon the particular topics included in the agenda.

3.11 The team considered two contributions on the current status and trends for the development of the GTS and the Improved Main Telecommunications Network (IMTN). The team noted the rapid introduction in the GTS, and in particular on the IMTN, of advanced data-communication services, such as managed data-communication networks and Frame Relay that provided efficient and cost-effective means, with a very high reliability and full security, a guaranteed quality of service and an easy scalability of capacity. The capacity of the links is selected to meet peak traffic requirements (i.e. NWP models output, satellite data), and a large spare capacity remains. The team also noted the GTS data-distribution systems via satellite, and the introduction of highly cost-effective digital video broadcasting (DVB-S) and digital audio broadcasting (DAB) data-communication techniques (e.g. VSAT in Region IV, DVB-S in Regions VI and I, DAB in Region II). In particular, EUMETSAT had implemented a DVB-S satellite-based system (EUMETCAST) for distributing MSG data and products over Europe, Africa and part of Asia, which should also support the distribution of WWW data and products.

3.12 The team was also informed of the outcome and follow-up of the Earth Observation Summit. It particularly noted that several items of the TORs of the *ad hoc* Group on Earth Observations (GEO) and its GEO Sub-groups were strongly related to the FWIS development, especially with respect to the Subgroup on Architecture and the Subgroup on Data Utilization. It noted that at its recent session the CBS-Management Group decided to provide, from the prospective of CBS, contributions to relevant GEO Sub-groups on the FWIS concept and its potential capabilities. CBS-MG also noted that, beyond the participation of WMO as an international agency in GEO Sub-groups, several participants from Member countries were affiliated to WMO activities, or even members of CBS. The CBS-MG agreed that CBS members participating in the GEO Sub-groups as national representative would be contacted by the Secretariat with a view to inviting them to participate in an e-mail exchange list including OPAG chairs to exchange and support comments and information relevant to the positioning of WWW in the EOS development. The ITT members agreed that they would also contribute to the promotion of FWIS with their respective national representatives.

3.13 Mr Gil Ross reported on a meeting of the Earth Sciences Portal workshop held at Daresbury, U.K. recently. This is an academic forum where climatologists, oceanographers and others interested in the exchange of large amounts of model grid data, gathered to report on developments in systems and software. Participants were mostly from the U.S. and U.K., but representatives from Germany, France and Netherlands also took part. The ESP workshop (http://esportal.gfdl.noaa.gov) reported considerable progress and highlighted the need for interoperability between systems. The team thought that FWIS (and also the ESP members) could benefit considerably by strengthening contact

and contributing to the portal development. The team recommended that a presentation on FWIS should be made at the next ESP workshop in June 2004.

4. REPORTS ON PILOT PROJECTS

4.1 Prof. Hoffmann and Mr R. Stanek informed the meeting on the progress of the EUMETNET UNIDART Project. The main goal of the UNIDART Programme (Uniform Data Request Interface) was the development of a meteorological Web portal, which would provide uniform access to meteorological data and products through the Internet, while data and products were stored in different formats at different source locations. The second phase of UNIDART, called UNIDART-II, that included the design, implementation and evaluation of a prototype of the system was endorsed by EUMETNET. The prototype development will focus on the access to climatological data and the development of the Future WMO Information System (especially concerning a WMO metadata standard). The team emphasized that UNIDART would constitute an important pilot component for the FWIS.

4.2 Mr Besprozvannykh made a presentation on the status of the CliWare project operated and being further developed by Roshydromet (Russian Federation), including a real-time demonstration over the Internet. The system is very technologically advanced and makes extensive use of international standard protocols, XML and ANSI SQL, open source software and supports the recently adopted WMO Core Metadata standard. The presentation included some detailed issues that were identified through the practical implementation and testing of the WMO Core Metadata standard. The task team expressed its appreciation for this important contribution to the further development of WMO Core Metadata standard, and it invited the forthcoming session of the ISS/ET-IDM (December 2003) to address these issues. The team confirmed that the CliWare project could be considered as a pilot to evaluate the catalogue and request/reply capabilities envisioned for FWIS.

4.3 The meeting also noted that it had not been possible yet to set up further trials using Internet Data Distribution software (IDD) by DWD, the UK Met Office or the South African Weather Service, but that comprehensive tests, including on security aspects, should continue. In addition, KMA informed the team of their operational experience with AFD and IDD, as well as their plan to test the performance over the Internet for data exchange between DWD and KMA.

4.4 The team reviewed in some details the development of the virtual (distributed) GISC (VGISC) concept in the framework of RA VI, through four contributions on the functional design, on management processes, on VGISC's centres interconnections and on a straw man of external communication interfaces. The three centres Bracknell (Exeter), Offenbach and Toulouse would share and distribute the responsibilities and functions of a GISC, while EUMETSAT and ECMWF would act as DCPCs by providing their data and products to the VGISC. The VGISC would act as a single GISC, as seen from an external user. The team noted that several functions relevant to the interoperation of the three centres as members of a VGISC would be a test bed for the interoperation of the GISCs, in particular as regards the synchronisation of catalogues and of data/products.

4.5 The team noted with interest the development of the VGISC activities, and agreed that the project was expected to be a central pilot project for the implementation of the FWIS.

4.6 The team also noted that the "WMO Core Metadata" profile within the context of the ISO Standard for Geographic Metadata (ISO 19115) was endorsed by CBS and EC. This core provides a general definition for directory searches and exchange that should be applicable to a wide variety of WMO datasets. The team emphasized that the agreed WMO Core Metadata standard was a significant step forward for the data and product catalogue, which was a crucial component of FWIS.

4.7 The team also noted that CBS (OPAG-ISS), recognizing the important role of the Internet, keeps under review guidelines on the most appropriate procedures and implementation options for data exchange via e-mail and Virtual Private Networks (VPNs), including use of Internet Protocol Security (IPSec), that would minimize the operational and security risks. The ECMWF carried out a comprehensive test of VPNs over the Internet and published a technical note on its evaluation.

4.8 Mr A. Kellie, Director, Scientific Computing Division of the U.S. National Center for Atmospheric Research (NCAR) made a presentation on the Earth System GRID and the Community Data Portal activities. The team was impressed by the considerable momentum and funding of these activities. The team noted that there were many areas where FWIS could benefit from collaboration.

4.9 The group discussed the momentum that seems apparent in closely related projects around the globe. These include the Earth System Grid Project in the USA which is designed to enable management, discovery, distributed access to, as well as processing and analysis of distributed "Terascale size" climate research data, and the NERC Data grid, which is building bridges between Environmental Sciences. There is apparent broad application of agreed to conventions in metadata and data representations as well as cataloguing and replication services to mediate the discovery.

