# THE FUTURE WMO INFORMATION SYSTEM CONCEPT

*Annex to Paragraph 5.4*

Final Report, ITT-FWIS 2003

## EXECUTIVE SUMMARY

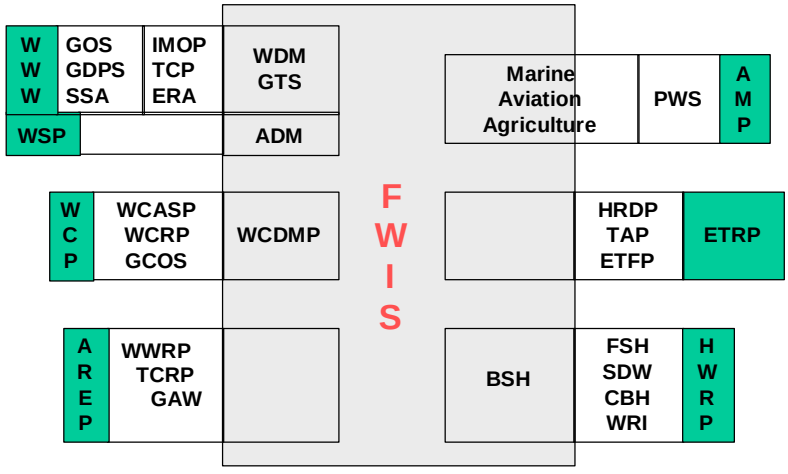
The current WMO information systems have been developed to meet a diverse set of requirements. The principal system is the GTS along with the related data processing and management functions that have been developed to serve the World Weather Watch (WWW). The GTS has a number of significant strengths: 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.

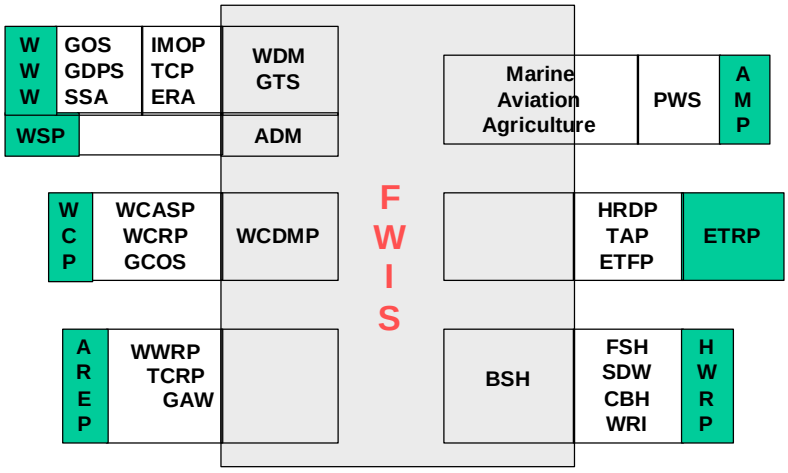



**Figure 1. FWIS relationship to WMO Programmes**

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
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- 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.

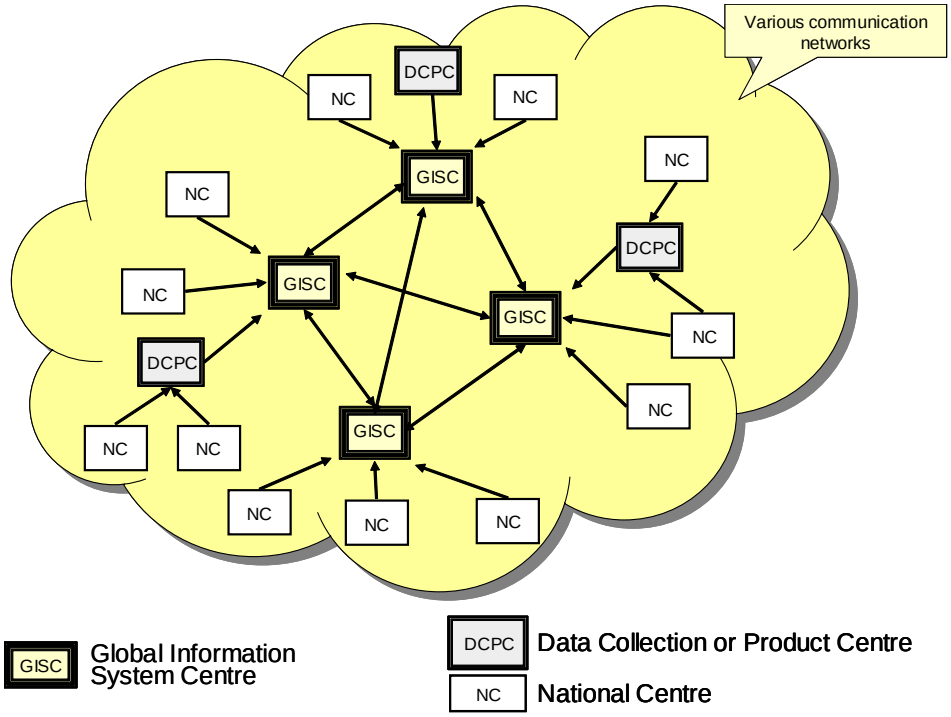


**Figure 2. Information collection data flow**
(Arrows indicate data flows; no physical links are implied)

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.

