21세기를 향한 GIS발전전략에 관한 국제세미나

3rd Annual International Seminar on GIS Development Strategies for 21 Century

September 10～11, 1998
Renaissance Seoul Hotel
Seoul, KOREA

Organized by
Korea Research Institute for Human Settlements(KRIHS)

Sponsored by
Ministry of Construction and Transportation(MOCT)

REPUBLIC OF KOREA

KOREA RESEARCH INSTITUTE
FOR HUMAN SETTLEMENTS

International Seminar on GIS Development Strategies for 21 Century

SEMINAR SCHEDULE

September 10, 1998 (Thursday) : Renaissance Seoul Hotel

9:30~10:20	Registration	
10:20~10:40	Opening Address	Hong, Chul (President, KRIHS)
	Congratulatory Address	Sohn, Seun Kyu (Vice Minister,MOCT[1])
10:40~11:30	Keynote Speech	Jack Dangermond (President, ESRI)
11:30~12:00	Introduction to National GIS Initiative in Korea	
	Kim, Se Chan	(Director, Land Bureau, MOCT)
12:00~14:00	Luncheon	

• Session 1 : Strategies for National GIS Development and Benefit/Cost Analysis for GIS Implementation

Moderator :	Kim, Tschang-Ho	(Professor, Univ. of Illinois)
Discussants :	Lee, Dong O	(Director, Information Promotions Committee, MOIC[2])
	Park, Chong-hwa	(Professor, Seoul National Univ.)
	Song, In Sung	(Professor, Chonnam National Univ.)
	Julie-Ann Kerin	(Executive Vice President, Genasys)

14:00~14:40	The Strategy and Development Status for NGIS Solution in Germany Hans Knoop (Professor, Technical University of Braunschweig)
14:40~15:20	GIS Development Strategy for 21 Century in Korea Kim, Young-Pyo (Head, GIS Research&Project Division, KRIHS)
15:20~15:40	Break
15:40~16:20	Cost-Benefit Analyses for GIS Implementation Katarina Lindgren (Director, Eken och Arken)
16:20~17:00	Using a Systematic GIS Planning Process to Maximise Benefits and Minimise Costs of National GIS Implementation David Alexander (President, Alexander Tomlinson Ltd.)
17:00~18:00	Discussion

[1]MOCT Ministry of Construction and Transportation
[2]MOIC Ministry of Information and Communication

September 11, 1998 (Friday) : Renaissance Seoul Hotel

8:30~ 9:00 Registration

- **Session 2 : Trends of New GIS Technology and Directions for Future Development**

Moderator :	David Alexander	(President, Alexander Tomlinson Ltd.)
Discussants :	Lee, In Won	(Director, National R&D Planning and Management, STEPI[1])
	Min, Tae-Jung	(Director, Geodesy Division, NGI[2])
	Jo, Myung-Hee	(Professor, Kyungil Univ.)
	Hans Knoop	(Professor, Technical University of Braunschweig)

9:00~ 9:40 Trends in Geographic Imaging
Craig, Erikson (Manager, ERDAS)
9:40~10:20 GPS Upgrading and Updating Spatial Database
Tan Siew Siong (Manager, Trimble)
10:20~10:30 Break
10:30~11:10 Spatially Enabling the Enterprise
Henry Tom (Director, Oracle)
11:10~12:00 Discussion
12:00~14:00 Luncheon

- **Session 3 : Database Management and Future Application**

Moderator :	Lee, Hyoun-Young	(Professor, Kon-Kuk Univ.)
Discussants :	Yang, Young Kyu	(Director, Image Processing Research, SERI[3])
	Kim, Jangsu	(Director, DBMS Division, Korea Telecom)
	Shin, Young Chul	(Professor, Chungbuk National Univ.)
	Henry Tom	(Manager, Oracle)

14:00~14:40 GIS and the Internet Come to the Rescue in Natural Disasters
Peter Southwood (Engineer, Autodesk)
14:40~15:20 New Horizons for the New Millenium
Julie-Ann Kerin (Executive Vice President, Genasys)
15:20~15:30 Break
15:30~16:10 Current Status and Future of GIS Technology
Richard G. Newell (Chairman, Smallworld)
16:10~17:00 Discussion

[1]STEPI Science & Technology Policy Institute
[2]NGI National Geography Institute
[3]SERI Systems Engineering Research Institute

GIS Development Strategies for the 21st Century

Jack Dangermond
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1. Introduction

Software development and application development efforts have made major advancements in the GIS industry over the last several years. These advancements are based on a number of industry-based technology standards such as OLE, Visual Basic, "Next Generation" Relational Database Management Systems, the movement towards object orientation, geoprocessing algorithm advancements, and network based (i.e., Internet) innovations. These innovations and advancements are influencing and leading the direction of the GIS industry. In addition, some very innovative and stunning applications and use of GIS technology are occurring along with new concepts and ideas which are driving forward GIS technology developments.

The GIS market as an industry sector, is currently going through major changes involving both enhancement and growth, on a global as well as on a regional basis. While the local or regional economy in some parts of the world may be having impacts related to short-term movements and directions (i.e., economic slow down may impact the amount of investment put into GIS in the short-term) the long-term outlook remains extremely strong and optimistic. A number of factors are influencing the development plans and strategies in the GIS market and the technical directions that are occurring.

2. Key Influences on GIS Development Environments

One of the driving factors behind GIS development, especially at a national level or at an international level, is the concept of advanced geoprocessing as it relates to information technology management. There has been a movement towards the merging of what some consider "classic GIS" with "classic information technology" (IT). This has led to the movement of GIS towards more of a "mainstream" role in the computing and information systems industry. Some factors that are influencing National Geographic Information System (NGIS) development efforts include standards for data formats, data exchange, and data interoperability. In addition, software development "standards" such as Visual Basic and OLE, as well as database management standards are influencing GIS development. Internet development and communication standards such as HTTP, HTML and Java are influencing GIS. Most GIS technology today has been "Internet Enabled." The more advanced of these provide GIS capabilities for the client, server and data management components. All of these factors are being driven forward through new development advancements and these will result in much greater use and exposure of GIS technology throughout the computing industry.

A key trend that is occurring is that GIS technology, for many purposes, is becoming ubiquitous. That is, GIS is becoming embedded within or part of many other "non-GIS centric" or "non-GIS specific" operations in organizations in both the private sector as well as government. This means, for example, that many day-to-day operations or tasks that individuals, organizations, or agencies, (at the local, regional, or national scales) undertake, will begin to take on spatially enabled capabilities through embedding or linking of GIS technology.

The results of many of these development efforts have been and will continue to result in great savings and cost advantages for those organizations that begin to implement GIS. This is true whether within "GIS centric" operations and applications or "embedded" applications and operations. A number of cost benefit analyses are beginning to show, especially in the last several years, that GIS implementation in organizations are indeed starting to have dramatic payoffs. In some cases these are substantial and support investments in GIS development that will be beneficial to the end user both in the short-term, but especially in the long-term as organizations become more spatially enabled and spatially literate.

3. Trends of New GIS Technology and Directions for Future Development

A number of trends related to GIS technology have been and continue to influence and steer GIS developments. These include "embedded" GIS algorithms and functionality inside non-traditional GIS applications (as was discussed briefly above). Through the componentization of GIS technology it now is possible to embed or program inside classic non-GIS applications to add capabilities for doing geographical analysis and management. This will continue to have a major influence and impact on the GIS development directions as we move into the next century.

In addition, this is especially becoming important because of the major role and the influence that the Internet is now having as GIS technology takes on a more embeddable development capability through such development languages such as Java and Active X. More GIS will become prevalent in day-to-day computer operations throughout government and the private sector.

Development directions are also occurring in the areas of integrating GIS solutions with non-traditional GIS applications such as Workflow, Imaging, CAD based systems, Graphic Diagramming and Case Tools. While there still are areas that need improvement, these advancements are taking place now. Some of the areas for improvement include such things as standards for interoperability and data exchange among program environments for technology such as Case Tools, GIS tools, database management tools and office automation tools.

Another area, which is greatly influencing the directions of GIS development, is in the area of what can be referred to as "Enterprise Solutions." Many companies such as SAP, Oracle, and Microsoft are moving in the direction of developing technology advancements and market development in the areas of "Enterprise Solutions." However, the more important aspect of this, as related to GIS development, is that GIS development efforts are now being linked with these development efforts for a much more Comprehensive Enterprise Solution. For example, SAP is going to be embedding core GIS technology in many of its foundation based platforms for doing enterprise-based computing and data management. This trend will occur more and accelerate as we move into the next century.

Another trend that is emerging is in the area of multiple participation among GIS organizations. These are beginning to be referenced to as Geographic Data and Service Utility ventures and partnerships. Organizations in the public sector as well as private organizations are now cooperating together and sharing data and information with GIS serving as the active integration catalyst. This phenomena will happen more in the future in many locations around the world as the benefits of non-data redundancy savings, efficiency in staff resources and computing resources, and more efficient decision making and analysis occur. All driven through GIS capabilities.

Another area, which has had a major impact on GIS development, is what is referred to as Open GIS. This has many influences, especially related to exchange and data interoperability. It also refers to the capability of GIS technology being "embedded" through common programming "standards" into applications using standard core foundation technology. Many GIS development organizations have published their data formats and have built, or are building, component technology based on open development platforms. These allow complete interoperability and integration of datasets, shared technology, operations, applications, etc. Open GIS consortiums and organizations are pushing this trend forward.

4. Database Management and Future Applications

There are a number of areas that are advancing in GIS development related to database management systems. These include new abstract data types (ADTs) that can manage and store geographic feature sets. Major RDBMS are being extended with these new ADTs (such as DB2 from IBM, Informix, Sybase, and Oracle). In addition, RDBMS' are becoming much more powerful in their capacity to deal with large spatial databases. Especially large databases are sometimes generated with some spatial datasets such as remotely sensed data and as more and more non-traditional IT databases are linked with GIS. As capabilities to store, manage, and operate on geographic data features are included inside relational database management systems, and as they move towards more hybrid object-relational models, the capability for even tighter integration between database management systems and GIS algorithms and operations is now possible. Much greater cooperation between relational database system vendors and GIS software development vendors is now occurring. Many joint research and development efforts are underway between these companies. Some of these development efforts are directly with GIS vendors and include the embedding of GIS technology inside their core foundation platforms and technologies.

5. Conclusion

As we move into the 21st Century, the opportunities for tremendous strides and advancements in GIS technologies are facing us today. With the rapid development of new technologies and influences from the general IT industry as well as new and innovative advancement and technologies from GIS vendors and GIS organizations, the future outlook for GIS implementation and applications is indeed bright. If one steps back and reviews the advancements that have been made over the last ten years in GIS technology, it is quite astounding to see where we have gone. If one stands back now and takes a look into the next ten years it is extremely exciting to see where we will be going and what opportunities exist for us. The 21st Century looks to be one that will be very exciting and beneficial for GIS users, developers, and beneficiaries.

여 백

한국의 국가GIS 추진현황 및 계획
National GIS Initiative in Korea

김 세 찬
건설교통부 토지국장

1. 머 리 말

불과 얼마전 까지만 하더라도 GIS(Geographic Information System)는 일반인들에게 다소 생소하게 느껴지는 단어였으며 일상생활과는 거리가 있는 전문가들만의 영역으로 여겨졌었다. 하지만 최근에 와서 우리가 인식하지 못하는 사이에 GIS는 사람들의 일상생활을 조금씩 변화시켜가고 있으며 비록 국내에서는 아직까지 이러한 변화가 가시적으로 나타고 있지는 않지만 선진외국의 경우 이러한 변화들이 피부로 느낄 수 있을 만큼 GIS가 일상생활 깊숙히 자리잡고 있다.

한국에서는 지난 80년대초 학계나 연구소에서 선진기술의 도입차원으로 GIS가 처음 소개되었나 80년대 말까지는 소규모의 실험연구 및 타당성 검토 수준에 머물러 있었고 90년대 초에 이르러 일부 수요기관에서 지형도 전산화 작업을 개별적으로 추진하기 시작하였으며 실제 행정업무 및 산업활동에 이를 접목시키려는 노력또한 점차 확대되기 시작하였다. 그러나 이러한 노력들이 체계적인 계획에 의해 이루어지지 못함에 따라 데이터의 중복제작에 따른 비효율성이 지적되기 시작하였고 각기 다른 형태로 제

작된 데이터들을 각 수요기관간에서 공동활용하는데 어려움이 발생하였으며 GIS를 실제 업무에 활용하는 과정에서 부딪히는 각종 기술적 문제들을 해결하는데 많은 시간과 노력이 필요하게 되었다.

정부에서는 이러한 문제들을 국가적 차원에서 해결할 필요가 있다고 생각하였으며, 앞으로 다가오는 21세기에는 GIS가 국가 경쟁력강화 및 행정생산성 향상에 기반이 되는 새로운 사회간접자본이라는 인식을 가지게 되었다,

따라서 이러한 시대적 요청에 부응하기 위하여 정부에서는 '95.5 『국가GIS구축 기본계획』을 확정·발표하게 되었고 이로써 국가적 차원의 GIS구축에 대한 장기적인 비젼이 제시되게 되었다.

2. 국가GIS사업의 목표

국가GIS구축 기본계획에는 1단계로 2000년까지의 목표를 다음과 같이 설정하고있다.

첫째, GIS구축에 있어 기본도로 이용될 지형도를 비롯하여 지적도, 지하시설물도등 각종 주제도를 전산화 함으로써 공간정보데이터베이스 구축기반을 조성함

둘째, 공간정보의 공동활용을 위하여 정보구축, 유통, 활용에 대한 국가표준을 제정함

셋째, 공간정보 데이터베이스를 활용할 수 있는 GIS S/W를 개발하고 전문인력을 양성함

넷째, 공공부문에 GIS를 활용할 수 있는 기반을 마련함

3. 추진전략

우리나라의 경우 '90년대 초반까지 GIS구축기반이 매우 미약한 실정이었다. 예를들

어 지형도 및 주제도 등 각종 지형정보의 전산화는 초기 입력단계였으며 GIS관련 소프트웨어는 대부분 외국산에 의존하는 형편이었다. 그리고 공공부문의 GIS활용도 아직까지는 시범사업 위주에 머무르는 실정이었다.

따라서 국내의 GIS구축을 촉진하고 관련산업을 육성하기 위해 민간부분에만 이를 맡겨두기에는 투자재원확보, 공간정보구축등에 한계가 있어 국가적인 차원에서 이를 추진하는 것이 필요하였고 이를위해 국가는 다음과 같은 역할을 수행하고 있다.

또한 국가GIS구축사업은 장기간에 걸쳐 추진될 예정이므로 단계별 추진전략을 마련하여 체계적으로 추진할 필요성이 있으며 다음과 같은 전략을 수립하였다.

표 1. 국가의 역할

공간정보 DB 기반구축 및 표준화	기술개발지원 및 전문인력양성
- 공간정보 기반 데이타베이스 설계 - 각종 지형정보의 전산화 - 데이터베이스 구축 표준화 - 정보호환 및 유통지원 표준화 - 공통데이타 교환포맷 표준화등	- GIS 핵심기반기술 개발지원 - GIS 응용기술 개발지원 - GIS 전문인력 교육 및 양성 지원
GIS 활용체계 개발지원	**제도정비 및 재원확보**
- 행정업무에 GIS활용체계 도입추진 - GIS활용시스템간 연계 강화 - 각종 시범사업 추진	-공간정보유통관리기구(Clearing House)의 설치 운용 - 관련제도 및 법규 정비 - GIS기반 조성을 위한 공공부문과 민간부문의 공동재원 조성

1단계 : 정보 구축단계

- 공간정보 수요/공급 현황조사
- 공간정보체계의 기본틀 정립
- 정보구축, 유통, 활용에 대한 표준제정
- 공간정보 『데이터 베이스』 구축
- 공간정보 『데이터베이스』 관리/유통체계 개발

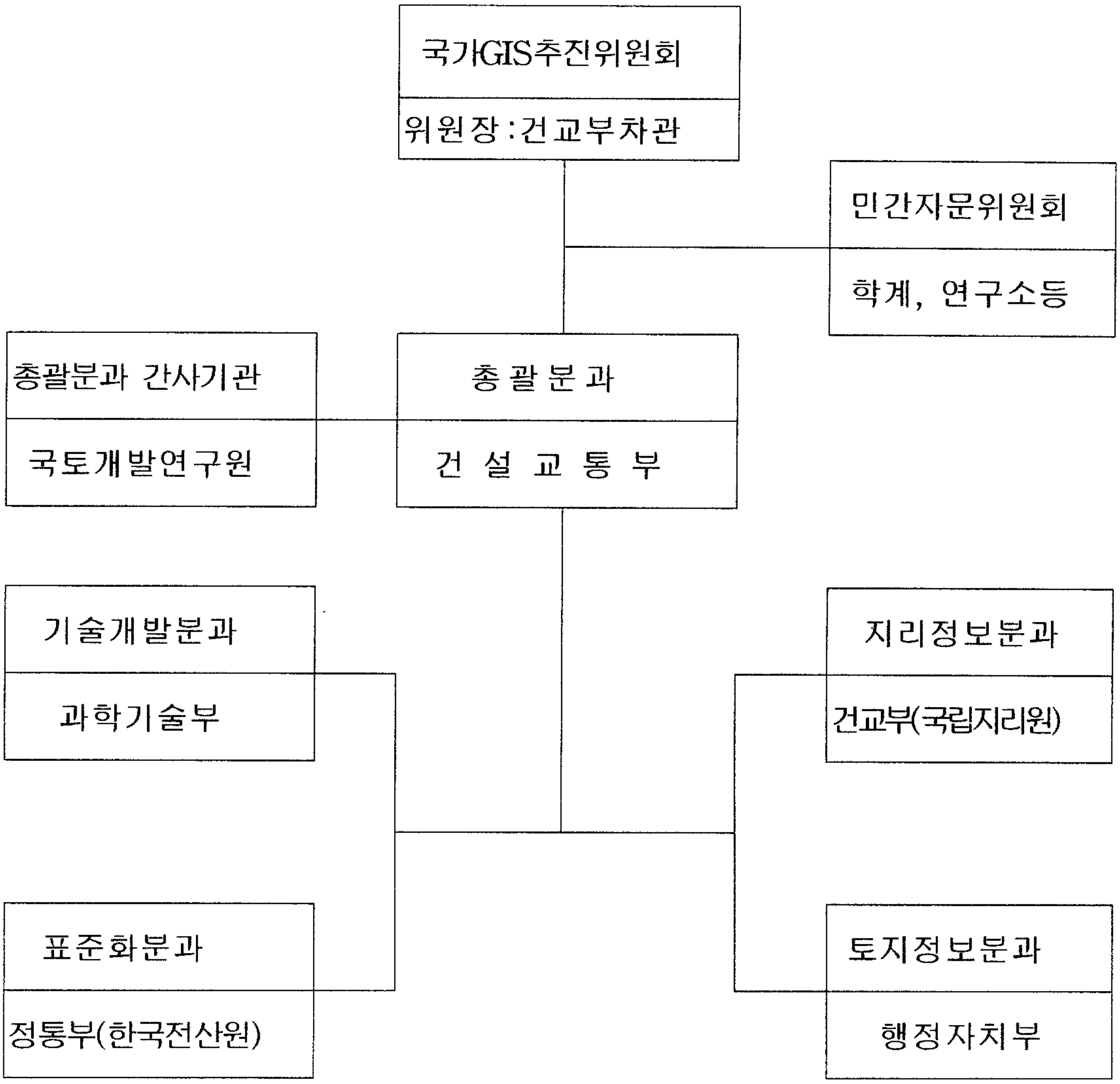
2단계 : 정보 활용단계

- 수요자 목적별 『데이터베이스』구축
- 공간의사결정 지원체계(SDSS)개발
- 업무 및 행정지원 시스템 구축
- 구축된 공간정보의 유지 · 관리

4. 추진체계

국가GIS사업 추진을 위하여 건설교통부가 주관이 되고 재정경제부, 행정자치부, 농림부,산업자원부, 정보통신부, 환경부, 과학기술부, 예산청, 통계청 및 산림청등 11개 중앙부처가 참여하는 국가GIS추진위원회를 구성하였고 추진위원회 산하에 총괄분과, 지리정보분과, 기술개발분과, 표준화분과, 토지정보분과 등 5개 분과를 구성하여 GIS구축관련 사업을 각 분과별로 분담하고 있으며 국토개발연구원을 총괄분과 간사기관으로 지정하여 각종 계획수립을 위한 기술적 지원을 담당케하고 있으며 또한 산학연 민간전문가로 구성된 민간자문위원회를 두어 전문적인 기술검토를 지원하고 있다.

표 2. 추진체제



5. 국가GIS사업 추진현황

5.1 지리정보분과 (국립지리원)

지리정보분과에서는 지형도, 주제도 및 지하시설물도의 전산화를 추진하고 있으며 세부적인 추진현황은 다음과 같다

지형도 전산화사업

GIS를 구축하는데 있어 가장 기본적인 데이터가 되는 지형도를 전산화하는 사업으로써 '95년부터 '99년까지 704억원이 투입될 예정이며 정부와 지자체 및 투자기관이 재원을 공동부담하고 있다.

- 1/1,000 지형도 : 78개시 (산악지역은 제외) 정부50%, 지자체 50%
- 1/5,000 지형도 : 산악지역을 제외한 전국 정부50%, 투자기관 50%
- 1/25,000 지형도 : 산악지역 전액 국고
- 1/1,000 지형도 전산화는 '98년까지 74개시를 제작할 예정이며, 1/5,000 및 1/25,000 지형도 전산화는 '97년 완료하였다.

주제도 전산화 사업

공공기관 및 민간부문에서 활용도가 높은 각종 주제도를 전산화 함으로써 수치지도의 활용도를 높이고 각종 GIS활용시스템 구축을 위한 기반을 마련하는 사업으로써 우선 도시계획도, 도로망도, 국토이용계획도, 지형・지번도, 토지이용현황도, 행정 구역도를 2000년까지 전산화 할 예정이다.

지하시설물도 전산화 사업

지하에 매설된 7개 시설물(상・하수도, 가스, 전력, 통신, 송유관, 난방열관)에 대한 매설현황 및 각종 속성정보(관경,재질, 시공일자등)를 전산화하여 통합 관리할수 있는 시스템을 구축하는 사업으로써 '2001년까지 전국 주요도시에 대해 시스템 구축을 완료할

예정이다.

5.2 기술개발분과 (과학기술부)

GIS관련 기술개발사업

GIS구축에 필요한 공통기반 S/W기술을 개발하여 국가GIS구축사업을 지원하는 사업으로써 '98년까지 Mapping기술, 기본 s/w기술, DB Tool기술, 시스템통합 및 응용기술 개발을 추진할 예정이다.

'98년까지 각종 s/w개발 및 테스트를 완료할 예정이고 '99년에는 개발된 기술에 대한 실용화를 추진할 계획이며 이를 바탕으로 향후 국제 경쟁력 있는 독자적인 GIS s/w 개발을 추진함으로써 GIS 세계시장 진출의 기반을 마련할 예정이다.

GIS인력양성사업

국가GIS구축에 있어 핵심적인 역할을 수행할 전문인력을 양성하는 사업으로써 단기적으로는 중앙교육기관을 설치하여 시급한 GIS현장 인력수요에 능동적으로 대처할 예정이며 장기적으로는 대학(원) 중심의 GIS핵심인력 양성과 GIS교육의 지방 분산화를 추진할 예정이다.

'96년부터 중앙교육기관을 통해 매년 700명의 GIS전문인력을 배출하고 있으며 이와 더불어 GIS표준교재 개발을 추진중에 있다.

5.3 표준화분과(정보통신부)

여러기관에서 생산되는 각종 공간정보를 공동활용하기 위하여 공간정보구축, 활용 및 유통에 관한 표준을 제정하는 사업으로써 '97년까지 기본도, 지하시설물도 및 주제도 표준을 제정하였고 '2000년까지 국가GIS의 표준화 참조모델을 제시하고 정보유통을 위

한 메터데이터 표준제정 등을 추진할 예정이다.

5.4 토지정보분과(행정자치부)

기존 지적도면 전산화사업

현재 전산화 되어있는 토지대장과 함께 지적도면을 전산화 함으로써 대장과 도면이 통합된 정보를 구축하여 토지종합정보시스템의 기반을 마련하는 사업으로써 '98년부터 2002년까지 1,128억원을 투입하여 전국의 지적·임야도면 702,372매를 전산화할 예정이다.