4.10 There was general agreement that the concepts of FWIS need to be exposed to these projects in order to leverage the maximum in technology development across the spectrum of activities that are important to FWIS and to these funded efforts. Common functions such as the data and metadata representation and conventions, the metadata and replica catalogues, access and control, security and portal development appear to have many common threads amongst these projects and direct analogies to FWIS. Their designs appear to support open freeware or shareware and this may well be an opportunity that the FWIS design and development can exploit with a view to accelerating the implementation rates of GISCs and reducing the overall costs to Members. In the longer term, the harmonizing across such a spectrum of activities might allow for easier integration of specialized DCPCs that have been traditionally outside the purview of information exchanged and available to WMO Programmes.

4.11 Mr Dong-Il Lee made an informative presentation on the Information and Communication strategy and development plans of the Korea Meteorological Administration (KMA). He indicated that KMA would be keen to promote the development of a V-GISC in East Asia, in cooperation with China and Japan.

5. REFINEMENT AND CONSOLIDATION OF THE FWIS CONCEPT

5.1 The task team noted that CBS-Ext.(02) had agreed that the FWIS should identify and acknowledge the national level of the WMO Information System, that were currently included in the GTS structure and were of crucial importance for the national data collection. It agreed that the role of data and products cataloguing, which is crucial for the whole FWIS operation, should be explicitly addressed. Each GISC should maintain and operate a comprehensive catalogue of data for routine global exchange; it should also maintain, as part of the catalogue, the necessary metadata information required to locate the NC, DCPC or other GISC providing other data made available for exchange, on the understanding that the full detailed catalogue of these data are maintained and operated by the responsible provider centre (NC, DCPC or GISC).

5.2 The team also refined the functions of NCs, DCPCs and GISCs, in particular with respect to data collection and storage, as well as users' access. It agreed that, in accordance with NCs' responsibilities to serve data and product needs of their country, NCs should provide for the authorization of their respective national users to access FWIS, as required. Appropriate identification, authentication and authorization procedures will be exercised through relevant standard techniques that are developed for a number of Internet applications. The team emphasized that data quality control and monitoring as well as data archiving was not an FWIS responsibility, and would remain under the control of the respective programmes and relevant centres. The FWIS would ensure the data access and delivery services, including the monitoring of these activities.

5.3 The team agreed that, in the further development and design of the core-communication network of the FWIS, particular attention should be given to traffic management to ensure the adequate prioritisation of different categories of exchange. It noted in this respect that WWW centres had been highly reluctant to use spare capacity of the GTS for other lower priority traffic to safeguard the effective WWW exchange. The team agreed that, to ensure a smooth transition, new request-reply and client-server services provided by FWIS should be supported via the Internet, while the GTS would continue to support high-priority "routine" traffic. However, current request-reply in the framework of routine exchange would continue to be routed on the GTS.

5.4 The team reviewed the FWIS vision that had been developed at the previous meeting and, with the above considerations in mind, it developed the consolidated “Future WMO Information System concept” as given in the annex to this paragraph.

6. OUTLOOK OF DESIGN AND IMPLEMENTATION PHASES, INCLUDING TRANSITION

6.1 The implementation and operation of FWIS requires the participation of many Programmes and centres. Since all WMO Programmes stand to benefit, each must actively participate and contribute its own expertise and resources. The support of many members of the WMO community, including regional associations and technical commissions will be required.

6.2 The team recommended that the further development and implementation of FWIS be pursued through a gradual introduction and evaluation of relevant pilot and prototype projects. Successful consolidated prototypes could then be expanded for wider implementation. In this way, the enhanced functions provided by FWIS would be gradually introduced and expanded.

6.3 The team emphasized that the development of the VGISC activities being carried out in Region VI would be a central pilot project for the implementation of the FWIS for testing the detailed design, implementation aspects, including transition, of GISCs functionalities and interaction. The team took note of the VGISC Web page that would be maintained by DWD under vgisc.ra-vi.wmo.int.

6.4 The team was very supportive of the possible development of a V-GISC project in Region II, and it noted the suggestion of an East Asia VGISC including Beijing, Tokyo and Seoul, and possibly integrating the relevant requirements of CAgM.

6.5 The representative of CAgM invited the discussion on the possibility of future involvement or participation of the uCAgM project as a partner of a VGISC pilot project in applied meteorology. Through his introduction on the uCAgM project with candidate pilot projects of CAgM as well as IT framework, he introduced identified resources including high performance networks and computing resources available in Asia-Pacific region. Through the support by FWIS in communication and data access, he hoped that WAMIS could be expanded into a Grid Portal in the near future.

6.6 The team stressed the importance of the general implementation of the WMO Core Metadata Standard. It emphasized that future development of FWIS catalogues and Metadata was vital. While CliWare and UNIDART were testing implementation of the proposed metadata standard, it recognized that metadata needed to be tested more widely. The team noted that CBS had recognized that several further actions were required before WMO could adopt the metadata standard for operational use. Noting the crucial importance of metadata for the FWIS, Congress requested all WMO Programmes to join their efforts in the further development of detailed WMO metadata standards.

6.7 The team emphasized that WMO Programmes should implement prototypes to apply the draft standard to their data, so that practical problems with using the standard could be identified. This would allow the problems to be identified and corrected before the standard is fully developed. The team noted with satisfaction that a session of the ISS/ET-IDM would be held from 11-18 December 2003, with an important focus on the further development of WMO Metadata standards. The team urged all its members to promote constructive contributions to the ET-IDM.

6.8 In view of the crucial role of catalogues and Metadata in the development of FWIS, the team strongly supported the requirement for organizing a workshop on Metadata and data catalogues, prior to CBS-XIII (see item 7).

6.9 The team fully supported and welcomed Mr Hiroyuki Ichijo (Japan) in volunteering to investigate in detail the new opportunities and development of data-communication providers and the Internet, in particular in Asia-Pacific, with a view to supporting the data-communication requirements of FWIS and ensuring a smooth transition from the GTS, including the IMTN.

7. FUTURE WORK PROGRAMME

7.1 The team agreed that its medium-term goal was to organize an FWIS workshop by CBS-Ext. 2006, based on prototypes and pilot project that would have demonstrated their operational feasibility. In

this regard, it would be important to demonstrate that small NMHSs (in particular in Africa and in the Pacific) could easily participate and take benefit from FWIS.

7.2 The Team expressed its appreciation to Mr Gil Ross (UK) for being the focal point for organizing the workshop on Metadata and data catalogues and identifying a suitable location and dates (likely mid-2004), as well as the key attendance. The team felt that a 2-day workshop would be appropriate, and it took note that no provisions were included in the WMO regular budget to support this event.

7.3 The Team was of the view that appropriate dates for its next session would be 6-10 September 2004.

Annex to Paragraph 3.9

Questionnaire to Technical Commissions

Preamble of Questionnaire

- Background including Congress statement on FWIS
- FWIS Vision
- Purpose of Questionnaire
- There will be follow-up to this questionnaire as the FWIS concept develops.
- List of members and additional experts in the ITT-FWIS
- Please nominate a contact point within your Commission.

