GIS Interoperability Issues for ITS Services: Map Datum and Location Referencing

최 기 주(崔岐柱)*
Keechoo Choi

요 약 지능형 교통체계(Intelligent Transport System: ITS)를 구현함에 있어서 반드시 필요한 상호운영성을 보장하기 위한 GIS/OGIS 측면의 두 가지의 문제 (미국의 Oak Ridge National Lab. 에서 수행하였던), 위치참조체계 및 ITS Map Datum에 대한 개괄적인 검토가 이루어졌다. 위치참조는 통신을 통한 교통정보 전달 및 데이터호환을 위한 필요도구이며, ITS Map Datum은 전체 서비스 지역, 주로 지역과 지역간의, ITS서비스를 구현하기위한 핵심으로서 도로망의 기본노드 및 관련속성의 집합이다. 이 두 요소는 ITS서비스 구현에서의 기본표준으로 요망되었고 이제 그 표준안이 제시되고 있다. 특히 실시간의 교통정보가 수집, 가공, 제공되어지는 시점에서 반드시 필요한 ITS Map Datum은 국가적인 정보인프라로의 성격을 지닌 요소로서, 위치참조를 구현함에 있어서도 필수 불가결하다. 위치참조의 프로파일이 외국으로부터 빌려서 쓸 수는 있어도, ITS Map Datum은 우리가 반드시 해결하여야 하는 부분이다. 미국 사례의 전체적 개요와 이런 과정에서 우리가 본받아야 하는 기본적, 제도적인 이슈 부분에 대한 언급이 장차 해결해야 하는 연구항목과 함께 제시되었다.

ABSTRACT Two GIS and/or OGIS issues for ITS interoperability have been proposed and reviewed with some implications to Korean setting. They are location referencing and ITS map datum. The former must support ITS communication and data sharing. Therefore, an introduction of location referencing and other related issues have been addressed along with the Oak Ridge National Lab.'s (ORNL) location referencing scheme. The latter, proposed by ORNL, is a planned network of anchor points across the nation, that could potentially serve as a positional reference for ITS application (Gottsegen, 1997). It is composed of a set of nodes and links in a standard non-plannar network at a coarse scale for the entire nation for referencing purposes. To provide case of real time traffic information and to guarantee the seamless interoperability, we do need to develop the core ITS map datum as a national infrastructure, and the location referencing scheme should also be either developed or borrowed and localized to meet the domestic needs. Some institutional issues are also addressed along with the future research agenda.

키워드 : ITS, ITS User Services, Interoperability, Location Referencing, Map Datum, Traffic Information,

1. Intelligent Transportation Systems : Introduction

Let's say you are on your way to OpenGIS workshop meeting and you are supposed to present a session. It is scheduled at 2:00 pm in the Yoido 63 Building. Now it is already 1:45 pm and you are still in the middle of road around Seoul station. The in-vehicle system of your car tells you that the traffic is backing up along the route connecting Wonhyo Gyo (Br). The route leading to Mapo Gyo (Br) may be an alternative route in this case. But is it likely to be any better for you?

In the midst of anxiety, your navigator still updates your location in the map every couple of seconds. It is in touch with the traffic information center (TIC) that monitors the traffic condition of Seoul urban network. It tells you the likely arrival time of 2:15 pm

* 종신회원, 아주대학교 환경도시공학부
keechoo@madang.ajou.ac.kr

based on the route via Wonhyo Gyo, whereas the Mapo Gyo connected route 2:09 pm. The latter route takes a shorter times in spite of a bit longer distance. What are you going to do at this situation? This is the typical arena that intelligent transport systems (ITS)-ATIS-can gives a helping hand, while there are other areas such as ATMS or CVO.

A set of diverse technologies such as computer, communication, control, information and intelligence, known collectively as intelligent transport systems, holds the answer to many of our transportation problems including congestion, accident, and environmental pollution. Traffic accidents and congestion take a heavy toll in lives, lost productivity, and wasted energy, and combining these technologies to our transportation system will save lives, save time, and save money. At the same time, it enables people and goods to move more safely and efficiently (ITS America, 1999).