이를위해 '97년까지 대전시 유성구를 대상으로 시범사업을 실시하였으며 시범사업을 통해 『대장+도면』 통합 민원서비스 시스템 및 지적관련업무 전산 시스템등을 개발하였다.

5.5 총괄분과(건설교통부)

총괄분과에서는 국가GIS구축과 관련하여 각 분과별 사업들을 조정하고 있으며 이와 함께 지하시설물 관리체계개발 시범사업, 공공GIS활용체계 개발사업 및 지원연구사업을 추진하고 있다.

지하시설물 관리체계개발 시범사업

전국적인 지하시설물도 전산화 사업을 시행하기전 과천시를 대상으로 시범사업을 실시하여 향후 사업시행시 발생할 문제점을 미리 도출하여 해결방안을 모색함은 물론 타시도에 표준이 될 모델을 개발하는 사업으로써 '97.4 시범사업을 완료하고 현재 이를 각 지자체로 확산중에 있다.

공공GIS활용체계 개발사업

현재 구축중인 공간정보를 이용하여 국토이용분야, 환경분야, 산림분야, 농림분야에 활용함은 물론 재해·재난방지를 위한 시스템을 개발하는 사업으로써 '98년부터 '2001년까지 863억원을 투입하여 토지관리정보시스템, 토양자원정보전산 시스템, 산림지리정보시스템, 지하수정보관리시스템, 지질정보관리시스템등을 구축할 예정이다.

GIS지원연구사업(국토개발연구원)

국가GIS구축과 관련하여 각종 기술적 측면 및 활용도 측면에 대한 연구를 추진하는 사업으로써 '95년부터 '99년까지 총 29개 과제에 대한 연구를 추진할 예정이며 이에소요되는 비용은 40억원이다.

'97년까지 공간정보 데이터베이스 설계 및 세부추진방안 연구등 17개 과제를 수행하였고 '98년에는 국가정보기반 구축방안연구등 6개 과제를 수행중에 있다.

6. 국가GIS사업의 향후과제

정부에서 적극적으로 국가GIS사업을 추진한지 이제 3년이라는 시간이 경과되었으며 그동안 노력의 댓가로 국내 GIS기반이 뿌리를 내려가고 있다. 그러나 국가GIS사업이 향후 성공적으로 완료되기까지는 해결하여야 할 과제들이 아직 많이 남겨져 있으며 이중 몇가지를 살펴보면,

첫째 안정적인 재원확보 문제이다.

1단계 국가GIS구축사업에는 다양한 세부사업들이 포함되어 있으며 이를 성공적으로 완료하는데 약 5,000억원 정도의 막대한 비용이 소요될 것으로 추정된다. 따라서 이에 소요되는 비용이 안정적으로 확보되지 않을경우 사업간의 연계성 확보가 어렵게되어 국

가GIS사업 전반에 대한 문제가 발생할 우려가 있다.

따라서 국가GIS사업에 소요되는 전체 비용을 안정적으로 공급받을 수 있는 재원이 마련되어야 할것이다.

둘째 법제도적 기반마련이다.

GIS구축사업은 일시적인 사업이 아니라 향후 지속적으로 추진하여야할 장기사업이므로 안정적이고 체계적인 사업추진을 위해서는 이를 뒷받침할 법제도적 기반이 마련되어야 한다. 그리고 생산된 정보의 공동활용을 통해 중복투자를 방지하고 정보의 누출로 인한 개인의 프라이버시 침해를 방지하기위해서는 이에대한 명확한 규정이 수립되어야 할 것이다.

마지막으로 구축된 정보의 유지 · 관리 문제이다.

지금까지는 주로 정보의 구축에 대해서만 고려해 왔으나 향후 몇 년안에 구축된 정보의 유지 · 관리가 우리에게 커다란 과제로 다가올 것이다.

정보는 항상 새롭게 변경되고 정확하게 유지되지 않으면 효용성이 현저히 저하되므로 현재 구축중인 각종 정보와 향후 구축될 정보의 유지 · 관리에 대한 충분한 고려가 있어야 하며 이를 위해서는 유지 · 관리의 주체와 절차상의 문제 및 비용부담 문제가 함께 검토되어야 할 것이다.

7. 맺 는 말

지금까지는 도로, 공항, 항만등의 물리적인 사회간접자본만이 국가의 경쟁력을 좌우한다고 생각해 왔으나 21세기 고도정보화 사회에서는 한 국가의 정보화 진행정도가 국가경쟁력의 척도가 되리라는 것을 확신하며 이를위해 정부에서는 국가GIS구축사업을 앞으로도 성실히 수행해 나갈 것이다.

또한 정부에서는 지자체 및 민간과의 협력을 강화하여 효율적인 사업추진을 도모할 것이며 GIS구축에 대한 선진외국의 경험과 기술을 우리의 현실에 맞게 소화하는 작업

도 게을리 하지 않을 것이다.

이러한 노력들이 성공적으로 결실을 맺을 때 우리는 국가GIS사업이 목표로하는 『모든 국토공간정보에 대한 자유로운 접근과 획득』를 달성할수 있을것이다.

여 백

The Strategy and Development Status for NGIS Solution in Germany

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ABSTRACT

Nowadays, all modern industrial nations have a strong need to develop and use GIS as a basic tool for their decision processes in a variety fields such as administration, economy and research.

Yet among the many aspects of GIS, the uniformity, standardization and data exchange, methods and systems are essential economic criteria for producers and users of geoinformation. In line with the worldwide development of GIS, the importance of standardization has led to the establishment of corresponding technical committees within ISO and CEN in 1992 and 1994 respectively. It is also evident that a coordination of the activities of the users on the national level as well as quality management is extremely necessary.

Germany has many advantages regarding the above-mentioned points throughout a highly qualified, traditional and experienced system of land registration, cadastral and state survey tasks. The base and content of the German-GIS is funding on an excellent data-collection with completeness, accuracy and up-to-dateness.

Starting from the national standardization in Germany the author will report on the situation and results of the international standardization as well as the requirements and activities concerning coordination and quality management. Last but not least, the strategy for the further development of German-GIS will be presented.

요 지

오늘날 모든 선진국가는 행정관리, 경제정책의 수립 및 연구활동과 같은 다양한 분야의 의사결정을 위한 기본도구로서 GIS의 개발과 이의 활용이 절실히 요청되고 있다. 지금까지 GIS구축과 관련된 다양한 면들을 고찰해 볼 때, 특히 단일성, 표준화, 자료교환, 방법 및 시스템 등이 지형정보의 창출자와 사용자를 위한 경제적인 기준을 설정하는 기본적인 요소이다. 범세계적인 GIS개발의 흐름에 맞추어 표준화의 중요성은 1992년과 1994년에 국제표준화기구(ISO)와 유럽표준화위원회(CEN)내에 각각 기술위원회의 설립을 탄생시켰다. 또한 사용자들간에 국가차원의 공조체제와 품질관리도 절실함을 인식하게되었다.

독일은 위에서 언급한 점들에 있어서 큰 장점을 가지고 있는데, 이는 독일에는 토지등록, 지적 및 측량업무에 대한 고품질의 전통적이면서도 숙련된 시스템이 존재하기 때문이다. 독일 GIS의 기저와 내용은 완결성, 정확성 및 현재성을 지닌 우수한 데이터 취득에 기초를 두고 있다.

독일의 국가표준화에 대한 설명을 시작으로 국제표준화에 대한 현황과 결과 및 공조체제와 품질관리에 대한 필요조건과 활동에 대한 사항들을 기술한다. 마지막으로 독일 GIS의 향후발전전략에 대해서도 소개한다.

1. Introduction and Current GIS-Situation

The development of national and international Geographic Information Systems is proceeding rapidly since many years. In the meantime in some countries, like in Germany since 1970, experiences in establishing, maintaining and especially using them, are available. Additionally other problems must be solved e. g. coordination and quality management. Many activities focus on these tasks worldwide. Germany has the big advantage of a highly qualified and traditional system of land registration, cadastre and state survey tasks.

For establishing and maintaining of such a system, there are special criteria concerning

- philosophy,
- law/regulations,
- organization,
- techniques and
- personal staff to be fulfilled.

Every aspect is well developed in Germany and experienced and always improved by latest technologies. Everything has been created by Germany itself, perfectly and in an economic way. The German system of cadastral and topographic mapping has a long tradition. Especially the system of land registration - concerning philosophy - there was no need to be changed from the beginning since 1900, though technology has always been improved according to its progress. Originally the system had been established for tax purpose in the last centry, but it got more and more functions up to a multipurpose cadastre, LIS and a basis of GIS.

According to law concerning cadastre and state survey, the real estate cadastre is the unique, complete and always updated documentation of all real estate - without any exceptions - of all parcels and buildings in the whole area of competence, in Germany the state, e.g. Lower Saxony. The parcel is the smallest unit of the system.

Besides of the non-geometric, alphanumeric description of the real estate, the so-called Cadastral-book, there is the geometric description, the Cadastral map, and the numerical data. It is of high accuracy and contains geometric, designative and descriptive data. Between cadastre and land register there are a strong linkage and a legal demand for the same level of updating and data exchange. By Law, there is a guarantee on contents of cadastral map and land register.

Besides photogrammetry or other techniques regarding to the coordinate cadastre, many electronical tachometers - this technology has been developed by the author himself in 1969 in Lower Saxony - are used and guarantee a direct data flow between field survey and the result of calculations, drawings and storage and data.

Although the roots of state survey base on the 250 years ago established topographic maps for military purposes and the cadastre more than 130 years ago based on cadastral maps for tax purpose, they form a unit in Germany since more than 70 years. Both parts belong to the same law - the law concerning state survey and cadastre - and administration, in Lower Saxony, to the Ministry of Interior.

1.1 German Basic Data Systems

Automated Cadastral Book(ALB)

This descriptive alphanumeric part of cadastre which is in strong connection to the land register, has been started in the 60ies in the Cadastral Office Hannover. By computerizing of real estate cadastre in Germany everything had to be developed, there was nothing worldwide in comparison. Every modern German solution started mainly in Lower Saxony. So computerization of the cadastral book was already finished more than 20 years ago, in 1976.

Automated Cadastral Map(ALK)

The Surveying and Cadastral Administrations of the Federal Republic of Germany(AdV) started in 1977 the project ALK. As it was with ALB, important basis research had to be done. In 1986, the procedure and implementation of ALK were decided. After extensive preparations as well as Software and Hardware-installations ALK has been established since the end of 80ies in the German states. ALK is built up by transfer of the analog map to digitized maps and updated by field survey activities. So data can be given in more flexible way and according to the demand in digital form or as well as a map. Besides the first digitization, the results of the fields survey concerning all updated areas are transferred into ALK-Data Base and continuously updated.

Authorative Topographic-Cartographic Information System(ATKIS)

In 1989, the AdV decided the project ATKIS containing two different data collections, the Digital Landscape Model(DLM) and the derived Digital Cartographical Model(DKM). DLM describes the objects and the relief in digital form with high accuracy concerning position and shape including names, attributes and relationship to other object. DLM is object-structured, vector-oriented, grid-based, map-sheet independent, and independent of scale. The contents of DLM are layed down to the object-catalogues.

All parts of German GIS have been realized in cooperation with SICAD Geomatics(former SIEMENS- NIXDORF), mainly by SICAD and SICAD-Open.

1.2 Legal and Political Frame Conditions

The establishment and administration of functional GIS are not only a technical challenge, but are only to be accomplished under legal and political framework.

2. Standardization

2.1 General aspects and definition

Standardization is one of the tools we use to organize our technical world. It has become an integral part of our economic, social and legal systems. International and European Standards can remove trade barriers and promote business across national frontiers. They are thus especially important for a country like Germany. The national standards of highly developed industrial countries are a readily accessible source of information on the current state of the art. They represent an important vehicle for the global transfer of technology and hence also foster economic cooperation with the Third World.

Standards play an essential part in the solution of many technical and economic problems; they serve all involved in trade and industry as an explicit and accurate medium of communication. The work of standardization as undertaken by DIN is a service in the field of science and technology that is provided for the entire community. The whole of the national economy benefits from the results of standardization. DIN is the authorized national standardization body of Germany and may be mentioned by way of example on national level. In its work DIN is guided by ten principles: voluntary basis, public, participation of all interested parties, uniformity and consistency, relevance, consensus, alignment with the state of the arts, alignment with economic factors, alignment with the public benefit, and global approach.

Standardization is the systematic process by which tangible or intangible subjects are reduced to a desired degree of order by the joint efforts of the interested parties for the benefit of the entire community (DIN 820 Part 1). DIN Standards are technical rules. They promote rationalization, quality management, safety, environmental protection, and communication in industry, technology, science, government and the public domain.

On the European level it is CEN (Comite European de Normalisation) and on the worldwide level ISO (International Organization for Standardization) which are the authorized standardization bodies to develop 'standards; all other organizations on national and international level produce 'de facto-standards.

International standards are important for use and exchange of spatial data, terminology and quality management are criteria to increase the economic effects.

2.2 National standardization

The actual work of standardization by DIN is carried out by about 34 000 external experts organized in 4 000 technical committees. The national professional work of 'surveying, geoinformation is done by 4 committees: geodesy, photogrammetry and remote sensing, cartography and geoinformation, surveying instruments and apparatus.

The German GIS-solution ATKIS/ALK/ALB/EDBS have been developed by ten Committees of ten Surveying and Cadastral administrations of the States of Germany (AdV).

2.3 European Standardization

The aim of European standardization is to create a uniform body of standards meeting modern needs and applying throughout the unique European market. This task is the responsibility of CEN/CENELEC and ETSI. European Standards are generally based on ISO-Standards, if available.

The focus of DIN's activities has shifted increasingly towards European standardization in the past few years. The proportion of purely national standardization work has fallen continuously since 1984 and now stands at a mere 15 %.

Concerning 'Geographic Information the Technical Committee CEN/TC 287 is developing standards since 1992 (Secretariat AFNOR, France), mandated by CEN. This basic work is done by 4 working groups and 5 project teams. All standards are nearly finalized. These are Geographic Information -reference model, -referencing position, -referencing-geoidentification, -processing-query and update, -data description - geometry, -quality, -metadata, -data transfer. By decision of the plenary all standards will be finalized on ENV-status and in short time. They will serve as a basis for ISO.

CEN/TC 278 'Road Transport Telematics developed the GDF-Standard (Geographic Data File), which is also used by ISO.

2.4 Worldwide standardization

Standardization at the international level is the responsibility of the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and the International Telegraph and Telephone Consultative Committee (CCITT), all located in Geneva.

In ISO, the national standards bodies of some 120 countries cooperate in activities that aim to facilitate the international exchange of goods and services by creating uniform standards with global validity and to stimulate cooperation in the scientific, technical and economic fields across national frontiers.

Concerning distribution of the general work load in ISO, DIN is number one of the involved countries.

ISO/TC 211 'Geographic Information/Geomatics had been established in 1994 (Secretariat NTS, Norway). In the meantime this committee has steadily increased, there are 28 full-members, 13 observer-members, 1 correspondent member. Further the important liaisons: besides 8 "internal" liaisons with other ISO-committees there are 11 "external" (A-)liaisons including the very powerful OPEN GIS CONSORTIUM (OGC), which has a special cooperation with ISO/TC 211 for promoting the results and mutual benefits.

The 20 working items are handled by 5 working groups 'Framework and reference model, 'Geospatial data models and operators, 'Geospatial data administration, 'Geospatial services and 'Profiles and functional standards and numerous project teams. Germany and Korea are also members of ISO, and Korea hosted ISO/TC 211 plenary in 1996 in Seoul.

2.5 Remarks

Due to the fact that the work in CEN/TC 287 and as well in ISO/TC 211 make good progress there are already decisions concerning standardization available for the progress of development on the national level.

Many efforts are needed; specialists and budget from the involved organizations accompanying the international work, which are often not available.

The standardization work for ISO is continuously increasing from 5 % of the DIN-work to 32 % in 1996 during the last 8 years.

3. Coordination of Geographic Information

3.1 Requirement for an interdisciplinary GIS management

Before describing the coordination and management of GIS activities in Germany and especially in the State (Land) of Lower Saxony, an attempt is made to present an index list with the most important aspects of GIS coordination tasks:

- coordination on different levels
  - section-, department-, case, country- and state overlapping
- determination of the need of coordination
  - dispute about competences
  - avoidance of double work
- definition of general standards
  - reference system
  - data format, data exchange format
  - data model, data base model, data contents
- meta-information-systems should be established
- definition and controlling of data quality (quality management - QM)
  - instrument of quality-planning, -controlling, -securing and -documentation
  - characteristics of data quality: actuality, data source, geometrical and

attributive correctness, completeness, consideration of general standards

- sales- and charges-management
  - establishment of a geographic data service enter to combine data producers, data servers (services) and data users logistically and technically
  - securance of political goals
- GIS-technology-development
  - hardware, network, software, methods(e.g. data integration, generalization, visualization)
  - team-work of GIS-researchers, -developers and -appliers
- data security, IT-security
- data protection and/versus data use
  - free access to all environment data should be possible
  - as a rule: low relation between space-related data and personal data
- GIS bases organization structure
  - change of working places and working processes
  - change of staff and qualification structures ('new tasks)
  - pressure to cooperate through system architecture
- employee management
  - strengthened GIS education and practice
  - interdisciplinary staff development
  - potential negative effects: demotivation, fear of new technologies
  - to be noticed: standardized GIS processes may also reduce formerly flexible manual processes

3.2 GIS coordination in the State of Lower Saxony (Land Niedersachsen)

In Germany, the Surveying and Mapping Agencies of the Länder (States) are building up two basic data sets - the Automated Cadastral MAP (ALK) in the scale region of 1:1000 and the Authoritative Topographic-Cartographic Information System (ATKIS) for medium scales. Many other departments are engaged in creating their own data bases containing digital data of special fields (e.g. Environment Information Systems, Land-Planing-IS, Forest-IS, Soil-IS, Road-IS, Municipal-IS, ...). The success of all these GIS-activities depends on the coordinated cooperation of these activities regarding data contents, data standards and data transfer.

In Lower Saxony, the foundation of a successful coordination of GIS-activities has been arranged by a resolution of the central government in 1990. This resolution prescribes that ALK/ATKIS-data of the Surveying and Mapping Agency have basic functions within the authorities of the State. Only the Surveying and Mapping Agency is allowed to digitize cadastral and topographic maps. ALK/ATKIS-data have to be the basis of all other digital data bases. Municipalities are recommended to proceed analogously.

In order to accomplish the demands of this resolution a governmental Working Group on "Geographic Information Systems (WG GIS)" has been installed in 1992. All related departments of the Land are members of the WG as well as some representatives of the municipalities. Important aims of the WG GIS are:

- to avoid double work (e.g. in data capturing),
- to make public and to use well-tested GIS-methods all over the state,
- to support the exchange of experiences with GIS and
- to consider comprehensive interfaces for data exchange and data integration between the related authorities at an early stage.

Organization of the WG GIS

The Governmental WG GIS is composed of computer and technical experts of all GIS-related departments of the State Lower Saxony. So, it is ensured that all departments are informed of what is going on and may participate in the direction and definition of main points of work. The chairmanship is delegated to the Lower Saxon Surveying and Cadastre Administration, as the Surveying and Mapping Authorities have great experiences and a long tradition in handling digital topographic basic data.

The coordination work is performed
- by individual members of the WG,
- by technical meetings of the WG and mainly,
- by the Office of the WG (consisting of three persons).

Regularly, the Office is responsible for the technical meetings, the agenda of the meetings and the resolutions of the WG. The Office is also sited in the Department of Surveying and Cadastre. Resolutions of the WG GIS are presented to the Central Office of Information and Communication Techniques of the Government, which may implement them as Governmental Standards.

Tasks of the WG GIS

In detail, the WG GIS is in charge of the following tasks:

a) Coordination

Objectives of the coordination work are that:

- space-related (geographical) data are captured, originally stored and up-dated continuously only from one responsible office in each case,
- redundant management of identical geographical data by different governmental offices is avoided,
- all geographic data bases are based on an uniform coordinate system and use topographic basic data,
- manifold usage of the GIS-data is enabled and
- the exchange of GIS-data between State authorities and municipalities (including a continuous up-dating) is guaranteed.

b) Definition of technical and data standards

The following areas are of general interest:

- principles of hard- and software,
- principles of GIS-methods and data models,
- integration of different space related data bases,
- collection and up-dating of space related data bases,
- standards for the exchange and raster data and
- glossary of technical items.

c) The complexity of the establishment of GIS in the work a day routine of an office requires substantial consultations and further information.

In order to fulfill these demands a GIS inventory has been carried out by the WG GIS.

3.3 GIS inventory in Lower Saxony

The GIS inventory has been performed in autumn 1993. All State authorities and a representative selection of municipal offices have been requested to answer a detailed questionnaire.

Conclusions from GIS inventory:

In general:

With regard to the contents the GIS data bases deal with a wide variety of subjects: environment, soil, forest, roads, land-planning, toxical areas, hydrography, ground water, real estates, mining, cancer register and so on. At first sight, there is only few redundant activity, but a great demand to coordinate the data exchange between the related offices can be seen. Although a lot of offices are already practising the exchange of their data, the inventory shows that a great number of offices need the digital data of other offices in the future. The particular creation of individual data interfaces between two data bases is costly and time-consuming, general data interfaces should be looked for and should be defined.

Raster data interface:

As digital cartographic data in vector format is not available for all purposes until now, raster data of topographic or cadastral maps are inquired by a high number of institutions. The WG GIS has decided to recommend the Tag Image File Format (TIFF) for the exchange of digital raster data. This decision gives all related persons and institutions (offices and software vendors) transparency about the requirements of their systems. The fulfillment of these interface-demand means to exchange raster data without difficulties, whilst non-observance may cause additional efforts.

Vector data interface:

The definition of a vector data interface is more difficult because the structure of vector data is not uniform (different data models, different data base models). The GIS inventory shows that a lot of different views of how to define and how to model data exist. The claim of an end-user of many different data sources is to get the data in the same way as far as possible. The claim of a data supplier is to standardize data delivery and to enlarge the benefit of this data in this way.

Data integration

Data integration includes aspects in all fields of digital data handling: data capture, data modelling and storage, data processing and data output. Data capture should be harmonized not only in the own domain but in connection with interested parties. Data modelling and its storage in data banks should be also considered in the interests of other parties. And of course, the implemented software tools must be able to handle data integration flexibly for the customers requests.

Related to the integration of different data sets GIS-software should not only provide facilities for data analysis and data modification (statistics, geometric conversions, raster-to-vector-conversion and vice versa, data merging, area intersection...), but GIS-software should especially provide the following facilities:

- The integration of data sets which are different in providing an accuracy must be possible at different levels.
- Concerning the level of data integration different functions for the combined cartographic presentation have to be offered.
- The computer-assisted updating of graphical and non-graphical GIS- and basic data must be possible.
- In special cases old data have to be stored in the database (historical data management). These developments in special fields and conditions of the past may be reconstructed.

Some of the most important forthcoming tasks are:

- Steering of data delivery:

The steering of data delivery means to establish a meta-information-system where all necessary information about other GIS data banks are stored. This steering institution (Geo-Server) may help the user to find his relevant data supplier. Further more the steering institution should be authorized to define uniform data prices and terms of delivery.

- Integration of new research developments:

Especially the development of tools for automated model generalization and automated cartographic generalization will be of great importance to the GIS world.

These tools would make possible the multiple use of one source data base for various purposes and scales; they would multiply the benefit of GIS-techniques.

4. Quality Assurance

4.1 General aspects

The worldwide demand for geoinformation does not only require the standardization of data formats and interfaces in order to facilitate the data exchange but is also one of the components of this market.

The environmental protection, the redevelopment of abandoned polluted areas, the federal, regional and local planning or the health protection (registration of cancer frequency) etc. make it even more necessary to think and act interdisciplinary and to achieve far-reaching admininistrative and political decisions. At present, these matters certainly represent the most important field of geoinformatic application.

lt would be expecting too much of actual data base systems and existing responsibilities if the respective geoinformation would be administered and processed as highly complex geodata. On the contrary, geobasic data and specific data are managed separately and are linked to solve particular problems and answer questions.

Subsequently, geoinformation is information about objects, phenomena, facts and knowledge which has a direct or indirect reference to the location on the earth's surface. All geodata are stored in data bases.

