THE DIGITAL GEOGRAPHIC INFORMATION EXCHANGE STANDARD AND MILITARY MAPPING

(on behalf of the Digital Geographic Information Working Group)

Pierre J.C. Beaulieu
Department of National Defence
Mapping and Charting Establishment
615 Booth Street
Ottawa, Ontario, CANADA K1A 0K2

Herman A. Dohmann
National Imagery and Mapping Agency
Standards and Interoperability Division
4600 Sangamore Road
Bethesda, MD USA 20816-5003

ABSTRACT

The Digital Geographic Information Working Group (DGIWG) has developed the Digital Geographic Information Exchange Standard (DIGEST) to support the exchange of geospatial data among producers and users. DIGEST enables interoperability and compatibility among national and multi-national systems and users. This paper describes the evolution and components of DIGEST, and its implementation in producing and exploiting DIGEST-compliant datasets/products. The paper also highlights the effort to harmonize DIGEST with other standards.

Today's military forces are required to fulfill a broad range of missions ranging from joint air, land, and sea combat within a coalition force, to humanitarian missions. Military organizations must be able to respond to rapidly changing situations anywhere in the world in a timely manner in spite of shrinking resources. Consequently, the focus on the deliberate production of earth-referenced information (geospatial information) has to shift to timely crisis response.

Accurate and timely earth-referenced information is mandatory to meet the mission requirements and information needs of modern military systems. As an example, the nerve center of any military organization, the Command and Control Information System, is composed of extensive time-tagged geospatial information. When implemented properly, technology offers increased opportunities and decreased levels of uncertainty in decision making.

On its own, no individual nation can afford to map the entire 149 000 000 Square Nautical Miles of the Earth. Cooperation in data production among nations allows for rapid and more extensive coverage. The required data volume and complexity dictate that multi-national agreements for geospatial data standards be established to assure compatibility and support interoperability.

INTRODUCTION

Digital Geographic Information (DGI) has evolved into an essential element in the planning and conduct of civil and military operations. The required data volume, demands and data complexity dictate that multi-national agreements for digital data standards be established to assure compatibility. In support of this aim these standards define those aspects necessary for the exchange of DGI, including: the data structures, format, feature and attribute coding scheme, exchange media, and administrative procedures. DIGEST is a comprehensive suite of standards intended to support the exchange of DGI among both producers and users. DIGEST-compliant datasets are being produced by several nations and exchanged to support a variety of military and civilian applications. Industry continues to develop and promote commercial software based on compliance with DIGEST.

BACKGROUND

The Digital Geographic Information Working Group (DGIWG) was established in 1983 to develop standards to support the exchange of DGI among NATO nations. Membership includes: Belgium, Canada, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, the UK, and the US, and four (4) observers: Australia, Portugal, Greece, and New Zealand. The DGIWG is not an official NATO body; however, the DGIWG's standardization work has been recognized and welcomed by the NATO Geographic Conference (NGC). DGIWG developed and maintains DIGEST as an exchange standard to facilitate the exchange of DGI to support interoperability within and between nations, and burden sharing of digital data production. The scope of this activity includes dataset specification development and harmonization of standards. The US National Imagery and Mapping Agency (NIMA) Vector Product Format (VPF) is one of several formats/encapsulations supported by DIGEST. Over the last few years DIGEST has become the basis for coproduction opportunities between nations.

DIGEST - AN OVERVIEW

DIGEST supports the exchange of raster, matrix, and vector DGI (and associated text) among producers and users. DIGEST can support the entire range of topological structures from no topology to full topology. Included in the DIGEST family of standards are Annex A based on ISO 8211, Annex B - telecommunication standard based on ISO 8824/5, Annex C - Vector Relational Format (VRF), Annex D - Image Interchange Format, and the Feature and Attribute Coding Catalogue (FACC). FACC is a comprehensive coding scheme for features, their attributes and attribute values. DIGEST has become a NATO standardization agreement (STANAG 7074).

As new technologies have developed, DIGEST has evolved to address these technologies and new geospatial requirements. DIGEST version 2.0 is scheduled to be released in 1997. This next version of DIGEST will support imagery, various compression algorithms, and mixing of data types; align DIGEST Annex C and the NIMA's VPF; ensure consistent Metadata across encapsulations; and logically restructure the document. Compatibility with other evolving standards such as the NATO Secondary Imagery Format (NSIF) and ISO base standards are important considerations in this next version of DIGEST.

BASIC CHARACTERISTICS

Limitations caused by restrictions in computer memory or distribution media capacity require that large geospatial databases be divided into manageable units, or tiles. DIGEST supports tiling using a concept of organizing primitives by geographic units and provides inter-tile topology to maintain geographic features in a logically continuous manner across tile boundaries. To the user, the data appears seamless.