Although ITS itself, real systems, products and services are at work throughout the world, the wide-scale development and deployment of these technologies is still evolving throughout the world, only part of implementations have been prototyped or realized to a varying degree due to interoperability problem, i.e., (1) since the definition of this capability is still emerging, and (2) due to the lack of interoperability and standards.

Because of the anticipated scale of the economic, legal, and social effects of ITS, it is important that there be penetrating, systematic evaluation of ITS, particularly in its early stages (ITS America, 1999). In US, to achieve this systematic evaluation, a program planning process has been established by which all interested parties in ITS can work together to implement ITS. An early outcome of the planning process was the identification of a number of capabilities, so called user services, that if deployed will collectively meet the goals of ITS stated before.

Under the ITS goals consistent with those presented in the strategic plan and national ITS program plan (ITS America, 1999, for the US case; and MOCT, 1997, for Korean case.), the US sorted all 30 user services under seven broad categories, whereas Korea 14 user services under 5 subsystems. They are 1. Travel planning, 2. Traveler information, 3. Travel management, 4. Travel payment, 5. Commercial vehicle operation, 6. Emergency management, and 7. Advanced vehicle safety systems. (US DOT, FHWA, 1994). Similarly, the EU and Japan sorted out a specific set of user services based on their strategic masterplans.

2. ITS User Services of Korea And Related Activities

Korea originally developed 20 user services and categorized these into six macro services in its national ITS program plan, so called the ITS masterplan. Later the user services have been shrunken down up to 14 user services as has been shown below, for five major subsystems (MOCT, 1997).

ATMIS : Advanced Traffic Management & Information System

- ATCS Advanced Traffic Control System
- AIMS Advanced Incident Management System (*)
- ETCS Electronic Toll Collection System
- HVMS Heavy Vehicle Monitoring System (*)
- ATES Advanced Traffic Enforcement System

ATIS : Advanced Travel Information System

- TRIS Traffic and Road Information Service(**)
- RGS Route Guidance System (**)
- TIS Traveler Information System (**)

APTS : Advanced Public Transportation System

- PTIS Public Transportation Information System (*)
- PTMS Public Transportation Management System

CVO : Commercial Vehicle Operation

- FFMS Freight & Fleet Management System (*)
- HMMS Hazardous Material Monitoring System

AVHS : Advanced Vehicle & Highway System

- AVS Advanced Vehicle System (or APA : Accident Prevention and Avoidance)
- AHS Advanced Highway System (or HCI : Highway Capacity Improvement)

Although all of the subsystem do not necessarily require, some subsystems marked with asterisks (one or two, represent the needs in that degree) are identified as those which need digital road maps to better serve the users. That is, to better implement the ATIS subsystem, a digital road map may be employed in the stages of data collection, processing, and information dissemination. Table 1 summarizes the user services and required map characteristics (Goodwin, 1995).

to both the public and private sectors. This challenge is further complicated by the necessity to convey locationally referenced information among kinds of databases and spatial data handling systems so that ITS products will work seamlessly across the region of the country, and sometimes across the nations.

In most cases, the data and/or map required is

Table 1. User Services of Korean ITS vs. Related Map Requirements

Service	Spatial Accuracy (meters)	Temporal Accuracy	Scope	Data Model
ATMS				
ATCS	1-100	Timely	Local/Region	NP Topo | NP Net
AIMS	>100	Timely	Local/Region	NP Topo | NP Net
ATES	10-100	Real time	Region/Nat.	NP Topo
ETCS	>100	Real time	Region/Nat.	NP Topo
HVMS	10-100	Timely	Region/Nat.	NP Topo
ATIS				
TRIS	10-100	Timely	Region/Nat.	NP Topo | NP Net
TS	>100	Update on change	Region/Nat.	NP Topo | NP Net
RGS	1-100	Timely	Local/Region/Nat.	NP Topo | NP Net
APTS				
PTIS	10-100	Real time/Timely	Region/Nat.	NP Topo I NP Net
PTMS	>100	Timely	Region/Nat.	NP Topo | NP Net
CVO				
FFMS	>100	Timely	Region/Nat	NP Topo | NP Net
HMMS	10-100	Timely	Region/Nat.	NP Topo | NP Net
AVHS				
AVS	0.1~5	Real time	Local	X
AHS	0.1~10	Real time	Region	X

Note : NP means non-plannar ; Topo, topology; Net, network.

