A Coastal and Ocean Information Network for Caribbean Marine Resource Management

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ABSTRACT

The establishment of an Inland Waters, Coastal and Ocean Information Network (ICOIN) is proposed as an information/data conduit for marine resource management systems being considered in the Caribbean. Organizations such as the OECS and the University of West Indies are suggested as regionally-oriented bodies in a position to coordinate such activities. The parameters reviewed in this paper include the technological challenges, personnel requirements, and infrastructure development that must be addressed before the implementation of such a network. The rationale for an information network of distributed databases is considered for both the Caribbean and Atlantic Canada, regions having much in common, particularly the importance of the marine and coastal resource sector to their respective economies.

INTRODUCTION

According to *Our Common Future*, the report of the World Commission on Environment and Development (1987) headed by G.H. Brundtland, three imperatives lie at the heart of the oceans management question:

- the underlying unity of the oceans requires effective global management regimes;
- the shared resource characteristics of many regional seas make forms of regional management mandatory;
- the major land-based threats to the oceans require effective national actions based on international cooperation.

These comments are particularly pertinent to the Caribbean because of the multiplicity of national jurisdictions, compounded by the establishment of two hundred mile Exclusive Economic Zones within a relatively limited geographic area.

Sustainable marine resource development and management, other themes of the Brundtland report, are dependent upon the availability of relevant and timely information and data in suitable formats for review and analysis. It should be appreciated that information and data are being generated at an accelerating rate. To manage and to benefit from this "information explosion", computerization and automation have become essential. "We have, for the first time, an economy based on a key resource that is not only renewable but self-generating. Running out of it is not a problem, but drowning in it is" (Naisbitt, 1984).

To meet this challenge and in the context of marine and coastal resource development, Canada has made considerable efforts to develop appropriate technology and infrastructure, including Geographic Information Systems (GIS), remote sensing/digital image analysis, and communication networks. These developments have particular relevance to the Caribbean nations in view of: the parallel importance of the marine and coastal resource sectors to their respective economies; the requirement for a regional fisheries management strategy as exemplified by the establishment of a Fisheries Secretariat by the Organization of Eastern Caribbean States (OECS), and the International Centre for Ocean Development (ICOD); and the anticipated expenditure of additional monies in the marine resource sector of Caribbean nations as a whole by ICOD, among other agencies.

In papers presented at the Martinique GCFI Conference (Butler, Macneil, and Fay, 1987) and at the Bermuda GCFI Conference (Butler *et al.*, 1989), the relevance of the Atlantic Canadian experience to the Caribbean with regard to fishery management and contingency planning were reviewed. Topics of discussion included the development of a Marine Resource Information System (MARIS) and its associated technologies (GIS and remote sensing). These subjects, among others, were subsequently reviewed in detail in two FAO Fisheries Technical Papers:

- Marine Resource Mapping: An Introductory Manual (Butler, LeBlanc, Belvin, and MacNeil, 1987)
- The Application of Remote Sensing Technology to Marine Fisheries: An Introductory Manual (Butler *et al.*, 1988)

THE ICOIN CONCEPT

In the past two years the concept of an Inland Waters, Coastal and Ocean Information Network (ICOIN) has evolved as a logical extension of earlier developments, such as MARIS. ICOIN has now reached its implementation phase in Canada.

What is ICOIN?

ICOIN is a network of geographically-referenced data bases which contain alphanumeric and/or graphic data (Figure 1). The data bases are produced and maintained by local experts within diverse agencies on a variety of automated systems. ICOIN and the associated infrastructure will develop incrementally. A parallel may be found in the evolution of the telephone system; small local

