測量工程（特稿）
第五十二卷，第一、二期，第 45-58 頁，民國 99 年 6 月
Journal of Surveying Engineering
Volume 52, Number 1&2, June 2010, pp45-58

地理空間資訊整合與應用

Geo-spatial Information Integration and Implementation in Mapping Technology

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摘 要

測繪科技包含精準測量與完善製圖，其中圖資建置工作因全球環境議題的廣受重視而益顯重要。圖資建置之重點，在於地理空間資料庫的質與量提升，其應用除要能有效回應實況演練之過程與結果，更要有效支援各種不同任務之操演，例如支援防恐維安、災害搶救等。本文首先探討地理空間資料庫質與量提升的面向，量的面向以北大西洋公約組織（簡稱北約組織或 NATO）認可的數位地理資訊交換標準（簡稱 DIGEST 系統）論述會員國間資訊相容與互操作的典範；質的面向則以美國防部（DoD）發展的綜合環境資料表示及交換格式規範（簡稱 SEDRIS 系統）爲標的探究圖資系統建置之模式。其次應用案例的面向則以其檔案傳輸格式進行地理空間資料交換，並開發介面程式。最後，實現圖資讀取、屬性統計與模式模擬，俾利測繪任務遂行。

關鍵詞：DIGEST，SEDRIS，模式模擬

ABSTRACT

There are two main fields in surveying and mapping. They are accurate global positioning system and perfect mapping technology. In global environmental changes and their relative issues mapping operations and datasets are more important because mechanism of decision making is directly supported by their results and implementation. The most crucial point of all to the establishment of digital geo-spatial information datasets in environmental issues is related to the quality and quantity of source data and their improvement. In the aspect of application the geo-spatial information system should be

able to process and feedback the results of environmental scenarios moreover support simulation and decision making from various missions such as modeling, gaming and disaster mitigation, etc. This paper discusses aspects of quality and quantity issues about battle field information mapping and datasets. First of all we look into the compatibility and interoperability of Digital Geographic Information Exchange Standard (DIGEST) system endorsed by NATO for digital information integration in quantity aspect and representation and interchange specification of synthetic environment data (SEDRIS) developed by Department of Defense, USA in quality aspect. Moreover, in application and implementation aspect we used SEDRIS transmittal format and developed interface program to precede battle field information exchange. Finally, implementation has been proved that the representation of geo-spatial information, attribute statistics, and model simulation are compatible to completion of operations.
Key words：DIGEST, SEDRIS, Modeling and Simulation.

1. Introduction

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 Taiwan and Isles 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.

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.

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 [1].

Briefly, the first section of 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.

2. Military Mapping and the DIGEST

2.1 Background of DIGEST

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 [2], and burden sharing of digital data production. The scope of this activity includes dataset specification development and harmonization of standards. The US National Geospatial-intelligence Agency (NGA) 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.

2.2 An Overview of DIGEST

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 has been scheduled to be released since 1997. The next version of DIGEST is able to support imagery, various compression algorithms, and mixing of data types; align DIGEST Annex C and the NGA'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 the next version of DIGEST.

2.3 Basic Characteristics of DIGEST

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:

(1) Self-Describing Format

(2) On-line Data Dictionary

(3) 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 [3].

2.4 Geospatial Data 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:

(1) Internal Exchange — the exchange within national agencies.

(2) Inter-agency Exchange — the exchange between map production agencies.

(3) Provision of Products — the transfer from data producers to their users.

(4) User Exchange — the exchange of data between user systems.

2.5 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.

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.

As the information technology market's reliance on environmental data and its needs to use and share such data increases the cost to acquire, tailor, and use geo-spatial information or environmental data (e.g. battle field related data) will decrease [4]. This, augmented with the continual improvements in acquisition methods of raw data that also reduce the cost of getting such data, will create rapid growth markets where environmental data will be an integral part of the applications that serve such markets.