2.1 ITS User Services and Map : An Inextricable Linkage

As shown in Table 1, many ITS user services will require map databases in digital (as opposed to analog) form, at least in the phase of information is dissemination. Due to the dynamic nature of ITS, the wide geographic coverage required for some applications. In addition, the diversity of applications, the design and development of spatial databases to meet the various needs of ITS pose a major challenge based on non-planar (i.e., considering under- and over-passes characterized by grade separation) data models. Link-node models are the essential part for the traffic and travel management, and many other services performing route planning and guidance. For example, spatial decision support and modeling functions of ITS require topological link-node network in the center, whereas the non-topological networks may be more appropriate in vehicles in which drivers should quickly comprehend the information provided.

2.2 Supporting Standards for Proper Linkage Between Map and Services

Supporting standards are very important in consolidating the map and user services and will be critical to the future ITS deployment, with respect to spatial data sets as well as for other system components and across interfaces. It is expected that at least three areas where spatial data set-related standardization will be needed in this regard.

First, it is data transfer standard. For example, to exchange different data sets among agencies who have and need traffic data and information, a standard like the ITS profile for the Spatial Data Transfer Standard should be developed and it is considered as one of the most important one among this category.

Second, the interoperability standards are also important. They are, for example, message sets and location referencing standards and protocols to promote data sharing among various ITS spatial data set environments.

Finally, there are data set storage and/or interface standards for spatial data so that vendor hardware and software products can work with spatial data sets from other vendors. In this paper, out of there three the second standard issue (focusing on the "interoperability") will be stressed, with GIS and/or OGIS prospectively playing a major role in implementation.

3. The Interoperability Problem and Two Key Issues

Let's say a TIC(Traffic Info. Center) is broadcasting information on congestion, i.e., at Banpo Bridge, the average speed is around 30lm/h. Speed is straightforward, but how does it describe the location of this observation? Two aspects of interoperability matters in this case. First, no two vendor's map of the same area are identical in all respects. Positional disagreement ranges from 0 to 150 meters. Hence a location could be specified very precisely with respect to one map base, but when transferred to another vendor's map it could be off by a block, allowing the real position of Banpo Bridge on the Han river in above example. Second, there are several ways of describing a location using various mechanism such as coordinates (longitude/latitude), route and distance, intersection name, landmark, and map grid reference (Joong-Ang Ji Do Sa's 1:10,000 Seoul Atlas, page 24 E-9, etc.)

Interoperability requires ready translation between these forms of messages. Some data needs are more stringent than others. For some purpose, measurement at the meter level is required; for other purposes 100 meter is sufficient. Here is one problematic scenario.

Three vendors, A, B, and C, offer databases for Seoul area. The TIC adopts vendor A, and broadcasts congestion information based on it. The Motor company in-vehicle system is base on B, whereas I have vendor C's map in my dashboard. I requested the 63 building in Yoido. When the data comes in and gets mapped on my system, the 63 building is in the middle of the Han river. Furthermore, when I ask for congestion data from the TIC, it gets attached to the wrong network link due to the coordinate misregistration. This is forgivable, but in case of emergency, it is usually not.

So far the initiatives at the international level (ISO/TC 204 TICS) and SAE's recommended practice J2256, and Japan's VICS and UTMS system have addressed the issue of messaging protocols. But, still the global consensus is still being built.