To support direct-use, DIGEST (Annex C) "coverages" group features by topological relationships ranging from no explicit topology to full topological relationships for all primitives. Varying degrees of integration are supported. When a product does not require relationships among data types, data can be stored in separate coverages. When full topology is required features may be combined into a single coverage. Complex features, and groups of features collected together and handled as a single entity, may be modeled. Utilizing these concepts, products may be designed as simple or as complex as necessary facilitating efficient storage and use. Some other features of DIGEST which enhance utility of geographic information are:

Self-Describing Format - In DIGEST (Annex C), each level has header tables that describe the information contained at that level and the level below. Each table has a header describing the table. This allows developers to design utility software which can adapt to any DIGEST(Annex C) database regardless of product design.

On-line Data Dictionary - The data dictionary allows the definition of features and attributes to be carried with the product to avoid misinterpretation by users. Users can employ this capability when adding their own data to the database. They can describe feature and attributes which have been developed solely for their own purposes. These can be defined in the database and passed on for all to use. This allows each coverage to be used by a wide range of users without prior knowledge of a coding system - enhancing interoperability and correct data interpretation.

Data Quality - DIGEST provides the capability to carry data quality information at the library, coverage, and feature Level. This information will help the user perform geographic analysis. It allows users to weigh a product’s accuracy, currency, and completeness when performing analysis.

DIGEST DATA

DIGEST has gained credibility world-wide as a standard backed by production. A vast quantity of data compliant with DIGEST has been produced and will continue to be produced for many years. Development of new products continue as requirements and applications expand. Listed below are several examples of DIGEST-compliant products:

Digital Chart of the World (DCW)® - The DCW is a comprehensive 1:1,000,000 scale equivalent resolution basemap of the world. The database is contained on four CD-ROMs. The database contains more than 1,500 megabytes of vector data and is organized in 10 thematic layers. The DCW also includes an index of geographic names to aid in locating areas of interest. The DCW is designed to support geographic information system (GIS) applications. (The DCW is scheduled to be replaced by the VMap level 0 product identified below.)

World Vector Shoreline Plus(WVS+)™ - WVS+ is a product which contains the world's shoreline at an equivalent resolution of 1:250,000. It also contains international boundaries including off-shore territorial boundaries and country names. Also included are representations of the world's shoreline at equivalent resolutions of 1:500,000, 1:1,000,000, 1:3,000,000, and 1:12,000,000.

Digital Nautical Chart(DNC)™ - The DNC product consists of VPF databases comprised of varying resolution libraries over a specified operational area. These libraries contain maritime-significant geographic and navigation information typically found on standard nautical charts. Each library consists of 12 thematic coverages. As an example a DNC may contain a General Library containing 1:1.2 million scale equivalent data; a Coastal Library containing 1:300,000 scale data; an Approach Library containing approximately 1:75,000 scale data; and a Harbor Library containing 1:20,000 scale equivalent information. When used by a navigator on-board ship, varying levels of detail are accessed by switching libraries as needed.

Vector Smart Map (VMap)™ - VMap is a suite of products which contain basic topographic geospatial data at a variety of levels of resolution. All VMap products contain identical thematic coverages; however the attribution may differ depending on the resolution. The coverages include: Boundary, Data Quality, Elevation, Hydrography, Industry, Physiography, Populated Places, Transportation, Utilities, and Vegetation. There are several varieties of VMap:

- VMap Level 0 - is the replacement to the DCW product described above, but in addition includes generalized bathymetry.

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• VMap Level 1 - will consist of approximately 234 CD-ROMs covering the world with 1:250,000 scale equivalent information.

• VMap Level 2 - consists of information with a resolution equal to 1:50,000 to 1:100,000 scale data. Individual Level 2 products cover small geographic areas determined by the geographic operational requirements of customers.

• Urban VMap - as the name implies, products cover urban areas. These products provide information at resolutions ranging from 1:5,000 to 1:50,000.

Raster products - ARC Standardized Raster Product (ASRP) and UTM/UPS Standardized Raster Product (USRP) are examples of DIGEST Raster products. All types of raster data are digital replicas of paper maps. ASRP and USRP are 8-bit Extended Color Coded (ECC), 100 micron resolution replicas of maps in which the data has been rectified, placed on a common projection and datum, margin areas removed, and finally merged with adjacent map sheets. The main difference between the two is that ASRP uses the Equal Arc-Second Raster Map/Chart (ARC) projection, while the USRP uses the Universal Transverse Mercator and Universal Polar Stereographic Projections.

Mixing of Data types - Several nations have developed national products that merge DIGEST compliant data types such as imagery/raster and vector data.