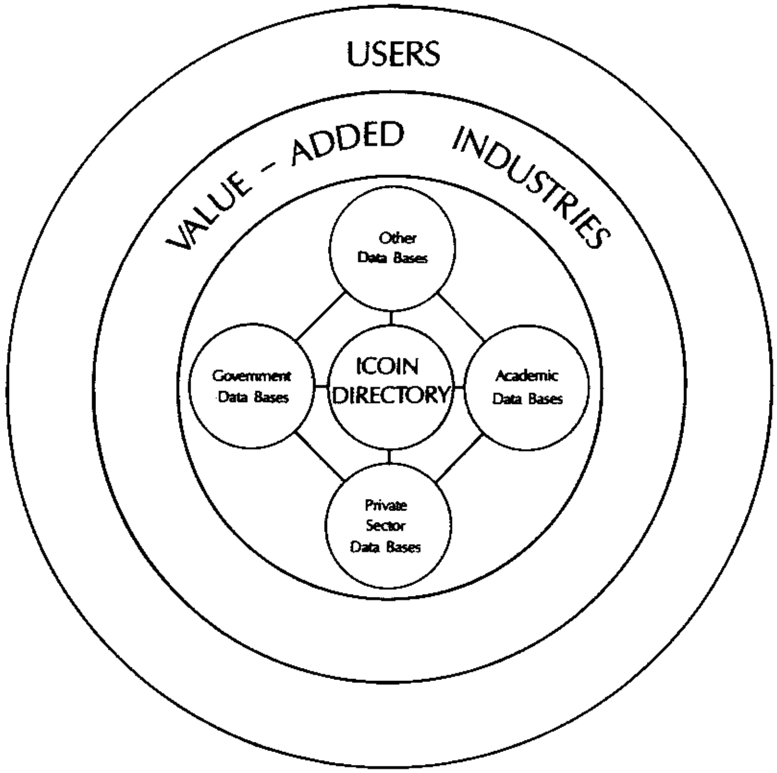

Figure 1. Conceptual model of ICOIN.

exchanges were eventually integrated into national and international systems. This integration process required the adoption of standards and the development of universal accessibility.

The relationship of geographically-referenced information based on scale and subject matter within ICOIN are portrayed in Figure 2. The foundation for the ICOIN conceptual model consists of hydrographic, bathymetric, and topographic base mapping at scales suitable to give a geographic context to the various levels of detail contained in the thematic and other data bases which constitute the network.

Using a data base directory, ICOIN will identify the data bases that reside within their host departments or agencies and that collectively constitute ICOIN.

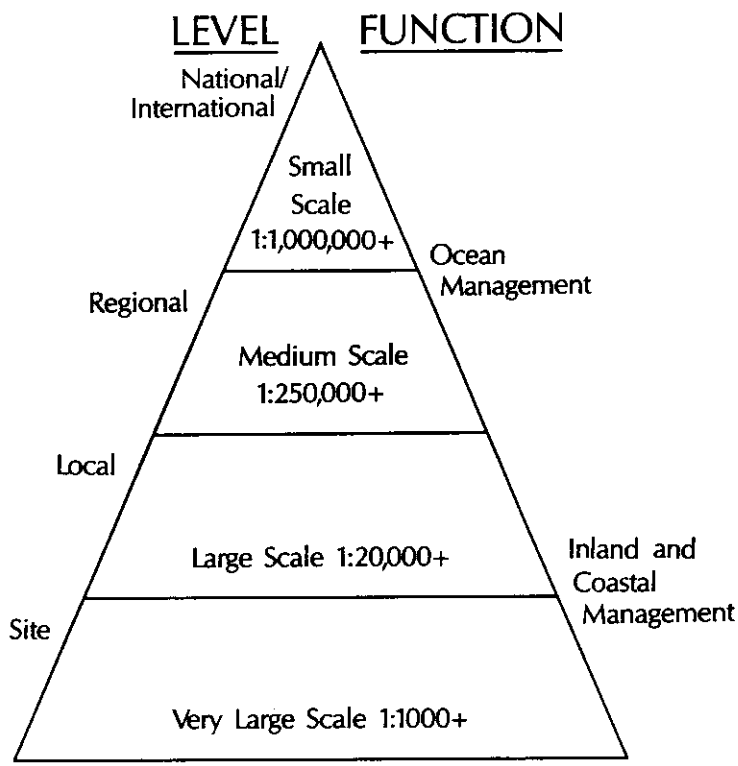

Figure 2. ICOIN foundation data/information.

There are many software packages on the market (statistical, data base management systems, etc.) that will facilitate the use of ICOIN data and information. In addition, GIS will increase the analytical options for manipulating graphic and alphanumeric data.