In US, the Oak Ridge National Laboratory (ORNL), located in Tennessee, has been tasked by the Federal Highway Administration (FHWA) to review the requirements of ITS applications for spatial data and location referencing, to develop consensus positions on spatial database issues, and to determine whether any Federal action is necessary to ensure those needs are met, particularly for nationwide applications. In this paper, the author will attempt to summarize works done so far on location referencing and to present a practical approach to standardization.

According to Goodwin (1996), it is generally considered that a consensus for ITS spatial data standards cannot be forced, given the reality of the public-private nature of ITS and limitations of authority of any one sector. Rather, the development of ITS systems and standards to serve the nation's interest must result from understanding and respecting the variety of viewpoints, histories, technologies, and technical languages present within the world of transportation. It is also believed that it is only within the commonality of worldview of an application community-of-interest that consensus on standards, whether for national spatial databases, location referencing, or database transfer standards, is achievable, but that a framework for accommodating different worldviews, building bridges between groups, and encouraging consensus is possible. Building a framework based on public and private sector cooperation is the ORNL's approach to meeting ITS spatial data needs. In next sections, with such approach in mind and with anxiety of "who's playing this kind of role in our case?" the author reviews the location referencing and ITS map datum as major building block of ITS implementation.

3.1 Location referencing : Introduction

Location referencing is a way of describing where something is. If we want to tell someone where something is, we do it by making reference to something else, whose location is commonly known. There are many ways doing this, and there ways are usually called location referencing methods. We can give a location with respect to some known point, for example the center of the earth, or the famous landmark such as 63 building, or the junction of two streets such as the national road 1 and 42 near Suwon. We can also refer to a location with respect to a set of points, for example a road, a field, or a shopping center. As shown in the Figure 1, there are several (but not all) possible common methods of locating a point X on a road. The point X lies 2km point after K. Univ. (Kyunggi University) toward N.Suwon IC; or it can be referenced using the Lat. 202 ° 55′21″, Lon. 444 ° 33′44″ in TM projection digital map.

The known location is not enough to make the reference by itself. A location referencing method must also include details of measurement and how the references are to be made. For example, referencing by geographic coordinates requires that people must agree on the geodetic datum to be used (the mathematical shape of the earth), an origin for measurements as is the case in TM based projection digital map in Korea, and a system of measurement (latitude, longitude, and elevation measured with respect to the datum). Similarly, use of a location reference method involving street names implies that users must have a common set of street names and also naming conventions for new streets entered into the database. (It is a possible alternative even in Korea, since the road names are appearing here and there as a result of the nationwide street naming project.)

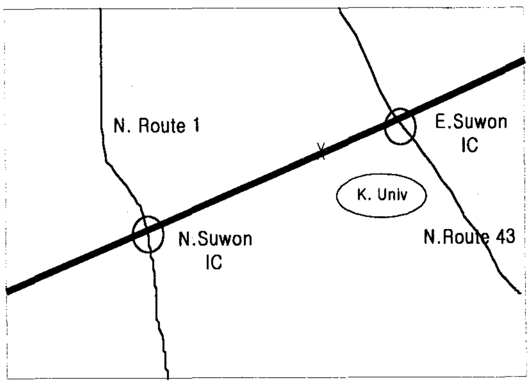

Figure 1. Some Methods of Locating a Point on a Road

3.2 Location Referencing Occurrences Within ITS?

To provide or to share traffic information, composed of location and attribute information, location referencing is required among various agencies (TIC, TMC-traffic management center, or both), i.e., between agencies and information service providers, and between ISPs (information service providers) and vehicles. This is needed primarily because the information should contain location as part of information and transmitted to some other information system. However, any component within the system may have a different spatial database than any other, and this is why a common referencing method should be employed. In addition, travelers should be able to drive from a place to another place, the distance of which are very far, with in-vehicle information system products that interface with traffic information and traffic management centers in any city and/or regional transportation center. Furthermore, data sets from different vendors should interface with any traffic information and/or management systems wherever implemented.