GEOSPATIAL DATA EXCHANGE

Concepts of Exchange - Geospatial data exchange is generally governed by a series of agreements among nations. Each nation is responsible for providing data to meet its international commitments and for holding data, both nationally produced and received from other nations. Nations may agree to arrange for the procurement of common hardware and software. However, standards have been developed with the assumption that, in general, nations are using different hardware and software. Standards for data exchange have been agreed to on a multi-national basis among DGIWG nations. The standards must allow for the exchange of both digital geographic products and basic geographic data. DIGEST supports global interoperability by supporting the following exchange relationships:

• Internal Exchange — the exchange within national agencies.

• Inter-agency Exchange — the exchange between map production agencies.

• Provision of Products — the transfer from data producers to their users.

• User Exchange — the exchange of data between user systems.

Coproduction - DIGEST has become the basis for many coproduction opportunities among nations. DIGEST Data is being produced, exchanged, and used by the military and civilian of NATO nations plus several nations outside NATO. The VPF profile of

DIGEST forms the foundation of current coproduction agreements. Product specifications describe an implementation of the DIGEST standard. The agreed specifications and capture criteria built on the DIGEST foundation ensures consistent data production among coproducers. DIGEST-compliant products Vector Map (VMap) and Digital Nautical Chart (DNC) are being produced and exchanged by a number of nations. At least Fourteen nations have agreed to produce VMap with the intent of gaining worldwide coverage by the year 2000. Commercial companies in North America and Europe have developed software to import and export DIGEST data into their systems.

RELATION TO OTHER STANDARDS

Through the diligent efforts of the DGIWG, significant work has been accomplished to harmonize DIGEST with other international and national standards. DIGEST is gaining acceptance beyond NATO for civilian as well as for military applications.

Harmonization with the NATO Secondary Imagery Format (NSIF) - Since May of 1995 the DGIWG has been active in harmonizing NSIF with DIGEST. The NSIF standard defines the format and structure for imagery transfer in NATO. As systems merge imagery data with traditional map data, it is imperative that the necessary parameters to ensure correct, consistent, and precise georeferencing are compatible. With this in mind the DGIWG developed the Data Support Extensions Annex to NSIF to ensure compatibility with DIGEST. In addition a new Image Interchange Format consistent with NSIF has been applied to DIGEST as Annex D.

Harmonization with S-57 - Considerable effort has been expended over the last few years to harmonize DIGEST with the International Hydrographic Organization (IHO) S-57 standard. It is desirable that the two standards have a sufficiently high level of compatibility so that it is possible to generate data in either standard from common surveys or other data sources. Compatibility is also desirable for situations where it is important to merge data sets. A Joint DGIWG-IHO Harmonization Working Group was established in 1995 in order to minimize the differences between the standards and to reduce data translation costs. An Interface Control Document (ICD) was developed to facilitate this harmonization and guide the evolution of DIGEST and S-57. The ICD compares and contrasts critical elements of both standards. Since 1995, significant progress has been made. The data models have been aligned to the point where data can be converted without loss of structure or information. A DGIWG-IHO certified mapping from the S-57 Object Catalogue to FACC is nearing completion.

Relation to ISO - The DGIWG continues to play an active role in the development of International geospatial standards in ISO, in particular in TC 211 - Geographic Information/Geomatics. TC 211 was established in 1995 to develop international geospatial base standards. DGIWG has a "class A" liaison with this organization and many DGIWG members are actively participating in ISO/TC211 activities directly or through their national standardization bodies. Promotion of DIGEST is very much welcomed in this ISO forum. WG 5 (Profiles and Functional Standards) of TC211 identified DIGEST as one of the three existing functional standards. TC 211

recognizes that DIGEST is already accepted by the user community and that there exists a vast amount of information in compliance with the standard. Development of profiles of ISO Standards that equates to DIGEST would herald a flying start for TC 211 standards. DIGEST is recognized as forming the bridge from military to ISO base standards. A DGIWG representative has been nominated to lead the Functional Standards new work item proposal. Other work items of particular interest to DGIWG in TC 211 include Cataloguing, Geodetic Reference Systems, Metadata, and Spatial Subschema.

Relations to National bodies - Over the years progress has been made to harmonize North American (US and Canada) national standards such as Spatial Data Transfer Standard (SDTS) and the Spatial Archive and Interchange Format (SAIF) with DIGEST. Similar harmonization efforts have occurred in Europe and other regions.

SOFTWARE DEVELOPMENT

Applications that use and/or integrate digital geographic data require access to standardized digital geographic data and services. At present, users of digital geographic data experience "data barrier" problems of accessing and integrating digital geographic data into application systems. Standardization of digital geographic services and related interfaces are a means to overcome the digital geographic data barrier. The data barrier affects users in several forms. More common issues related to the barrier include: the wide variety of digital geographic data products, different and incompatible data formats, the use of many different coordinate systems and projections, and geographically dispersed databases operating on heterogeneous computing platforms. Further considerations include the increasing quantity of digital geographic data, and the growing number of organizations collecting and using digital geographic data.

