# THE TELECOMMUNICATION OF MAP AND CHART DATA

T. Evangalatos
Canadian Hydrographic Service, Ottawa

Z. Jiwani
Energy, Mines and Resources, Ottawa

D. McKellar
Department of National Defence Canada

C.D. O'Brien
IDON Corporation Ottawa

## ABSTRACT

The structuring and communication of electronically formatted information is becoming increasingly important in a wide number of diverse fields. Industrial and office information systems are becoming widespread and world standards are developing both for the establishment of data communications networks as well as for the structuring of data to be communicated over these networks. A major effort is going on world wide for the development of a suite of international standards for Open Systems Interconnection (OSI) which form the basis of the international data communications networks. Standards for the structuring of data are developing for Facsimile, Computer Graphics, Computer Aided Design and Manufacturing, Office Automation (Forms), Videotex (Home Information Services) as well as for Cartography and Navigation Systems.

This paper discusses the trends in telecommunications standards and shows how they apply to the communications of cartographic information. The relationship of the International Standards Organization standards ISO 8824/5 (Abstract Syntax Notation and Coding), ISO 8211 (Data Descriptive File Format) and ISO 2022 (Code Extension) to cartographic data interchange is described. The Map And Chart Data Interchange Format (MACDIF) is discussed as a method of interchanging cartographic information in a flexible manner compatible with developing telecommunications networks.

## 1.0 INTRODUCTION

Tremendous changes are occurring in the fields of cartography and hydrography and although these disciplines have used computers for many years, it is only recently that the direct interchange and communication of digital data has been undertaken. With the need for data communications, the requirement for standards has become more important. The early efforts towards standardization concentrated on the structuring of data, but was limited to traditional magnetic tape interchange. Current efforts are also addressing the need for communicating data over public telecommunication networks based upon international telecommunication standards.

The effort to develop MACDIF is being carried on cooperatively by several Canadian Federal Departments, in particular the Canadian Hydrographic Service, the Department of Energy Mines and Resources, the Department of National Defence, the Public Archives of Canada and the Department of Communications as well as with the Ontario Ministry of Natural Resources, and the U.S. National Ocean Service.

MACDIF is a flexible format which can be used to communicate anything from raw digitized map information to a fully symbolized and cartographically enhanced map or chart. Annotation may be in English, French or any other language. MACDIF organizes information into a number of categories which define the overall structure of the spatial data, its relation to a world coordinate system, the features which make up the data set, their attributes and boundaries, and optionally any related symbolization and topological relationships. This data format allows for a blind interchange; that is, there is only one single flexible format for encoding data which may be interpreted by various levels of receiving computer or terminal devices.

The rapid establishment of telecommunication facilities has permitted the direct communication of digital information. This is leading to more sophisticated formats for the

representation, storage and communication of spatial data. In addition to creating standards for the organization of the underlying information content, it is also important that the data be formatted in such a manner so that it can be communicated over a variety of networks in a manner independent of the supporting telecommunications media.

Standards are being developed in the major international standardization bodies which permit the interconnection of virtually any digital data communications system. A new standard is required for the representation of spatial data which builds upon these data communications standards and defines a method of organizing the data in a flexible manner so that all or some of it may be used in a variety of applications, ranging from the production of paper maps and charts, to electronic display and non presentation uses of the data.

## 2.0 GENERAL CONCEPT

The establishment of a standard format for encoding map and chart data for the purpose of interchange and storage will have a profound impact. Not only will it be possible to communicate the electronic replacement of paper maps or charts, but a wide range of applications may be developed which make use of the attributes pertaining to map or chart features. The proposed interchange format provides the necessary common reference point to unlock the growing store of mapping and charting information and so facilitate the utilization of that information in a large number of diverse applications and by a broad audience. MACDIF accommodates the requirements of interchanging map and chart data between agencies and for the distribution of such data to private, commercial, and public users.