3.3 Basic Methods of Location Referencing

Various location referencing methods are in use today both in transportation agencies and private industry. In spite of this diversity, one can discuss them in terms of methods that depend on networks of nodes and links, and methods that depend on some coordinate or grid system. Transportation agencies have historically depended on network methods which take advantage of the fact that vehicle movement is confined to roads. While the former simplified model of the world as a network means that data in this case can be constrained to positions on the network only, the latter, geographic coordinates, express location anywhere on the surface (x,y) or above or below it (x,y,z).

Two major categories of coordinate references are: continuous coordinate fields and coarse coordinates. Methods based on continuous coordinate fields range from global geographic coordinates (e.g. latitude and longitude) defined with respect to some global frame of reference, for example WGS-84, to local offsets from known points in spherical coordinates, Cartesian coordinates in planes touching the earth, or earth-centered coordinates.

Coarse coordinates are commonly referred to as raster or grid schemes. The common element of coarse coordinate schemes is a regular subdivision of a surface into finite shapes, typically rectangular, and the assignment of coordinates in some regular way (e.g. letters A-Z for columns and numbers 1-10 for rows, as we commonly use with commercial atlases. For example, we can refer a location on page 24 E-9 in Joong-Ang Ji Do Sa's 1:10,000 Seoul Atlas, or etc.).

3.4 Difficulties of the Standardization of Location Referencing

Location referencing is difficult to standardize due to both technical and non-technical factors. The technical problem is that referencing is always done with respect to some model of reality, not to the real world itself (Figure 2). All maps and spatial databases are simplified models of reality, for example, a complex cloverleaf interchange is often modeled as a point (Figure 3), and planar representations of road overpasses are often made when the reality is not planar (they don't really meet, Figure 4).

The closer one gets to reality in the database, the more expensive and time-consuming they are to make, especially when attributes such as navigation

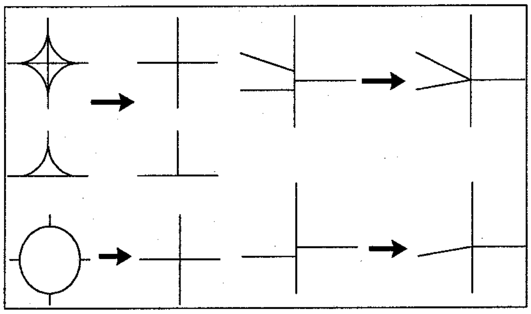

Figure 2. Some Road Models of Realities

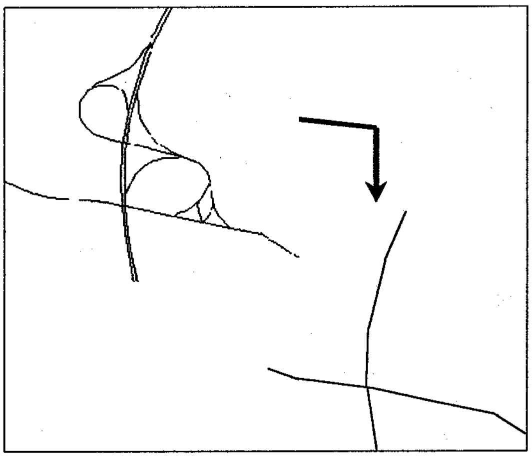

Figure 3. Modeling of Grade-Separated Interchange to Point

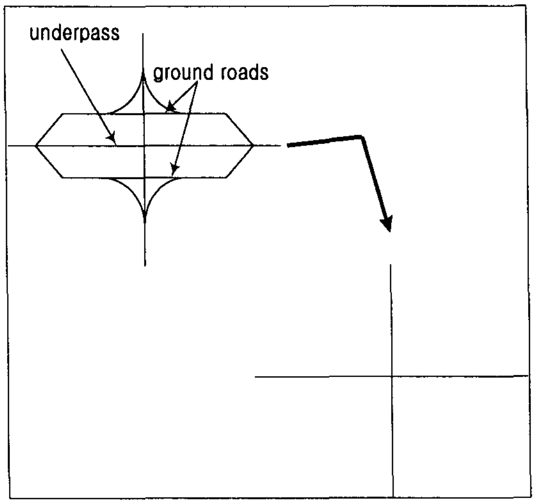

Figure 4. Modeling of Over-and Under-passes to Point

restrictions, which are not readily seen on aerial photos, are required by the application. The result is that no two map databases are exactly alike, and all have errors? when measured against the real world. Indeed, what constitutes an error? may itself differ depending on the application.