Since SEDRIS is about representation of environmental data (not just visual or modeling & simulation systems), anyone interested in describing, interchanging and, in general, making their data available or needing access to others' data through a uniform mechanism would be interested in what SEDRIS has to offer. This includes a variety of markets that deal with environmental data, including the meteorological and oceanographic community, the communication sector, the simulation sector, environmental planning and management, the geographical information systems community, the military operational community (i.e., C4I), emergency response systems, and many others.

Briefly, the second section of this paper describes the SEDRIS objectives, what SEDRIS is, and what SEDRIS is not. Description also focuses on the two key aspects of SEDRIS, and how SEDRIS is sometimes confused with some of the applications that it serves.

3. SEDRIS and Military Mapping

3.1 Objectives of SEDRIS

Since its start, SEDRIS has maintained several fundamental objectives. The most notable of these are: (1) to provide a powerful methodology for articulating and capturing the complete set of data elements, and the associated relationships, needed to fully represent environmental data; (2) to provide a standard interchange mechanism to distribute environmental data and to promote database reuse among heterogeneous systems; and (3) to support the full range of applications across all environmental domains that span ocean, terrain, atmosphere and space.

3.2 Characteristics of SEDRIS

SEDRIS is fundamentally about: (1) the representation of environmental data, and (2) the interchange of environmental data sets. To achieve the first, SEDRIS offers a data representation model, augmented with its environmental data coding specification and spatial reference model, so that one can articulate one's environmental data clearly, while also using the same representation model to understand others' data unambiguously. Therefore, the data representation aspect of SEDRIS is about capturing and communicating meaning and semantics.

For the second part, practice indicates that it is not enough to be able to clearly represent or describe the data; we must also be able to share such data with others in an efficient manner. So the second aspect of SEDRIS is about interchange of data that can be described using the data representation model. For the interchange part, the SEDRIS API, its format and all the associated tools and utilities play the primary role, while being semantically coupled to the data representation model.

Put together, SEDRIS is simply an infrastructure technology. It provides the enabling foundation for IT applications to express, understand, share, and reuse environmental data. Since sometimes the line between an infrastructure technology and the applications that use it can be blurred, it helps to enumerate what SEDRIS is not.

Because SEDRIS technologies are often used in the database conversion process, sometimes people think SEDRIS is an application that converts databases. Some have thought SEDRIS is an authoring tool, used to build environmental data sets. Others have assumed SEDRIS is really a single environmental database that can cater to many needs, or that it is an archiving, repository or a discovery mechanism for environmental data.

SEDRIS is none of these, but as an enabling technology it plays a significant role in each of these areas. As an interchange mechanism, SEDRIS is at the crossroads of many diverse IT applications that require environmental data. And its powerful

representational concepts and schema have already influenced many authoring, database generation, and IT applications. So it's easy to see how it can be confused with some of the applications that it serves. But the fundamental aspects of SEDRIS remain the unambiguous representation of environmental data and the efficient interchange of such data through its software technologies.

3.3 Five Core Technology Components in SEDRIS

To achieve its representation and interchange objectives, SEDRIS relies on its five core technology components. These are the SEDRIS Data Representation Model (DRM), the Environmental Data Coding Specification (EDCS), the Spatial Reference Model (SRM), the SEDRIS interface specification (API), and the SEDRIS Transmittal Format (STF).

Three of these (DRM, EDCS, and SRM) are used to achieve the unambiguous representation of environmental data. The combination of these three core components provides the mechanism for description of environmental data. In some respect, this capability within SEDRIS can be viewed as analogous to a language for describing data about the environment.

The DRM, the EDCS, and the SRM enable us to capture and communicate meaning and semantics about environmental data. The SEDRIS API and the STF allow the efficient sharing and interchange of the environmental data represented by the other three components.

3.4 Interoperability and Reuse of SEDRIS: Samples of Projects Using SEDRIS

SEDRIS has been adopted in the U.S. DoD Joint Technical Architecture, and is specifically cited in the NATO M&S Master Plan. The U.S. Army Program Executive Office for Simulation, Training and Instrumentation (PEO STRI) has established a policy that all environmental data will be delivered in SEDRIS format. Several large simulation developments have also committed to the use of SEDRIS technologies [5].