MACDIF can be viewed in different ways dependent upon the context in which it is discussed. From the technical point of view it is a coding scheme for the representation and communication of map and chart data; that is, it is a set of rules, a grammar, by which one may represent (encode) a digital description of a map or chart. The information is structured according to a rigorous, unambiguous syntax. This establishes a norm which forms the basis upon which to build a number of different independent applications, all sharing common data. This development of a general underlying coding scheme promotes the compatible development of a number of broadly-based applications.

MACDIF is also termed a proposed standard since it is intended that it be used as the common basis for a number of applications. The term standard is often misused to represent the specification of a commonly used coding scheme or other specification upon which systems or applications are based. However, the term standard more rigorously applies to a norm which has been established in an open public forum so that it represents the consensus derived from the consolidated experience of the industry. The development of a standard is carried on under the auspices of a national or international standards-making body according to certain well-established formal procedures and adherence to the principles defined by other national and international standards. This also provides stability and a mechanism by which a standard may be publicly maintained and updated.

## 3.0 PRINCIPLES

MACDIF is designed to be a general standard for communicating spatial data and is intended both for professional use of mapping and charting agencies as well as for the dissemination of information to industry and the public in electronic form. In order to achieve the maximum flexibility, it was important that the coding scheme be designed according to certain universal principles. These principles include :

- independence from hardware constraints of the equipment used within the applications,
- independence from the media used for communications or storage,

- communications transmission efficiency,
- the ability to build upon other norms already established in the industry
- blind interchange,
- meaningful defaults,
- the ability to accommodate a wide variety of applications,
- the capability to support multiple languages (including non Roman scripts)
- the ability to accommodate modification and extension in a forward and, where possible, backward compatible manner, and
- stability by being a public domain standard.

In order to establish an independence from the communications network and the eventual database or presentation media, MACDIF is defined in an abstract manner. Only at a final stage in the processing of MACDIF data, received over a standardized communications facility, would a binding to a particular coordinate system be established. For example, by communicating MACDIF positional information as fractions of a normalized unit coordinate system, a device-independent rendering may be achieved for use in a database or for presentation on anydisplay screen or on any plotter. That is, the coordinate system used within MACDIF is based on a unit square (with a 0 to 1 range for X and Y). Parameters for a transformation are communicated along with the data relating it to the real world coordinate system. Any presentation process may make use of the transformation specification and scale this data into its own device dependent coordinate system. This approach to coordinate specification is also the most efficient manner of storing and communicating such data since the number range matches exactly the area of interest and no extra digits are required to handle fixed biases. Coordinate and other information is packed into a small number of bytes while retaining the capability to specify these values to various levels of precision.

Independence from the coordinate system used in the target display device is not the only dimension of independence which is required. All parameterized variables associated with the graphical presentation of map or chart information should be specified in terms of normalized variables where possible.

The MACDIF coding scheme is also structured so as to be independent of the manner by which it is communicated or stored. The format is based on existing telecommunications standards so that data may be communicated over public telecommunications facilities as well as specialized private facilities. In order to achieve this independence, MACDIF has been defined in alignment with the International Standards Organization's (ISO) reference model for Open Systems Interconnect (OSI); that is, it separates the coding and formatting of information from the means by which it is communicated. In OSI terms MACDIF is an application data format for general mapping and charting applications which utilizes and builds upon existing and specialized presentation data coding standards. MACDIF defines what the data entities are and makes use of existing or specialized presentation data coding standards in order to encode the data entities. For example, textual data is coded in terms of the International ASCII character code standard.