Also, the fact is that a great amount of money has been spent on spatial databases by many public agencies and private companies. The legacy databases and the organizations that support them make change expensive, as is the case both in US and in Korea. Such aspect of huge cost also add to the difficulties of standardization of location referencing.

In spite of such difficulties, the ORNL/FHWA's location referencing have been proposed and approved recently by SAE. LRMS is a flexible framework for accommodating different location referencing methods and it is composed of several profiles that contains a start code to identify the kind of message or profile, a series of attributes associated with the kind of message. (For a detailed description of the draft, see Goodwin, 1996).

4. Building Blocks of Interoperability : Things that should be done

Then, what should be done to solve the problem of location referencing for applications at local level as well as at national level? And is it possible to do this with one standard location referencing method? Probably not. To solve the problems, it is considered that there are three approaches (to guarantee the interoperability).

4.1. Building A Common Data Set and Related Cost Issues

The first approach is to build a national data set according to a national standard, which all vendors and localities would use. The biggest problem with this is cost for database creation and maintenance. The federally supported database creation and maintenance is actually very difficult. At least, the maintenance can be better implemented at the local level, although the creation can be purely done by the central government. In Korea, a joint effort of public and private sectors had been made in this regard in 1995. That is "making a skeletal digital road map for navigation system." 10 private companies and the ministry of trade and industry were the stakeholders.

In US, it is estimated that a full-fledged navigable spatial database for ITS at an accuracy level equivalent to 1:24,000 scale maps (required for many ITS applications) would cost between $300M and $500M to produce initially in the US. If navigation attributes are left to private industry and a skeleton map only is produced, costs could be reduced to the order of $100M. (Heft, 1997)

Also, for a data set of sufficient quality and detail for ITS use as a single database for referencing, the problem of timely updates becomes overwhelming. This problem is particularly acute for transportation networks, which may change several percent per year in some areas, and it is even severe in Korea, who is gaining the network linkage with such rapidity. Experience indicates that only by accepting updates continuously from the local level can a national data set remain uniformly current. It is doubtful that any centralized, national-level organization would be able to keep up with update and maintenance requirements for ITS. Maybe this is shedding light on our circumstances and will be a valuable experience for us.

However, costs for both development and maintenance and timeliness of update processing decrease with database scale. Properly defined, a national spatial map database could provide a mechanism for joint sharing of spatial map database development costs by both the public and private sectors. For example, the public sector might develop or provide funding for the development of the skeleton database, while the private sector would fund the development of more detailed spatial map databases that would automatically connect to the skeleton database using a well defined standard.

4.2. Use of Base Geodetic Framework

Many of our data sharing problems have arisen because of the increasing sophistication of our data handling tools, allowing us to build complex data structures on top of specific data models, data sets, and underlying datums. The connection between internal data models and external data sharing possibilities is limiting for highly evolved GIS products and databases, to the extent that it is no longer possible to talk about "internals" separate from the "externals" of such systems. (This may be the motivation behind the Open Geodata Interoperability Specification-OGIS-and other current interoperability efforts. See)

On the other hand, for the new, real-time, non-GIS side of ITS, the geodetic framework is close at hand. In fact, GPS technology produces low-level georeferenced coordinates as a matter of course. For this, we can stick close to the geodetic framework and talk in the simplest, most fundamental terms called coordinates. This approach is thus to use low-level geographic coordinate referencing for those applications involving especially the ISP-to-Vehicle interface.

However, can we use coordinates by themselves? Database quality affects the validity of coordinate references, regardless of the state of the art of GPS. Even when very accurate DGPS observations are available, the reality of spatial data sets today is that map matching must be performed to remove ambiguity. The more difficult problem for coordinate referencing comes for references between two different data sets, where GPS is irrelevant. Even if both are to within the accuracies of 10-100m at nodes, differences in representations of the real world along a link, e.g. by different methods of assigning shape points, can produce much greater errors.