Questions

1. Do you feel that your data management and exchange requirements within your programmes or with other programmes can be met by the FWIS? What specific issues can you identify?

2. What are the sources (providers) of data within your programmes? Who are the users of these data?

3. What are the entities (organisations) that need to be provided with your data within each WMO Member country?

4. Please map your current and future data exchange structure into the FWIS structure (see diagrams) with respect to GISCs, DCPCs and NCs, and corresponding data flows. Are there any specific issues related to this mapping?

5. Roughly how much volume in total needs to be exchanged by your programmes at present and in the foreseeable future?

   What proportion of your data is required to be exchanged within the following timeframes:
   - up to 15 minutes?
   - 15 to 60 minutes?
   - 1 to 3 hours?
   - 3 hours to one day?
   - longer than one day?

6. What proportion of your data is exchanged by:
   - the WWW GTS?
   - the Internet?
   - other mechanisms? Please specify.

7. What proportion of your data is exchanged by:
   - routine dissemination (push)?
   - request-reply?
   - other mechanisms? Please specify.

8. Please specify the general formats of your data with respect to:

- WMO standards?
- other international standards?
- proprietary or other formats?

9. Please describe the existing or planned metadata and catalogue standards within your programmes.

10. Is there any other information about the data management and exchange requirements of your programmes you think FWIS needs to be aware of?

Annex to Paragraph 5.4

The Future WMO Information System concept

EXECUTIVE SUMMARY

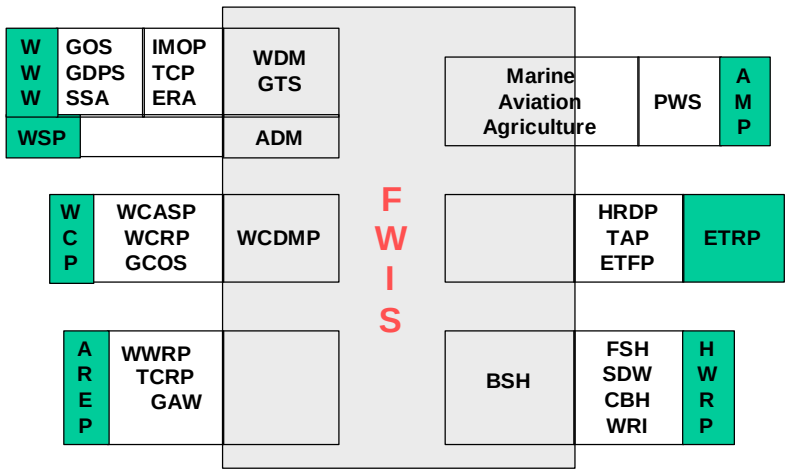
The current WMO information systems have been developed to meet a diverse set of requirements. The principal system is the GTS along with the related data processing and management functions that have been developed to serve the World Weather Watch (WWW). The GTS has a number of significant strengths: it is an operational private network that mainly provides for the exchange of real-time high-priority data, it is mature, well tested and operated according to well-defined procedures and shared responsibilities.

Other information systems that have been developed to meet the needs of other programmes and Commissions have their own advantages. Given the diversity of these systems it is difficult to provide a concise summary. However, most share a common strength: they have been developed by individual programmes to meet their specific requirements. Thus, the systems are generally focused in their approach and do not suffer from compromises and inefficiencies that can sometimes result from development of generalised systems.

The multiplicity of systems operated for different Programmes has, however, resulted in incompatibilities, inefficiencies, duplication of effort and higher overall costs for Members. Continuing to develop systems in this uncoordinated manner will exacerbate these problems and will further isolate the WMO Programmes from each other and from the wider environmental community. It will increase the difficulty in sharing information between programmes, which is essential for them to fulfil their requirements. As a consequence, other organizations, environmental programmes or commercial concerns might assume responsibility for providing essential data and services and WMO would thus lose its leadership role.

One option to address these problems might be to enhance the GTS in such a way as to generalize the services to all Programmes. However, the GTS would still suffer from well known inherent deficiencies that prevent it from meeting all of the requirements of WMO Programmes.

Therefore, an alternative approach is proposed: a single coordinated global infrastructure, the Future WMO Information System (FWIS). It is envisioned that FWIS would be used for the collection and sharing of information for all WMO and related international programmes. The relationship between functions performed by FWIS and similar functions performed by current WMO Programmes is illustrated in the figure. The FWIS vision provides a common roadmap to guide the orderly evolution of these systems into an integrated system that efficiently meets all of the international environmental information requirements of Members.



FWIS relationship to WMO Programmes

FWIS should provide an integrated approach to meeting the requirements of:

- Routine collection and automated dissemination of observed data and products ("push").
- Timely delivery of data and products (appropriate to requirements)
- Ad-hoc requests for data and products ("pull")

FWIS should be:

- Reliable
- Cost effective and affordable for developing as well as developed Members
- Technologically sustainable and appropriate to local expertise
- Modular and scalable
- Flexible and extensible - able to adjust to changing requirements and allow dissemination of products from diverse data sources and allow participants to collaborate at levels appropriate to their responsibilities and budgetary resources

FWIS should also support:

- Different user groups and access policies, such as WMO Resolutions 40/25
- Data as well as network security
- Integration of diverse datasets

Taking into account that information systems technology is evolving rapidly, FWIS should utilize industry standards for protocols, hardware and software. Use of these standards will reduce costs and allow exploitation of the ubiquitous Internet and web services.

The ultimate implementation of FWIS would build upon the most successful components of existing WMO information systems. It would continue to rely upon the WMO communication system (initially the GTS) to provide highly reliable delivery of time-critical data and products.

To clarify the concept of FWIS, three functional components are defined: National Centres (NC), Data Collection or Product Centres (DCPC) and Global Information System Centres (GISC). The information and communication responsibilities of existing WWW and other WMO Programme centres can be mapped into the corresponding functions within FWIS as illustrated in the table below. It should be noted that the FWIS functions will be added to the existing functions and responsibilities of the participating centres, which will continue.

Current WWW Centres	**FWIS Functions**
NMC (as regards information and communication)	NC
RSMC (as regards information and communication)	DCPC and/or GISC
WMC (as regards information and communication)	DCPC and/or GISC
RTH	DCPC
RTH on MTN	DCPC and/or GISC
Other Programme Centres	NC and/or DCPC

NMHSs span a range of responsibilities and capabilities. FWIS provides a flexible and extensible structure that would allow NMHSs to enhance their capabilities as their national and international responsibilities grow.

Centres considering participation in FWIS may be concerned that this would entail additional costs and replacement of equipment. However, FWIS will be built upon existing systems and these systems can continue to carry out their current tasks without modification. Additional equipment will probably be required if centres choose to provide the enhanced services offered by FWIS but, overall, cost savings will likely be realized since FWIS will not require maintenance of equipment once it becomes obsolete.