Other data barrier issues are related to the many and expanding uses of digital geographic data. Different organizations use digital geographic data for various applications, such as municipal planning, forestry, mining, environmental, natural resource, and command-and-control. Generally, each application area has specific requirements (e.g., raster or vector representation, level of detail, projection, datum), and uses different systems to manipulate and store the data. Collectively, these data barrier issues increase the complexity of spatial data while also increasing the need for standardized solutions. Listed below are several software developments/applications which use DIGEST-compliant datasets or products:

DIGEST Software Tools Project - The DIGEST Software Tools, also known as the Open Geospatial Datastore Interface (OGDI), is open and highly flexible. The same object code can be used to access different geographic datastores (geographic information exchange formats or geographic products) without having to recompile using the "plug and play driver" concept. Applications using OGDI can ignore underlying data communication protocols between themselves and the datastore because data values are retrieved in a convenient and uniform transient data structure

regardless of the source. Datastores can be accessed locally or remotely using a concept similar to that of the World Wide Web.

OGDI provides tools to solve digital geographic data interoperability problems. It maps digital geographic data formats into a uniform transient data structure, adjusts coordinate systems, cartographic projections and platform-dependent data representations, and retrieves geometric and attribute data -- all "on the fly." In short, OGDI provides a data interoperability solution to access the growing number of digital geographic data products and formats, using the Internet or Intranets as mediums to access/distribute digital geographic data products. Conceptually, the premise of OGDI is analogous to the multiplicity of spoken languages that coexist. If multilingual people can share information with each other without having to translate into their mother tongue, they won't have to learn to write in other languages. Similarly, if standard digital geographic services were able to open and read digital geographic data formats, GIS software vendors would not need to build translators and maintain techniques for the exchange of many diverse data formats. Advantages of this approach are that by allowing a basic level of access and heterogeneity, and reducing the need to update, access to digital geographic data can be simplified and expanded. The basic components of OGDI include:

- a naming scheme for uniform resource locators (URLs) to globally identify digital geographic datastores;

- a library of application program interface (API) client functions that allow applications to connect to any digital geographic datastore defined by a URL, and use queries to select sets of geographic features and retrieve digital geographic data regardless of the original native structure;

- an intelligent driver manager that performs driver loading, memory management, error services, coordinate and projection transformation, and a limited number of geospatial operators;

- a set of OGDI drivers that provide 'on-the-fly' access to native format digital geographic datastores; and

- a new transfer protocol to facilitate the reliable and uniform exchange of digital geographic information over the Internet or Intranet.

More info on the OGDI can be found at **http://www.j2geo.ndhq.dnd.ca**

VPFView Software - VPFView software is designed to access any database implemented in VPF. It allows the display of chosen combinations of features or themes for a user selected geographic area of interest. The software supports the display of VPF databases directly from CD-ROM, hard drive, or diskette without loading or converting the data. Display scale can be changed by zooming in or out. Portions of a database can be copied from removable storage media and saved on a computer's hard disk in VPF. Simple plots can be generated in postscript format.

Defense Mapping Agency MC&G Utility Software Environment (DMAMUSE) - DMAMUSE was developed to provide a sample suite of software exploiting NIMA digital products. DMAMUSE operates in the Windows, Macintosh, and SUN MOTIF/Openlook environments. Full source code is provided to allow users to understand and develop their own versions of access software. DMAMUSE provides routines to access and process a wide variety of DIGEST products. DMAMUSE supports raster importing, vector importing, demonstration/briefing display tools, map fusion (overlaying raster data with vector information), standard NIMA datum transformations and coordinate conversions, line of sight computation and display, and perspective scene generation by fusing raster map data and elevation data. DMAMUSE will extract data from VPF products; spatial extent is defined by entering geographic coordinates for the desired area; thematic selection is performed by allowing the users to define the coverages, libraries, and feature types to be accessed. VPF databases can be filtered by attribute by creating "thematic expressions". More information on DMAMUSE and VPFView can be found at **http://www.nima.mil**

CONCLUSION

Over 400 years ago Gerardus Mercator's dream was to publish a volume of maps, which would provide a history of the world since creation. Called the 'Atlas', the first edition was published in 1569. This important pioneering effort remains with us today. Our interpretation of Mercator's dream in the context of the 20th century is an on-line 'Atlas', a digital geographic data warehouse linked to digital gateways. This electronic 'Atlas' will allow tomorrow's user unlimited flexibility to exploit digital geographic data through the information superhighway. Standards such as DIGEST must continue to evolve to support the challenges of satisfying the requirements of the next generation of users and producers.

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