A GIS permits the automated inventory and management of geographically-referenced (spatially related) data. The essential elements of an automated GIS are indicated in Figure 3. A combination of hardware and GIS software are used to input, store, analyze, manipulate, merge, display, and output geographically-referenced graphic, alphanumeric, and textual data in a variety of formats.

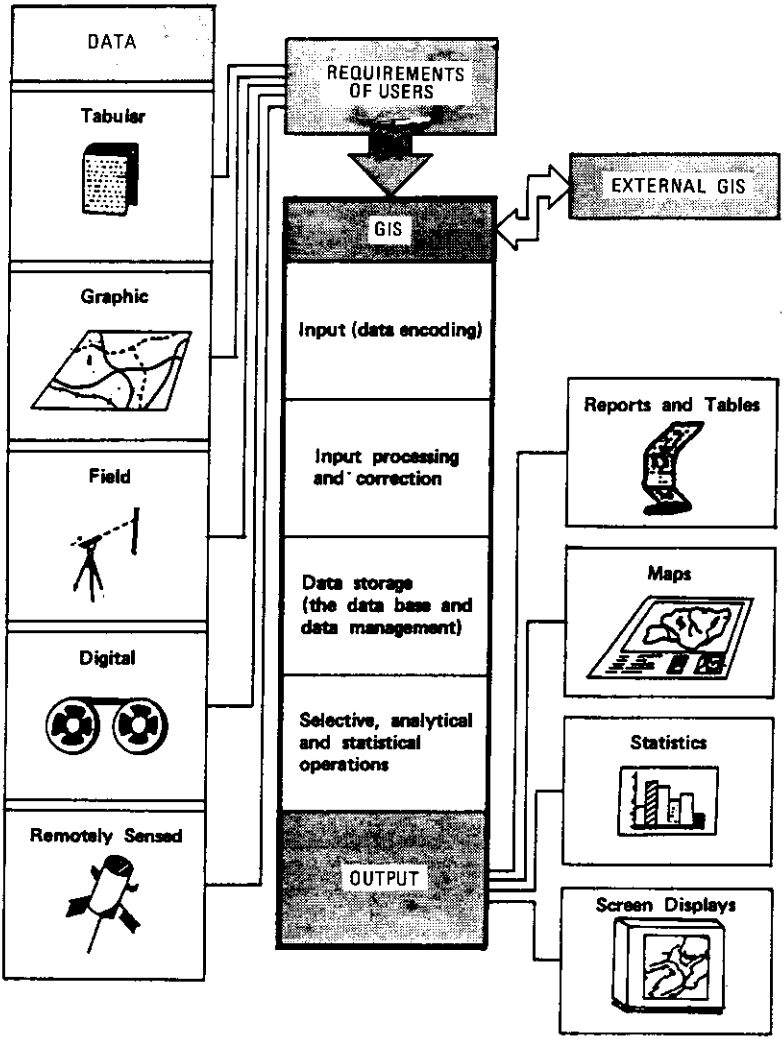

Figure 3. The essential elements of an automated Geographic Information System (GIS).

Rationale for ICOIN

Sustainable resource development, the ability to ensure the needs of the present without compromising the ability of future generations to meet their needs, is increasingly dependent upon the availability of appropriate information and data to developers, administrators, and scientists in both government and industry. This information must be provided at the right place and in the desired format(s). It must also be provided precisely when required, for the right price and within an increasingly restrictive time frame. In addition, the value of geographically-referenced information (graphic, textual, and alphanumeric) to the decision-making process is becoming increasingly apparent.

ICOIN would be a major information/data conduit for resource management systems such as that proposed by Butler, MacNeil, and Fay (1987) at the Martinique GCFI Conference. The objectives of such a system were documented in that paper, *e.g.*:

- an inventory of fisheries resources, their distribution and associated habitat (*e.g.* Mahon and Mahon, 1986);
- identification of critical marine/coastal zones;
- development of coastal zone management plans;
- identification of sources of pollution;
- contingency planning and emergency measures preparedness;
- environmental conflict resolution;
- sight specific oceanography and meteorology for aquaculture (*e.g.* Kapetsky *et al.*, 1987);
- habitat evaluation;
- fish distribution and catch analysis.