Further development and implementation of FWIS should be pursued through a gradual introduction and evaluation of enabling technologies through pilots and prototypes. Successful prototypes could then be expanded to serve additional communities and/or distributed to other Members and centres for wider implementation. In this way, the enhanced functions provided by FWIS would be gradually introduced and expanded.

The Future WMO Information System concept

1. INTRODUCTION

1.1 The current WMO information systems have been developed to meet a diverse set of requirements. The principal system is the GTS along with the related data processing and management functions that have been developed to serve the World Weather Watch (WWW). The GTS has a number of significant strengths: it is an operational private network that mainly provides for the exchange of real-time high-priority data, it is mature, well tested and operated according to well-defined procedures and shared responsibilities.

1.2 Other information systems that have been developed to meet the needs of other programmes and Commissions have their own advantages. Given the diversity of these systems it is difficult to provide a concise summary. However, most share a common strength: they have been developed by individual programmes to meet their specific requirements. Thus, the systems are generally focused in their approach and do not suffer from compromises and inefficiencies that can sometimes result from development of generalised systems.

1.3 Considering the current state of the WMO Information System and the overall vision of a future system, some of the key points are:

- There is now limited utilisation of the Internet for operational store and forward applications
- There is limited connectivity between applications developed to serve the needs of the different Commissions
- There are a large number of different applications whose development has not been coordinated making integration of data sets technically challenging
- Multidisciplinary application of meteorological, hydrological and oceanographic data is hampered by lack of agreed standards needed to effectively identify, acquire and use all of the relevant data

1.4 The multiplicity of systems operated for different Programmes has resulted in incompatibilities, inefficiencies, duplication of effort and higher overall costs for Members. Continuing to develop systems in this uncoordinated manner will exacerbate these problems and will further isolate the WMO Programmes from each other and from the wider environmental community. It will increase the difficulty in sharing information between programmes, which is essential for them to fulfil their requirements. As a consequence, other organizations, environmental programmes or commercial concerns might assume responsibility for providing essential data and services and WMO would thus lose its leadership role.

1.5 One option to address these problems might be to enhance the GTS in such a way as to generalize the services to all Programmes. However, the GTS would still suffer from inherent deficiencies, some of which are listed below:

- Use of proprietary high-level protocols that are not supported by the marketplace.
- Volume restrictions preclude the transmission of satellite imagery, as well as video and other high volume data sets (in the order of gigabytes or terabytes).
- Lack of support for a request/reply system providing ad-hoc access to the data and products available for international exchange.
- Inability to facilitate information insertion and distribution to programmes and public and other clients beyond the meteorological community.
- Inability to rapidly (i.e. routinely near-real-time) identify where data losses are occurring and undertake remedial action.
- Inability to easily accommodate requirements that include short periods of high volume traffic followed by lengthy periods of low or no traffic.
- Inadequate product identification and metadata leading to duplication and uncertainty of content.

1.6 Therefore, an alternative approach is proposed: a single coordinated global infrastructure, the Future WMO Information System (FWIS). It is envisioned that FWIS would be used for the collection and sharing of information for all WMO and related international programmes. The relationship between functions performed by FWIS and similar functions performed by current WMO Programmes is illustrated in Figure 1 below. The FWIS vision provides a common roadmap to guide the orderly evolution of these systems into an integrated system that efficiently meets all of the international environmental information requirements of Members.

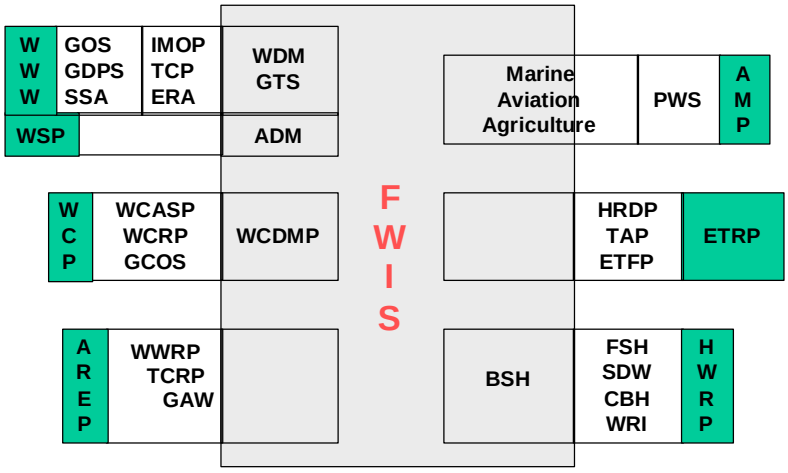


Figure 1. FWIS relationship to WMO Programmes

1.7 FWIS should provide an integrated approach to meeting the requirements of:

- Routine collection and automated dissemination of observed data and products ("push").
- Timely delivery of data and products (appropriate to requirements)
- Ad-hoc requests for data and products ("pull")

FWIS should be:

- Reliable
- Cost effective and affordable for developing as well as developed Members
- Technologically sustainable and appropriate to local expertise
- Modular and scalable
- Flexible and extensible - able to adjust to changing requirements and allow dissemination of products from diverse data sources and allow participants to collaborate at levels appropriate to their responsibilities and budgetary resources

FWIS should also support:

- Different user groups and access policies, such as WMO Resolutions 40/25
- Data as well as network security
- Integration of diverse datasets

1.8 Taking into account that information systems technology is evolving rapidly, FWIS should utilize industry standards for protocols, hardware and software. Use of these standards will reduce costs and allow exploitation of the ubiquitous Internet and web services.

1.9 The ultimate implementation of FWIS would build upon the most successful components of existing WMO information systems. It would continue to rely upon the WMO communication system (initially the GTS) to provide highly reliable delivery of time-critical data and products. Currently, this requires a private network but this is likely to change as public communications services evolve.

1.10 Executive Council has noted that a window of opportunity exists now to arrive at an agreed standard for FWIS.

2. FUNCTIONS AND RESPONSIBILITIES

2.1 To clarify the concept of FWIS, three functional components are defined: National Centres (NC), Data Collection or Product Centres (DCPC) and Global Information System Centres (GISC). It should be noted that this is a functional description defining responsibilities for data and product exchange. One physical centre could perform the functions of one or more of these components. Likewise, several physical centres could cooperate to perform the functions of a single functional centre.

National Centres

2.2 FWIS NCs would serve data and product needs of their country. For this purpose, each country will implement and maintain an appropriate infrastructure, being the national component of FWIS. Most NCs would be part of an NMHS. However, there might be others within the same country having national responsibility for functions falling within WMO Programmes but located outside of the NMHS. The participation of the centres would be coordinated through the national Permanent Representative to WMO. NCs would:

a. Collect observational data from within their country
b. Provide observations and products intended for global dissemination to their responsible GISC (possibly via a DCPC)
c. Provide observations and products intended for regional or specialised distribution to the responsible DCPC
d. Collect, generate and disseminate products for national use.
e. Participate in monitoring the performance of the system.