In this case, the combination of some form of coordinates and street name is the best candidate to date for a general standard for ISP-to-Vehicle location referencing. In US, it is strongly recommended the adoption of a national standard coordinate-based location referencing method for the ISP-Vehicle interface. This may shed light on our circumstances since we are also inventing a framework of street naming.

4.3. Development of an Interoperability Framework

The third approach to the problem of ITS location referencing is that of an interoperability framework of skeletal spatial objects. The first key framework element is a National ITS Datum-a national standard network of ground control points that will anchor spatial references between databases of different kinds (satisfy the national interoperability requirement) and that will also serve as a skeleton database of manageable size.

If two data sets have a common frame of reference (datum), then location referencing is a simple matter of posing references in terms of the common datum. The need for a common datum explains why the long-standing search for a common link ID scheme for ITS has proven fruitless. A standard, replicable by anyone, universal method of link ID assignment independent of network implementation is not likely, since link IDs are essentially network labels, rather than real world artifacts or measurements.

To the extent that transportation networks can be labeled systematically, e.g. from network topology traversals, IDs can have meaning, but this meaning is always with respect to the network model of the real world, not to the real world itself. Hence, communication without ambiguity is only possible if the users have the same model, or if their different models are registered together. The ITS Datum is composed of two parts: the ITS Network, a link-node network whose nodes are accurately georeferenced and whose link lengths are accurately measured, and the ITS Geodetic Datum, a standard geodetic datum specification for ITS based on WGS-84 and an elevation datum. The ITS Datum Network is a set of nodes and links which all ITS users have as a standard non-planar network for referencing purposes. The contents of the datum network should be:

The **node table**, consists of unique node, node latitude, node longitude, node elevation. For each unique node, a list of the IDs of other connected nodes to which navigation exist. The **link table** is composed of unique link ID (from-node-ID + to-node-ID), link length, road/street name ID from an ITS standard names table provided with the datum (Siegel, 1996).

The datum is not required to be as large as the data sets which use it. In the case of ITS, the datum needs to be of sufficient node density to permit other data sets to be registered to it. The ITS Datum overall supports directly both coordinate and network (Link ID and Linear) spatial references, which constitute the majority of ITS referencing requirements, and also can be searched for standard road and street names.

The ITS Datum derived from the NHPN (National Highway Planning Network sponsored by FHWA and US Army)is now under construction and will be available on the World-Wide Web for community testing upon completion. The second key framework element is a national standard Location Reference Message Protocol (LRMP or LRMS)- a framework for standardization of location reference message formats to meet the needs of both public and private users. Since multiple kinds of location references must be supported for ITS applications, multiple presentation formats must be developed, based on the needs of the various communities-of-interest under the ITS umbrella. The formats are community based, i.e., they will be developed from the standard practices of the application communities and requirements specific to those communities (including ATMS, ATIS, CVO, APTS, AVHS, and GIS-T at a minimum), but will be specified, tested, and promulgated under an overall ITS umbrella. (A more detailed, but similar effort are also undertaken by FGDC Ground Transportation Subcommittee, 1998, who is trying to provide a more general tool for exchanging data between sources, rather than ITS application.)

The LRMP development result will be available on the World Wide Web for general public use for testing of the protocol capabilities, for testing of user data compliance with the protocol, for general-purpose ITS data transfer site to site, and for ITS Datum test area access and testing. Wouldn't it be easier if everyone used one location referencing method? Over time, the underlying technology of spatial databases has grown to support a variety of data models, including topological networks and object-based representations of real-world transportation features. GIS in particular has moved us further away from the geodetic framework into a world of application-dependent abstractions, and variations in location referencing methods have flourished. Each agency, state, vendor, etc., develops its own flavor? The early call to solve this problem within the larger ITS community was for a common location referencing method for all of ITS. We believe, however, that this approach is not practical. Applications are simply too diverse and are properly supported by diverse communities with valid interests in maintaining their legacy databases and their points of view. It is believed what is apt to be more productive is a location referencing system which will accommodate diversity, rather than one method imposed from the top down.