ICOIN will also facilitate access to similar networks under development or established by other nations. Some development decisions within the Caribbean, for example, are dependent on data collected on a global scale and therefore reach beyond direct Caribbean access and/or national jurisdiction. The regular exchange of information (*e.g.*, meteorological) between nations is now necessary and commonplace. This trend will become increasingly widespread in other disciplines which include those potentially associated with ICOIN. Foreign networks that might interface with ICOIN include those of the United States, *e.g.*, the Pilot Ocean Data System (PODS); the National Ocean Data System (NODS); Global On-Line Data (GOLD); and the Spatial Analysis Network (SPAN). A European example is the Marine Information System (MARIS) currently under development by the Netherlands and its North Sea neighbours. A significant program of the Inter-governmental Oceanographic Commission (IOC) is IGOSS, the Integrated Global Ocean Station System.

BENEFITS TO GOVERNMENT

Governments have inevitably become the major collectors and repositories for data by virtue of their mandates and associated financial resources. An increased and more effective utilization of this information, for instance via ICOIN, will have immediate and long-term benefits to both the providers and users of the information.

Benefits of ICOIN will include:

- a general increase in productivity and efficiency and a decrease in the size of the bureaucracy required to support the information infrastructure;
- a greater efficiency in the dissemination of information;
- an increased efficiency in coastal and ocean information management;
- the reduction of duplication in coastal and ocean information activities;
- improved coordination between governments and government departments regarding expenditures for GIS-related technologies and information;
- increased and new cost-recovery opportunities from the sale of ICOIN information;
- an increase in decision-making efficiency because of the provision of up-to-date and comprehensive information in a timely manner;
- the stimulation of the information and mapping industries in general from an intellectual and management perspective through the institution of this information network program;
- the development of value-added industry and employment opportunities.

ICOIN STATUS

In 1987 the Maritime Resource Management Service (MRMS), an agency of the Council of Maritime Premiers, in Amherst, Nova Scotia, was contracted by the Canadian Department of Fisheries and Oceans to prepare a discussion document on an Inland Waters, Coastal and Ocean Information Network (MRMS, 1988). The discussion document was submitted to DFO in February 1988 and became the basis for a series of ICOIN workshops held at several locations across Canada during the period December '88 to May '89. These workshops were organized by the Champlain Institute on behalf of DFO and were designed to focus and initiate the ICOIN program. They culminated in a national ICOIN Forum which took place in Fredericton, New Brunswick, June 13–14, 1989. The papers presented at the Forum and the related discussions are the subject of a Proceedings to be published later this year (Champlain Institute, 1989).

As directed by the participants at the ICOIN Forum, the Champlain Institute subsequently convened an Atlantic ICOIN Task Force consisting of volunteers identified at the Forum. The mandate of the Task Force included the clarification of the ICOIN objectives and the development of an implementation strategy. The Atlantic ICOIN Task Force has representatives from the private sector, academia and government. The membership of the Task Force will vary to reflect current ICOIN issues. The Champlain Institute was designated by the Task Force members as the Secretariat of the Atlantic ICOIN Task Force and will coordinate implementation activities. The Task Force is chaired by a representative of DFO. Other regional ICOIN task forces will be established at a later date.

CHALLENGES TO IMPLEMENTATION OF ICOIN

There are both perceived and real problems in the implementation of ICOIN. The management and personnel challenges will be far more intractable than the technical problems; all, nevertheless, are solvable given good will, ingenuity and adequate funds.

Management Challenges

Liaison. The successful implementation of ICOIN will depend, to a great extent, on intergovernmental and interdepartmental cooperation. The coastal region is subject to the authority of many jurisdictions. For this reason, it is essential that ICOIN be planned on a regional basis. The Fisheries Secretariat of the OECS and the University of West Indies are well placed to facilitate this process.