Data Collection or Product Centres

2.3 Several dozen centres would serve as DCPCs. An existing RSMC would fulfil the function of a DCPC but many additional centres would also serve as DCPCs. This would include suppliers of special observations (e.g. ARGOS, ARINC, field experiments) and centres producing products related to a specific discipline (e.g. ECMWF, NESDIS). As appropriate, DCPCs would:

a. Collect information intended for dissemination to NCs within its area of responsibility (i.e. regional collections)
b. Collect special programme-related data and products
c. Produce regional or specialized data and products
d. Provide information intended for global exchange to their responsible GISC
e. Disseminate information not intended for global exchange
f. Support access to their products via WMO request/reply (“Pull”) mechanisms in an appropriate manner
g. Describe their products according to an agreed WMO standard and provide access to this catalogue of products and provide this information as appropriate to other centres, in particular a GISC
h. Ensure that they have procedures and arrangements in place to provide swift recovery or backup of their essential services in the event of an outage (due to, for example, fire or a natural disaster).
i. Participate in monitoring the performance of the system.

Global Information System Centres

2.4 Several (perhaps 4 to 10) centres would serve as GISCs. Each GISC would have a defined area of responsibility. GISCs would usually be located within or closely associated with a centre running a global data assimilation system or having some other global commitment, such as a WMC. However, the proposed architecture does not dictate that this be a requirement. The responsibilities of a GISC can be summarised as follows. Each GISC would:

a. Receive observational data and products that are intended for global exchange from NCs and DCPCs within their area of responsibility, reformat as necessary and aggregate into products that cover their responsible area
b. Exchange information intended for global dissemination with other GISCs
c. Disseminate, within its area of responsibility, the entire set of data and products agreed by WMO for routine global exchange (this dissemination can be via any combination of the Internet, satellite, multicasting, etc. as appropriate to meet the needs of Members that require its products)
d. Hold the entire set of data and products agreed by WMO for routine global exchange for at least 24 hours and make it available via WMO request/reply (“Pull”) mechanisms
e. Maintain, in accordance to the WMO standards, a catalogue of all data and products for global exchange and provide access to this catalogue to locate the relevant centre
f. Provide around-the-clock connectivity to the public and private networks at a bandwidth that is sufficient to meet its global and regional responsibilities.
g. Ensure that they have procedures and arrangements in place to provide swift recovery or backup of their essential services in the event of an outage (due to, for example, fire or a natural disaster).

h. Participate in monitoring the performance of the system, including monitoring the collection and distribution of data and products intended for global exchange.

Security and authorisation

2.5 In accordance with NCs' responsibilities to serve data and product needs of their country, NCs would provide for the authorization of their respective national users to access FWIS, as required. Appropriate identification, authentication and authorization procedures will be exercised through relevant standards.

Data archives

2.6 FWIS would not control data archiving, which remains the responsibility of the respective WMO programmes and relevant centres.

Data flow

2.7 The flow of information between these centres is illustrated in figures 2 through 4. Figure 2 outlines the collection of observations and products. It is not considered necessary to standardise the physical links to be used between all of the suppliers and collectors. These could instead be decided by bilateral agreement to best match the requirements and capabilities of the parties involved. However, Members would be encouraged to use standard protocols recommended by WMO.

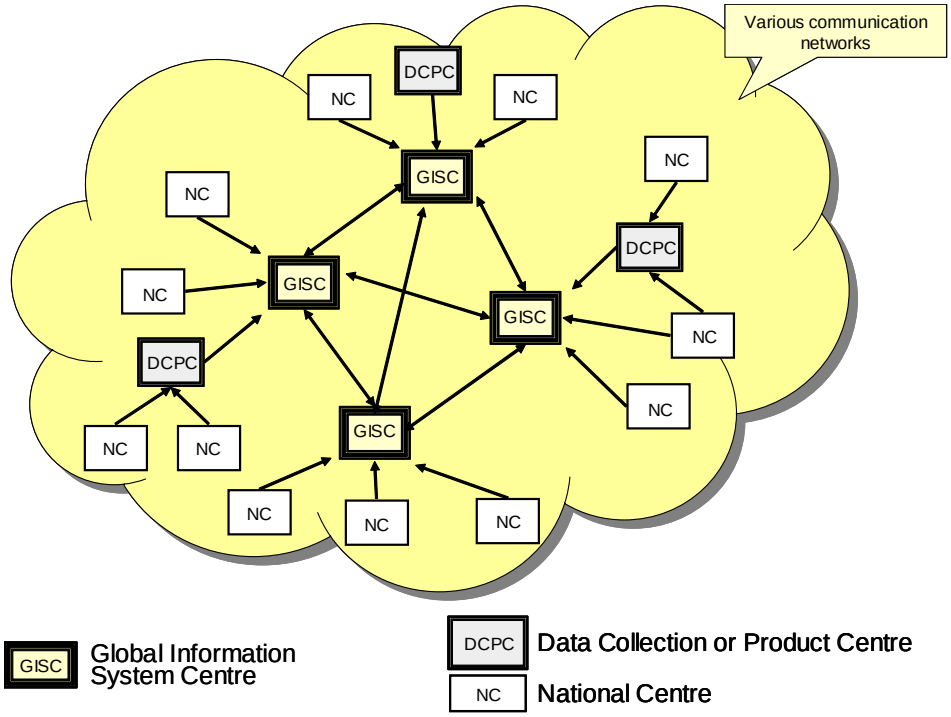


Figure 2. Information collection data flow
(Arrows indicate data flows; no physical links are implied)

2.8 Figure 3 illustrates the dissemination of products (both routine and non-routine). Routine (i.e. scheduled) dissemination of observed data and products would be accomplished through an automatic broadcast or "push" system that could be implemented via a variety of technologies, including the existing GTS. Ad-hoc (non-scheduled) and special requests for data and products would be satisfied by a request/reply ("pull") system. The "push" and "pull" systems, operating in parallel, should be available to all users of WMO data and products.