Unlike geoinformation, geobasic data are data which describe the real world of earth's surface with reference to a three-dimensional system in a topographic and estate-orientated way and are therefore extremely suitable for the linkage with specific geodata.

This way of local collection and management of data and their linkage for processing leads to useful and reliable results provided that the quality of data is known and sufficient for the respective evaluation purposes. Data must therefore have quality characteristics which

- give information about the quality and
- may be computerized to provide an automatic quality evaluation of the

results.

The production of geodata must also be assured by a safe production process with guaranteed quality. Therefore, quality assurance by indication of quality characteristics and quality management are further components of the geoinformation market.

4.2. Quality characteristics

According to EN ISO 8402, quality is the characteristic of a product agreed upon between a purchaser and a contractor (or between customer and supplier). In Germany, at least the establishment of geobasic data is not based on a specific agreement. The predominant idea is that basic data are only of national economic use if they are not prepared with highest quality for single users but with sufficient quality for as many users as possible.

The producer is obliged to provide a responsible and deductive quality with discernible quality characteristics. Apart from merely technical quality characteristics, economic and legal aspects are also relevant; in this context, technical and economic quality characteristics refer to data and data base systems whereas legal quality characteristics belong predominantly to the relationship between customer and supplier.

Technical quality characteristics (examples)

- Up-to-dateness dependent on the time intervals of data collection the use older data becomes more unreliable and leads to wrong results.
- completeness as reference to the detail of data collection. It is connected with a general or project-related catalogue of objects and closely correlated with up-to-dateness.
- accuracy as geometrical accuracy of the dimensional reference of the geodata.
- producer / origin as responsible supplier. He has to verify the quality characteristics already during the production process and to improve or maintain them by appropriate measures, e.g. by a quality management system.

Economic quality characteristics (examples)

- the existence of meta data
- the availability of data
- the easy access to data

as criteria for the performance of data bases.

Legal quality characteristics (examples)

- unambiguous basis of contract between customer and supplier or producer and user of data or
- unambiguous regulation of questions relating to access and further processing (copyright protection) and the like.

The interaction between various quality characteristics within a quality model for GIS data is described.

4.3 Quality assurance/quality management

Nobody can deny that geoinformation is an expensive product. In order to satisfy the required exchangeability, geodata have to comply with the agreed quality requirements, have to be reliable and, nevertheless, have to be produced under reasonable economic conditions.

Quality and user's satisfaction are the ultimate criteria of success, and they apply to the product as all other commercial products.

In 1987 the series of standards DIN ISO 9000 was established to create a system of standards specifying requirements for the management systems of a production process. Experience with these standards has shown that the performance of an enterprise (supplier) and its production may be improved, the production costs cut down and the competitiveness be increased when the enterprises follow these requirements.

The requirements regarding the structures, responsibilities, processes of planning, execution and review as well as the documentation are described in 20 quality management elements by which the agreed quality has to be guaranteed.

The enterprise has to provide the quality management elements in a quality management manual. This manual is to provide the transparency of and confidence in the targets of the enterprise and their transfer to employers and customers. The expenditure for the introduction of such a quality management system, however, will only be useful if the enterprise realizes that the system is not a one-off matter but part of a continuous process of development in line with market requirements.

Moreover, an enterprise has the possibility of the introduction and compliance with the quality management system to be confirmed and controled by an independent party (certification). Regarding the increasing linkage between suppliers and users on the regional or international level, such a certification may provide competitive advantages.

Due to the fact that the quality management system is not product-specific, it may also be applied to the customer/supplier-relation concerning geodata.

One reason for structural differences might be that in Germany the production of geobasic data cannot take recourse to an explicit agreement on maps. It is consistent with the specifications of the quality management systems, however, to investigate or establish a wide interest of users by other means or by feed-back and to take it into account within the quality management system.

5. Conclusions and Further Development

The importance of geographic information systems is steadily increasing. The development of standardization, coordination and quality management by the GIS-world communitiy is running rapidly. In order to save money and time, as many countries and institutions as possible, should be involved and focus their efforts on one aim: to find the best solutions for the future.

Germany is now, after many experiences in developing and using GIS for large and small-scale working on integration of ALK/ALB(ALKIS) and ATKIS concerning contents and implementation concept of the ALKIS/ATKIS-data model using the latest international standard, for example CEN/ISO, which become now available, as a base of a future system for all partners of GIS.

Another point of our interest is GPS. Lower Saxony, as the first state, has already possessed own receivers in the early of 80ies. We also developed the field application methods and evaluation programs and used them in fundamental survey for the establishing of first oder control network. Now we have implemented GPS in detailed survey(boundary points, building construction points etc.) and therefore in our regulations.

Besides, since some years in Germany, we are carrying out economic management instruments in our administration as a successful example for implementation in all governmental administration of our country.

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21세기를 향한 한국의 GIS발전전략
GIS Development Strategy for 21 Century in Korea

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ABSTRACT

Since 1995, the Korean government has implemented "A Master Plan for National Geographic Information System(NGIS)". Currently, the Korean government plays a leading role in the first phase (1995~2000) of a long term NGIS development plan. Government has focused on the construction of various digital maps such as topographic maps, thematic maps, and underground facility maps as well as the development of the training program, GIS standardization, and GIS technique. In addition, institutions and laws related to GIS activities have been also restructured and reviewed by government.

Establishment of NGIS requires costs and time. Thus, NGIS should be linked with government's strategy for informationalization. It is suggested that government should take a full charge for development of NGIS until year 2010. During the first phase, infrastructure for Korean GIS should be stabilized, and, a major focus will be made on the spread of GIS application in the second phase (2001~2005). Finally, in the third phase (2006~2010), GIS will be regarded as a social mechanism spatial information should be generated, distributed and used at anytime and anywhere it is needed. To be a GIS leading country, strategy for NGIS development should be continuosly planned and accomplished.

요 지

한국은 1995년부터 정부차원에서 국가GIS구축사업을 추진하기 시작했다. 현재 추진중인 1단계사업(1995~2000)은 정부주도로 이루어지고 있다. 정부는 지형도 · 주제도 · 지하시설물도 · 지적도 등의 기초 공간자료를 수치지도화하여 GIS초기수요를 창출하는데 주력하면서, 한편으로는 공간정보의 표준정립, 관련제도 및 법규의 정비, GIS기술개발, 전문인력양성, 연구지원 등을 통해 GIS기반을 조성하는데 중점을 두고 있다. 국가GIS를 구축하는데는 많은 비용과 오랜 기간이 소요된다. 그러므로 우리나라의 국가GIS구축은 정부의 국가정보화전략과 궤를 같이 하면서, 적어도 2010년까지는 정부주도하에 추진되어야 할 것으로 판단된다. 1단계 기간중에는 GIS기반조성을 마무리하고, 2단계(2001~2005)에서는 GIS활용을 확산해 나가야 할 것이다. 그리고 3단계(2006~2010)에서는 우리사회에 GIS가 정착되어 언제 어디서나 필요한 공간정보를 편리하게 생산 · 유통 · 이용할 수 있는 GIS활용의 보편화를 실현하여 GIS 선진국으로 발돋움할 수 있도록 국가GIS구축전략을 수립해 나가야 할 것이다.

1. 머 리 말

우리는 지금 21세기 정보화사회로 향하고 있다. 산업사회에서 정보화사회로 바뀌면서 국토정보분야의 환경과 여건도 빠르게 변하고 있다. 산업사회에서는 도로, 항만, 공항 등 물리적인 기반시설이 사회발전의 원동력이었지만, 정보화사회에서는 GIS(Geographic Information System)와 같은 컴퓨터 응용시스템이 생활의 질을 높여주는 중요한 열쇠가 된다. 특히 GIS는 국토와 관련된 모든 정보를 각종 지도와 함께 전산화하여 국토개발 · 환경보전 등 각종 정책수립과 행정업무, 시설물관리, 대민행정서비스 등에 널리 활용할 수 있는 정보처리수단이다. 다시 말해서 GIS는 도로 · 철도 등 지상의 각종 시설물을 비롯하여 상하수도 · 가스 등 지하매설물과 수자원 · 산림 · 토양 더 나아가 대기 및 강과 바다의 생태정보를 데이터베이스로 만들어 국토정보인프라 구축을 가능하게 하는 정보처리시스템이기 때문에 국토정보관리분야의 핵심요소로 부상하고 있다. 정부는 이러한 기술발전과 사회변천에 대처하기 위해 95년 「국가GIS구축 기본계획(1995~2000)」을 수립하여 범정부차원에서 국가GIS구축사업을 활발히 추진하고 있다.

이 글에서는 현재 추진되는 국가GIS구축사업의 중장기 목표를 재설정하고 주요 현안을 살펴서, 앞으로 우리나라의 국가GIS 발전전략을 모색해 보고자 한다.

2. 국가GIS 구축목표

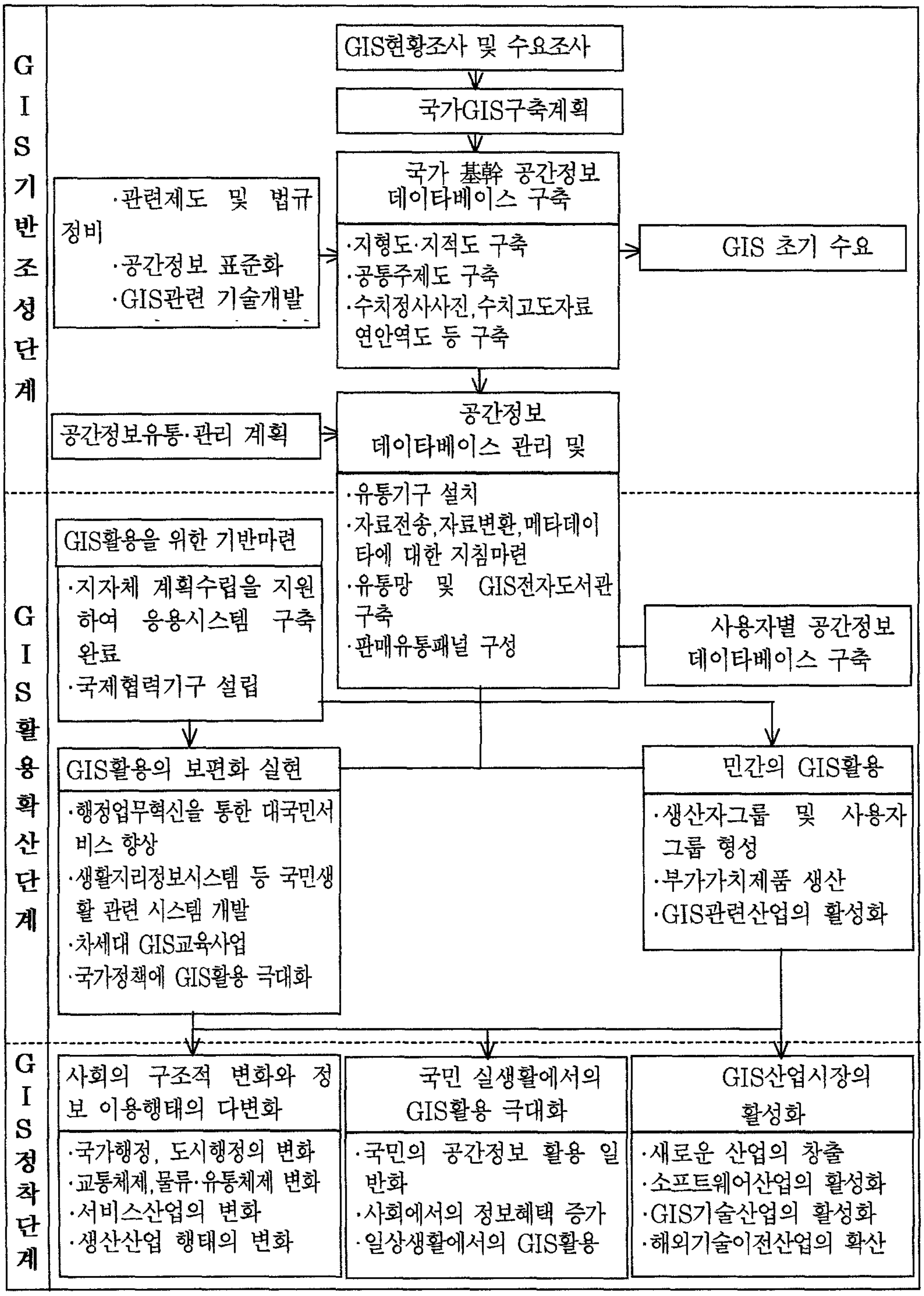
국가GIS구축사업의 목표는 국토공간과 관련된 정보를 통합구축하여, 국가정책 및 행정업무를 쇄신하고 대국민서비스를 향상시키며, 공간정보 인프라를 확충하고 GIS관련산업을 육성하여 국가발전을 꾀하는 데 있다. 따라서 국가GIS구축사업은 다른 국가정보화사업과 보조를 맞추어 추진하는 것이 능률적이다. 국가GIS구축사업은 95년부터 2010년까지 15년간을 수행하되 GIS기반조성단계, GIS활용확산단계, GIS정착단계 등 3단계로 나누어 정부주도하에 단계적으로 추진하는 것이 바람직하다.

2.1 제1단계(1995~2000): GIS기반조성단계

현재 추진중인 제1단계사업에서 정부는 GIS시장이 활성화되지 않아 민간에 의한 GIS기반조성이 어려운 점을 감안하여 정부 주도로 투자 및 지원시책을 적극 추진하고 있다. 특히 GIS의 바탕이 되는 공간정보가 전혀 구축되어 있지 않은 점을 감안하여 먼저 지형도, 주제도, 지하시설물도, 지적도 등을 전산화하여 GIS초기수요를 창출하는데 주력하고 있다. 또한 GIS구축 초기단계에 이루어져야 하는 공간정보의 표준정립, 관련 제도 및 법규의 정비, GIS 기술개발, 전문인력양성, 지원연구 등을 통해 GIS기반조성사업을 수행하고 있다.

2.2 제2단계(2001~2005): GIS활용확산단계

제2단계에는 지방자치단체와 민간의 참여를 적극유도하여 GIS활용을 확산시키고, 제1단계사업에서 구축한 공간정보를 활용한 대국민 응용서비스를 개발하여 국민의 삶의 질을 향상시킬 수 있는 방안을 모색하도록 해야 할 것이다. 구축된 공간정보를 수정보완하고 새로운 주제도를 제작하여 국가공간정보데이터베이스를 구축함으로써 GIS활용을 위한 기반을 마련해야 한다. 또한 공간정보유통체제를 확립하여 누구나 쉽게 공간정보에 접근할 수 있도록 하고, 차세대를 대상으로 하는 미래지향적 GIS교육사업을 추진하여 전문인력양성기반을 넓히도록 해야 한다. 민간에서 공간정보를 활용하여 새로운 부가가치를 창출할 수 있도록 관련 법제를 정비하고, GIS관련 기술개발사업에 민간의 투자확대를 유도해야 한다.



〈그림 1〉 국가GIS구축의 단계별 목표

2.3 제3단계(2006~2010): GIS정착단계

제3단계는 언제 어디서나 필요한 공간정보를 편리하게 생산·유통·이용할 수 있는 고도의 GIS활용단계에 진입하여 GIS선진국으로 발돋움하는 시기이다. 이 기간중에 정부와 지자체는 공공기관이 보유한 모든 지도와 공간정보의 전산화사업을 완료하고 유통체계를 통해 민간에 적극 공급하는 한편 재정적으로도 완전히 자립할 수 있을 것이다. 이 시점에서는 민간의 활력과 창의를 바탕으로 산업부문과 개인생활 등에서 이용자들이 편리하게 이용할 수 있는 GIS서비스를 극대화하고 GIS활용의 보편화를 실현할 것으로 전망된다. 또한 축적된 공간정보를 활용한 새로운 부가가치산업이 창출되고, GIS정보기술을 해외로 수출할 수 있는 수준에 도달할 것이다.

3. 국가GIS 추진실적과 주요현안

3.1 사업 개요

국가GIS구축사업은 국가GIS추진위원회 총괄하에 10대 사업을 중심으로 추진되고 있다. 위원회는 총괄분과, 지리정보분과, 토지정보분과, 표준화분과, 기술개발분과 등 5개분과를 두고 있다. 10대 사업은 총괄분과에서 국가GIS구축사업 지원연구, 공공GIS활용체계 개발, 지하시설물관리체계 개발 시범사업을 주관하고, 지리정보분과에서 지형도 전산화사업, 6개주제도 전산화사업, 지하시설물도 전산화사업을 주관하고 있다. 토지정보분과는 지적도 전산화사업을 주관하며, 표준화분과는 GIS표준을 정립하고, 기술개발분과는 GIS관련 기술개발사업과 GIS전문인력 육성사업을 주관하고 있다. 이러한 국가GIS구축사업에 2000년까지 소요될 비용은 총 4,638억원으로 추산되는 바, 이는 중앙정부 · 지방자치단체 · 투자기관 · 민간에서 분담하도록 되어 있다.

3.2 추진실적과 계획

1) 지형도 전산화사업

이 사업은 GIS를 구축하는데 있어 가장 밑바탕이 되는 지형도를 여러 가지 응용시스템

에서 이용할 수 있도록 전산화하는 사업이다. 78개 도시지역을 대상으로 한 1/1000 지형도는 총 1만4,349도엽중 4,820도엽의 전산화를 완료했거나 작업중이며, 98년말까지 아직 전산화되지 못한 9,529도엽의 전산화사업을 마무리하도록 계획되어 있다. 산악지역을 제외한 전국을 대상으로 한 1/5000 지형도는 총 1만1,430도엽의 전산화를 올해에 모두 마치고 이 달부터 일반에 판매하기 시작했다. 산악지역을 대상으로 한 1/25000 지형도는 96년에 총 159도엽의 전산화를 모두 마쳤다. 정부는 1/25000 지형도에 대해서 앞으로 예산이 확보되는 대로 1/5000 지형도로 새로이 제작할 계획이다.

2) 6개 주제도 전산화사업

이 사업은 공공기관 및 민간에서 활용도가 높은 각종 주제도를 전산화 함으로써 GIS를 일선 업무에서 쉽게 활용할 수 있도록 기반을 마련하는 사업이다. 수많은 주제도 중 수요조사 결과에 따라 지형지번도, 행정구역도, 토지이용현황도, 도로망도, 도시계획도, 국토이용계획도 등 6개 주제도에 대해 우선적으로 전산화를 추진할 계획이다. 특히 근자에 98년도 정보화 근로사업에 주제도 전산화사업이 채택되어 150억원의 예산이 확보되어 10월 초순부터 토지이용현황도와 도로망도의 제작 및 전산화 사업을 착수할 예정이다.

3) 지하시설물도 전산화사업

이 사업은 지하에 매설된 상수도・하수도・전력・가스・통신・송유관・난방열관 등 7개 시설물에 대한 매설현황과 속성정보를 전산화하여 통합관리할 수 있는 시스템을 구축하는 사업이다. 전국적으로 본 사업을 시행하기에 앞서 시행착오를 줄이기 위해, 96년 7월부터 97년 4월까지 과천시를 대상으로 지하시설물관리체계 개발 시범사업을 실시하였다. 시범사업 결과를 토대로 2001년까지 주요도시를 대상으로 지하시설물도 전산화사업을 확대해 나갈 계획이다. 이 사업에 대해서도 98년도 정보화 근로사업비에 국고 200억원이 책정되어 지방비 200억원을 합쳐 총 400억원 규모의 지하시설물도 전산화사업이 10월 중순부터 12개시에서 실시될 예정이다.

4) 지적도 전산화사업

이 사업은 토지관련 정책 및 민원서비스 제공에 가장 기초가 되는 지적도면을 전산화하는 사업이다. 96년과 97년에 걸쳐 대전시 유성구를 대상으로 지적정보통합시스템과 데이터

베이스 구축을 위한 지적도전산화 시범사업을 실시하였다. 지적도전산화 시범사업 결과에 따라 앞으로 도시·농촌·산간지역으로 나누어 총 72만매에 이르는 기존 지적도의 전산화사업을 수행할 예정이다.

5) GIS 표준화사업

이 사업은 여러 기관에서 생산되는 각종 GIS자료를 공동으로 활용하기 위한 표준을 제정하는 사업이다. 지형도 · 지적도 · 해도 · 군사지도 등의 지형지물과 속성의 분류방법 및 부호체계를 정의한 『국가지리정보체계의 국가기본도 표준』과, 서로 다른 GIS간 정보교환을 위한 데이터포맷을 규정한 『국가지리정보체계의 공통데이터 교환포맷 표준』을 확정고시(96.6.28)하였다. 그리고 지하시설물도 표준(안)과 일부 주제도 표준(안)을 마련하여 심의중에 있다. 앞으로도 다른 사업들의 결과를 바탕으로 각종 표준화작업을 계속해서 추진하면서, 이미 고시된 표준에 대해서도 보완작업을 계속할 예정이다.

6) GIS관련 기술개발

이 사업은 GIS구축에 필요한 소프트웨어를 국내기술로 개발함으로써 외국기술에의 의존도를 낮추고 향후 세계시장 진출의 기반을 마련하려는 사업이다. GIS관련 기술개발사업은 관 · 산 · 학 · 연 공동으로 추진되고 있는데, 현재까지 각종 소프트웨어에 대한 시스템 분석 및 설계를 실시하였고 99년까지 GIS구축을 지원할 수 있는 응용소프트웨어 개발을 완료할 예정이다.

7) GIS전문인력 육성

이 사업은 국내의 부족한 GIS전문인력을 종합적이고 체계적으로 단기간에 양성하여 GIS 구축사업을 효율적으로 지원하기 위한 사업이다. 한국정보문화센터에서 96년과 97년에 총 44회에 걸쳐 797명에게 GIS관련 전문교육을 실시했고, 98년에는 53회에 걸쳐 750명에게 교육을 실시할 예정이다.

8) 공공GIS활용체계 개발사업

이 사업은 현재 구축중에 있는 각종 공간정보를 바탕으로 토지 · 자원 · 농림 · 재난재해 등의 공공 행정업무와 대민서비스에 활용할 수 있는 각종 시스템을 개발하여 공간정보의 효

율성을 높이려는 사업이다. 이 사업에서는 먼저 외국의 GIS활용사례 조사결과와 국내의 수요조사 및 연구결과를 바탕으로 앞으로 개발이 필요한 GIS활용시스템을 도출하였다. 그 중 토지관리정보시스템, 토양자원정보시스템, 산림지리정보시스템, 지하수정보관리시스템, 지질정보관리시스템 등 5개 시스템을 우선사업으로 선정하여 98년부터 2000년까지 시스템을 개발할 예정이다.

9) 국가GIS구축사업 지원연구

이 사업은 국가GIS구축사업이 계획대로 소기의 목적을 달성할 수 있도록 세부계획을 수립하고 관련 제도를 정비하며 올바른 정책방향을 제시하기 위한 사전연구를 수행하는 사업이다. 국가GIS구축사업 지원연구는 95년부터 99년까지 국토개발연구원에서 총 29개의 연구과제를 수행하도록 되어 있다. 95년에 『국가지리정보체계 구축방안 연구』등 5개 과제를 수행했고, 96년에 『공통주제도 수치지도화 실험연구』등 5개 과제를 수행했으며, 97년에 『국가GIS구축 2단계사업 추진을 위한 기본구상』등 7개 과제를 수행했다. 98년에는 『국토관리를 위한 GIS활용방안 연구』등 6개 과제를 수행하고 있으며, 99년에는 『제2차 국가GIS구축 기본계획 수립연구』등 6개 과제를 수행할 예정이다.

3.3 주요 현안

1) 국가GIS구축을 효율적으로 추진하기 위한 법제 미비

중앙행정기관, 지방자치단체, 공공기관, 민간 등에서 국토공간의 이용과 관련된 GIS수요가 크게 증가하고 있으나, 관련 법률과 제도가 미비하여 국가GIS구축사업을 효과적으로 추진하기 어려운 실정이다. 따라서 국가GIS구축사업을 법적차원에서 뒷받침하면서 생산되는 공간정보를 체계적으로 관리하고 효율적으로 유통시키기 위해서는 『(가칭)국토공간정보화촉진법』의 제정이 필요하고, 공간정보유통기구를 설치하여 공간정보의 유통과 활용을 촉진해야 한다. 이러한 문제들을 해결하기 위해 건설교통부는 올해 안으로 입법예고를 거쳐 99년 상반기에 관련 법률(안)을 국회에 제출할 계획이다.