Identification and location of information. The existence and the location of the majority of digital and other data bases are unknown other than to the owners. Even within government departments this situation is not uncommon. This results, at the least, in the unnecessary duplication of data collection and the associated expenditure of time and money. In addition, resource managers and developers are denied one of the prerequisites for informed decision-making, namely comprehensive information. The preparation and maintenance of a current Data Base Directory will identify the location and contents of the data bases available through the ICOIN network.

Accessibility. The knowledge of the whereabouts of data does not necessarily ensure its accessibility. However, the development of a functional ICOIN will ensure access to the networked data bases in accordance with criteria established by ICOIN and the constituent data base owners.

Ownership. The owners of the data bases that constitute ICOIN will wish to maintain autonomy over their data bases. ICOIN will promote the networking of, rather than the integration of, data bases within a distributed network that will be administered according to previously established principles and criteria.

Quality control. The reliability, currency, scientific credibility and quality control of data within ICOIN will be a matter of major concern. The evaluation of data must be the responsibility of the users. It will, however, be incumbent upon ICOIN and its contributory data base owners to provide an Audit Trail to ensure that the source and reliability of data can be identified and adequately assessed. Quality control in the context of compatible and acceptable data collection methodology and instrumentation will be the responsibility of the data base owners.

Maintenance/update costs and responsibility. Progress in research and development is dependent on the availability of up-to-date data and historical records. Within ICOIN, the responsibility and obligation for the maintenance and update of constituent data bases and, when necessary, the conversion of extant data bases clearly will reside with the owner. This is a costly responsibility, however, these costs could be offset by significant financial benefits to the data base owner:

- access to other equally updated and accredited data bases within ICOIN at preferred rates;
- the ability to sell data to non-ICOIN members (consultants, etc.) at market prices and thereby to generate resources for data base maintenance and update.

Confidentiality/freedom of information/security. A great deal of information and data is unavailable to potential users because of supposed "confidentiality". This may take the form of "concealment", unintentional or otherwise, by virtue of the public's ignorance of its existence, restricted dissemination routes or sunset clauses, *i.e.* the information is not made available for a specific time period. The extent of this period may or may not be flexible, lacks uniformity between departments and in general is based on some arbitrary decision. In addition the problem of security may inhibit the potential ICOIN participant.

The Freedom of Information legislation in many countries will obviously have an impact on the potential availability of data and information, particularly that collected at public expense. The confidentiality of information will probably be reassessed in light of more persistent demands for data that will result from ICOIN publicity and marketing and Freedom of Information legislation. The security of digital files can generally be assured via appropriate authorization codes (passwords); experience, however, indicates that no security system is infallible. Information of a confidential nature would not be available through ICOIN.

Accreditation. The publication of research papers is an important factor in assessing a scientist's credibility and promotional prospects. The contribution of data from a scientist's data base to ICOIN and its use by others, even in other contexts, may undermine the requirement for originality of research material in refereed primary publications.

Appropriate recognition should therefore be accorded to the data base contributor in lieu of publication. This will be particularly relevant when the contents of the data base are the result of the contributor's analysis. Raw data sets, in contrast, would be of less, but not insignificant, concern.

Misinterpretation. There is a fear that data made available through ICOIN may be misinterpreted or misused by ICOIN clients. This problem is not peculiar to automated data systems. The provision of audit trails and the establishment of data base standards by ICOIN, in consultation with its constituent data base owners, will minimize but not preclude this possibility.

Access policies, procedures and pricing: Excessively complex access policies and procedures and unrealistic access prices will deter potential ICOIN users and hence will undermine the rationale for the network. ICOIN, in consultation with its constituent data base owners and the communication utilities, will establish mutually acceptable and market-oriented access policies, procedures and pricing.

Personnel Challenges

Attitude. The proprietary attitude of a scientist or manager toward his own data bases is deeply rooted. This can result in an unwillingness to share data in a context such as ICOIN. The realization that information can be exchanged as a commodity, *i.e.* used as a lever, will have a significant liberalizing effect on this attitude.

Computer illiteracy. The widespread utilization of computers as a sustainable resource development tool is a relatively new phenomenon. Computer illiteracy is common but often is not acknowledged. Only by appropriate education and training will computer illiteracy be reduced significantly and the potential of ICOIN be exploited fully. However, simple third party access to the network is a pre-requisite.