2.9 Figure 4 provides a simplified view of the various categories of information flow.

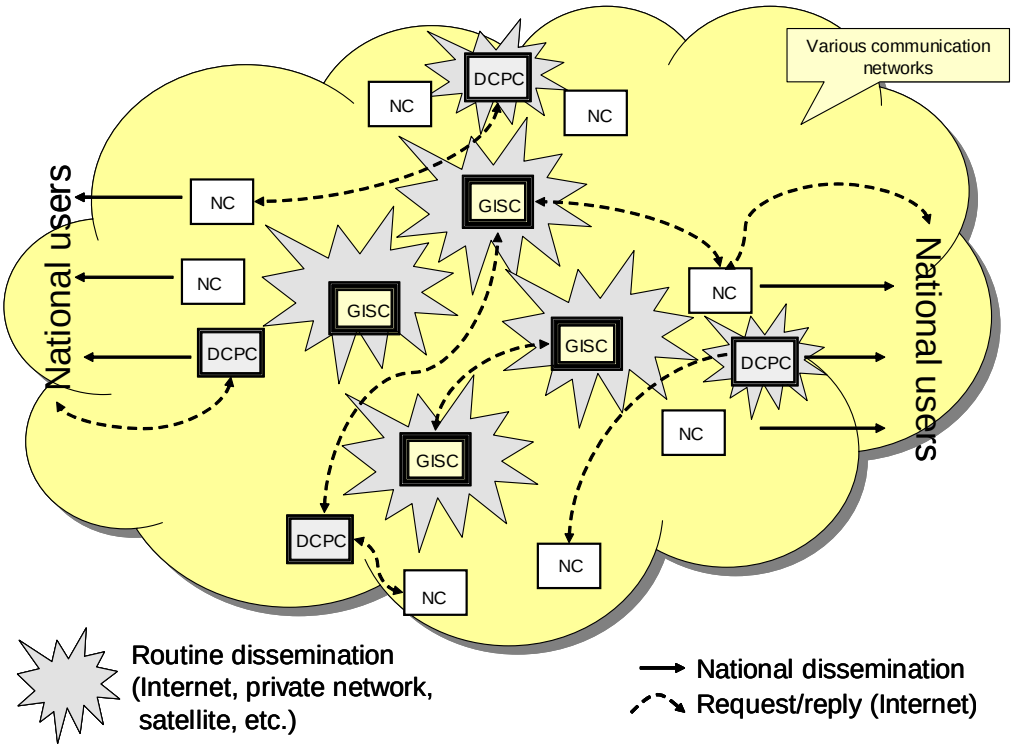


Figure 3. Information distribution
(Arrows indicate data flows; no physical links are implied)

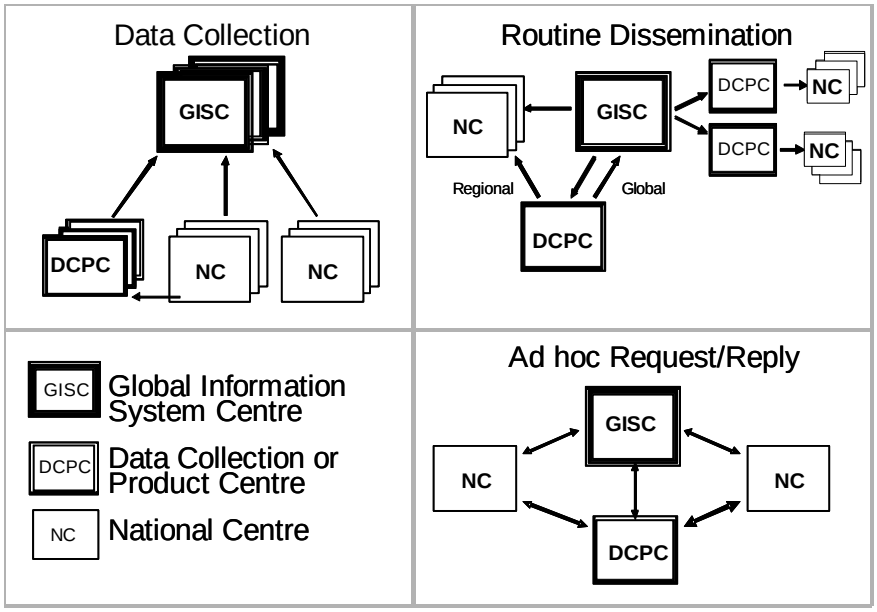


Figure 4. Overview of communication topologies

3. RELATIONSHIP TO EXISTING CENTRES

3.1 The information and communication responsibilities of existing WWW and other WMO Programme centres can be mapped into the corresponding functions within FWIS as illustrated in the table below. It should be noted that the FWIS functions will be added to the existing functions and responsibilities of the participating centres, which will continue.

Current WWW Centres	**FWIS Functions**
NMC (as regards information and communication)	NC
RSMC (as regards information and communication)	DCPC and/or GISC
WMC (as regards information and communication)	DCPC and/or GISC
RTH	DCPC
RTH on MTN	DCPC and/or GISC
Other Programme Centres	NC and/or DCPC

4. ENHANCED CAPABILITIES IN RESPONSE TO INCREASING RESPONSIBILITIES

4.1 NMHSs span a range of responsibilities and capabilities. FWIS provides a flexible and extensible structure that would allow NMHSs to enhance their capabilities as their national and international responsibilities grow. FWIS services of less developed NMHSs with less demanding requirements could be successfully implemented with Personal Computers and dial-up Internet connections, provided they receive basic products via satellite broadcast (e.g. EMWIN, MDD, RETIM2000, etc.). As resources and requirements increase, NMHSs could be equipped with increased capabilities as illustrated in Figure 5. It should be noted that there is not a direct relation between the functional FWIS components and the centres illustrated in the figure.

4.2 Increased capabilities at an affordable cost could be provided using one or more PCs, a permanent connection to the Internet and, possibly, satellite communications for assured and timely receipt of WMO products. Centres with these facilities would have the capabilities to function as a NC or small DCPC.

4.3 Further capacity would be provided by PCs, workstations or servers, a broadband Internet connection, and connection to the WMO communication system (GTS with a dedicated message switch, and/or Internet Data Distribution (IDD)). A centre with this infrastructure could serve as a fully functional NC or DCPC.

4.4 A full capacity centre would be equipped with a large computer system (mainframe, multiple interconnected servers, workstations and PCs), a very broadband Internet connection, and a high-speed connection (or multiple connections) to the WMO communication system. A fully equipped centre with these capabilities could provide the services of a sophisticated NC, DCPC, GISC or any combination of these three centres.

5. TECHNICAL CONSIDERATIONS

5.1 For the near future, transmission of the current suite of global products will continue to be distributed to WMO Centres via the existing GTS infrastructure. However, implementation of request/reply systems and exchange of high volume datasets (e.g. radar data, satellite imagery, and high resolution model output) cannot be supported by the existing GTS. Realization of the FWIS vision requires that the existing GTS dedicated communication links and message switches be augmented by additional communications capabilities such as those provided by the commercial Internet and other communication options.

5.2 The current GTS can be extremely costly to WMO Members and inhibit participation in WMO data exchange due to high costs associated with dedicated lines, acquisition of message switches, and ongoing costs of maintaining message switch routing tables. Consequently, the Internet is likely to become the default communication carrier for WMO FWIS data exchange and only where it does not meet the requirements of WMO Programmes would use of private, dedicated network services and message switches be justified. However, the current capabilities of the Internet raise concerns for Members' requirements for:

- reliable and continuous connectivity,
- sufficient bandwidth to handle peak-period data transmission,
- responsive delivery of time-critical information,
- a secure networking environment

These concerns must be addressed through long-term testing of Internet capabilities and advanced methodologies (e.g. IPv6, QoS) that promise to provide a secure network environment and predictable performance.