2) 일부 부처의 협조체제 미흡

국가GIS구축사업은 거의 전 부처와 관계있는 사업이므로, 무엇보다도 유관부처간에 긴

밀한 협조가 필요한 사업이다. 그러나 일부 사업에서는 부처간에 이해가 상충하여 계획에 차질을 빚고 있는 실정이다. 예컨대 땅위에 있는 지형지물을 나타내는 지형정보와 토지의 소유·용도 등을 나타내는 지적정보에 대해서는 개별수요도 많지만, 두 자료를 연계하여 사용하고자 하는 수요도 많다. 그러나 정보관리부처간의 이해가 상충하여 그러한 수요에 적절히 부응하지 못해 국가GIS관련 기반정보 구축에 지장을 초래하고 있는 실정이다. 따라서 국토정보를 체계적으로 관리하고 유용하게 이용하기 위해서는 지형과 지적정보의 관리체계를 일원화하거나 또는 적어도 연계활용할 수 있는 방안을 마련해야 할 것이다.

3) 공간정보기반 구축사업의 확대 및 유지보수대책 마련 필요

98년도에는 현재 추진중인 지형도 전산화사업을 모두 완료하게 된다. 이렇게 구축된 수치지형도는 공공부문에서 뿐만 아니라 민간부문에서도 여러 가지 형태로 활용될 것이다. 그러나 공간정보를 활용하는 측면에서 보면 수치지형도는 기본이 되는 자료이고 그 외에도 다양한 주제도가 필요하다. 물론 수요기관의 목적에 따라 필요로 하는 주제도의 성격과 유형이 다르지만, 대부분의 기관에서 공통적으로 필요한 주제도가 있다. 이러한 주제도들은 국가차원에서 전산화사업을 추진하여 예산이 중복 투자되는 낭비를 막는 것이 바람직하다. 따라서 현재 부진한 지적도와 지하시설물도의 전산화사업을 비롯한 각종 주제도의 전산화사업을 정보화사회의 정보인프라를 구축하는 차원에서 적극적으로 추진하여야 한다. 한편 이미 제작된 수치지도는 여러 분야에서 활용될 수 있도록 유통체제를 확대해 나가야 한다. 뿐만 아니라 자료의 최신성을 유지하고 질을 높이기 위한 유지보수방안도 마련해야 한다.

4) GIS기술개발사업의 전환 및 전문인력 육성기관의 다원화

현재 GIS기술분야에 대한 사업은 매핑분야기술을 비롯해서 데이터베이스 툴 기술, 기본 소프트웨어 기술, 응용 소프트웨어 기술 등 여러 갈래로 분산투자되고 있으나, GIS관련 기술개발사업을 재검토하여 정부는 핵심과제에 중점적으로 투자하는 것이 바람직하다. 즉 GIS 기술개발사업 중 민간부문에서 담당할 수 있는 기술분야는 민간에 맡기고, 정부는 세계시장을 겨냥한 핵심기술 개발분야에 집중적으로 투자하는 것이 바람직 할 것이다. 또한 앞으로 공간정보의 종류가 다양해지고 이용도가 높아져 유통이 활발해질 때를 대비하여 공간정보의 유통기술에 관한 연구와 소프트웨어의 개발도 필요하다. 한편 부족한 GIS전문인력을 짧은 기간내에 대량으로 육성하기 위해서는 GIS교육기관을 좀 더 다변화해야 한다. 아울러 장기적인 안목에서 미래지향적인 교육전략을 수립하여 다수의 인원이 다양한 교육을 받을 수 있는 환경을 조성해 나가야 할 것이다.

5) 안정적인 재원확보방안 강구

현재까지 투입된 공간정보의 전산화 비용은 대체적으로 지형도·주제도·지하시설물도의 전산화 사업비와 활용체계개발에 대한 사업비 등이다. 그런데 이러한 사업을 원활히 수행하기 위해서는 사업에 소요되는 재원을 안정적으로 확보하는 일이 무엇보다 중요한 일이다. 특히 국가GIS구축 기본계획에 따라 투입될 재원의 30% 이상을 지방비로 충당해야 하는데 지자체의 넉넉치 못한 재정여건을 감안할 때, 이에 대한 현실적인 대처방안이 강구되어야 할 것이다.

4. 국가GIS 발전전략

4.1 GIS기술의 발전동향

1) 空間·時間·人間의 결합체를 지향하는 GIS

GIS의 첫 글자인 geographic은 가이아(Gaia)에서 파생한 「geo」와 그린다는 뜻인 「graph」의 합성어이다. 가이아는 원래 그리이스 신화에서 만물의 어머니인 대지의 여신이다. 지리학은 대지인 가이아의 표면을 탐사하여 산, 물, 바다의 위치를 가늠하는 학문이다. 지리학을 근간으로 하는 GIS는 이와 같이 처음부터 땅이라는 공간요소를 바탕으로 탄생하였다. 한편 시스템은 공간요소, 시간요소, 인간요소의 결합체라 정의할 수 있다.[1] 하나의 시스템인 GIS도 마찬가지이다. GIS가 기술측면에서나 데이터베이스 관리측면에서 공간, 시간 그리고 인간의 3요소 결합체로 발전할 때 비로소 GIS는 공간정보 관리·분석의 기능 뿐만 아니라 GIS기능의 결정체라 할 수 있는 의사결정지원시스템으로서의 역할을 완벽하게 수행할 것이다. 그러나 현재 활용되는 GIS데이터베이스와 시스템구조는 기술적 한계로 인하여 대부분 시간요소와 인간요소를 배제한 채 주로 공간위주의 자료를 관리하고 분석처리하는 정도에 그치고 있다. 그렇지만 앞으로 GIS기술은 공간·시간·인간의 3요소 결합체로 발전해 나갈 것임에 틀림없다.

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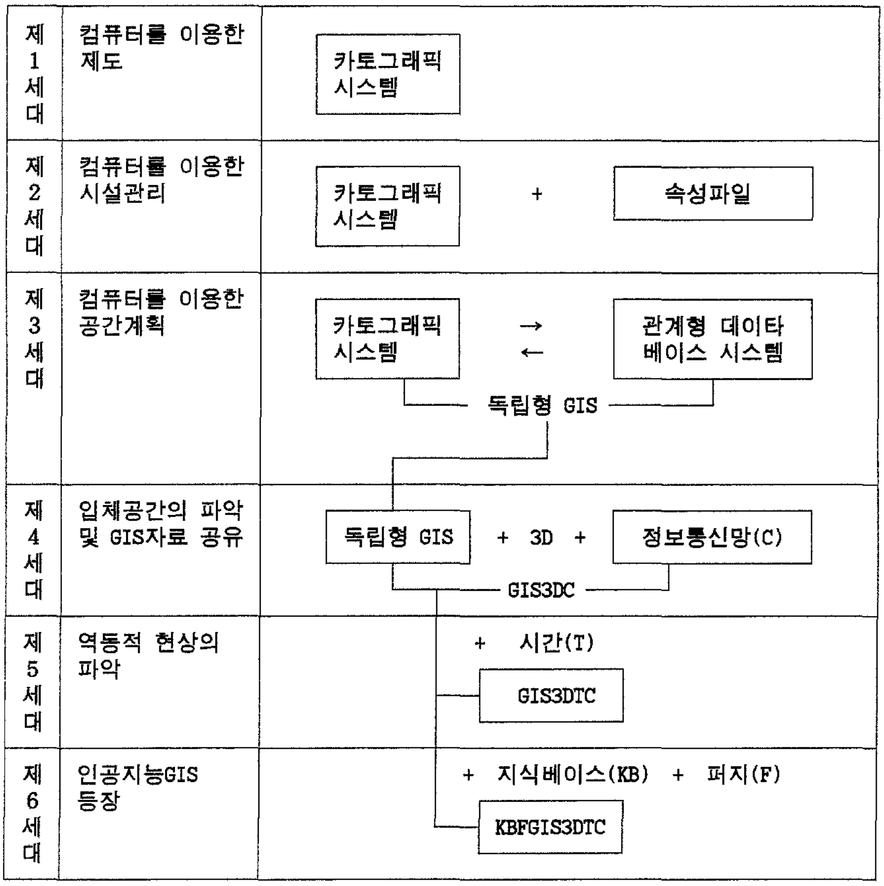
1) 우리가 상상할 수 있는 가장 큰 시스템은 宇宙이다. 淮南子에서 宇는 四方上下 즉 空間을 말하며, 宙는 古往今來 즉 時間을 뜻한다고 기술되어 있다. 그러므로 "공간과 시간이 어우러져 있는 틀"이 곧 우주인 것이다. 이러한 공간과 시간에 그것을 인식할 수 있는 인간을 더해서 흔히 우주의 三間이라고 한다.

2) GIS기술의 성장과정과 발전동향

GIS는 단순한 지도제작작업과정에 컴퓨터를 이용하여 작업을 쉽고 빠르게 수행하는 카토그래픽시스템(Cartographic System)의 등장에서 비롯되었다. GIS기술의 제2세대는 속성파일을 이용하여 시설관리를 가능하게 하였으며, 카토그래픽시스템과 관계형데이터베이스시스템의 완전한 결합체인 ARC/INFO가 등장한 80년대 초를 제3세대 GIS의 태동기라 할 수 있다. 현재는 제4세대로 3차원(3D) 자료처리기법과 정보통신망(C)을 이용하여 GIS시스템간의 정보공유가 가능한 세대이다[GIS+3D+C]. 또한 머지않은 장래에 GIS기술은 시간차원(T)을 수용하는 제5세대로 발전할 것이다[GIS+3D+T+C]. 이어서 확률개념에 바탕을 두고 불확실성을 다루는 퍼지이론(F)과 인공지능(I)을 GIS시스템에 응용하는 제6세대로 발전할 것으로 전망되며[GIS+3D+T+F+I+C], 이 단계에서 GIS시스템은 거의 완벽한 의사결정지원시스템의 역할을 수행할 것으로 기대된다.



〈그림 2〉 GIS기술의 발전과정 및 전망

4.2 단기적으로 해결해야 할 과제

정부가 국가GIS구축사업을 추진한지 3년이 지났다. 현 시점에서 사업을 종합적으로 평가해 볼 때, 당초의 계획대로 순조로이 진행되는 사업이 있는가 하면, 일부 사업은 예산미확보, 기술력 부족, 부처간의 협조미흡 등의 원인으로 당초 목표에 미치지 못하는 경우도 있다. 앞에서 제시한 2010년까지의 국가GIS 구축목표를 단계별로 달성해 나가기 위해서는, 현 시점에서 단기적으로 해결해야 할 과제와 중장기적 안목에서 전략적으로 차근차근히 접근해야 할 과제가 있다. 여기서는 먼저 단기과제에 대해 간단히 살펴보고, 다음 절에서 국가GIS 발전을 위한 중장기 전략에 관하여 자세히 언급하고자 한다.

국가GIS구축사업을 추진하는데 있어서 1단계사업 기간중에 마무리해야 할 과제로는, 첫째 앞에서 제기한 『(가칭)국토공간정보화촉진법』을 비롯한 『(가칭)공간정보매매법』 등과 같은 국가GIS사업을 뒷받침할 법률을 새로이 제정하거나, 필요한 경우 기존의 법률들을 정비하는 작업이 필요하다. 둘째 많은 비용을 들여 구축된 수치지도가 폭넓게 활용되도록 널리 홍보하면서, 아울러 늘 최신자료가 유지될 수 있도록 수치지도의 갱신 및 유지보수방안을 마련해야 한다. 셋째 정부는 지난 9월 1일부터 수치지형도를 판매하기 시작했으나 현재의 공급체제는 개선해야 할 소지가 많다. 앞으로 수치지도를 보다 체계적으로 공급하고 일반인들이 보다 쉽게 접근할 수 있도록 하기 위해서는 공간정보유통기구의 설립을 서둘러야 할 때이다. 넷째 1단계사업 기간중에 외국의 프레임워크데이터(Framework Data)와 같은 국가GIS 기반데이터에 관한 개념을 정립하고 추진계획을 수립하여 2단계사업 초기에 바로 프레임워크데이터 제작사업에 착수할 수 있는 사전준비를 해 두어야 한다. 다섯째 공간정보의 표준정립 작업을 보다 구체적으로 추진해야 한다. 특히 GIS데이터 교환포맷표준으로 결정된 SDTS(Spatial Data Transfer Standard)에 대한 구체적인 프로파일을 제시하여 사업추진에 더 이상 혼선이 생기지 않도록 해야 한다. 여섯째 지방자치단체에서 GIS기본계획을 수립할 때 참조할 수 있는 GIS계획 수립지침을 중앙정부 차원에서 마련하여 제공함으로써 지자체의 불필요한 시행착오를 줄여야 한다. 일곱째 GIS를 쉽게 풀이한 책, 만화, CD-ROM, 비디오 등을 제작하여 널리 알림으로써 일반인들도 GIS에 친숙해 질수 있는 홍보전략을 마련해야 한다.

4.3 국가GIS 발전을 위한 중장기 전략

1) 「時空人통합정보인프라」를 구축하여 창조적 지식국가 건설 지원

GIS기술의 발전동향을 전망해 볼 때 우리나라의 향후 공간정보인프라 구축사업은 마땅히 「時空人통합정보인프라」의 구축을 향해 나아가야 한다. 그러기 위해서는 현재의 국가 GIS 공간정보 생산방식과 체제에 대하여 일대 발상의 전환이 있어야 한다. 첫째 공간요소적 측면에서는 지하·지상·바다·공중의 핵심적인 공간자료들이 하나의 좌표체제에서 3차원적으로 완벽하게 운용되는 방안이 마련되어야 한다. 다시 말해서 핵심적인 공간정보들이 형상적인 측면과 공간적인 측면에서 통합될 수 있는 토대를 갖추어야 한다. 둘째 시간요소적 측면에서는 현재의 여건으로는 전국토에 대한 공간정보를 특정시점 기준으로, 전체 자료를 생산하는 일도 어렵지만, 앞으로는 공간정보에 시간요소를 내재시킨 역동적인 공간정보를 생산하는 체제를 갖추어 나가야 한다. 그러기 위해서는 연도별로 변화하는 속성정보를 담을 수 있도록 각종 수치지도의 갱신작업이 끊임없이 이루어져야 한다. 그러한 과정에서 시간요소가 내재된 공간정보와 속성정보를 통합한 「時空통합정보인프라」를 구축할 수 있다. 가장 먼저 시도해 볼 만한 「時空통합정보인프라」 구축사업으로는 5년 또는 10년 마다 실시되는 통계청의 인구및주택조사·광공업통계조사·총사업체조사·국부조사 등 각종 센서스의 연도별 자료와 조사구요도(調査區要圖)를 각종 수치지도와 한 데 묶어서 새로운 형태의 통합정보 인프라를 구축하는 일이다. 셋째 인간요소적 측면에서는 인공지능기술을 한층 가다듬으면서 동시에 각 분야에서 관련 지식기반데이터베이스를 구축하는데 많은 관심을 가져야 한다. 다시 말해서 사람이 판단하는 것과 유사한 인간의사결정요소를 GIS시스템에 수용하는 기술과 정보 구축사업에 대해 중장기적인 계획을 수립해야 한다.

2) 「1가구 1GIS」를 보급하여 GIS활용의 보편화 실현

수년 내에 「1가구 1PC」가 달성될 전망이다. 이와 때를 같이 하여 GIS기술 개발에 박차를 가하고 아울러 차세대에 대한 교육을 강화해 나간다면, 「1가구 1PC」 달성이후 늦어도 5년 이내에 「1가구 1GIS」를 보급할 수 있을 것으로 전망된다. 그렇게 되면 GIS활용의 보편화를 보다 앞당겨 이룰 수 있을 것이다.

3) 초등교과과정에 GIS를 포함시켜 GIS의 생활화 유도

현재 우리나라는 GIS전담교육기관과 대학 그리고 일부 민간업체에서 GIS교육을 실시하고 있다. 그러나 다수의 전문인력을 꾸준히 안정적으로 확보하기 위해서는 보다 근원적이고 미래지향적인 GIS교육 프로그램의 개발이 필요하다. 즉 장기적으로 중고등학교는 물론 초등학교의 교과과정에 GIS교육을 포함시켜 GIS에 대한 국민적 이해의 폭을 넓히고 GIS의 저변을 확대해 나가는 방안을 강구해야 한다.

4) 국가프레임워크데이터를 작성하여 국토공간정보화의 기틀 마련

현행의 1단계 사업에서는 지형도를 기본으로 하여 종이지도에 수록된 모든 지형공간정보를 수치지도화 하였다. 그런데 지금의 수치지형도는 국가GIS기본도로 활용하기 어려운 점이 많다. 왜냐하면 수치지형도에는 GIS용도로는 불필요한 내용을 너무 많이 포함하고 있고, 다른 한편으로는 GIS기본도로서 꼭 필요한 일부 내용이 포함되어 있지 못하기 때문이다. 앞으로 여러 종류의 공간자료들을 중첩시키거나 추가시킬 수 있는 틀로서의 국가프레임워크데이터를 작성하여 국토공간정보를 체계적으로 구축하기 위한 기틀을 마련해야 할 것이다.

5) GIS활용시스템 개발을 촉진하여 대국민 GIS서비스 확대

국가GIS구축사업은 궁극적으로 GIS관련 기술을 활용하여 행정업무의 생산성을 제고하고 대국민서비스의 수준을 높이는데 그 목적이 있다. GIS활용분야는 공간정보데이터베이스의 구축을 전제로 한다면 거의 무제한적이다. 이처럼 다양한 분야에 대한 활용시스템을 일시에 구축한다는 것은 불가능하므로 우선순위를 매겨서 단계별로 사업을 추진해야 한다. 그 때 행정업무 개선효과와 범용성이 큰 업무, 정보교류의 활성화 효과가 큰 업무, 의사결정지원효과가 높은 업무 등에 우선적으로 투자하는 것이 바람직하다. 이러한 조건에 적합한 사업으로는 첫째 문화생활, 관광생활, 행정정보열람 등 국민생활과 밀접하게 관련된 정보를 일반국민이 쉽게 얻을 수 있는 GIS서비스체제를 구축하는 생활지리정보시스템 개발사업을 꼽을 수 있다. 둘째 지적도, 도시계획도, 토지이용계획확인서 등 행정관청의 각종 민원업무를 전산화하여 국민생활의 행정편의를 꾀할 수 있는 행정서비스 지원사업을 고려해 볼 수 있다.

6) 공간정보유통망을 구축하여 누구나 쉽게 필요한 정보 취득

국가GIS사업으로 구축된 공간정보는 여러 분야에서 널리 사용될 때 그 효과가 극대화되고 GIS활용의 보편화를 실현할 수 있다. 그러기 위해서는 무엇 보다도 정보통신망에서 공간정보유통기구, 자료생산기관, 공간정보대리점, 사용자가 상호 연결된 공간정보유통망을 구축하여 누구나 쉽게 필요한 공간정보를 검색하거나 매매할 수 있는 체제가 갖추어져야 한다. 또한 국내외의 GIS관련 정보를 통신망으로 제공하는 GIS전자도서관의 설립도 추진해야 할 사업의 하나이다.

7) GIS추진체제를 정비하여 국가GIS사업의 효율성 제고

현행의 국가GIS추진체제는 수치지도를 생산하는데는 효과적인 체제이나, 생산된 수치지도를 바탕으로 GIS활용시스템 개발사업을 활성화 하는데는 미흡하다. 또한 국가GIS사업을 추진하는데 있어서 지방자치단체의 역할이 매우 중요하나 지방자치단체가 국가GIS사업 추진에 대한 의사결정과정에 직접 참여하지 못해 정부의 GIS정책에 대한 이해가 낮은 실정이다. 따라서 국가GIS추진위원회의 현행 5개 분과외에 정보응용분과와 지방자치단체분과를 신설하면 국가GIS사업의 효율성을 한층 높일 수 있을 것이다. 정보응용분과는 각종 GIS활용시스템 개발사업을 주관하도록 하여 GIS활용확산을 촉진하도록 하고, 지방자치단체분과는 지자체의 GIS구축 지원전략을 수립하고 지하시설물통합관리시스템, 도시정보시스템 등 지자체의 GIS구축을 지원하고 선도해 나가도록 한다. 한편 국가GIS사업의 규모가 더욱 커지고 사업내용이 복잡해 질 경우 이를 종합적으로 지원하기 위한 GIS연구소의 설립도 고려해 볼 만하다.

8) 범지구정보를 구축하여 GIS분야의 세계화 달성

현재 우리나라는 국내의 공간정보 자체도 보급이 미약한 실정이므로, 다른 국가나 세계의 특정지역에 대한 정보수요는 아직 적은 편이다. 그러나 세계경제가 블록화, 단일화되는 시점에서 세계 각국의 지형정보는 경제 및 환경정책적인 측면에서 그 유용성이 커지고 있다. 따라서 우리나라도 서구 선진국과 마찬가지로 세계의 지형정보, 환경정보, 자원정보, 기후정보, 토양정보, 식생정보, 문화재정보 등 국제화시대에 걸맞는 세계지리정보를 구축해 나가야 하고, 지금부터 이에 대한 준비를 해야 한다.

9) GIS핵심기술을 개발하여 세계시장에 진출하고 GIS선진국으로 발돋움

2단계사업에서는 현재의 기술개발연구비 지원방식을 지양하고, 정부가 GIS기술개발지원 5개년계획을 미리 발표한 후, 매년 우수 GIS기술개발보고서와 우수 GIS소프트웨어 제품을 공모하여, 일정한 수준 이상의 기술력을 갖춘 결과물에 대해서 정부가 제품을 대량 구입함으로써 GIS기술개발을 지원하는 방식을 채택하는 것이 바람직하다. 이러한 방식은 기술개발에 참여하는 기술인력의 확대와 개발된 기술의 실질적인 상품화라는 측면에서 효과가 클 것으로 기대된다. 그러한 완전경쟁체제하에서 개발된 기술만이 세계시장에서 생존할 수 있을 것으로 판단되며, 경쟁력 있는 기술은 GIS선진국으로 발돋움하는데 밑거름이 될 것이다.

10) 국토정책평가모형을 개발하여 국토정책의 시행효과 사전 측정

경제부문에 있어서 국가경제의 예측모형과 경제정책의 파급효과 측정모형이 중요하듯이, 국토관리에 있어서도 국토관련 지표를 예측하고 각종 국토관련 정책의 시행효과를 측정할 수 있는 국토정책평가 시뮬레이션모형이 개발된다면 매우 유용하게 활용될 수 있을 것이다. 그동안 유사한 모형을 개발하려는 시도가 일부에서 있었으나, GIS기술의 뒷받침없이는 근본적으로 불가능한 일이었기 때문에 성공적인 결과를 산출하기 어려웠던게 사실이다. 그러나 앞으로 GIS를 바탕으로 국토정책평가 시뮬레이션모형을 개발할 수 있는 여건이 마련될 것이고, 이를 통해서 사회간접자본의 투자파급효과를 측정하고 국토계획의 영향을 예측하며 국토이용계획의 변경효과까지 사전에 예측할 수 있을 때 GIS활용수준이 한층 고급화될 것이다.

5. 맺 는 말

지난 95년부터 시작된 국가GIS구축 1단계사업은 오는 2000년에 마무리된다. 지난 3여년 동안 계획에 따라 큰 비용을 투입해 사업을 추진해 온 결과, 그 성과물들이 하나씩 가시적으로 나타나고 있다. 그러나 11개 정부부처가 참여하는 방대한 정보화사업을 짧은 기간에 달성목표를 의욕적으로 설정하다 보니 국가GIS구축사업을 뒷받침할 법과 제도의 정비, 공간정보유통체제의 확립, GIS응용시스템 구축의 활성화 등 해결해야 할 과제들이 계속 제기되고 있다. 따라서 이 시점에서 국가GIS구축사업 전반에 대해 차분히 되짚어 보면서, 1단계사업을 충실히 마무리하고, 앞으로의 발전방향과 단계별 추진전략을 마련해 나가야 할 것이다.

Cost-Benefit Analyses for GIS Implementation

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ABSTRACT

Investments in Geographic Information System (GIS) can be very profitable. This is showed by the result of evaluations, in terms of costs and benefits, for the implementation of GIS in four different organizations: A municipality, a state owned company, a forest industry and an association of master-builders. The evaluations were made in 1997, seven years after the organizations adopted GIS in their every day work. In the year of 2000, when GIS has been in use for ten years, the four organizations will receive two to five times in return of their investment. The new information system has also affected other working methods in positive directions. Users and managers were encouraged when new possiblities emerged besides those originally aimed. New challenging tasks were solved more successfully than expected. The cost-benefit analyses were commissioned by the Swedish Development Council for Land Information (ULI).