Technical Challenges

Geographic referencing. The information contained within many extant data bases is not geographically referenced (spatially referenced), *i.e.* not input in association with precise geographic coordinates such as degrees of latitude and longitude or Universal Transverse Mercator (UTM) grid coordinates. The use of geographic referencing for the location of spatial data is dictated by user requirements and GIS technology. Newly created data bases of potential relevance to ICOIN must be geo-referenced. Extant data bases can be converted as required.

Input procedures. Inputting graphic data into a GIS by the process of digitization is labour intensive and therefore expensive. The manual digitization of data is being replaced by the automated processes of laser and photographic scanning. These processes, however, have technical limitations, *i.e.* the manuscripts must be coded and of a quality to allow the proper interpretation of the linework by the scanner and the topology must be "built" for some analytical requirements. If the quality of the manuscript is not adequate for scanning, manual digitization becomes the most cost effective technique. It should be noted also that manual digitization will provide significant employment opportunities for relatively unskilled labour.

Geographic Information Systems. The cost and complexities associated with the operation of a GIS have historically inhibited their use by many agencies. However, recent technological developments are now contributing to their widespread use, including:

- the downloading of GIS software from mainframe and mini-computers to the ubiquitous micro-computer;
- improvements in data base management systems (DBMS);
- interface software to permit transference of files between remote sensing digital image processing systems (DIPS) and GIS;
- interface software to permit GISs to communicate.

Many of these GIS systems were recently reviewed in the July/August, issue of GIS World (1989). The information within these different systems is invariably compiled in file formats which are incompatible. The development of interface formats such as the Digital Line Graphic (DLG) format permits the transfer of files from one brand of GIS system to another. With vendor cooperation, however, direct access can be achieved with customized software. The latter is considerably quicker and less costly because of the reduced machine time required to exchange data.

Integration of remotely sensed data. For some resource development decisions the provision of real-time or near real-time data is essential. Acquisition of data by remote sensing is now a reality. The analysis of this digital and raster formatted data on digital analysis systems can be carried out in near real-time. The results of the analysis can be interfaced with GISs and can be transmitted by radio facsimile or satellite transmission to remote receivers. The results also can be converted to vector format if desired.

Standards. The adoption of standards are fundamental to the efficient networking of information and data. Refer to Appendix A for additional details.

- Data coding: ICOIN data will be transferred to clients by magnetic tape or disk, over telephone or dedicated lines via modem and by satellite. In contrast to alphanumeric data, digital graphic data is represented by large quantities of bytes. Transmission of graphic data via currently available communication protocols, therefore, is time consuming, expensive and error prone.

- The development of new coding protocols specifically designed for graphic transmission such as MACDIF (Mapping and Charting Data Interchange Format) will permit the compression of graphic data and therefore a reduction in transmittal time and cost. MACDIF will also provide a more efficient check for transmission errors of graphic data.
- Data communication: The transfer of digital information over the telephone lines is slow because the telephone system was designed for analog voice transmission. A set of technical standards, the Integrated Services Digital Network (ISDN), has been established for the interconnection of telecommunication equipment. It permits the conversion of an ordinary voice telephone line into a single pipeline for voice, telex and data.
- The Electronic Chart Program of the Canadian Hydrographic Service (CHS) is demonstrating the potential of an increasingly important data conduit, satellite communications. Complete chart files and data have been transmitted on an experimental basis from CHS, Ottawa, to the Bedford Institute of Oceanography, Dartmouth, via ANIK C of the International Datacasting Company (IDC) satellite system. The eventual distribution of the most up-to-date digital hydrographic chart information throughout Canada via satellite linkage will provide a virtual Print on Demand (POD) capability.

CONCLUSION

The development of a network of distributed, geographically-referenced information data bases will be essential for the effective management and development of Caribbean marine and coastal resources. The regional institutions, technology and expertise required to implement such a network already reside within the Caribbean nations. This paper advocates the early consideration of the challenges associated with the implementation of a network such as ICOIN.