A principal feature of the MACDIF approach is the ability to support "blind interchange". This means that map and chart information is defined independent of context so that it may be communicated without the need for negotiations between the sending and receiving entities. The same format of data is used in all communication regardless of the application. The entity which receives the data interprets those portions of the data which pertain to a particular application. For example, an application which simply displays an outline map may not be interested in topological information, and would ignore it if it was encountered. On the other hand, "raw" data, as collected by a digitization/supplier organization, might

not contain sufficient information to support certain applications such as the production of a paper chart. This data, although in the same format, would require processing and cartographic enhancement before it could be used for such a purpose. It is important to avoid negotiation over the format of data in order to eliminate the need to reformat the data for communications with each type of receiving computer or terminal.

MACDIF provides facilities to encompass a broad range of applications such as structured and symbolized maps or thematic uses of maps and charts. It permits a comprehensive data description of a chart or map while maintaining flexibility and extensibility of the coding structure.

Multiple languages may be supported since the character sets used to encode textual information are drawn from the ISO 2375 registry of character sets. The basic character set is the International Reference Version (IRV) character code table, which is identical to ASCII (the American Standard Code for Information Interchange), except that it contains a generalized monetary symbol. Accented characters are handled by the use of a supplementary table of accents, diacritical marks and special characters. This table is standardized in ISO 6937 and used in several other international standards. By the combination of these two code tables characters for any Latin alphabet based language may be coded. Characters for other languages such as Hebrew, Greek, Cyrillic languages, Arabic languages, African languages and even Japanese and Chinese Kanji may also be invoked in this manner.

By basing MACDIF on existing standards for code extension, it benefits from the extensibility built into these standards. As new coded character sets are defined and included in the registry, they may be used within MACDIF. Similarly, the capability to support code extension permits MACDIF to take advantage of the advancements in the coding of graphical data currently standardized or under development in ISO.

## 4.0 MACDIF INFORMATION STRUCTURE

A map or chart is a highly structured description of a geographical area. A map consists of features such as lakes, rivers and roads which not only have a geographical boundary, but which also have a large number of other attributes. The number and type of features used in a map is unlimited and the volume of data required to describe a map or chart can be very large.

A data interchange format for the communication of mapping and charting information must be flexible in order to accommodate many different uses. These range from the communication of basic digitized map data from a supplier to the intercommunication of map or chart data extracted from a data base and transferred between agencies, or to the distribution of spatial information to industry or the public in electronic form. The data which is required to specify a map or a chart in each of these situations is somewhat different.

In order to provide flexibility of use, the Map And Chart Data Interchange Format (MACDIF) breaks the data description down into various sections. Each of these sections addresses a separate class of information in the map or chart description. Certain descriptors are mandatory since they contain basic map information, whereas other descriptors are optional since they contain auxiliary information which is required only in certain views of the spatial data

### 4.1 Overall Data Structure

The overall structure of a map or chart in MACDIF consists of a contiguous ordered unit of data. This application data unit can be broken down into an administrative header and data set descriptor. The header contains information such as the data set name, format version, update indicator etc. which are required to identify the map or chart in question. The map definition section contains the data describing the remaining components of a map or chart.

It contains a description of the transformation which positions the spatial data set into real world coordinates, a description of the features, attributes and boundary definitions which compose the data set and optional topological, symbolization or other related information. This is illustrated in Figure 1.

The overall map or chart structure is defined as a syntactic hierarchical tree where each section is broken into sub-sections and sub-sub-sections down to the data element. A MACDIF data file may contain several map descriptors under a single administrative header. A second map descriptor file may be used to overlay thematic information such as census population data over a basic geographic map extracted from a library.

The definition of a map is divided into several subsections each of which addresses a different portion of the information required to define a map or chart. These subsections are:

- Administrative Header Definition
- Transform Definition
- Feature Definition
- Segment Definition
- Topological Definition
- Symbolized Map Definition
- Associated Information Definition