3.4.1 USA Projects

The U.S. Joint Simulation System will be using SEDRIS interchange within its federation. The Land Development Agent (the Army Warfighter's Simulation (WARSIM)) is using SEDRIS standard interfaces to improve COTS reuse. This minimizes reliance on proprietary formats and reduces sole source dependency. The cost avoidance has been figured at half to three-quarters of a million dollars.

The WARSIM Terrain Data Fusion System is built with SEDRIS capability, as well as the evolving Meteorology/Oceanography import system. Specifically, use of the SEDRIS Spatial Reference Model has yielded another four hundred thousand-dollar savings in direct cost avoidance, risk mitigation, and schedule reduction. Through use in the Terrain Common Data Model, WARSIM has adopted SEDRIS as the simulation's environmental language.

3.4.2 UK Projrcts

The U.K. Ministry of Defence (MoD) has adopted SEDRIS as core technology in developing a simulation database facility through the Defence Science & Technology Laboratory (DSTL). DSTL has also favorably evaluated SEDRIS use for improved interoperability and environmental representation in networked applications. Additionally, following successful use of SEDRIS in the U.S. Close Combat Tactical Trainer (CCTT) program where several million dollars cost saving has been reported, developers of the U.K.

Combined Arms Tactical Trainer (CATT) have adopted SEDRIS as their database interface and interchange mechanism.

3.4.3 Other International Projects

Other international use and investigation of SEDRIS technology is successfully progressing within NATO, at the government level in Sweden, France, Singapore, Australia and the Netherlands, and through SEDRIS industry partners in Germany, France and Israel. Technical experts from national standards organizations in the U.K., France, Germany, Japan, Korea, Czech Republic, the Netherlands and the U.S. are also evaluating SEDRIS through their direct participation in the international standards development process.

Through an aggressive testing program, SEDRIS has been used for environment database and information interchange in several applications. These have included the interchange of U.S. Joint Strike Fighter (JSF) Multi-Spectral Database (MSDB) content for simulation-based acquisition; the common language and standard interface for federations designed around the Special Operation Forces Air Crew Training System (SOFACTS); and an Environment Federation implementing former Synthetic Theater of War (STOW) dynamic terrain components.

The growing use of SEDRIS technologies will continue to benefit the M&S community and the simulation projects by supporting interoperability through reuse and sharing.

4. A Case Study of Implementing SEDRIS

In the case study we developed a STF Reader and made it possible to have attribute data inquired and analyzed in our platform. As follows is the implementation of the step-by-step case study using SEDRIS.

4.1 Test of Transforming Mapping Data

In order to test interoperability of the MIF formatted digital highway maps in Taoyuan area we used MapInfo GIS software to manipulate and investigate the quality of data transferred and shown in Figure 1.

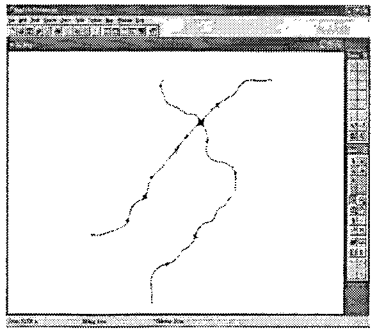

Fig. 1 The result of interoperability in MapInfo while MIF data had been read.

Then we used the MIF to Shape function of ToolBOX in ArcGIS to transfer the original map data and derive SHP files as shown in Figure 2.

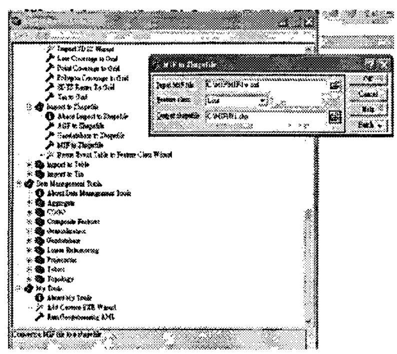

Fig. 2 Data transformation from MIF to SHP.

SHP files have been transformed to STF ones using Shape_to_STF tool in SEDRIS and tagged with a secured code for identification of priority check supervised by SEDRIS security system shown in Figure 3.