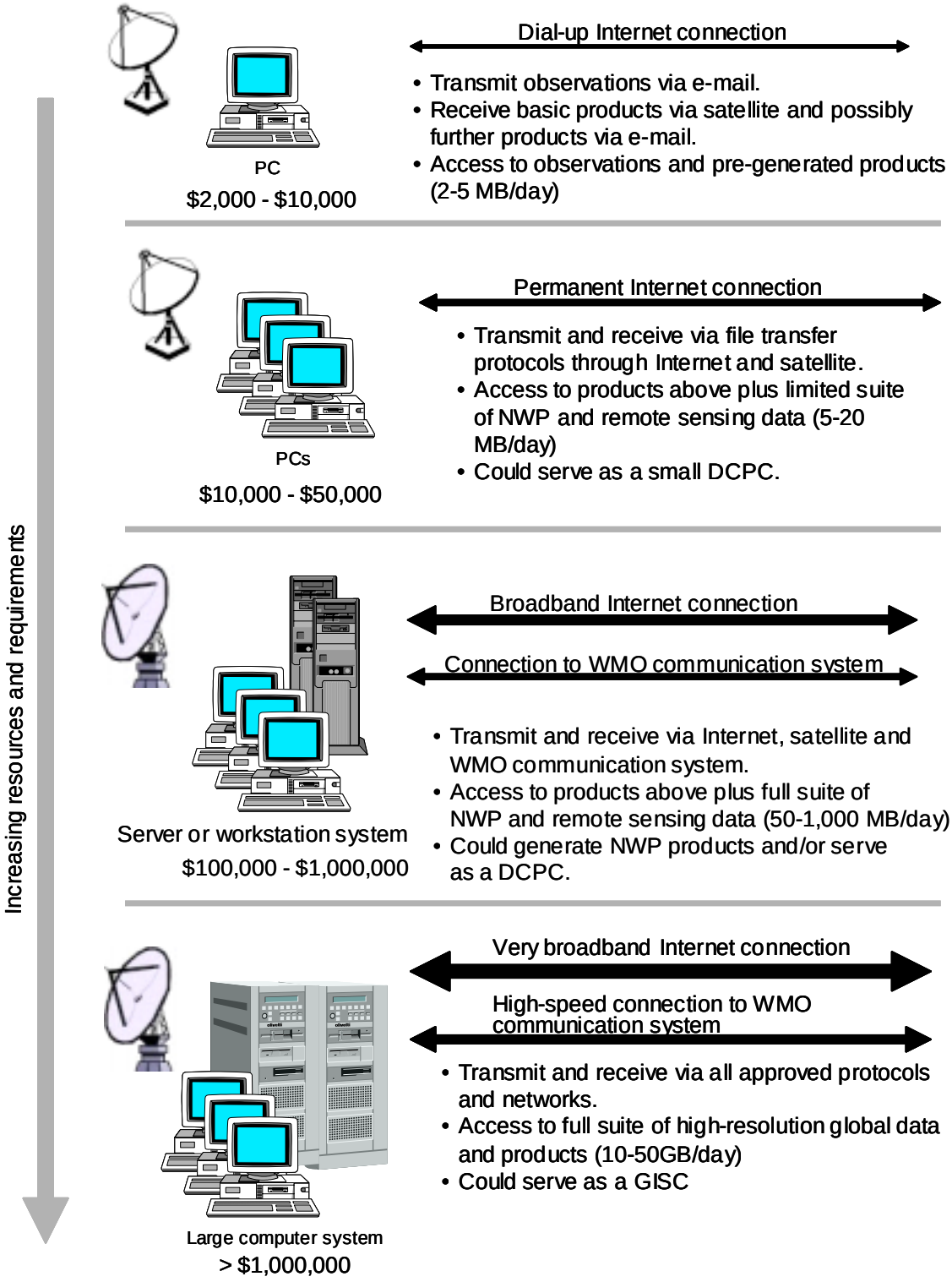


Figure 5. Capabilities of centres in response to increasing requirements
The approximate value of computer hardware and software performing FWIS functions is provided for each level in US dollars.

5.3 Use of alternative communications pathways and software to facilitate data exchange can lower costs and simplify operational management of basic data exchange between Members and can provide

flexible and scalable solutions to meet changing data exchange requirements, e.g. Data-Grid-services, OPeNDAP, etc. Alternative methodologies to communicate messages include the Automatic File Distribution (AFD) system developed by the DWD and the IDD developed by the UNIDATA Program Center. While these systems take different approaches to the transmission of data products, they both have a proven history of operation and offer cost-effective alternatives to message switches. Additionally, these methodologies can coexist on dedicated or public communication pathways to provide maximum flexibility for data exchange in a store and forward (push) environment.

5.4 For the request/reply mechanism and catalogue enquiries Web-services and Web portals should be considered, e.g. as in the UNIDART project.

5.5 In environments where dedicated communication lines are prohibitively expensive or unreliable, receipt of basic data and pre-generated products can be accomplished by relatively low cost satellite communication. However, the sending of observations via two-way satellite transmission may be too expensive so use of dial-up communications would be necessary.

5.6 To reduce costs for Members FWIS should:

- Use cost-effective communication systems whenever practicable. Cost-effective communication choices will vary between Regions and between Centres with differing responsibilities and local communications infrastructure but compatibility should be a paramount consideration.
- Use commercial off the shelf or open source software where it is available to meet requirements at reasonable cost.
- Employ well-supported open-source software as the foundation for system development when new software is required. System costs will be lowered and continued development of systems will not rely on proprietary system components. Software code will be readily available for modification to meet evolving needs.
- Foster development of open-source projects. Parallel system development is on-going at many Member organizations. Organized open-source projects, focussed on common needs, will result in improved systems benefiting all Members.

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LIST OF PARTICIPANTS

Task Team members

Geerd-Ruediger Hoffmann
Chairman
Deutscher Wetterdienst
Kaiserleistrasse 42
D-63067 OFFENBACH
Germany
Tel: (49 69) 8062 2824
Fax: (49 69) 8062 3823
E-mail: geerd-ruediger.hoffmann@dwd.de

Robert Stanek
Deutscher Wetterdienst
Kaiserleistrasse 42
D-63067 OFFENBACH
Germany
Tel: (49 69) 8062 2837
Fax: (49 69) 8062 3836
E-mail: Robert.stanek@dwd.de

Hiroyuki Ichijo
Japan Meteorological Agency
1-3-4 Otemachi, Chiyoda ku
Tokyo 100
Japan
Tel. (81 3) 3218 3825
Fax. (81 3) 3211 8404
E-mail h_ichijo@naps.kishou.go.jp

Yap Kok Seng
Malaysian Meteorological Service
Jalan Sultan
46667 Petaling Jaya
Malaysia
Tel (6 03) 79678003
Fax (6 03) 79550964
E-mail yks@kjc.gov.my