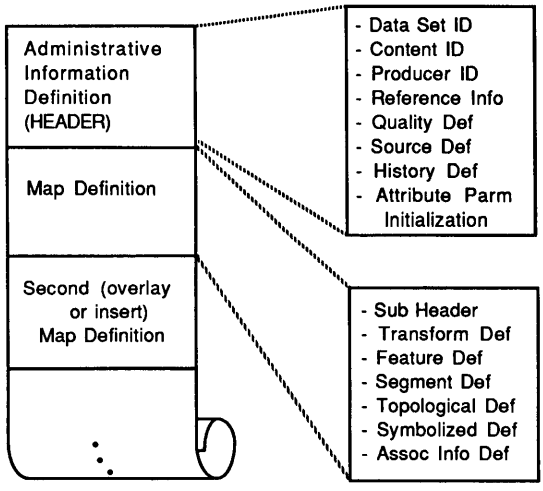


Figure 1 Overall Map (or Chart) Structure

## 5.0 RELATIONSHIP TO OPEN SYSTEMS INTERCONNECT (OSI)

The development of standards for telecommunications among computer based information processing systems is a central area of study in the international standardization committees. With the onset of the information economy throughout the world, it has become increasingly important to establish universal standards for communication. It is important that MACDIF coded information be available via any kind of data communications means. This section presents background information pertaining to telecommunications standards as they relate to MACDIF.

## 5.1 The OSI Communications Environment

The International Organization for Standardization (ISO) and the International Telephone and Telegraph Consultative Committee (CCITT), part of the United Nations-sponsored International Telegraphic Union (ITU), have been developing a general structure for a set of interlocking telecommunications standards which are expected in the near future to handle the majority of the world's data communications traffic. Underlying this work is a basic layered architectural model for Open Systems Interconnection (OSI). The principle behind this model is to separate the various operations involved in communicating data into seven independent layers. In concept, each layer is separate, and a number of different standards may be defined for each layer. For example, the lower layers might make use of different protocols for various communications media, such as over a terrestrial land line or over a satellite communication channel.

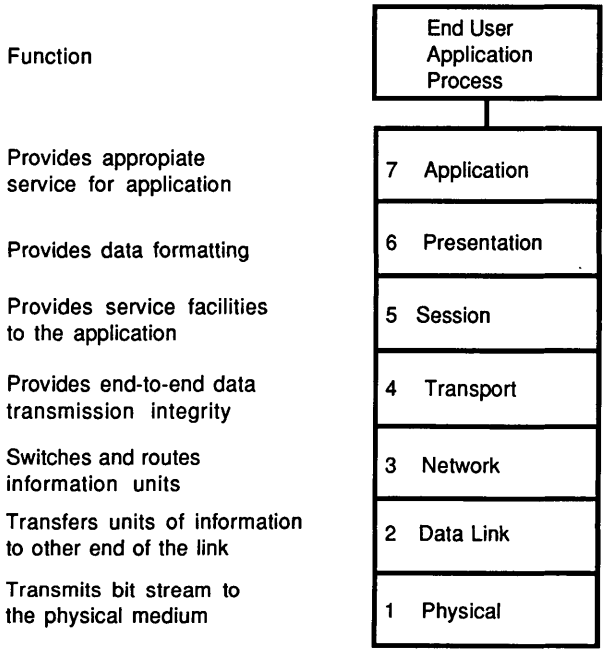


Figure 2: The Seven Functionally Separate Layers of the OSI Model

OSI is concerned with the communication of information between open systems. An open system can be any assemblage of communicating entities which is open to general interconnection. That is, the communications network is not predetermined and closed. The seven OSI layers shown in Figure 2 can be grouped into three broad categories. Layers 1 to 3 are concerned with communicating data over physical media such as wires, microwave links, satellite channels, etc. Layers 4 and 5 are concerned with the end-to-end communications dialogue and the assurance of maintaining end-to-end data integrity. Layers 6 and 7 are concerned with the data that is communicated. Layer 6, the presentation layer, defines the coded representation of the data and layer 7, the Application layer, provides resource management to the application process which makes use of the data.