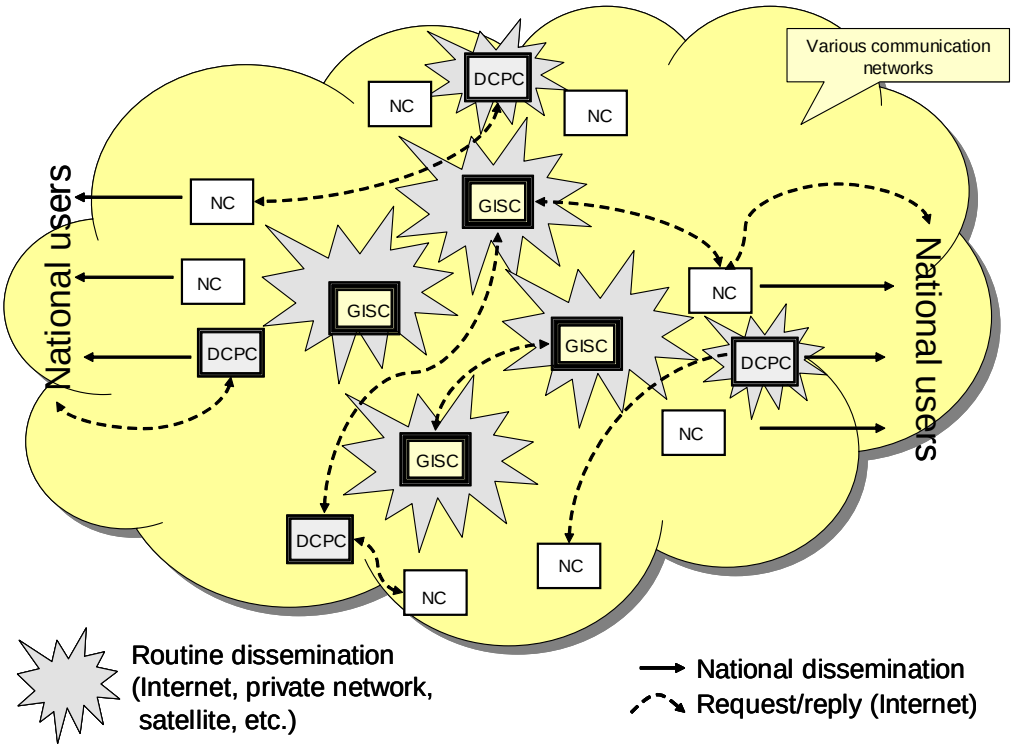


**Figure 3. Information distribution**
(Arrows indicate data flows; no physical links are implied)

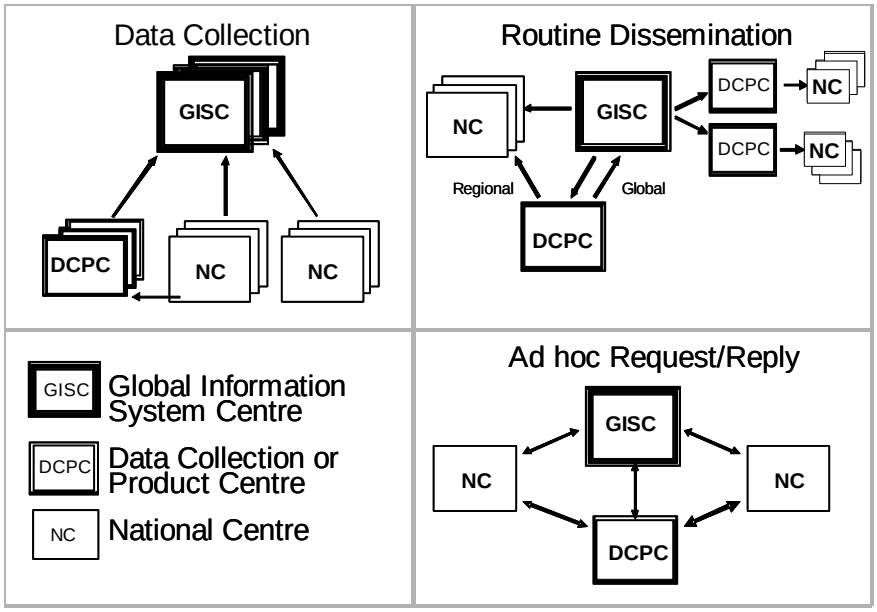


**Figure 4. Overview of communication topologies**

## 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 |
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| | |
| **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.