5. Implications to Korean Setting

As of today, the Korean government is revising the masterplan made in 1997 and small changes will be made at the end of this year, with the issue of interoperability untouched. Still we are not paying much attention to the issue and just making the bare minimum such as digital road map using DXF, without considering the issue too much. Although some private companies such as car manufacturers are contemplating this issue, they are soon to be discouraged by their inability to solve the problem by themselves, which the public sectors should make it clear beforehand. That is, the motor companies or part suppliers such as Hyundai, Samsung, Mando were developing digital road maps and were trying to solve the related interoperability issue. That is why they were hand in hand with map producers such as Pan Asia, Iljin, Hanjo Eng., respectively, while leaving the problem of multiple investments for a single goal (seeing from the national viewpoint). But the core map format is still being borrowed from Japan, which is Naviken format.

Now, the real problem occurs at the time of real time traffic information sharing and broadcasting. We do need the core ITS map datum, at least a national level, and location referencing scheme. Although the LRMS might be borrowed at the worst case (see Goodwin, 1996 for a detailed description of the Location Reference Message Specification, final design), the ITS map datum should be contemplated and solved here in Korea locally.

6. Conclusion

Roads are owned, maintained, and policed (mostly) by public sector agencies such as the MOCT (ministry of construction and transportation), local governments, but the products put on those roads (chiefly vehicles) are owned, maintained, and operated (mostly) by the private sector. Successful ITS deployment will require, for the most part, both public sector and private sector involvement and cooperation. The public-private cooperative aspect of ITS is real and essential, even in the area of digital map.

Two GIS and/or OGIS issues for ITS interoperability have been proposed and reviewed with some implications to Korean setting. They are location referencing and ITS map datum. The former must support ITS communication and data sharing, and the ORNL/FHWA's location referencing have been proposed and approved by SAE. LRMS is a flexible framework for accommodating different location referencing methods and it is composed of several profiles that contains a start code to identify the kind of message or profile, a series of attributes associated with the kind of message.

The ITS map datum, proposed by ORNL, is a planned network of anchor points (monuments) across the US, that could potentially serve as a positional reference for ITS application (Gottsegen, 1997). It is a set of nodes and links in a standard non-plannar network at a coarse scale for the entire nation for referencing purposes. It provides commonly known ground control points for important highways, provides registration points for "rubber sheeting" datasets from many sources, and provides local reference points for LRMS referencing between "compliant" datasets.

Now, in case of real time traffic information provision, we do need the core ITS map datum and location referencing scheme. Although the LRMS might be borrowed, the ITS map datum should be developed locally. Prior to an expensive national scale densification efforts, question need to be answered on the following research agenda. They are point selection rule, database structure, associated information items, and administrative and maintenance mechanism, which will be elaborated a bit more in the next paragraph.

As is the case in US, the national highway planning network (NHPN) can be devised, hopefully at the end of this year's KOTI transportation database project, where both attribute databases such as origin-destination and other travel data and graphic data transformation would be made. Surveyors and transportation planners roles are very important in this stage, for allowing and arranging such future needs in the area of ITS. The efforts devoted will truly light the community of ITS, GIS-T and transportation sectors in overall sense. We have been granted a role of establishing a set of standard that will guide a whole set of ITS implementations. The society of Korea OGIS community is not an exception in this wanted situation.

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최기주

1984년 서울대학교 토목공학과 졸업 (학사)

1986년 서울대학교 토목공학과 교통공학 석사

1992년 일리노이대 도시공학 교통계획 박사

1993년~94년 8월 서울 시정개발연구원 책임연구원

1994년, 1998년 9월 아주대학교 교통공학 조교수

1998년 10월 아주대학교 교통공학 부교수

관심분야 : 교통계획 교통정보, GIS-T, ITS