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 (an IBM standard) in another. The OSI reference model has recently been adopted as an international standard. Along with this basic standard, ISO and CCITT are developing a number of specific standards for each layer which align with the model and which may be used to communicate over various communications media. Some of these protocols such as the X.25 packet-switched protocol for network communications are well established. Other protocols, such as the file and message handling protocols (X.400 series) for future electronic mail services, are under development.

The Presentation Layer (Layer 6) provide a means of encoding data and giving meaning to data entities. Data may be coded in alignment with any of a number of data coding standards such as ASCII, binary bit images, or other data syntaxes for graphical or other types of data. An Abstract Syntax Notation (ASN.1) has been defined in the standard ISO 8824 which permits data elements to be coded according to different data syntaxes for different types of data elements and assembled into an application-specific data format. Together with the Abstract Syntax Notation a set of encoding rules have been defined in ISO 8825 for communication over OSI data networks.The Application Layer (Layer 7) communicates directly with the End User Application Process. Specific Application Layer Service Element standards (SASE) are being developed for various applications. A set of Common Application Service Elements (CASE) is defined for all Application Layer standards for basic functions such as establishing a communication or recovery from an error condition.

For the communication of spatial information in an OSI environment, the communications facilities from the Session Level down can be assumed to be available. In addition, some standardized data syntaxes are available at the Presentation Layer and may be used to code data. At the Application Layer, a specific data format suited to the particular application of communicating map and chart data must be defined. To suit the OSI environment it should be specified in the Abstract Syntax Notation of ISO 8824.

## 5.2 Structure of the Interchange Format

The structure of the MACDIF syntax consists of a hierarchical tree of information elements. Each element is tagged so that it may be identified in a data set. The data set is interpreted by scanning the information in the order defined by the tree structured syntax. The process which interprets (or parses) the data set matches each data element in the data set to the type of data element expected by the syntax. For example an alphabetic code identifying a particular Feature Type is identified by a unique tag. This information element must be contained in the set of data following the numeric code identifying that particular Feature Number. Since each type of information element is identified by a unique tag, it is not necessary to include filler information in the data set for optional information which has not been specified.

This method of structuring the information content of MACDIF is extremely flexible and very efficient. The only overhead is the tag code on each information element, but even this minor overhead is offset by the fact that redundant information need not be included in the data set. There are no preset lengths for any information element since each element is delimited by the tag which identifies it. This provides total flexibility since information need only be specified to the precision which is meaningful. Redundant "zeros" or other place fillers are not required, and there is no limit to the length of a data element.

The general syntactic structure of MACDIF consists of an Administrative Header which identifies the Data Set and many overall parameters about the Map or Chart. This is followed by one or more Map Definition sections which contain data describing the remaining components of a Map or Chart. A portion of the description of MACDIF represented in ASN.1 format is presented below for illustrative purposes. Note that the *complete description of MACDIF in ASN.1* is twenty-five pages long.

```
Digital-Map-or-Chart::=    SEQUENCE { Map-Header,
                                      Map-Def-Section   }
```

```
Map-Def-Section     ::=   SEQUENCE OF     Map-Definition

Map-Definition      ::=   SEQUENCE {
                          [1] Map-Sub-Header  OPTIONAL,
                          [2] Transform-Definition-Section,
                          [3] Feature-Definition-Section,
                          [4] Segment-Definition-Section,
                          [5] Topological-Definition-Section OPTIONAL,
                          [6] Symbolization-Definition-Section OPTIONAL,
                          [7]Associated-Information-Definition-Section
                                                              OPTIONAL }

Map-Header          ::=   SEQUENCE {
                          [1] Data-Set-ID,
                          [2] Content-ID,
                          [3] Producer-ID,
                          [4] Reference-Information,
                          [5] Quality-Declaration-Section  OPTIONAL,
                          [6] Source-Declaration-Section OPTIONAL,
                          [7] History-Description OPTIONAL,
                          [8] Parameter-Definition OPTIONAL    }

Map-Sub-Header      ::=   SEQUENCE {
                          [1] Content-ID OPTIONAL,
                          [2] Producer-ID OPTIONAL,
                          [3] Reference-Information OPTIONAL,
                          [4] Quality-Declaration-Section  OPTIONAL,
                          [5] Source-Declaration-Section  OPTIONAL,
                          [6] History-Description OPTIONAL,
                          [7] Parameter-Definition OPTIONAL    }
```