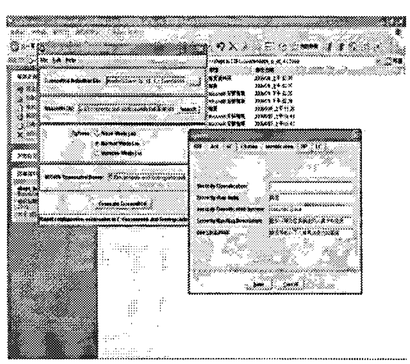

Fig. 3 Shape_to_STF transformation and security supervision in process.

4.2 Interface for Maps Integration and Attribute data inquiry

Shown in Figure 4 is self-developed interface (or platform) for the processes to maps integration of highway information in Taoyuan area. The interface was developed by using the DIGEST Software Tools. The 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 [6].

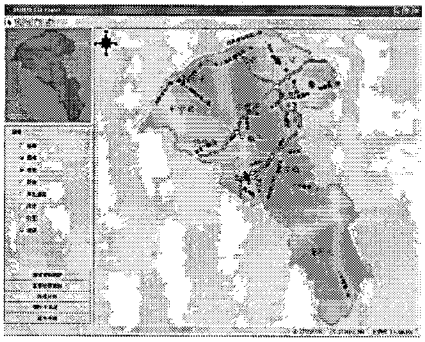

Fig.4 The self-developed interface to map integration and representation.

As geographic data contain attribute data or metadata for geo-reference and other information for application it is required to implement functional availability to process statistic analysis. We sought to develop an interface for dynamic integration of the data and meta-data collected from multi-sources which had been transformed to SEDRIS transmittal files shown as figure 5. When implemented properly, this functional tool offers increased opportunities and decreased levels of uncertainty in decision making.

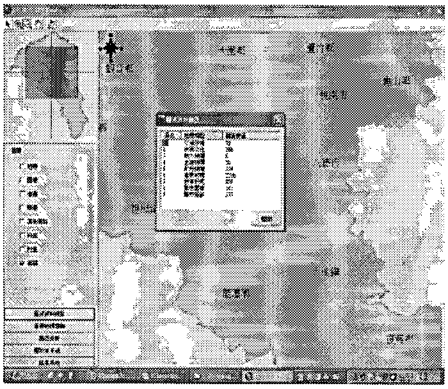

Fig. 5 Attribute data processed and represented in our interface self-developed in our study.

5. Conclusions

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.

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 co-producers.

Establishing formal standards was a key part of the SEDRIS development plan. Pursuing international standardization helped ensure a broad base for applying SEDRIS technologies, and opened interoperability opportunities in multiple national and international markets. However, developing formal specification standards was insufficient to realize all the interoperability potential that SEDRIS could provide. Establishing tested implementations, guidance and education documents, and data coding mapping documents was also required. Toward this end, in the spring of 2000 the Simulation Interoperability Standards Organization (SISO) established two Product Development Groups (PDGs) to address technical implementation of the SRM and EDCS ISO/IEC standards.

Having a standard way to accomplish something considered an infrastructure technology serves two very useful roles. First, it frees the user to concentrate on the more important application-level development, since there is no need to devote time and resources to designing the infrastructure. Secondly, it makes it possible for the users to communicate effectively and unambiguously through a standard mechanism. This, in turn, makes interoperability possible.

Another important role of standards, and particularly international standards, is to subject the technology to scrutiny by a wider, more diverse audience. This was the primary reason the SEDRIS Organization elected to pursue the development of international standards.

This paper discusses aspects of quality and quantity issues about battle field information mapping and datasets. Firstly we look into the compatibility and interoperability of DIGEST system endorsed by NATO for digital information integration in quantity aspect and SEDRIS developed by Department of Defense, USA in quality aspect. Moreover, in application and implementation aspect we used SEDRIS transmittal format and developed interface program to precede battle field information exchange. Finally, implementation has been proved that the representation of geo-spatial information, attribute statistics, and model simulation are compatible to completion of military operations and humanitarian missions.

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申請日期：990524
修正日期：990610
接受日期：990625