The project had some relations to the activities of the National GIS Strategy.

In two of the four organizations a broader cost-benefit approach was used to forecast further GIS implementation. This was done for the municipality and the state owned company, showing that more coordinated GIS implementations can give even more positive benefits. An approximate calculation indicates benefits forty to sixty times bigger than the costs.

요 지

지리정보시스템에 대한 투자는 매우 이윤이 높다. 이것은 네 개의 각기 다른 기구, 지자체, 주정부가 소유한 회사, 목재회사, 그리고 건설협회에서 GIS의 실행에 따른 비용편익분석에 의한 평가 결과이다. 평가는 각 기구에서 GIS를 업장마다 매일 실행시킨지 7년이 지난 1997년에 이루어졌다. GIS 사용이 10년이 지나는 2000년에는 네 개의 기구에서 GIS투자에 대한 이윤을 2배에서 5배까지 얻을 수 있을 것이다. 새로운 정보시스템은 다른 작업방법에 긍정적인 영향을 미쳐왔다. 사용자와 관리자는 처음 계획하였던 목표치보다 새로운 가능성의 출현으로 인해 고무되었다. 새로운 도전이 되었던 과업은 기대했던 것보다 더 성공적으로 완수되었다. 투자효과분석은 토지정보를 위한 스웨덴 개발심의회에 의해 준비되었다.

프로젝트는 국가지리정보체계 전략의 활동과 어느정도 연관이 있다. 네 개의 기구중 두 곳에 광범위한 투자효과접근방식이 GIS실행을 예견하는데 사용되었다. 이것은 지자체와 주정부가 소유한 회사 두곳에 사용되었는데 업무에 GIS를 실행할수록 더 나은 긍정적인 효과가 있음을 보여주었다. 대략적으로 투여된 비용보다 40배에서 60배정도의 실익이 있었음을 보여준다.

1. Introduction

This presentation is divided into four parts. I will start with an overview of evaluations made of the costs and benefits in four organizations. Then I will continue with forecasting analyses made for two of the mentioned organizations. The third describes the analysis method developed and used in the studies. Finally I will end the presentation with some words about national activities in Sweden related to the cost-benefit question of GIS.

2. Cost-benefit evaluation of four organizations

2.1 Case studies

Stockholm City Planning Administration, South District; Construction of detailed development plans. Telia (Swedish Telecom), Network Services;

Documentation and project design of the fixed national network. Korsns Forest Industry; Forest mapping and ecological landscape planning. Association of Master-Builders, Sweden west; Travel analyses.

Organizational changes

In 1997 I was commissioned by the Development Council for Land Information (ULI) to evaluate the GIS diffusion process of four Swedish GIS pioneers. The Development Council is a Swedish association that aims for more efficient use of land information. It is an independent non-profit making organization that works in close co-operation with the government departments and agencies, municipalities, universities etc. The membership is open to all Swedish organizations.

Six years had gone from the start in 1990 of using GIS in the day-to-day work in the studied organizations. During these six years three of them had been re-organized to a great extent. Privatization and dividing into client-server divisions were some of the changes. At the same time the personnel were considerably reduced. Districts and regions were put together. The use of GIS and other new technology were important elements in these changes. My evaluations show good economic outcomes during these years, determined by GIS and other technical factors in combination with new organizations and working routines.

User benefits

Estimations of the net present value were made for the four organizations during a ten-year period (1990-1999). The quantitative benefits were estimated as follows:

- About 4 times the cost in the GIS implementation in the Stockholm City Planning Administration. (This means that each invested dollar resulted into four dollars in return.);
- About 2 times as great as the costs in the Swedish Telecom;
- About 3 times as great in Korsns Forest Industry;
- The Master-Builders Association could calculate 5 times return on the investments made.

The benefits that could be estimated quantitatively were in most cases turn outs of the rationalization process, such as reduction of personnel or changes of activities. In the case of the Master-Builders Association the calculated benefit is related to the employees compensation of travel expenses.

This good economic outcome was calculated for the primal users. In addition to this the GIS information could be beneficial also for a lot of other users inside and outside the studied organizations. Some examples are the building and consulting companies that could benefit from the digital development plans and network maps of the Stockholm City Planning Administration and the Swedish Telecom. In a wider cost-benefit analysis the four organizations could add the benefits of the secondary users within the organization, as well as the inhabitants or the private enterprises of the region.

High costs of data

The cost-benefit analyses of the four different organizations have also shown the rich information amount of some useful databases. This has made them very expensive. A way to manage this problem could be by co-ordinating the efforts of different interest groups. This makes it possible to produce the databases and make them accessible in a less expensive way. A success story of this matter is the Stockholm City Basic Map. From the viewpoint of public economy money could be saved if common frames could be created to ease co-ordination and finance of geographic databases.

Common use of information will be successful

The four evaluated cases are already making money and other benefits by using GIS. In addition to this there are more to benefit from GIS.

One type of benefit is due to the extension of the implementation process. In all the four organizations it took longer time than expected to implement the system. Especially the databases have cost more time and money than calculated. In most of the cases the time of approval and implementation into the organizations were widely underestimated. The supervisors have taken it too easy in most cases. My evaluations show that a slow and extended implementation process will keep the return on investments on a low level. A parallel use of the new and old systems and routines will result in ineffectiveness. Therefore, in some of the cases there are additional benefits that will emerge when all potential parts of the organization are operating GIS users.

Recycling of information

Another benefit will occur when the secondary users in and outside the organization start to use the databases in additional ways than originally aimed. When more and more users and clients get involved, series of new questions will be raised to the managers. One question is about rules and prices for the access and use of information. When users emerge from new departments and organizations this query will be more and more important.

Development of use

A third type of benefit could occur when the databases are developed or combined for multipurpose use. To combine information from registers and maps, to develop topology in the databases and to keep them available through the electronic network are some further stages of development. To find ways of continuous co-operation about use and development of the information systems are other coming questions for the four organizations.

To learn from practice

The case studies point out several factors that managers and other involved did not expect. One task more complex than foreseen was the construction of the data bases. In some of the organizations it was more difficult than expected to implement a broad practice in all potential parts of the organization. But one of the most interesting results of the evaluation is the experience that the new geographic information techniques gave unforeseen opportunities, for example to manage new and challenging tasks in a better manner than ever believed.

2.2 Cost-benefit forecasts of two case studies

In 1997 I was commissioned by the Stockholm City Council to forecast the costs and benefits of a better co-ordination of GIS in the city administration. The City Basic Map, the City Statistic Map and several environmental databases were run as different GIS projects with different software, ways of access, taxonomy, prices etc. The City had decided to make them accessible in a co-ordinated way on the internal network to new groups of the City Administration. They are for example the District Administrations, the Civic Offices and the Streets and Real Estate Administration.

My task was to estimate the costs and benefits of this GIS co-ordination project. By interviews and calculations I could estimate the benefit-cost rate to 40 after five years. This sensational result of the analysis was due to the relative low investments that will be needed to co-ordinate databases that already have been constructed for the primal users. Another success factor is the great improvement of accessibility that will be possible when the databases are connected to the common network. A critical factor is however the extension of the implementation process. The sensitivity analysis showed that a slower implementation effects enormously on the benefit-cost rate. A 4-5 years implementation period instead of 2-3 years will make the rate 20, instead of 40.

In another study I was commissioned by Telia (Swedish Telecom) to make a forecast of the benefits of all potential users in the Network Services Company. Also this study showed a much higher benefit than that of the primal users only. The result made the managers more interested than before to support further GIS implementation.

2.3 Methodology

I have used the methods of net present value and pay-off to estimate the costs and the benefits that could be quantified. The steps are as follows:

1) Compare the costs of handling geographic information in a traditional way (0-alternative) to the costs of using GIS over a period of time. Then estimate the difference each year.

2) Estimate the benefits that could be quantified by comparing the 0-alternative and the GIS-alternative. Calculate the differences each year and show the savings and incomes. It could be a decrease of personnel, less copies of maps and distribution, increased production etc. Then transform the differences into the value of money.

3) Choose the number of years of the analysis period. (Compared to other investments, an exceptional long time must be used when you are analysing GIS-investments.) I have chosen a ten years period from the starting date of using GIS permanently.

4) Transform the costs and benefits into the value of a current year (net present value). I have chosen 4 percent as the rate of calculation in the main alternatives. And in the evaluating study I have chosen the present value of 1996. The costs and benefits each year were converted into the cost-level this year. In

the two forecasting analyses I have chosen 1997 as the year of value. Then cumulate the result, in two ways: The sum of costs and benefits each year until you get the year of pay-off, then for the sum-of-years to get the rate of benefit-cost. Count and calculate in worksheets and present the results in tables and charts (Diagram 1 and 2. The diagrams will be presented at the seminar).

Sensitivity analyses

A great number of assumptions have been made to make it possible to calculate the costs and benefits of GIS implementation. By use of sensitivity analyses I have focused on the assumptions that is less decisive. These are: The percent of contribution from GIS to effectiveness and efficiency, the number of years until full implementation, the number of years in the cost-benefit analysis after pay-off. The discount rate is also of great importance.

In Diagram 3 (presented at the seminar) you can find the result of the sensitivity analyses in the case Korsns Forest Industry. You can see that a lower discount rate, 2 percent instead of 4 percent raises the rate of benefit-cost. A higher discount rate, 8 percent, reduces the benefit-cost rate. Assumptions of the percent of GIS contribution to effectiveness have an even greater effect on the benefit-cost rate.

Balanced Scorecard

Besides the methods of net present value and pay-off I have used Balanced Scorecard, as a way of presenting the analyses and making them comprehensible. The estimations are divided into costs and benefits from different perspectives.

The traditional perspective on the development of organizations is the strategic and financial perspective. By use of Balanced Scorecard you can also focus on the clients perspective, the development perspective and the perspective of the organisation internally. The different perspectives give a better overview of the analyses. It is also easier to compare the quantitative and the qualitative parts of the analyses. Even comparison between different organizations is simplified by use of Balanced Scorecard.

Qualitative benefits

A complete cost-benefit analysis consists of costs and benefits which are more or less easy to quantify. For example, it is difficult to quantify the costs of loosing effectiveness when personnel need time training to use the new information system. Examples of benefits difficult to quantify are the following: Better public service, better in time being, higher accuracy and quality, better control and security. The qualitative part of the analysis is text represented and then summarised into tables showing the strengths, weaknesses and future opportunities.

2.4 National Activities

The Swedish Government has supported several activities about new information technology and geographic data. Some of these are:

National IT Strategy and working program, adopted by the Parliament in 1996

Special attention was directed to the potential of a rapid construction of geographical databases. Measures should be adopted to develop the public databases with wide application areas, such as registers of population, firms, real estate, buildings and basic geographic data.

Forum of Upper Management (Director Generals)

Initiated by the Ministry of Finance in 1994. GIS was one of their projects, studying the information flow between local and regional government. They found the common request of a digital mapped background, including the division of real estate.

Governmental Task Force

In 1995 the Swedish government appointed the Ministries GIS co-ordinating group (REGGIT). The last report was presented may 1997, a result of studies on co-operation within the field of geographic information. The basic national geographic databases were specified and a price policy was established for data owned by the public. The Development Council of Land Information (ULI) has been a supporter of the group. The evaluation of costs and benefits of GIS implementation in four organizations was one of the ULI supporting activities.

Investigation of basic national data bases

In the end of 1997, a study of the national registers of population, firms and real estate data resulted in a program for the future development of accessibility and provision of data. A suggestion of using cost-benefit analyses before investment decisions was a new approach to the field of financing further measures. The same approach to financing data bases have been found this year in a governmental proposal to the parliament, concerning the future of state administration.

Standardisation activities

The Swedish project on standardisation in geographic information (STANLI) was initiated by the Swedish Development Council for Land Information and established in 1990 as a national project within the Swedish General Standards Institute. The work programme includes development of a framework of standards for description and transfer of data as well as national application schema standards. The project has 23 member organizations participating in the funding (83%) and providing of manpower. So far work has started on application schemas in the following domains; Real estate, Road and rail networks, Locational adresses and Utility networks (electricity, gas, water, telecom). The work on utility networks is the latest, started in 1998. Before the start a benefit analysis was made to estimate the potential savings of the standardisation work. The study indicates a net profit for the public economy of approximately 200 000 U.S. dollars every year, when the systems are fully implemented.

여 백

Using a Systematic GIS Planning Process to Maximise Benefits and Minimise Costs of National GIS Implementation

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ABSTRACT

This paper outlines how thorough cost - benefit analysis within a systematic GIS planning methodology can be used to estimate costs and benefits for a representative set of nationally significant information products. The process also contributes to a better understanding of:

- strategic development options to implement GIS(maximise benefit/minimise cost)
- the potential scope of a National Information Infrastructure
- the institutional and operating requirements to streamline the delivery of GIS output products and services
- the framework required to monitor ongoing costs and benefits of GIS investment strategies

Our approach to planning a geographic information infrastructure, (most recently applied to develop specifications for the Queensland Spatial Information Infrastructure), identifies a representative set of priority information products; required because of their strategic, legislative or national program significance to

government and the private sector.

The GIS planning process systematically describes users requirements for these information products, and supports a comprehensive assessment of the costs and benefits required to justify their development.

요 지

이 논문은 비용편익분석이 체계적인 GIS 계획수립방법내에서 얼마만큼 철저하게 21세기 국가GIS실행을 위한 전략을 개발시키는데 적용할수 있는지에 대하여 전반적으로 다룬다. 국가차원에서의 성공적인 GIS 개발을 위해 이해가 요구되어지는 아래 네가지 주요분야에 대한 비용편익분석의 기여도가 논의된다.

• 전략적 방향
• 국가정보기반
• 제도적 및 운영상의 요구사항
• 감시 및 검토

공간 정보 기반 계획에 대한 우리의 접근방식(최근에 Queensland 공간 정보 기반을 위한 상세내역 개발에 적용된)은 이해당사자들이 공공 공간자료 기반의 개발참여를 유도하는 정보생산을 위해 전략적으로 필요한 요구사항 즉 정보의 우선순위, 순차적인 데이터 우선순위, 데이터 모델링, 데이터셋 내력 등을 통하여 필요사항을 구축하기 위한 것이다. 이것은 우선 필요한 국가정보생산품, 전략적인면에서 요구되어지는 사항, 정부와 민간분야에 중대한 법적 또는 국가 프로그램의 파악이 있어야한다.

전체적인 비용편익분석을 계획과정의 일부로서 준비된 정보관련 제품의 상세내력이 본 논문에서 상세히 기술된다. 정보관련 제품에 대한 접근방식에 대한 가치는 다음과 같다:

유형적 편익과 무형적 편익을 모두 포함해서 국가적 차원에서 관심있는 필수적인 정보관련 제품을 파악하여 21세기를 위한 국가 GIS 발전전략의 최우선 순위로 매겨져야 한다.

대다수 이해당사자들의 필요성을 공급하기 위한 통합된 국가정보기반 개발을 위한 틀을 파악하여 정보 관련제품, 온라인 서비스, 사용자에 필요한 자료를 최대한으로 공급 하기위해 요구되어지는 제도적, 운영적,그리고 정책과 표준화에 대한 이해를 도모하고 진행되는 GIS 전략투자의 비용편익을 감시하기위한 일관된 틀을 파악한다.

우리가 현재의 환경안에서 관리하는데 도움이 되는 자료기반을 개발하는 것이 중요한 일인 반면에, 우리의 경험은 중대한 정책적 지원이 장기적인 국가의 기반인식을 설계함으로써 그리고 주 현안 문제를 조정하든지 또는 현재의 사회경제와 자원토대의 개선을 다룸으로써 성취될 수 있음을 보여준다.

최근의 우리의 Queensland 연구에서, 주 감사보고 위원회는 Queensland의 다음 10여년간 주의 깊게 보아야할 현안들에 대한 전체 정부 프로그램 레벨 검토사항을 제공하였다. 이들 현안은 22개의 대표적 주 정보관련제품들의 셋트를 위한 설계변수가 되었다. 국립토지와 물감사는 공간정보시스템개발을 위한 전략적 방향을 제공하는 또다른 예이다.

이 논문에 논의된 종합적인 비용편익분석기법은 지리정보시스템의 선수자인 Roger Tomlinson 박사에 의해 개발된 방법으로 과거 20년 동안 연방정부, 주정부, 지자체, 북미전역, 유럽, 호주와 개발도상국, 세계은행과 FAO의 지원을 받는 기구에서 실질적인 GIS 투자를 위해서 사용되어 왔다.

1. Introduction

A national approach to GIS development, involving potentially many agencies provides scope for increasing the benefits of GIS implementation over uncoordinated, single agency initiatives. A coordinated approach to GIS development has the potential to overcome many of the problems experienced over the last two decades; such as duplication of data and systems; and lack of data standards, procedures and policies needed to support the transfer of data between agencies.

The problem addressed in this paper is . . .'how to determine information and data priorities at the national level?' Cost-benefit analysis has traditionally been used as the tool for making better investment decisions in the public sector. However, cost-benefit analysis of GIS development options across a large number of government agencies is a more difficult task than undertaking such analysis for one department.

This paper draws on our experience in multi-agency GIS planning in Australia over the last decade, to present a methodology to assess information and data priorities for national GIS development in the 21st century. It is based on rigorous cost-benefit analysis. The GIS planning process also provides a range of outputs to assist in the development of strategies for national GIS implementation.

The planning methodology outlined below is equally well suited to the identification of costs and benefits of GIS implementation within an individual agency, as it is to the state or national level. It builds on earlier work carried out to assess the benefits of geographical information systems (Smith and Tomlinson 1992). This paper focuses on the application of the methodology at the national level.

2. GIS Planning Input to Cost Benefit Analysis

Before presenting a detailed review of the cost - benefit methodology, it is important to understand the principles of GIS planning, and how each part of the planning process contributes information to the assessment of costs and benefits. The fundamental principle of GIS planning is to identify the information that has to be produced by the system. The term Information Product is used for this purpose. An information product is defined as the output generated by processing two or more data sets, where the newly generated information has greater value than that of the individual data sets. (It is accepted that simply providing access to a single data set also has a certain value, but that simple data retrieval under-values the power of available spatial analysis technologies to add information value).

The identification of information requirements leads to the identification of the data that need to be entered into the system; and identifies the system functions that have to be employed to process the data into the required information.

The priority assigned to the required information guides the priority of data input. The frequency of system function use, together with the volume of data to be processed by the system, determine the characteristics of the system that has to be acquired. The benefit of information to the day-to-day operations of the agency is then balanced against the cost of system acquisition. These estimates are used to determine the benefit-cost ratio of the investment.

In summary, we consider benefit is only associated with information generated by the system; - all else is cost (ie. hardware, software, staff, and data). Information is considered to be beneficial if it has a positive impact on the desired business outcomes of an agency / nation; - that would not occur without that information.

3. Steps in the Cost-Benefit Analysis

The steps in traditional cost-benefit analysis (Smith and Tomlinson, 1992) are:

- specify the objective or desired outcome of the activity in question and determine all relevant impacts;
- use identified impacts to identify all costs and express these in dollars of the

base year;

- identify positive impacts (benefits) occurring over time and assign dollar values for the base year;
- benefits and costs spread over a period extending many years into the future must be discounted to the base year using a discount rate to capture the time value of money;
- the appropriate decision criteria are that socially desirable projects should generate positive net present values (NPV). The NPV is calculated by subtracting the present value of costs from the present value of benefits.

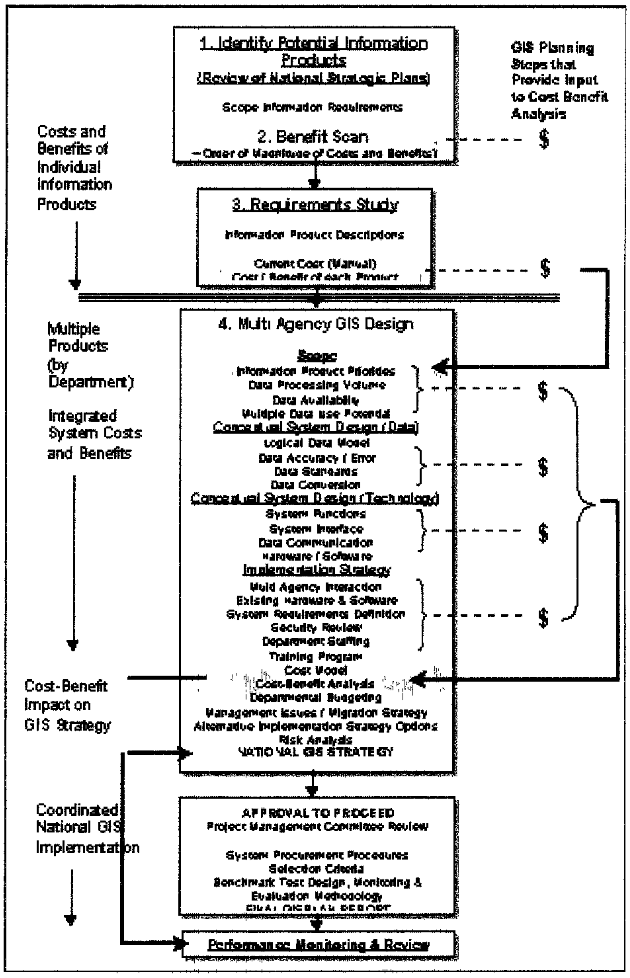

Fig. 1 Overview of Steps in the GIS Planning Process-Input to Cost-Benefit Analysis

The benefit-cost ratio is simply the present discounted value of benefits divided by the present discounted value of costs. Sensitivity analysis is usually required by Government agencies to assess how changes to parameters such as the discount rate affect the benefit-cost ratio and NPV calculations.

The GIS planning process (Figure 1), supports estimates of costs and benefits for inclusion in cost-benefit analysis. It is extremely thorough at identifying costs, but very conservative in its estimation of benefits.

In the context of multi-agency / national GIS development, the GIS planning process (Figure 1), can be broadly divided into two phases:

Phase 1 Identification of the costs and benefits of generating individual information products, from the Requirements Study.

Phase 2 Identification of the costs and benefits of coordinated development of many information products across many departments; ie. an integrated National Information Infrastructure initiative.

Each phase of the planning process comprises a logical sequence of steps. Steps that provide input to the cost-benefit analysis are described in detail. The order in which the steps are described follows the diagram shown in Figure 1.

3.1 Phase1 Costs and Benefits of National Information Products

Step1 Identifying Potential Information Products from National Strategic Plans

The first step is to identify information requirements of national interest, recognising that the World Wide Web (WWW) now creates opportunities to access information across a more diverse client base located in departments, provinces, nations and sites around the globe. Potential users include governments, industry and the community.

Conservatively, the minimum requirement is to establish a direct link between government priorities and departmental and divisional responsibilities, and their need for information to assist in making informed decisions about infrastructure, the environment, society and the economy.

This task is made easier where recent reviews of government performance are available. Two examples illustrate how the identification of significant state and national issues provided the initial impetus for co-ordinated national and state-wide GIS development.

- The National Performance Review (USA), which took place following the change of government in 1994; recommended major cost cutting programs to reduce the budget deficit. Significantly, information required to compare risks associated with cost reduction programs across the nation became an important commodity.

The importance of information to the United States was subsequently recognised in President Clinton's Executive Order 12906 in April 1994, "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure" which stated:

'Geographic information is critical to promote economic development, improve our stewardship of natural resources, and protect the environment. . . . ' The National Performance Review has recommended that the executive branch develop, in cooperation with State, local and tribal governments, and the private sector, a coordinated National Spatial Data Infrastructure to support public and private sector applications of geospatial data in such areas as transportation, community development, agriculture, emergency response, environmental management and information technology'.

The Order acted on the recommendations arising from the National Performance Review, to advance the goals of a National Information Infrastructure; to avoid wasteful duplication of effort, and promote effective and economical management of resources by Federal, State, local and tribal governments.

- In our recent GIS planning study for the State Government of Queensland, Australia, the Commission of Audit review identified major threats to the State's economic prosperity and social wellbeing over the next decade. These issues provided an initial indication of the type of information needed to support improved decision-making on billions of dollars of planned capital expenditure over that period.

In the absence of strategic planning documents, Business Information Requirements Workshops are conducted to identify a candidate list of information products required to address major national issues over a 6-year planning period.