## 5.3 Data Formats

The Application layer of the MACDIF standard describes which information may be used in the description of a map or chart and how that information is interrelated. In addition, the Presentation layer specifies how MACDIF information would be represented in terms of a stream of digital data. This distinctly separate layer is responsible for the representation and coding of data. Both the Presentation and Application layers are also completely separate from the method by which the information is communicated or stored.

**5.3.1 Supporting Data Syntaxes** The information entities which make up the various components of a MACDIF specification of a map or chart consist of textual information, pictorial information, numerical parameters or specialized identifiers and pointers. Each of these must be represented as bit patterns in terms of various data syntaxes. For example, standards currently exist to encode the letters of the alphabet for almost all languages in the world. In North America the alphabetic coding standard is called ASCII. Similarly, standards exist or are under development for coding pictorial information such as graphical points, lines, and polygons and numerical and other information.

MACDIF makes use of existing standardized general data syntaxes to define textual and numerical formats in order to achieve maximum compatibility with telecommunications services and related applications defined in other contexts. Standards exist to define textual, numerical and pictorial data types, and since these types are defined by international standards they are implicit types for application by the ISO standard Abstract Syntax Notation in which the syntax of MACDIF is specified.

The coding of pictorial and numerical information in MACDIF is based on a standardized approached. MACDIF requires a pictorial data type primarily to communicate points, line segments, arcs and polygons in the definition of the boundary of features. Since boundary definitions are the principle data component in the definition of a map or chart, it is

important that the coding of pictorial coordinate data be compact and simple. Over eighty percent of the data volume of a map is pictorial. Complex drawing attributes are not required. For this reason only a simple pictorial coding scheme is needed by MACDIF.

## 5.4 Coding Standards

There are two principal methods of coding data: the bit-coded method and the byte-coded method. In the bit-coded method, meaning is given to specific bit patterns and all the bits in a bit stream are significant. In order for this method to work, a mechanism, usually provided as a service from an OSI lower layer, must be available in order to delimit the start of a bit sequence. This is slightly more efficient than the byte-coded method which is self-delimiting in that specific codes (Escape sequences) have been reserved to control the coding environment. However, the byte (or character)-coded method is more flexible. It does not rely on any services provided by the lower layers of a communications system.

One of the fundamental requirements for MACDIF is generality. Since data syntaxes defined according to the rules for character coding may be communicated both over bit-transparent OSI communications systems and character-oriented asynchronous protocols, MACDIF is built upon character coded data syntaxes. In the character coded approach eight-bit bytes (or octets) of data are organized into code tables where each code has an assigned meaning. Seven of the bits are used as an index into a 128 character code space and the eight bit is reserved either for parity data error checking by lower layers of the communications system or for code extension to another code space of 128 characters.

Code tables may be invoked into the code space to specify the current interpretation for each of the respective codes. This is best illustrated by examining the ASCII code table. Individual characters from the Latin alphabet may be selected from the ASCII code table. An alternate code table of supplementary accents, diacritical marks and special characters may also be invoked into the code space to become the "In-Use Table". An accented character such as é in French may be composed by first selecting the non-spacing accent character from the supplementary code table and then selecting the character to be accented.

The international standard ISO 2375 establishes a world-wide registry of character code tables. Any characters from the repertoire of registered character sets may be invoked. The registry includes over 59 code tables which includes tables for the International Reference Version of the Latin alphabet (IRV), ASCII, Japanese Katakana, Greek, Cyrillic, Arabic, Supplementary Diacritical Marks, Accents and Special Characters, and the large Japanese and Chinese Kanji character sets. By incorporating this coding technique, MACDIF supports the presentation of text in virtually any written language.