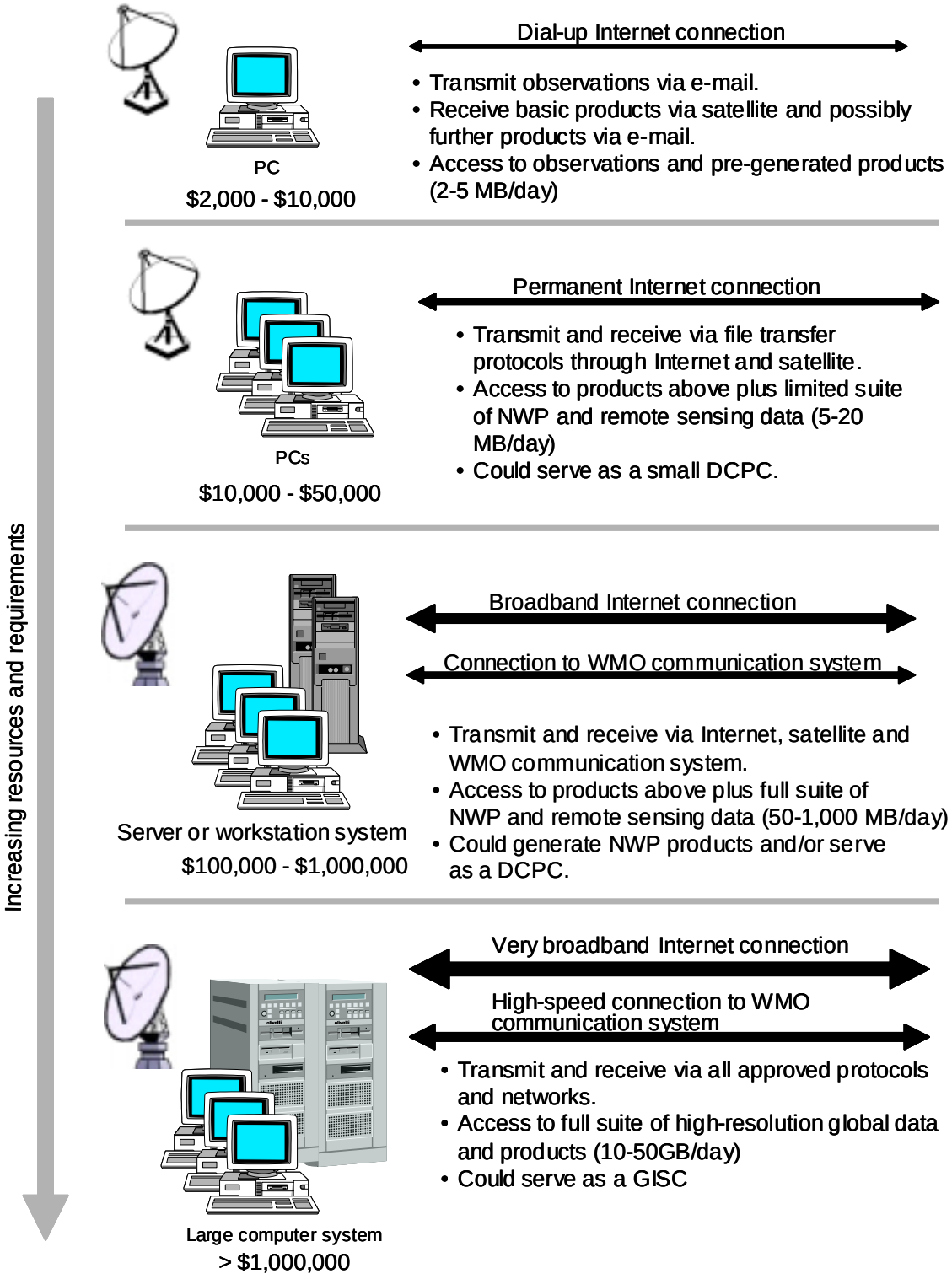


**Figure 5. Capabilities of centres in response to increasing requirements**
The approximate value of computer hardware and software performing FWIS functions is provided for each level in US dollars.

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.