Representatives from government agencies, the private sector, academia and the community are invited to attend these workshops.

Step2 Screening Process to Identify Significant Information Products (Benefit Scan)

The GIS planning methodology (GISPLAN) requires detailed information product descriptions to be prepared. It takes from 3 to 5 days to complete one product description of average complexity. To avoid spending time describing 'low risk / low benefit', potentially duplicative information products, proposed products are screened to assess their likely magnitude of benefit. The objective is to select a 'representative' set of information products to seed the development of a National Information Infrastructure. The information products selected for detailed planning should draw on the majority of data sets expected to comprise a National Spatial Data Infrastructure.

The benefit-scan process takes the form of a combined high-level risk assessment and high level benefit-cost analysis. Order of magnitude estimates are made of the likely costs and benefits of proposed information products (including the preparation of statements relating to qualitative benefits).

Criteria to select and prioritise a representative set of information products to undergo preparation of detailed product descriptions include:

- analysing the number of programs / processes / clients likely to benefit from having access to the information generated by the information product;
- comparing risks associated with each information product not proceeding, by grouping them into categories of concern (high; medium; low);
- assessing the extent to which the proposed products contribute to risk reduction across agency programs;
- estimating the order of magnitude of tangible benefits (categories of benefit are direct cost savings leading to a reduction in government expenditure; benefits to the agency and future and external benefits; and the significance of qualitative benefits, such as social and environmental considerations);
- gauging stakeholder consensus on the level of risk associated with information products not proceeding;

Figure 2 shows how the benefit scan process was applied to develop a framework of representative information products to seed the development of the Queensland Spatial Information Infrastructure.

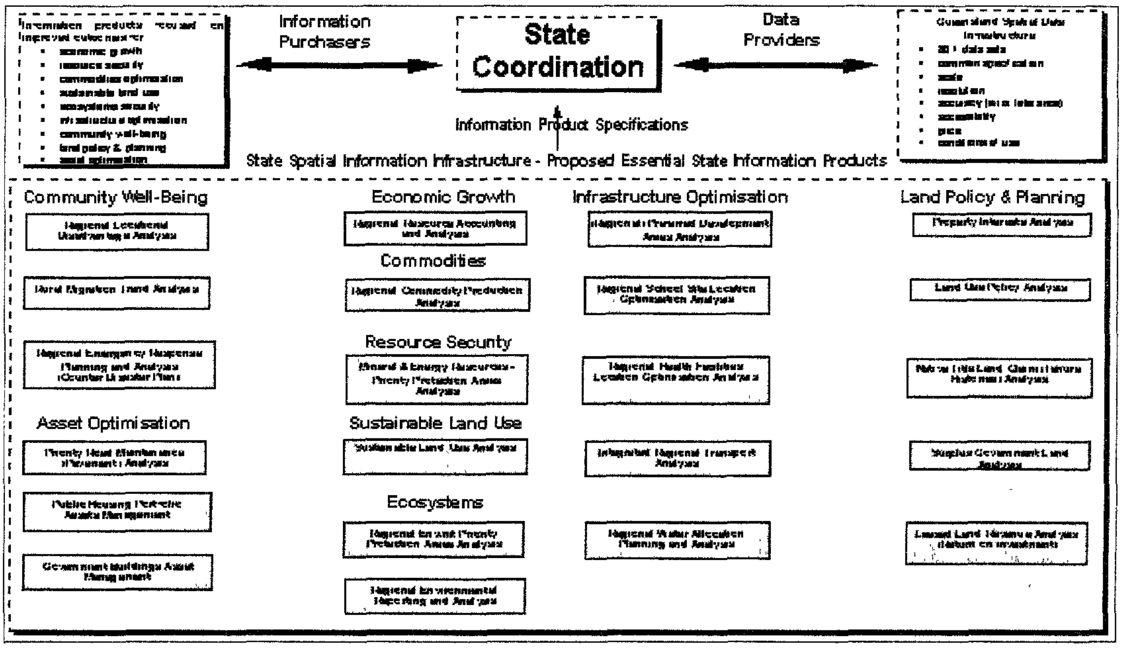

Fig. 2 Example: Information Products Comprising the Queensland Spatial Information Infrastructure (Alexander Tomlinson, 1997)

Step3 Information Product Descriptions

The task of describing information requirements is supported by methods proven to be effective for more than a decade. It is essential that professional staff describe the maps and reports they need to meet their responsibilities, and that senior management considers the time and effort put into this task as a necessary part of the departmental workload. In overview, an information product description requires consideration of:

- Map and List Output Requirements
- Data Requirements
- System Functions
- Frequency
- Data Linkages

- Error Tolerance
- Costs
- Benefits
- Master Input Data List
- Data Volume

The potential impact of these assessments on the costs and benefits of implementing each information product is discussed below:

Map and List Output Requirements

The first task is to describe the output maps and lists that have to be produced by the system. Standard forms are used for this purpose. Inaccurate specification of requirements at this stage of the planning process can have a major impact on the estimated costs of generating information products. Information that is too detailed adds unnecessarily to the cost of data supply. Conversely, insufficient detail may seriously jeopardise decision-making capability.

Data Requirements

Identification of map and list requirements leads to the identification of the data sets that must be incorporated into the system to produce the required information.

Consideration of error in the data leads to an understanding of the level of data accuracy required for a specific purpose. Increased data accuracy usually results in an exponential increase in the cost of data collection and conversion programs. Conversely, data of insufficient accuracy can have a major impact on decision-making, that in the worst case may lead to loss of life, or damage to property or the environment (eg. in emergency response applications). The GIS planning process minimises the risk of poor data investment, given that data costs can be in the order of 80 per cent of the total cost of implementing a GIS.

System Functions

A further outcome of the planning process is the identification of a complete set of system functions required to create each information product (and the frequency that they are applied). This information is used to select GIS software with appropriate functionality. Failure to consider system functional performance when selecting GIS software can significantly add to the costs of generating information products.

Frequency

For each information product, the frequency of output maps and lists generated is determined. These estimates have implications for hardware and staff resourcing costs required to deliver the system outputs.

Data Linkages

Significant additional costs are often involved in retrospectively adding data elements to create links between data sets. Understanding the relationships that must be established to 'connect' data sets required to create information products is critical to reduce the cost of data development, and to facilitate multi-agency data sharing. Missing data linkages may prevent the product from being created, and the achievement of expected benefits.

Error Tolerance

The importance of creating national data sets with 'acceptable' error levels is a trade off between 'fitness for purpose' and cost, that must be considered in a multi-agency environment. Data duplication is likely to occur (to satisfy specific user requirements) unless the majority of stakeholders can agree on an acceptable level of error.

Costs

Cost-effectiveness analysis (cost cost comparison), is used to compare the baseline cost to produce the information product now, using manual methods, compared to the cost of producing the product using GIS. In the past, some systems have been justified on the savings associated with the replacement of manual mapping applications with digital mapping techniques. In a well-planned GIS, such benefits could be expected to be small in comparison to the magnitude of potential benefits of improved business performance. Estimates of cost effectiveness are often used to justify GIS investment when mainly intangible benefits are encountered in conventional cost-benefit analysis.

The cost components required to undertake cost-effectiveness and cost-benefit analysis are grouped under six main categories: hardware, software, applications development, data, staffing and site establishment costs.

Full costs of spatial information systems implementation are included in the assessment of new GIS sites. Only the incremental costs of the enhanced activities associated with implementing the information product are included in cost estimates for existing GIS sites.

At this point in the planning process, it should be noted that the strategy for implementing multiple information products at a site will have a major bearing on the cost items listed above. For example, hardware may be 'sized' to generate one or many information products at a site; data set specifications may change in the light of demands for increased data accuracy, from agencies using external data sources to generate their information products.

As cross-agency considerations such as these cannot be resolved until all related or dependent products are described, preliminary cost estimates are prepared for each information product using the cost model components outlined below (yearly expenditure identified for a 6 year planning period):

- Hardware : Includes the cost of computers, storage devices, backup systems and related data input / output devices. Where spatial information is already well established in an organisation, only the additional hardware resources needed to support the development and delivery of the information product are included. Upgrades and ongoing hardware maintenance costs are included in the assessment.
- Software : Includes costs for DBMS and GIS software and license renewal fees. (Operating system software, etc., is included in the hardware purchase).
- Applications : Includes the cost of customised software and any application specific user interface development required to support each information product; together with programming costs associated with data input and analysis required to establish a working product.
- Data : The costs associated with data acquisition, such as editing, conversion, update, reconciliation and maintenance are compiled for each data set.
- Staff Costs : Includes any additional staff required to operate the system,

staff training and related costs incurred in establishing a competent user base needed to deliver output maps and reports. The development of user-friendly, menu-driven interfaces (GUI's) within a web based Intranet or Internet environment, can greatly simplify the task of creating or accessing information products. As a result, extensive training of staff / users is not generally required. Staff awareness of spatial analysis concepts; and training of staff to use customised software, is considered to be part of the recurrent departmental staff budget. (Staff required to support product development are included under applications development).

- Site Establishment : Costs include site preparation (including site security), communications and networking, intra and inter agency system interfaces, and set up costs, fees and charges associated with establishing web sites. Costs associated with publishing and maintaining data on the World Wide Web must also be included.

Benefits

The main categories of benefit included in the cost-benefit analysis are:

- Cost Savings

  Examples of cost savings are:
  - a decrease in person hours required to carry out a specific task
  - a reduced level of expenditure to provide the same output
- Benefits at the Agency Level

  Examples of agency benefits are:
  - benefits accruing to the agency acquiring GIS, attributable to the new information generated by GIS
  - beneficial changes in operating procedures
  - increased effectiveness of planned expenditures (more output for less cost)
  - increased revenue
  - reduced risk of poor investment
  - reduction in liability

- development of more sharply focused policy options

• Future and External Benefits

Examples of future and external benefits are:

- benefits that accrue to agencies other than those acquiring GIS (eg. in other parts of government, or to the public good).

Within these three main categories, benefits can be further qualified according to whether they are quantitative or qualitative assessments, have an internal or external impact; or relate to the current or future business environment.

Benefit-cost analysis must be credible and easily replicated by independent reviewers. Cost and benefit assumptions must be explicitly stated, their rationale to decide on the level of benefit clearly documented; the strengths and weakness of such assessments reviewed; and the sources and nature of uncertainty in the data characterised. Both tangible and intangible benefits and costs need to be considered in the same way. Risks associated with the likelihood that the estimated level of benefit will not materialise should also be clearly documented.

It is most important that the department concerned can defend claimed benefits. These benefits play an important role later in the study when cross-agency priorities are assigned to each information product. Departments could also expect to be held to account in subsequent performance reviews, to demonstrate that benefits have been achieved.

Master Input Data List

Descriptions of all data sets required to create information products are compiled in a Master Input Data List (MIDL). The MIDL is effectively a meta data description for each data set taking into account data source; extent of coverage/percentage availability, graphical and textural characteristics; complexity; volume; etc. From the MIDL, a much clearer indication of the costs of data acquisition; data upgrade; and sustainable data maintenance can be determined.

Data Volume

Based on the frequency of generated output maps and reports, system functions utilised and data availability, it is possible to calculate the data-handling load per user group, per year. Conversely, where digital data is not currently available, an estimate (by year) can be made of the data that must be made available to accomplish a nominated workload. Sound estimates of data volume associated with each information product lead to more accurate estimates of hardware processing and data storage requirements.

3.2 Phase2 Identification of Costs and Benefits of Coordinated (Multi Agency) National GIS Development

Phase 1 of the planning process presented a methodology to identify costs and benefits of individual information products. Costs and benefits associated with the development of multiple products within the framework of a National Information Infrastructure must now be determined.

Although users are likely to demand that all information products are generated in the first year, constraints that will have a major influence on which products can be developed first include data availability, cost of data acquisition and conversion, availability of trained staff and processing capacity.

In phase 2, these considerations are brought into the cost model for national GIS development. This is achieved by the following steps:

Step4 Scoping of Multi-Agency Integrated System Design

Scope of National Implementation Project

The information products described at Step 3 will need to be scheduled for staged development over the 6-year planning period. This requires priorities to be assigned to each information product. Normally this task is addressed firstly by a Steering Committee established to manage the project, which then makes its recommendations to an Executive Committee.

Criteria to prioritise information products include:

- revenue generation potential
- improved client services
- internal efficiency cost savings
- reduction in risk or liability
- environmental benefit

- public safety / public good
- political sensitivity
- magnitude of tangible benefit
- comparatively lower cost of production
- greater availability of data
- quality of data
- ratio of benefit to cost / difference between benefit and cost

Once priorities have been assigned to information products, and sponsoring agencies nominated, the following reviews are completed for sets of related and dependent information products: (- for each information product, the impact on costs and benefits is determined).

Considerations influencing the assignment of priorities for product development include:

Potential data processing constraints		Impact on Cost / Benefit
• Data handling load	→	Cost of hardware / storage.
• Data availability requirements	→	Distributes data costs over 6 years.
Opportunities		
• Multiple data use potential	→	Sharing costs of data conversion / maintenance.

Step 5 Conceptual System Design (Data)

The next step in the GIS planning process is the conceptual design of the data model. This may include adding logical linkages and upgrading database structures so that they are optimised for the type of analysis required to generate the information products.

From the individual product descriptions, the data specifications for related products are reviewed to create a conceptual data model (eg. to serve land administration functions), with appropriate attributes and attribute linkages defined. This may lead to some rationalisation of data structures with the potential to increase or decrease costs of data base development, depending on the extent of modification required.

Conceptual design considerations include:

Potential to Increase Data Costs	Impact on Cost / Benefit
• Data accuracy	► Cost of data collection / conversion
• Data standards	► Cost to modify / upgrade to comply
• Data conversion	► Cost of conversion / translation costs Time to deliver benefits over costs

Step 6 Conceptual System Design (Technology)

Step 6 addresses the need to accurately specify hardware and software requirements to efficiently generate the number of information product maps and reports at each site.

System functions are determined for all proposed information products to be processed at the GIS site to assist in specifying software functionality and hardware requirements. Highest priority functions are those that are used most frequently and must be performed very efficiently by the system. The system utilisation functional requirements could be expected to differ for every department, based on the specific set of information products to be developed at each site.

Other technology considerations include:

Potential Technology Costs	Impact on Cost / Benefit
• System interface requirements	► Additional hardware / software costs.
• Data communication	► Cost of connecting to LANS & WANS. Lower costs cooperative processing.
• Hardware and software	► Improved accuracy of cost estimates through GIS planning process. Time interval to next upgrade.

Step 7 National GIS Implementation Strategy

The implementation strategy addresses a number of institutional issues and additional cost items that must be addressed at the multi-agency level. These include:

- Institutional interaction / cooperation
- Existing hardware / software
- System requirements definition
- Security analysis
- Staffing
- Training
- Data communication
- Hardware and software

Cost / benefit impacts of the implementation strategy include:

Potential Implementation Costs/Opportunities	Impact on Cost / Benefit
• Institutional interaction →	Shared costs of system development Increased benefit Integration costs
Fasterprogress-standards/coordination	
• Existing hardware / software →	Cost of migration to new system
• System requirements definition →	Cost of consultant services
• Security analysis →	Cost of security upgrade
• Staffing →	Costs of additional staff
• Training →	Costs of staff training program
• Data communication →	Cost of connecting to LANS & WANS.
Lower costs cooperative processing.	
• Hardware and software →	Improved accuracy of cost estimates

Once these issues have been addressed, the cost model and cost-benefit analysis for the national GIS implementation can be finalised.

• Cost Model

Individual information product cost models developed in Step 3 include allowances for hardware; software; data; staff; applications development, and site costs such as communications and interfaces. Based on the strategy for developing information products at each departmental site, a cost model for each site can be developed from the individual product cost models. The departmental site cost models can then be represented as a national GIS implementation cost model, taking into account the adjustments required to costs and benefits associated with the operation of an integrated national system.

• Cost-Benefit Model

Benefits are treated in a similar way to costs, outlined above. Benefits for individual products determined in the Requirements Study are converted to departmental site benefits, and then into national system benefits.

This approach generates sets of cost-benefit figures for GIS implementation by department; and at the national level.

The cost-benefit analysis prepared for the State Government of Victoria, Australia, illustrates this approach. In that study, 61 information products were identified across 39 divisions and agencies (Table 1). They have the potential to deliver $312 million of benefit to the state at a cost of $56 million, over the 6 year planning period.

The figures in Table 2 are cumulative discounted benefits and costs for the 6 years 1994 to 1999, associated with the development of the 61 information products across 5 main programs.

It is necessary to discount both costs and benefits to a common year (1994 in the Victorian study, with all figures from 1994 to 1999 originally in constant 1994 dollars). This approach recognises that benefits realised in 1999 in the above example, are less valuable than the same dollar amount of benefit realised today.

The net present value (NPV) of approximately $ 256 million is calculated by subtracting the present value of costs from the present value of benefits.

The benefit-cost ratio is simply the present discounted value of benefits divided by the present discounted value of costs (in this example, 5.5:1). Sensitivity analysis is usually required by Government agencies to assess how changes to parameters such as the discount rate affect the benefit-cost ratio and NPV calculations.

In reality, benefits may lag behind costs by 2 or more years, but for well-planned and managed systems, they could be expected to outweigh costs within a 3 to 7 year timeframe.

Figure 3 shows the break even point where benefits exceed costs for the Land Status and Asset Management program listed in Table 2.

Table 1 List of Information Products Government of Victoria GIS Planning Program 1992-93

(Tomlinson Associates, 1993)

Information Product Title	Information Product Title
School Planning	Cadastral Examination
V-Codes (Health Patient Funding) Analysis	Vicroads Asset Management
Nursing Home Locational Effectiveness	Property Information Request
Country Fire Brigade Response Profile	School Facilities Management
Emergency Services CAD - Police	Urban Lot Chart
Emergency Services CAD - Ambulance	Land Resources
Emergency Services CAD - Fire	Wood Utilisation Planning
Maintenance of Electoral Roll	Groundwater Management
Multiple Administration Boundaries	Geological Exploration & Development
Electoral Query System	Current Agricultural Production
Re-districting	Fish Stock Size
Voter Catchment Analysis	Cultural Resources
Non Voter Analysis	Flora and Fauna
Road Pavement Management System	State-wide Wetlands
State Digital Road Network	Limitations to Agricultural Production
Industrial Site Selection	Land Capability for Statutory Planning
Residential & Industrial Site Evaluation	Land Liable to Flooding
Extractive Industry Interest Areas	Flooded Properties by Zone
State Digital Map Base	Environmental Exclusion Zones
Crown Lands Leasing	Bushfire Threat
Planning Schemes	National Estate Planning
Planning Certificates	Land Suitability - Agricultural Purposes
Property Evaluation	Monitoring Sustainable Farming Practice
Housing - Assets Management	Irrigation District Sustainability
Housing - Contract Formulation	Irrigation Asset Renewals Planning
Services (Utility) Information	Fire Risk
Surplus Land Disposal	Regional Fire Protection Strategy
Tax Class Evaluation	

Table 2 Cost-Benefit Analysis State of Victoria Australia (Tomlinson Associates, 1993)

DISCOUNTED CUMULATIVE COSTS AND BENEFITS	1994	1995	1996	1997	1998	1999
COSTS						
STATE ELECTORAL OFFICE	1,382,200	2,469,800	3,481,300	4,438,400	5,354,800	6,175,300
LAND STATUS & ASSETS MANAGEMENT	7,526,300	13,072,200	16,696,100	19,460,700	21,259,600	22,939,600
EMERGENCY SERVICES	0	1,995,000	3,530,000	5,340,000	5,887,000	6,096,000
HUMAN SERVICES	81,500	130,900	176,800	219,600	259,200	296,200
NATURAL RESOURCES	3,327,200	7,298,200	10,188,000	12,262,800	13,933,200	15,486,700
PLANNING & INFRASTRUCTURE	1,828,100	2,826,700	3,508,100	4,146,500	4,731,400	5,276,200
TOTAL COSTS	14,146,300	27,792,800	37,580,300	46,857,000	51,425,200	56,270,000
BENEFITS						
STATE ELECTORAL OFFICE	1,579,400	3,046,600	4,437,400	5,815,100	7,051,000	8,363,900
LAND STATUS & ASSETS MANAGEMENT	2,483,700	12,336,300	29,697,100	53,876,700	79,351,800	105,475,000
EMERGENCY SERVICES	0	3,028,000	8,522,000	16,393,000	23,685,000	30,466,000
HUMAN SERVICES	395,200	3,467,400	6,324,600	8,981,500	11,413,000	13,674,200
NATURAL RESOURCES	5,304,500	19,891,300	46,081,100	75,566,900	108,344,400	139,805,800
PLANNING & INFRASTRUCTURE	3,474,600	3,142,300	6,284,600	9,207,000	11,924,800	14,462,300
TOTAL BENEFITS	13,237,400	44,910,900	101,346,700	169,840,200	241,770,000	312,237,200
BENEFIT:COST RATIO	0.94	1.62	2.70	3.70	4.70	5.55

※ Cumulative discounted (7 %) benefits and costs for the 6 years 1994 to 1999.

4. Strategies for National GIS Development

It has been shown how a comprehensive GIS planning process can be used to estimate costs and benefits for a representative set of nationally significant information products. The process also contributes to a better understanding of:

- strategic development options for GIS implementation (to maximise benefit and minimise cost)
- the potential scope of a National Information Infrastructure
- the institutional and operating requirements necessary to optimise the delivery of output products and services
- the framework required to monitor performance of a national GIS implementation

4.1 Strategic development options

The preparation of detailed information product descriptions leads to a clear understanding of the benefits and costs of a range of multi-agency, national GIS development options. The process encourages full participation from stakeholder groups; and takes into account any existing strategic planning directions over a 5 to 10 year planning horizon. The approach identifies a critical path for data acquisition, supporting development of the most important information products first.

4.2 Potential Scope of a National Information Infrastructure

The representative set of information products selected to seed the development of a National Information Infrastructure are screened at the outset to ensure that only products of national importance proceed to the next level of detailed product description. While other products could have been identified, the selected products are intended to thoroughly test the data structures and standards required to establish a national spatial data infrastructure.

4.3 Institutional and Operating Requirements

The success of a national GIS implementation depends on key agencies accepting responsibility for progressively developing priority information products, according to agreed standards and specifications. With a clear description of the outputs required from a national GIS implementation, institutional and operating procedures can be designed to streamline delivery of the specified information products. Similarly, accelerated funding programs can be targeted to product development of maximum benefit to the nation.

The planning process can also assist government to identify an appropriate operational and administrative infrastructure, to undertake system development and data conversion, including the pursuit of strategies to foster the development of a strong private sector industry specialising in value - added products and services.

4.4 Framework to Monitor the Performance of a National GIS Implementation

The information product approach provides a suitable framework for periodically reporting on the benefits expected to arise as each information product becomes available. Given the rapid rate that technology is changing, it is recommended that the GIS planning process is repeated every 18 24 months, involving a wide range of stakeholders, to assess whether key users are actually receiving the benefits identified during the planning phase.

5. Conclusions

This paper demonstrates how a systematic GIS planning process focused on information products can be used to analyse the costs and benefits of GIS development at the national level.

The information product approach has many advantages over less formal methods of cost-benefit analysis, including techniques to establish priorities for information and data based on the level of benefit generated by each information product. The step by step methodology systematically identifies all significant costs associated with developing and maintaining a GIS. The product approach is also useful to monitor the delivery of benefits over the long term.

The approach is also scaleable; making it is equally applicable to an individual agency, or for use in a multi-agency environment.

It has been clearly demonstrated that GIS planning provides comprehensive information to assist managers to lower the risk of poor investment in hardware, software, data, human resources and communications infrastructure. It also leads to a better understanding of the institutional and administrative frameworks required to support information product development.

Pressure to reduce government expenditure (drive down costs) provides strong incentive to use credible cost-benefit analysis and risk assessment techniques to identify priorities for national GIS development. Thorough cost-benefit analysis using the methodology outlined in this paper can assist to direct scarce GIS resources to areas of greatest benefit.

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The comprehensive cost - benefit analysis techniques discussed in this paper, were developed over the last 20 years by Dr Roger Tomlinson, Tomlinson Associates Ltd., Ottawa, Canada. (Dr Tomlinson is widely recognised as the pioneer of geographic information systems as we know them today). His GIS planning methodology (GISPLAN) referred to in this paper has been used to substantiate GIS investment by an extensive list of federal, provincial, state, municipal and corporate agencies throughout North America, Europe and Australia; and in developing nations of the world through World Bank and FAO sponsored initiatives.