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APPENDIX A
STANDARDS

ICOIN implementation, to a great extent, will be dependent on the establishment of standards as the telegraph system was dependent on the Morse code in the 19th century. The telecommunications, computer and television industries are large, growing and of vital importance to economic development. All are based on internationally agreed upon standards. These three industries are now combining to form a huge information technology industry which is even more dependent upon internationally agreed upon standards.

Significant international standards programs include:

- Open System Interconnection (OSI). This represents a description of the master plan for all computer communications standards.
- International Standard Organization (ISO). Within the field of data communications and information processing, ISO is primarily concerned with the top four OSI layers, 4 through 7 (refer to Data Coding Section Below).
- International Telephone and Telegraph Consultative Committee

(CCITT). This is a committee of the International Telecommunications Union (ITU), a United Nations treaty organization.
- Integrated Services Digital Network (ISDN). This is the first mass market digital communications system designed according to ISO principles.

Data Coding

Two types of telecommunication networks currently exist: digital and analog. Information may also be communicated on physical media such as magnetic tape or various disk storage devices. Ideally, information pertaining to a map or chart is coded in such a manner that it may be communicated over all of these media. The Mapping and Charting Data Interchange Format (MACDIF) is an example of such a code; it conforms to the OSI model. The International Standardization Organization and the Consultative Committee in International Telephone and Telegraph have been developing a general structure for a set of interlocking telecommunications standards within the context of a basic layered architectural model for Open Systems Interconnection. OSI is concerned with the communication of information between open systems, *i.e.* an assemblage of communicating entities that is open to general interconnection. The principle behind the OSI model is to separate the various operations involved in communicating data into seven independent layers:

- The Physical Layer (Layer 1) provides mechanical, electrical and procedural functions to establish, maintain and release the physical connection. For example, it is concerned with the transference of bits of data over a wire or a microwave channel;
- The Data Line Layer (Layer 2) provides a data transmission link across one or several physical connections. Error correction, sequencing and flow control are performed in to maintain data integrity;
- The Network Layer (Layer 3) provides routing, switching and network access considerations to make invisible to the Transport Layer how underlying transmission resources are utilized. This permits multiple and dissimilar communication links to be used;
- The Transport Layer (Layer 4) provides an end-to-end transparent virtual data circuit over one or several network transmission facilities;
- The Session Layer (Layer 5) provides the means to establish and disconnect a session connection and to support the orderly exchange of data and other related control functions for a particular communications service;
- The Presentation Layer (Layer 6) provides the means to represent and interpret the information in a data coding format in a way that preserves its meaning. Standards such as ASCII for text coding and graphical

coding data syntaxes exist at the Presentation Layer;

- The Application Layer (Layer 7) is the highest layer in the reference model and the protocols of this layer provide the actual service sought by the end user. The format and semantic meaning given to data are defined in the Application Layer.

Each of the layers of the OSI model is independent and different standards may be substituted at each layer in different situations. For example at the Presentation Layer (Layer 6), data may be coded in the ASCII character code standard in one situation or in EBCDIC (the IBM standard) in another.

Data Communication

Under the auspices of a committee of the International Telecommunications Union (ITU) a set of technical standards, the Integrated Services Digital Network (ISDN), has been established for the interconnection of telecommunication equipment. ISDN is digital. It offers an inexpensive way of converting an ordinary voice telephone line into a digital channel carrying 144 kilobits per second (144 kbps), divided into two 64 kbps "bearer" circuits, each of which can transmit either digitized voice traffic or a stream of computer data, and a 16 kbps channel which is used to control traffic and provide packet-switching instructions. Currently a user must either lease special high-speed data lines or use a modem and ordinary telephone lines with transmission speeds of only 2.4 kbps for the transmission of digital data. ISDN is replacing all of the various specialized lines (voice, telex, data) with a single information pipeline. ISDN establishes a set of standards for wall plugs, switching systems and signals that will enable voice, data, video and text to be transmitted simultaneously and interactively among the world's 600 million telephone subscribers.

Services utilizing ISDN will be available from as early as 1990. France is currently the most advanced country with 50% of its local exchanges and 60% of its long distance exchanges currently operating digitally.

Beyond the establishment of ISDN is the proposed Universal Information Service which will integrate voice, data and pictures on the same fibre-optic super pipe.