Kevin Alder
Meteorological Service of New Zealand
30 Salamanca Road
Box 722
WELLINGTON
New Zealand
Tel (64 4) 472 9379
Fax (64 4) 4735231
E-mail kevin.alder@metservice.com

Alexander V. Besprozvannykh
RIHMI-World Data Centre
6, Korolev St.
Obninsk, Kaluga Reg, 249035
Russian Federation
Tel: +7 08439 74959
Fax: +7 095 2552225
E-mail alexander@meteo.ru

Tom Potgieter

South African Weather Bureau
Department of Environment Affairs
Private Bag X097
PRETORIA 0001
South Africa
Tel. (27) 12 367 6127
Fax (27) 12 367 6194
E-mail potgiet@weathersa.co.za

Ted Tsui

Marine Meteorology Division (Code 7540)
Naval Research Laboratory
7 Grace Hopper Avenue
MONTEREY
CA 93943-5502
USA
Tel (1 831) 656 4738
Fax (1 831) 656 4769
E-mail Tsui@nrlmry.navy.mil

John Shortridge
(Representing CCl)

Bureau of Meteorology
GPO Box 1289K
MELBOURNE, VIC 3001
Australia
Tel: (613) 9669 4282
Fax: (613) 9669 4760
E-mail j.shortridge@bom.gov.au

David Thomas
(Representing JCOMM)

Bureau of Meteorology
GPO Box 1289K
Melbourne, VIC 3001
Australia
Tel: (613) 9669 4349
Fax: (613) 9662 1223
E-mail david.thomas@bom.gov.au

Byong-Lyol Lee
(Representing CAgM)

National Centre for AgroMeteorology
Korean Meteorological Administration (KMA)
208-16 Seodun-dong
Suwon 441-805
Republic of Korea
Tel. (82) 31 291 0170
Fax (82) 31 291 0366
E-mail blee@kma.go.kr

Marc Morell
(Representing CHy)

Woisydes Coordinator
IRD
911 Avenue Agropolis
BP 64 501
34394 Montpelier
France
Tel. (33 4) 67 63 64 20
Fax (33 4) 67 41 21 33
E-mail morell@ird.fr

Additional experts

Dong-Il Lee

Chief, Supercomputer Center Branch
Information Communication Division
Korea Meteorological Administration (KMA)
460-18 Shindaebang-dong Dongjak-gu
SEOUL 156-720
Republic of Korea
Tel. (82 2) 835 9818
Fax (82 2) 2181 9208
E-mail ldi@kma.go.kr

Gil Ross

Met Office
FitzRoy Road
Exeter, Devon
EX1 3PB
United Kingdom
Tel: +44 1392 886973
Fax: +44 1133 361072
E-mail: gil.ross@metoffice.com

Al Kellie

Director, Scientific Computing Division
NCAR
1850 Table Mesa Drive
Boulder, Colorado 80305
USA
Tel: +1 303 497 1206
Fax: +1 303 497 1298
E-mail: kellie@ucar.edu

WMO Secretariat

Jean-Michel Rainer

Chief, Telecommunications and Monitoring Unit
World Meteorological Organization
7 bis, avenue de la Paix
Case postale No. 2300
CH-1211 Genève 2
Switzerland
Tel. (41 22) 730 8219
Fax. (41 22) 730 8021
E-mail jmrainer@wmo.int

ANNEX

LIST OF ACRONYMS

ADM	Alternative dissemination methods
AFD	Automatic file distribution
AMP	Applications of Meteorology Programme
ANSI	American National Standards Institute
BSH	Basic Systems in Hydrology
CAeM	Commission for Aeronautical Meteorology
CAgM	Commission for Agricultural Meteorology
CBH	Capacity Building in Hydrology and Water Resources
CBS	Commission for Basic Systems
CCl	Commission for Climatology
CDP	
Cg	WMO Congress
CHy	Commission for Hydrology
CIMO	Commission for Instruments and Methods of Observation
DCPC	Data collection or product centre
DMAC	Data Management and Communications of the Integrated Ocean Observing System
DWD	Deutscher Wetterdienst (German Weather Office)
EC	Executive Council of WMO
ECMWF	European Centre for Medium Range Weather Forecasts
EMWIN	Emergency Managers Weather Information Network
ERA	Emergency Response Activities
ESP	Earth Sciences Portal
ET	Expert team
ETFP	Education Training and Fellowships programme
ETRP	Education and Training Programme
FAH	Forecasting and Application in Hydrology
FTP	File transfer protocol
FWIS	Future WMO Information System
GAW	Global Atmosphere Watch
GCOS	Global Climate Observing System
GDPS	Global Data Processing System
GISC	Global information system centre
GOS	Global Observing System
GRDC	Global run-off data centre
GSN	GCOS Surface Network
GSP	
GTN-H	Global Terrestrial Network for Hydrology
GTS	Global Telecommunications System
GUAN	GCOS Upper-Air Network
HRDP	Human Resources Development programme
HWRP	Hydrology and Water Resources Programme
IDD	Internet data distribution system
ICT	Implementation-coordination team (of CBS)
IMOP	Instruments and Methods of Observations programme
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IODE	International Oceanographic Data and Information Exchange
IOS	Integrated Observing System
ISO	International Standards Organization
ISS	Information Systems and Services
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
LDM	Unidata's local data manager
MB	Megabyte, 10^6 octets

METGIS	Meteorological Graphic Information System
MSS	Message Switching System
MTN	Main Telecommunications Network (of the GTS)
NERC	Natural Environment Research Council
NMHS	National Meteorological or Hydrological Service
NWP	Numerical Weather Prediction
OPAG	Open Programme Area Group (of CBS)
OPAG-ISS	Open Programme Area Group on Information Systems and Services
OPeNDAP	Open Source Project for a Network Data Access Protocol
PC	Personal computer
PWS	Public Weather Services
RMDCN	Regional meteorological data communications network
RTH	Regional telecommunications hub
SAWS	South African Weather Service
SDW	Sustainable Development of Water Resources
SQL	Standard Query Language
SSA	System Support Activities
SSUP	Satellite Systems Utilization and Products
TAP	Training Activities programme
TCP	Tropical Cyclone programme
TCP/IP	Transport control protocol, internet protocol
TCRP	Tropical Cyclone Research Programme
UNIDART	Uniform Data Request Interface
VGISC	Virtual Global information system centre
WAFC	World Area Forecast Centre
WAFS	World Area Forecast System
WAMIS	World Agrometeorological Information Service
WDM	World Weather Watch Data Management
WCASP	World Climate Applications and Services Programme
WCDMP	World Climate Data and Monitoring Programme
WCP	World Climate Programme
WCRP	World Climate Research Programme
WHYCOS	World Hydrological Cycle Observing System
WMO	World Meteorological Organization
WRI	Water-related Issues
WSP	WMO Space Programme
WWRP	World Weather Research Programme
WWW	World Weather Watch
XML	Extensible mark-up language