Trends In Geographic Imaging

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ABSTRACT

The Geographic Imaging community is undergoing a revolutionary change. Since the launch of the first satellite in the early 1970s that provided commercially available satellite imagery, the industry has remained relatively unchanged. However, several technological and political factors are converging to revolutionize the industry. One of the primary influences is the recent change in governmental policies allowing commercial companies to build and launch satellites with capabilities that were never before available to commercial users. More and more sensors are coming on-line that offer better spatial, spectral and temporal resolution. The new data sources are making it economically feasible for numerous industries to implement new strategies utilizing imagery for their daily activities. At the same time, hardware technology continues to move forward in leaps in terms of processing speed, network speed, graphics capabilities, data storage capacity, and cost. These changes are bringing the Geographic Imaging market out of the back room and into the hands of a wide range of new users that could have never dreamed of utilizing the technology in years past. Not long ago remote sensing and image processing were tools that could only be utilized by scientists with extensive education in the field. Now this technology is beginning to be put in the hands of a greater base of users that are less interested in how the technology works and more concerned with solving their particular application. Soon other technologies

such as photogrammetry and radar processing will be moving into the hands of these users. ERDAS is working to meet the challenge of providing easy to use tools that are appropriate for all levels of users within an organization.

요 지

이미지는 혁명적인 변화를 가져왔다. 위성사진을 제공한 1970년대 초의 첫 번째 위성의 발사이래로 이 산업은 비교적 변화없이 유지되어 왔다. 그러나 몇가지 기술적이고 정치적인 요소들이 산업의 변화를 가져왔다.

첫번째 영향은 이전에는 상업적인 이용으로는 절대 사용하지 못했던 위성을 상업회사에서 만들고 발사할 수 있도록 허가해준 최근의 정치적인 변화가 그것이다. 더 좋은 공간, 스펙트럴, 시간해상력을 가질 수 있도록 더 많은 센서들이 설치되었다. 동시에 하드웨어기술이 속도, 네트워크 속도, 그래픽능력, 데이터저장능력과 비용면에서 괄목할만한 도약을 계속해왔다. 이러한 변화들은 과거의 기술로는 꿈도꾸지 못했던 새로운 사용자들을 통해서 지리영상 시장을 이끌어왔다.

최근에 원격탐사와 이미지프로세싱은 야외의 교육현장에서 과학자들에 의해서만 이용되었다. 그러나 최근에 이기술은 특정한 분야의 이용과 관련되어 이용자들이 늘어나고 있다. 곧 사진측량과 레이더프로세싱과 같은 다른 기술이 이러한 이용자들에게 익숙해질 것이다.

1. What is Geographic Imaging?

The collection and processing of data from satellites has traditionally been called Remote Sensing. Likewise, the processing and analysis of aerial photographic data has been called Photogrammetry. In a third category, Geographic Information Systems (GIS) have traditionally been viewed as working on tabular and vector based datasets only. In the 1980s, the three technologies were individually addressed by a number of companies. No one company or product was able to provide solutions to problems in the three areas.

In the 1990s, Remote Sensing, Photogrammetry and GIS have been drawn together into a single entity that we at ERDAS call Geographic Imaging. A simple definition of Geographic Imaging is:

The processing and analysis of imagery of the earths surface to the highest possible accuracy, combined with geographic Information to aid in enhanced decision making

Users of Geographic Imagery can be split down into three broad segments:

- The Remote Sensing and Photogrammetry market (comprised of imagery aware users)
- The GIS market (geographically aware users)
- The Engineering and CAD market (imagery naïve users).

2. Trends in the Geographic Imaging Market

The Geographic Imaging community is undergoing a revolutionary change. Since the launch of the first satellite in the early 1970s that provided commercially available satellite imagery, the industry has remained relatively unchanged. However, several technological and political factors are converging to revolutionize the industry.

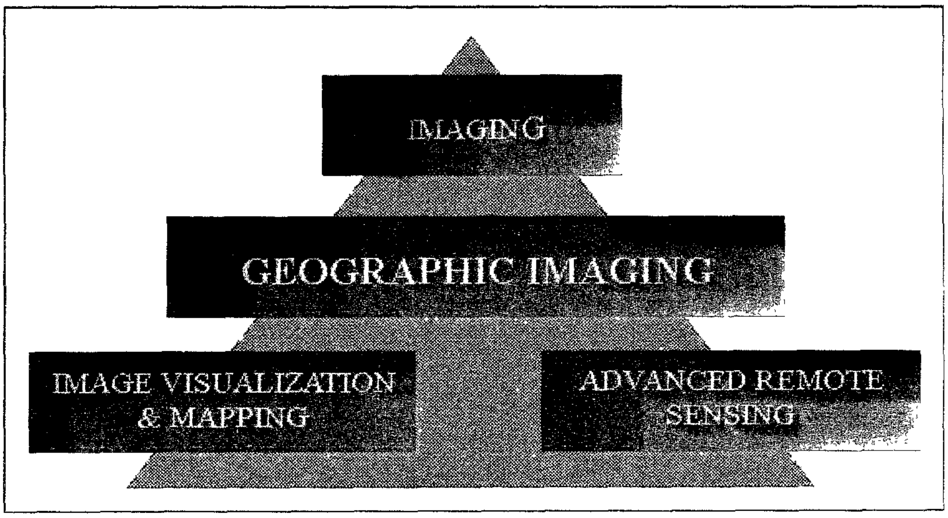

fig 1. Geographic Imaging Components

2.1 New Data Sources

One of the primary influences is the recent change in governmental policies allowing commercial companies to build and launch satellites with capabilities that were never before available to commercial users. This relaxation of national laws and policies has primarily occurred in the US, Russia, and France. Another factor is the technological advancements that are occurring in satellite and rocket technology. These advancements are allowing more and more commercial companies and more nations to develop, exploit, and commercialize space-based imaging.

These changes have resulted in new sensors coming on-line that offer better spatial, spectral and temporal resolution For the first time commercial companies can acquire and sell satellite imagery with spectral resolutions as low as 1 meter. Many of these new sensors also offer multispectral capabilities, and commercially available hyperspectral imagery acquired by satellites is just over the horizon. The explosion of available data will especially be beneficial for temporal studies such as change detection applications, which require frequent revisiting of the same location of the earth. The new imagery vendors are also very cognitive of the need for quick processing and distribution of the data once an image has been acquired. This is necessary for applications such as agriculture where a 3-month-old image is worthless, but a 1-day-old image could mean the difference between the success and failure of a crop. The new data sources are making it economically feasible for numerous industries to implement new strategies utilizing imagery for their daily activities.

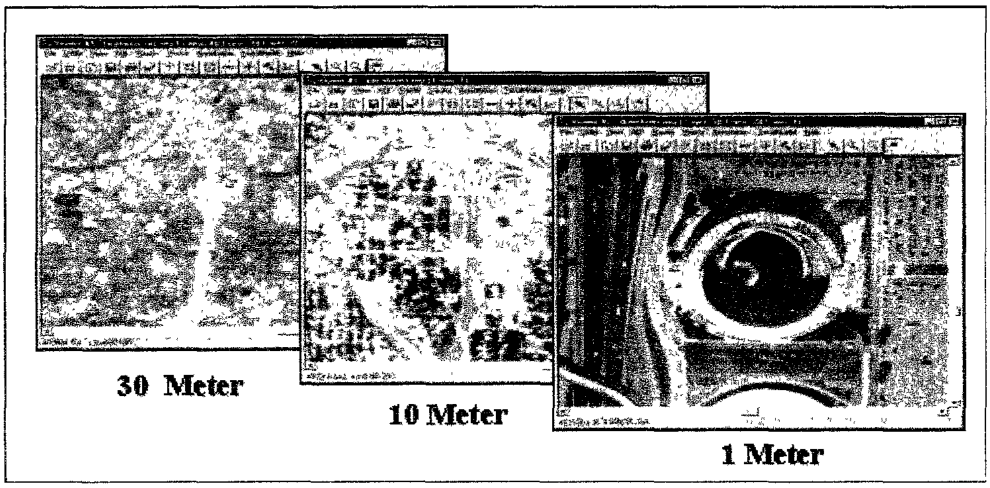

fig2. Resolution(Spatial)

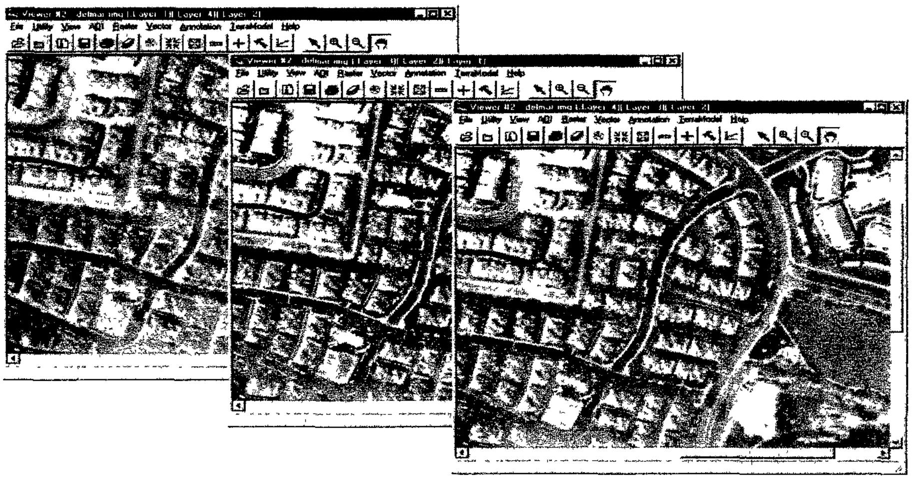

Fig 3. Resolution(Spectral)

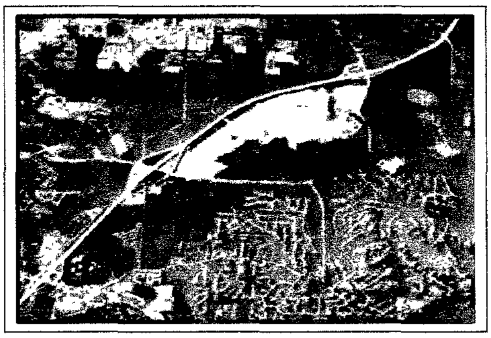

Fig 4. Resolution(Tempolral)

2.2 Hardware Improvements

At the same time, hardware technology continues to rapidly advance in leaps in terms of processing speed, network speed, graphics capabilities, data storage capacity, and cost. Geographic data, especially imagery, can be very large and consume huge amounts of system resources in order to process. In the past the hardware necessary to process geographic imagery data could be cost prohibitive to many organizations. These limitations are being removed with the continuing improvements in system performance and decrease in hardware costs.

2.3 Integration and Consolidation

Remote Sensing and Photogrammetry have been the traditional market addressed by Remote Sensing software packages. Users tend to be trained in the usage of imagery, either on the scientific side (universities, R & D organizations) or on the photointerpretation side (military, oil & gas etc.). These professionals use a broad range of imagery in a wide variety of formats and carry out somewhat complex operations on imagery, ranging from aerial triangulation through image enhancement to land cover classification.

The GIS market is the one of the highest growth areas in computer software. The manipulation of geographic information (of which imagery is one source) is finding applications in areas as diverse as route finding for delivery drivers, environmental monitoring and urban planning. The usage of imagery within GIS is very scale dependent. With the launch in 1998 of the Space Imaging IKONOS satellite, able to provide 1m resolution imagery, applications at scales as low as 1:2400 can be addressed. Imagery will not only be used for base mapping, but also for map updating, impact assessment and visualization and modeling.

The Engineering and CAD market has the highest installed base of users of any of these markets. Primarily a PC based market, the applications tend to be at scales of 1:2000 and below, which tend not to lend themselves to imagery. However, as space-borne imagery begins to provide higher resolution data and desktop scanners become geometrically accurate enough to scan aerial photos, the usage of imagery data for base mapping and visualization will proliferate.

None of the technologies can stand-alone anymore. Instead, they are integrated into solutions oriented software able to address the requirements of a new breed of user who wants fast, accurate information upon which to make critical decisions.

3. How is ERDAS Preparing to Meet these Challenges

ERDAS is responding to the changes in the Geographic Imaging market in many ways. By developing innovative and advanced products, ERDAS is remaining a technological leader in the industry. But just as importantly ERDAS is paying close attention to developing products that focus on connectivity, standards and integration with other leading software packages.

As the use of imagery moves form the world of scientists and highly trained image interpreters to a broader range of users, software developers must expand their product line. For years ERDAS has offered the successful IMAGINE product line aimed at the professional remote sensing users. But recently two new product lines have been developed to meet the needs of other users.

The MapSheets product line was introduced for users that want to integrate Geographic Imaging into their desktop environment. MapSheets utilizes Microsoft standards and operates within the Microsoft environments. Uses can quickly create maps from geographic information and embed these maps into other applications such as Microsoft Word, and PowerPoint. Analysis on geographic data can also be done in the familiar Microsoft Excel package including using Excel tools to create tables and graphics associated with the geographic data.

The latest product line from ERDAS is the ArcView Image Analysis extension. The ArcView Image Analysis extension is designed to easily manage, display and manipulate a wide range of image data within the ArcView GIS environment. This product is designed to be simple to use for users that are geographically aware but not necessarily imagery aware.

Of course ERDAS is continuing to develop new products in the IMAGINE product line for the more advanced remote sensing users. New products are being developed in the photogrammetric area as these technologies continue to converge with traditional image processing. The OrthoBASE product is designed for block triangulation and orthorectification of many sources of imagery. A product called StereoBASE is also being developed to facilitate the collection of 2D/3D features in a stereo environment.

ERDAS has also recognized the need for new tools in the area of radar processing. By releasing the Radar Mapping System, ERDAS will have a complete suite of products for Orthorectification of radar imagery (OrthoRADAR), and DEM extraction from radar images (StereoSAR DEM & IFSAR DEM).

4. Summary

Over the next few years all indications are that Geographic Imaging market will experience tremendous growth. Many commercial companies are expending a great amount of effort to develop and market new sources of geographic imagery. These new sources of data that offer capabilities that were never available in the past will bring the use of geographic imagery to a much broader range of users. ERDAS is prepared for this new market through the development of new product lines that address the needs of the new user and through the forging of industry partnerships and the recognition of industry standards.

GPS Upgrading and Updating Spatial Database

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ABSTRACT

Until recently, most GIS databases are created using hand digitizing or scanning of existing analog data. These converted data often come from a variety of sources and of different accuracy. Spatial database is good only if its spatial and aspatial data are current and often the updating or upgrading may took several weeks or months using traditional field techniques. With the wide acceptance of GPS as an alternative tool for data capture, this task can now be carried out in a more efficient and effective manner. This presentation will discuss the evolution of GPS and introduce the various GPS solutions for upgrading or updating GIS databases.

요 약

최근까지 대부분의 GIS 데이터베이스들은 기존의 아나로그데이터를 스캐너하거나 디지타이징함으로써 구축되었다. 이러한 변한 데이터의 출처는 종종 다양한 소스로부터 획득 되었거나 여러 가지 다른 정확도를 가지고 있다. 공간데이터베이스는 그 공간정보 혹은 비공간정보가 최신의 것일 경우에만 유용하다. 전통적 현장 테크닉을 사용하는 데이터 갱신과 개량을 하는데는 아마 수주일 혹은 몇 달정도 걸릴 것이다. 데이터 획득의 대안으로서 GPS를 사용한다면 이러한 작업은 현재 좀더 효율적이고도 효과적인 방식으로 수행될 수 있다. 이번

프리젠테이션은 GPS의 개선점들을 논의하고 GIS 데이터베이스들의 갱신과 개량을 위해 다양한 GPS 솔루션을 다룰 것이다.

1. Introduction

Various form of data capture methodology are available for GIS, which includes hand digitising or scanning of existing paper maps. These converted data often come from a variety of sources and of different accuracy. In order to maintain a useful spatial database, these spatial data needs to be upgraded or updated in order to maintain its currency. Upgrading or updating may take several weeks or months using traditional field surveying method. With the wide acceptance of GPS as an alternative tool to deal with this upgrading or updating task, this task can now be carried in a more efficient and effective manner. In most data capture operation using off-the-shelf GPS solution is often sufficient, however, there are situation where custom integration of GPS and GIS is required. This paper will discuss; the use of GPS for GIS data capture; the concept of GPS; method and resources of getting accurate observation for GPS data capture; finally, an integrated GPS/GIS solution for customised data capture needed for efficient field data collection is described.

1.1 Why use GPS for GIS Data Capture?

GPS is an excellent data collection tool for creating and maintaining a GIS. It provides accurate positions for points, lines, and areas, making it ideal for many GIS applications.

GPS can also be used to relocate to previously recorded sites for inspection, maintenance and update of GIS data. Even when the locations of features are already known GPS provides an excellent tool for GIS update and validation. This is because many features look the same and it is easy to accidentally inspect or maintain the wrong feature. With GPS, spatial and aspatial features can be verified on-site. (Morag Chivers AURISA 1997)

1.2 What is GPS?

GPS is a satellite based positioning system operated by the U.S. Department of Defence (DoD). GPS involves three segments, satellites, ground control and the user.

Satellites

There are 24 NAVSTAR satellites orbiting the earth every twelve hours at an altitude of about 20,200km. Each satellite contains several high-precision atomic clocks and constantly transmits radio signals using its own unique identifying code. The reason for the high orbit is to reduce atmospheric drag and ensure the orbit is stable.

Ground Control

The ground control segment is the DoD who is responsible for maintaining the system. They have four ground-based monitor stations of which three are upload stations and one is a master control station. The monitor stations track the satellites continuously and provide data about the satellites to the master control station. The master control station calculates any changes in the satellite's position and timing. These changes are forwarded to an upload station. The upload stations transmit this data to each satellite at least once a day to ensure all satellites is transmitting accurate information about their orbit path.

User

The user segment consists of civilian and military users around the world using GPS receivers. GPS receivers use the signals sent from the satellites to determine where the satellites are. This information is then used to calculate the receiver's position on earth. The position information is then used in many applications, including surveying, mapping, vehicle location and navigation.

The Limitations of GPS

Although GPS provides a worldwide, 3D positions, 24 hours a day, in any type of weather, the system does have some limitations. First, there must be a relatively clear "line of sight" between the receiver's antenna and four or more satellites. Anything shielding the antenna from a satellite can potentially weaken the satellite's signal to such a degree that it becomes too difficult to ensure reliable positioning. Buildings, overpasses and other obstructions between the satellite and the observer (GPS antenna), make it difficult to work with GPS. These difficulties are particularly prevalent in urban areas. The GPS signal bouncing off nearby objects may present another problem called multipath interference.

The effectiveness of GPS can be affected by multipath. This is caused when the receiver is unable to distinguish between the signal coming directly from the satellite and the "echo" signal that reaches the receiver indirectlyby bouncing off a building for example (see diagram 1). Advanced signal processing technology (such as Trimble's Everest technology) and well-designed antennas help minimise this.

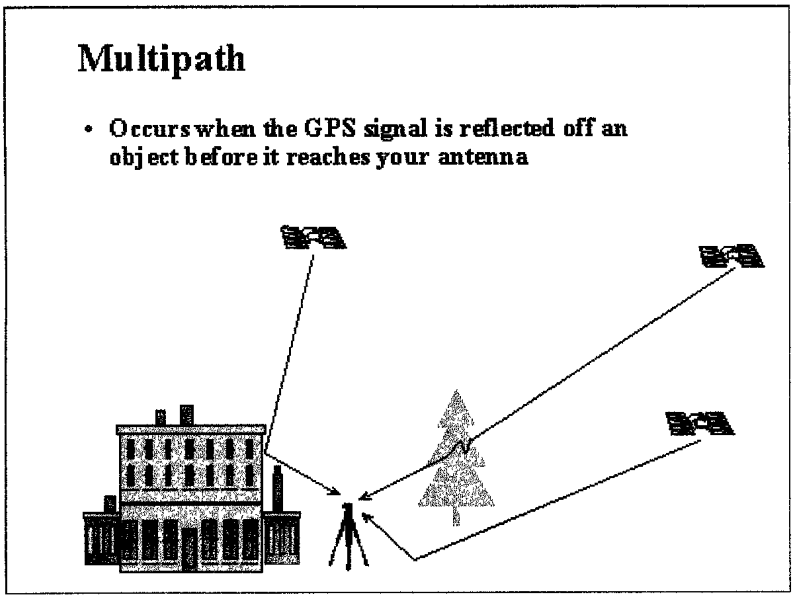

Fig1. Multipath

The receiver must receive signals from at least four satellites in order to calculate a 3D position. In addition, these satellites must be well spread in the sky. This is the norm for areas with a relatively open view of the sky, due to the satellites orbit.

Another significant source of error is Selective Availability (S/A). Selective Availability is an artificial degradation of the satellite signal by the Department of

Defence. It causes errors in a GPS position of up to 100 metres. S/A can be removed using differential correction.

1.3 How a GPS Receiver Calculates Positions

The position of a point is determined by measuring distances (pseudo-ranges) from the receiver to at least four satellites. The GPS receiver knows where each satellite is the instant the distance was measured. These distances will intersect only at the GPS receiver (antenna). The GPS receiver performs mathematical calculations to determine the distance from the satellites to determine its position. The position can be displayed, and saved along with any other descriptive information entered by the operator.

The way in which a GPS receiver pseudo-ranges to the satellites depends on the type of GPS receiver. Basically, there are two broad classes: code based and carrier phase based. Some receivers have the capabilities to collect both.

Receivers: Determining Pseudo-ranges

Code-based receivers use the speed of light and the time interval that it takes for the signal to travel from the satellite to the receiver, to compute the distance from the satellites (see Diagram 2). At least four satellites are needed in order for a receiver to produce a position fix. Position fixes are made by the receiver every second. Due to S/A position fixes are limited to within 100 metres. In order to produce acceptable results, GPS code-based data must be differentially corrected either in real-time, or by Postprocessing. Postprocessing code-based GPS data increases the accuracy of data to sub-metre. Postprocessed code-based data is ideal for applications, which dont require centimetre accuracy.

The carrier phase receivers, used extensively in geodetic control and precise survey applications, are capable of sub-centimetre differential accuracy. These receivers calculate pseudo-ranges to visible satellites by measuring the number of whole and partial wavelengths between the satellites and the receivers antenna (see Diagram 2). Collecting carrier phase data should be considered for applications requiring precise positioning, such as mapping underground services.

1.4 Why use Differential Correction?

A single GPS receiver can only achieve accuracies of around 100 metres due to the sources of error discussed earlier. In order to achieve accuracies of a few metres, or even a few centimetres, data needs to be differentially corrected. The vast majority of people who collect GPS data for GIS differentially correct their data due to the improved accuracy obtained.

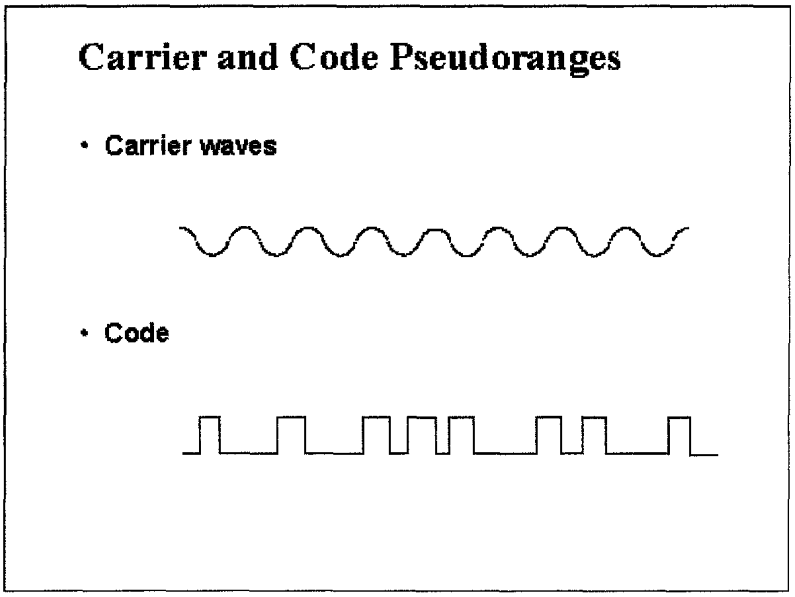

Fig. 2 Carrier and Code

1.5 How Differential GPS Works

DGPS requires a GPS receiver to be set up on a precisely known location. This GPS receiver is typically referred to as a base station or a reference station. The GPS receiver records information from the satellites and compares its GPS location to its know location. This difference is then applied to the GPS data recorded by a second GPS receiver (known as the roving receiver). The corrected information can be applied in real-time (i.e. in the field) using radio signals or by postprocessing (i.e. after data capture) using special processing software.