The ISO 2022 standard on Code Extension in a Character-Coded Environment is the basic standard upon which a code table-oriented coding structure operates. It defines the procedures for code extension using the ESCAPE (ESC) character control function. A fixed set of rules allows all escape sequences to be interpreted as functions to manage the character coded environment or to be cleanly ignored if they do not apply. The ESCAPE character (code position 1/11) and the ESCAPE sequences are guarantied to always have the same interpretation. MACDIF makes use of this standard as the underlying standard upon which the supporting data syntaxes used for coding text and pictorial data are based.

The use of code tables is not restricted to the coding of characters. Pictorial information and special control functions are also specified in this manner. The ISO working group on picture coding is establishing a standard approach to defining code tables for pictorial and numeric information. This is in support of the work on information publishing for telematic services under study in CCITT and computer graphics under study in ISO. This work forms the basis of the pictorial coding scheme used in MACDIF. The code table in MACDIF for pictorial primitives contains thirty-two primitives, such as commands to draw a point, a line, or a polygon, etc.

Another method of encoding data is the directory structured approach of ISO 8211. It is a standard designed for communicating structured data bases of information and is being

employed in exchanges using hard media, particularly in the United States. The ISO 8211 and the ISO 8824 (ASN) are both viable methods by which to encode spatial data. The ISO 8211 method more closely aligns with the practises used to establish data bases, whereas ISO 8824 aligns with telecommunication practices and is therefore more data efficient.

## 6.0 MACDIF DEVELOPMENT

The Map And Chart Data Interchange Format MACDIF is derived from work done by the Ontario Ministry of Natural Resources (OMNR) on the definition of a Map Data Interchange Format MDIF. The work on MDIF was done in conjunction with IDON Corporation and endeavoured to marry the needs of mapping to telecommunications. Cooperative work began in 1986 between the Canadian Hydrographic Service, other Canadian federal government departments (including the Department of Communication, Department of National Defence, Energy Mines and Resources, the Department of Supply and Services), the OMNR and the U.S. National Ocean Service in developing MACDIF. Work on the MDIF has been going on in parallel with the broader development of MACDIF, and MDIF can be considered as a profile of MACDIF for use in land mapping applications. The interest of the OMNR has been directed toward the acquisition and distribution of digital mapping information by a central mapping agency. Digital map data may be compiled by one or several industrial sources, and communicated to the OMNR by using MDIF. Through cooperation with industry in the process of reviewing and refining the interchange format, the OMNR is introducing MDIF as the method of interworking between the OMNR and the mapping information source suppliers in Ontario. MDIF will also be implemented for the distribution of digital mapping data to other agencies and to users of such data.

The interest of the Canadian Hydrographic Service is concentrated on the aspects of MACDIF which are more concerned with the "electronic chart", a concept in which digital navigational information can be made available on a display device on the bridge of a ship. MACDIF can play an important part in the distribution of electronic chart data and updates to the end users on vessels. CHS and most of the other agencies involved are also concerned about the broader issues of international standards for the telecommunications of digital map and chart information.

## 7.0 CONCLUSIONS

Although , at the moment, the demands for telecommunication based spatial data exchange standards are limited it seems apparent that such standards will become very important when:

1. There is a general availability of base mapping data.
2. A broader use of "Electronic" Atlas' and similar digital publications develops - Initially these needs may be met with CD-ROMS, but in the longer, term, applications will move on-line in order to provide users with up-to-date information.
3. There is wider use of electronic systems for navigation, both on land and water.
4. The GIS - Information Utility is developed.

MACDIF has the flexibility, efficiency, extensibility and other desirable capabilities to meet these evolving needs on both a national and international basis

## REFERENCE

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