The underlying premise of differential GPS is that any two receivers that are relatively close together will experience similar errors. By having one receiver at the known location, you can remove all errors that are common to both receivers.

For GIS applications the roving GPS receiver can be up to 500km from a base station. However when higher accuracy data is required, working closer to the base station is recommended. This baseline length will have an effect on accuracy depending on the type of receiver.

1.6 Differentially Correcting by PostProcessing

Differentially correcting GPS data by postprocessing involves a base GPS receiver logging positions at a known location and a rover GPS receiver collecting positions in the field. The data obtained from the base station is used for the differential correction process back in the office. The files from the base and rover are transferred into the office processing software. This software then computes the corrected positions; the resulting file can be viewed or exported into a GIS.

Postprocessed DGPS allows greater flexibility for field crews due to the 500 km maximum distance a rover can be from a basewith good GPS receivers and processing software.

Elevation mask

If it is necessary to work with long baselines, modification of the receiver configuration is important. A parameter known as the elevation mask will set a receiver to use satellites above a certain elevation to compute its position (see Diagram 3). For long baseline work, it is important to set the roving receiver(s) to a higher elevation mask than the base station. This results in the base acquiring satellites prior to the rover when the satellites rise, and continue to track them longer when they set. (see Table 1)

1.7 Obtaining Base Station Data

There are many permanent GPS base stations currently operating throughout the world that provide users of code-based receivers the data necessary for differentially correcting GPS. Depending on the technology preferred by the base station owner this data can be downloaded from the Internet, or via a BBS.

Sources of base station data for postprocessing fall into three categories: public sources, commercial sources, and owning a base station.

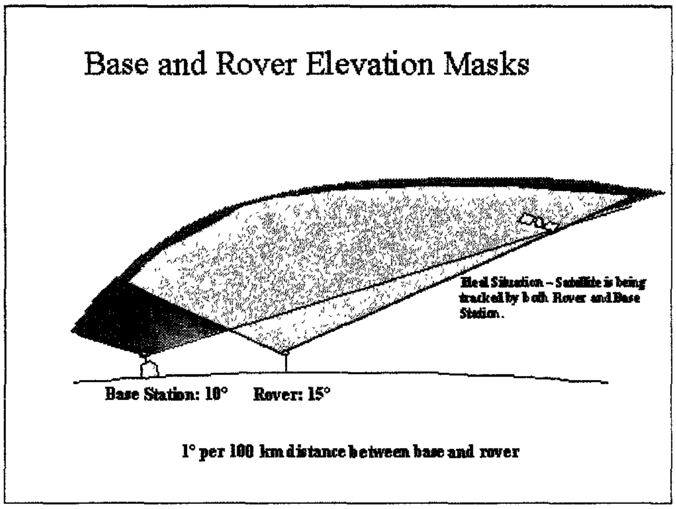

Fig 3. Set Base Elevation Mask Lower than the Roving Receiver

Table 1. Appropriate Elevation Masks for Various Baseline Lengths

For baseline lengths of	Base	Rover
500 kilometers or less	10°	15°
1,000 kilometers or less	5°	15°
1,500 kilometers or less	5°	20°

Public Sources

Government bodies worldwide collect and store base data. However laws regarding public access to government data vary between countries as well as between different government agencies. Agencies that collect differential data have legitimate concerns about offering it to the publicfor example, issues of legal liability and cost recovery.

Commercial Sources

Some consulting companies and universities collect base data. In general this data can be purchased on a per hour or daily rate. You can obtain the details of the base station which is closest to you by browsing the Internet, by calling Base

Station Distributors in your area, or by talking to your local GPS sales representativesthey generally know where base stations have been sold and whether the data is available to the public. This may prove to be the most cost effective way to obtain data for postprocessing

Owning a Base Station

This is the most flexible means of obtaining base data for postprocessing. This way you have your own GPS receiver logging the data you require within the range that is optimal to you. This has set-up costs because two GPS receivers will need to be purchased. If large amounts of data will be collected then the investment is often worthwhile.

1.8 Real-Time DGPS

Real-time DGPS occurs when the base station calculates and broadcaststhe correction for each satellite as it receives the data (see Diagram 4). The correction is received by the rover via the radio signal and applied to the position it is calculating. As a result, the position displayed and logged to the data file of the GPS receiver is a differentially corrected position.

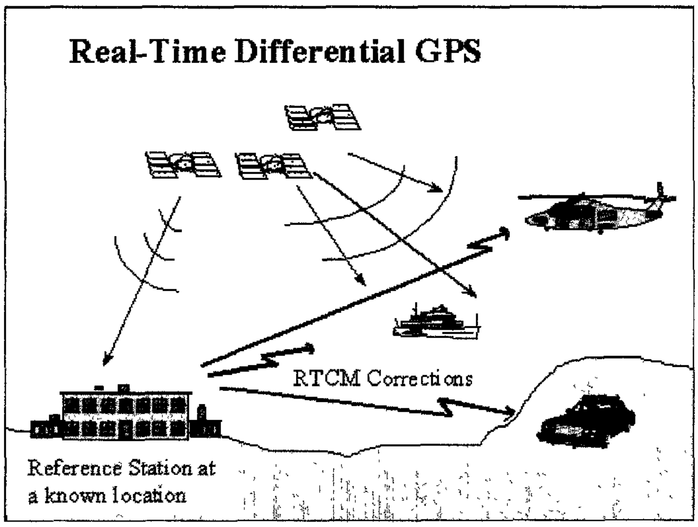

fig 4. Real-Time Differential GPS

The Radio Technical Commission for Maritime Services (RTCM) was set up to define a differential data protocol for relaying GPS correction messages from a base station to a field user. The RTCM SC-104 recommendations define the correction message format. Each correction message has large amounts of information including: data about the station position and health, satellite constellation health, and the correction to be applied. Using real-time differential corrections, you can navigate directly to within a metre of any location on earth depending on the service and the GPS receiver.

The major cost of real-time DGPS involves the expense and maintenance of the telemetry link between the base GPS receiver and the roving GPS receiver(s). The maximum range of real-time differential is limited by the telemetry system. Transmitters with the power to broadcast signal more than a few kilometres usually requires a licence to operate. In addition, digital radio modems are expensive, require additional power and constitute additional weight. If your application does not require accurate coordinates while you are in the field, then postprocessing your GPS data will be sufficient.

1.9 DGPS Radio Beacon Systems

In many parts of the world DGPS radio beacon systems are operational. These stations are part of a large network, which cover many coastal areas, navigable rivers, and more recently inland agricultural areas. Their main purpose is for marine navigation, however they have a range of a few hundred kilometres inland. These stations can provide real-time differential accuracy in the one metre range, depending on the GPS receiver and the distance from the radio beacon. This system offers free and reliable real-time differential GPS, which is ideal, if your application involves relocating features. At present there are a few beacons in Korea, owned by the Ministry of Mineral and Fishery (MOMF) which are scheduled to be operational by the end of 1998.

1.10 Satellite Differential Services for Real-time

Another method for obtaining real-time data in the field is to utilise geostationary satellites. This system uses differential corrections from more than one reference station in order to get corrections for the roving GPS receiver. This is useful when a long baseline is necessary. Reference Stations collect the base station GPS data and relay this (in RTCM SC 104) to a Network Control Centre. The Network Control Centre sends the information to a geostationary satellite for verification. The verified information is then sent to the roving GPS receiver to ensure it obtains GPS positions in real-time.

The area of operation for receiving satellite differential corrections is typically very large, up to 1,000 kilometres. This service is particularly useful if your application is located inland, away from any beacon coverage.

1.11 Postprocessed Real-time Data Collection Method

The postprocessed real-time (PPRT) method of differential correction involves a GPS receiver in the field collecting and storing real-time positions. This data is then differentially corrected with post processing software back in the office to further enhance accuracy

Postprocessed real-time (PPRT) data collection requires additional data to be logged by the GPS receiver. RTCM-corrected GPS positions is worthwhile if the real-time base station you are using is a considerable distance from where you are collecting data, and your postprocessing base station is nearer.

A typical application for PPRT would be to use free real-time services such as the Beacon services mentioned earlier to get typical accuracies of 1-10 meters in real-time for navigation purposes. This data can then be postprocessed in the office to get accuracies as good as sub-metre.

2. GPS / GIS Integration

The integration of GPS into custom Mapping applications is a growing trend. It is therefore worth examining the options that are available for integrators and developers, who are faced with challenge in efficient use of an integrated, customised and specialised data collecting system and would like to build a highly specialised data collecting systems.

GPS/GIS integration enables data to be collected and updated in the field. This minimises the amount of work performed in the office. The field crews can carry out Quality Assurance in the field by doing visual comparisons between the information stored in the database and the real world. Therefore, the data collected does not require further manipulation back in the office, making it more valid and accurate.

This part of the paper will discuss an integrated GPS/GIS solution for efficient and specialised data collection system.

2.1 Ways of communicating with GPS

There are two basic ways an application can communicate with the GPS receiver. One is using an ASCII protocol such as NMEA and the other using the GPS receiver specific protocol. The receiver specific protocol can be used in two ways: a developer can either use an off-the-shelf systems data logger to communicate with the GPS receiver or use software components for GPS to develop an application that communicates with the receiver directly. The following sections examine and evaluate both protocols in detail and look at their benefits and drawbacks for system integration.

2.2 NMEA protocol

NMEA is an interface protocol created by the National Marine Electronics Association. This protocol was originally established to allow marine navigation equipment to share information. It is a simple ASCII protocol, which defines both the communication interface and the data format. Over the years NMEA has become the most common method of interfacing with a GPS receiver. A large benefit of the NMEA protocol is that it is generic and most GPS receivers can optionally provide data in the NMEA format.

However, this common level of compatibility does not allow the user to take advantage of the many special features often present in todays specialised GPS receivers. The communication is only unidirectional with data flowing from the GPS receiver to the field computer. As a result, the application cannot control the GPS receiver. For example the application using NMEA cannot easily store GPS observation data for differential postprocessing to enhance datas positional accuracy. This limitation means that data accuracy is limited to about 100m or data collection professionals must use real-time processing techniques. With NMEA the user does not have the control over the GPS receiver settings, masks and filters which optimise the accuracy and productivity of GPS data collection. Further, the NMEA protocol cannot control real time differential correction settings in the GPS receiver.

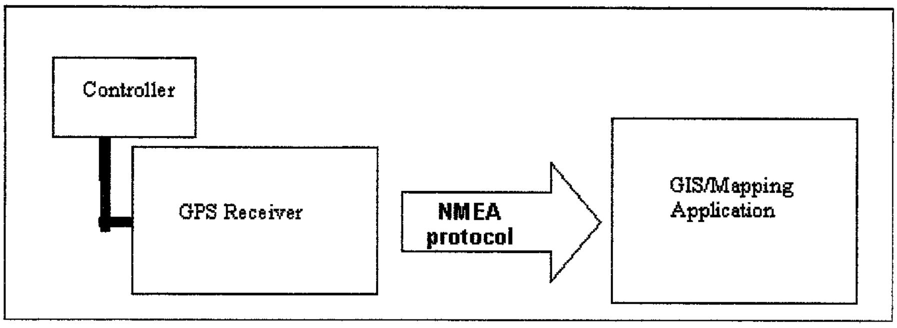

Fig 5. GPS/GIS Interaction using NMWA Interface Protocal

2.3 Receiver specific protocol

A receiver specific protocol is generally defined and maintained by GPS receiver manufacturers. The major benefit of using receiver specific protocol is the ability to fully control the GPS receiver and its configuration, which cannot be done by NMEA. Also, data can be stored in a receiver specific format for differential post processing.

Along with this flexibility, however, comes the responsibility of making intelligent parameter selections consistent with each other and the overall application. This often requires an expertise in GPS technology and good knowledge of the interface (Trimble TSIP Reference, 1998).

System integrators can benefit from the powerful capabilities of a receiver specific protocol in two ways. To develop an application that communicates with the GPS receiver directly you can either: use the data logger that comes with an off-the-shelf system or use the software components for GPS.

In the first set-up (shown in Figure 3.) the application communicates with the GPS receiver via a data logger to form a semi-integrated system. The data logger is a commercial product developed by various GPS vendors. The data logger is an essential part of the data collection set-up as it communicates with the GPS receiver using the receiver specific interface protocol. As a result, the user can take advantage of many special features often present in todays GPS receivers. Most data loggers are capable of storing GPS observations for differential postprocessing. They can usually control GPS receiver settings, masks, and filters to optimise the accuracy and productivity of GPS data collection. For receivers with appropriate capabilities, they can control the real time differential correction from RTCM beacons and communication satellites. This system is semi-integrated, however, because the position is transferred to the field computer in the form of a NMEA string or ASCII equivalent. The application cannot directly interact with the GPS receiver. Also, most of the data loggers contain a number of features that may not be relevant to the field application making the system less compact and focused.

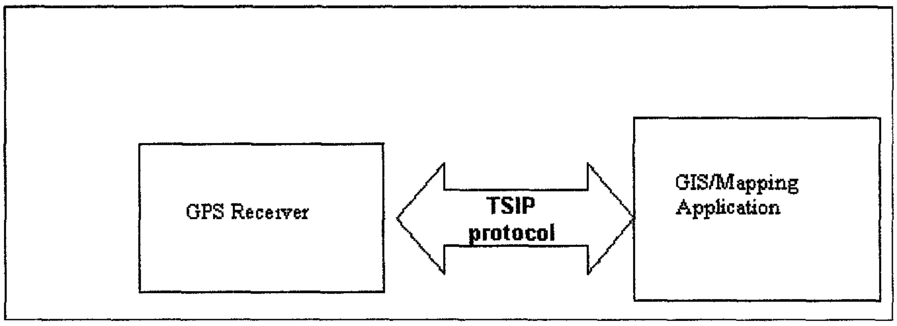

Fig 6. GPS/GIS Interaction using Protocol Interface Protocol

In the second set-up (shown in Figure 6.) the application communicates with the GPS receiver directly. There is no data logger to control the GPS receiver and the custom-built application can communicate with the GPS receiver via the receiver specific protocol. This is possible because the custom application running on the field computer has been developed using software components for GPS.

Software components for GPS unbundle the GPS receiver specific interface and expose it to the developer in the simple form of organised, programmable objects. This means that a developer can use the powerful capabilities of the receiver specific protocol without the intricate knowledge of its interface. Whats more, the software components simplify the GPS integration because they become the building blocks of the application. This allows System Integrators to develop their custom systems quicker and easier.

As object component technology is becoming more popular among developers, some GPS companies are developing software components that allow GPS integration into the custom applications. Trimbles Pathfinder Tools SDK is an example of GPS object components. Most software components are built as ActiveX components that adhere to Microsoft standards. ActiveX components are commonly used in industry, as they allow for application development in 32-bit programming environments (Chappell & Linthicum, 1997). This way, developers can write their applications in the programming environment that they are familiar with such as Microsoft Visual Basic or Visual C++. The applications developed in such environment are Windows compliant and can operate on both Windows 95 and NT platforms.

Some GPS software components may allow fuller control of the GPS receiver then others. The most sophisticated GPS software components will allow the GPS observations to be saved for differential postprocessing. This is an important feature and often a requirement of many GIS data collection professionals as the real-time links are not always available or economic. The control over GPS receiver settings, masks and filters is useful for optimising the accuracy and productivity of GPS data collection. Depending on the GPS receiver used and on the GPS components the developer may be able to control the real time differential correction from RTCM beacons and communication satellites. Some receiver components simplify GPS integration even further by providing developers with components that take care of unit conversions and can transform the collected data into various coordinate systems used world-wide.

In more complex and specialised applications the developer may use GPS components along with other third party software components or software development kits. For example, an application may use GPS components along with mapping or charting components to create a data collecting system that incorporates a GPS position on a background map.

The custom applications built with GPS components benefit GIS data collecting professionals in many ways. GPS can be fully embedded in the field application and the application can communicate directly with the GPS receiver. Also the final product can be lightweight, focused and customised to fulfil data collecting needs.

3. Conclusion

This paper discusses various GPS technology for upgrading and updating GIS and also the benefit of integrating the GPS with custom mapping/GIS application is also shown. Various GPS approach in getting accurate observation is also described which include the postprocessing, real-time differential using beacon, radio-link and satellite.

An approach using an integrated GPS/GIS is also mentioned which reduce the expensive and time consuming process of GIS data collection. This approach uses a more efficient integrated, customised and specialised data collecting system built using Trimbles Pathfinder Tools with custom mapping application. GPS/GIS integration also enables data to be collected and updated in the field. This minimises the amount of work performed in the office. The field crews can carry out QA in the field by doing visual comparisons between the information stored in the database and the real world. Therefore, the data collected does not require further manipulation back in the office, making it more valid and accurate.

The paper also describes several ways in which the system integration can be accomplished. At the basic level the GPS receiver can communicate with an application via a NMEA interface protocol resulting in a system with limited capabilities. Full GPS integration can be achieved with GPS components, which gives developers complete control over the GPS receiver. With this flexibility, this integration technique can be applied to improve the maintenance of spatial databases.

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여 백

Spatially Enabling the Enterprise

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ABSTRACT

The integration of GIS technology into numerous applications is widespread. Concurrently, the enterprise-wide need to improve organizational effectiveness, efficiently, and services while minimizing costs has become the rule. Until recently, the integration of GIS applications directly into the enterprise database has been a formidable challenge. This presentation discusses emerging database technology and their implications for users of GIS tdchnology and saptially enabled databases.

요 지

GIS 기술을 응용분야에 적용시키는 일은 널리 통용되고 있다. 동시에, 경비절감이 하나의 법칙이 되어 있지만 엔터프라이즈-와이드는 조직의 효과성, 효율성, 서비스의 개선이 요구된다. 최근까지 GIS 응용분야를 엔터프라이즈 데이터베이스와 직접 통합시키려는 노력은 꾸준히 도전되어왔다. 이번 프리젠테이션에서는 GIS 기술 사용자와 공간적으로 사용가능한 데이터베이스를 위하여 새로 출현하고 있는 데이터베이스 기술과 그들의 응용에 대해 논의한다.

여 백

Using GIS and the Internet for Emergency Services and Disaster Response with the American Red Cross

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ABSTRACT

In response to natural disasters, the American Red Cross provides food, housing, health services, and psychological care to victims. For the Red Cross, timing and location is extremely important effecting its ability to provide emergency services quickly - when and where people need help.

The Red Cross regularly must apply manpower and materials to geographic areas where mobility is limited and information and communication is hard to obtain. Managing the Red Cross emergency response process is a major challenge.

On scene Red Cross disaster directors manage emergency operations with assistance from Red Cross National Headquarters located outside Washington, D.C. The organization's ability to bring to bear the correct amount of resources and financial assistance is based on their analysis of a disaster during the first hours after the event occurs. Under-estimating the scope of a disaster lowers the Red Cross' ability to respond to human need; over-estimating wastes large amounts of valuable donated resources.

In the past, mapping and GIS technology was too difficult to use and too hard

to deploy to offer the Red Cross any real help. Paper street maps with pushpins were the norm. Now thanks to internet based GIS technology, spatial information can be shared by Red Cross management nationwide in real time while an event is still unfolding. On scene managers can now receive help from experienced Red Cross personnel located anywhere around the country. Information and communication is available as never before possible.

요 지

자연재해에 대응해서, 미국 적십자는 희생자들에게 양식, 거주, 위생, 그리고 정신적인 도움을 제공한다. 적십자는 도움이 필요한 사람들에게 언제 어디서나 긴급한 서비스를 제공해야하기 때문에 시간과 위치는 그들의 역량에 중대한 영향을 미친다.

적십자는 정규적으로 인력과 구호품을 운송이 어려운 지역이나 정보와 통신이 잘안되는 지역에 투여해야만 한다. 긴급대체 처리과정을 관리한다는 것은 적십자에 주요한 도전이 된다.

적십자 재해국장은 그 현장에서 긴급운영을 워싱톤시 외곽에 있는 국가적십자본부의 지원을 받아 대체한다. 그 조직의 올바른 자원과 재정적 지원총량을 산출하는 능력은 재난발생후 처음몇시간동안의 재난분석을 통해 이루어 진다. 재난에 대한 축소 평가는 구제민들의 필요에 적절히 대체해야하는 적십자의 능력을 낮추는 결과를 가져올 것이고, 과도한 평가는 기부한 귀중한 자원의 낭비를 초래할 것이다.

과거에는 지도와 GIS 기술을 적십자에 필요한 도움을 주기에는 정말이지 너무 사용하기가 힘들었다. 도로종이지도와 제도용핀이 도움의 전부였다. 지금은 GIS기술을 바탕으로한 인터넷덕분으로 재난이 벌어지고 있는 실시간에 전국 적십자관리소와 공간정보가를 공유할 수 있다. 그 자리에서 관리자들은 이제 국내 어디에 있든지 경험있는 적십자 사람으로부터 도움을 받을 수 있다. 정보와 통신은 과거에 전혀 불가능했던 것을 가능케 하고 있다.

1. Using GIS and the Internet for Emergency Services and Disaster Response with the American Red Cross

Natural disasters such as earthquakes are totally unpredictable. Yet living in California they are part of my everyday life. Mother Nature reminds my family occasionally that she is still alive and well by giving us small shakes of the ground we live on.

As a family we try and plan for any major situation by storing some essential food items and water. One day we may need them.

Should that minor shake become a catastrophic major earthquake, I feel that my family is prepared, but how does an organization like the American Red Cross manage with such an event?

Today I would like to talk about the technology tools developed to help the American Red Cross co-ordinate, manage, and deploy personnel, food, medicines and money in such an event as a major natural disaster.

In response to natural disasters, the American Red Cross provides food, housing, health services, and psychological care to victims and their families. For the Red Cross, timing and location is extremely important effecting its ability to provide emergency services quickly - when and where people need help.

During major natural disasters caused by earthquakes, floods, tornadoes and hurricanes, timing and location are major determinants to how well you will weather the emergency.

The Red Cross regularly must apply manpower and materials to geographic areas where mobility is limited and information and communication is hard to obtain. Managing the Red Cross emergency response process is a major challenge.

There are variables for every disaster. These include but are not exclusive to the following:

- Location
- Where??
- Time - Every minute counts
- When??
- Scope/Size of event
- How much?? How many??
- Type of disaster
- What happened?

These points may seem obvious, but all of this information is essential to determine the required response and that response could result in the loss or saving of a life.

So who are the people that require this information in a disaster?

- Red Cross management and staff
- Citizens affected by emergency
- National government / military
- Local government
- Local emergency services
- Families of victims
- Suppliers of food / medical / other
- Red Cross financial partners
- Media

There may be hundreds of people responding to the disaster. They need a constant supply of information and be able to report on the situation in real time. Knowing and reporting the, what, when, where scenarios are essential.

2. So what are the key factors Key factors in a disaster?

The organization's ability to bring to bear the correct amount of resources and financial assistance is based on their analysis of a disaster during the first hours after the event occurs. Under-estimating the scope of a disaster lowers the Red Cross' ability to respond to human need; over-estimating wastes large amounts of valuable donated resources.

- Money and resources
- Not enough = Inability to provide services
- Too much = Waste and shortages for other emergencies
- Location of resources
- Includes professional expertise
- Resource re-location
- Getting resources to where they are needed

3. What are the critical factors for a Red Cross success?

On-scene Red Cross disaster directors manage emergency operations with assistance from Red Cross National Headquarters located outside Washington, D.C.

In the past, mapping and GIS technology was too difficult to use and too hard to deploy to offer the Red Cross any real help. Paper street maps with pushpins were the norm. Now thanks to Internet based GIS technology, Red Cross management nationwide in real time can share spatial information while an event is still unfolding. On scene managers can now receive help from experienced Red Cross personnel located anywhere around the country. Information and communication is available as never before possible.

Where you are and when you were there will decide your safety and the impact a natural disaster will have on you and your property. Knowing what to do and where to go both before and after a natural event is very important. Often times, however, you don't have the luxury of knowing ahead of time when natural events like earthquakes, tornadoes and floods will hit your little place in the world. After disaster strikes, you need to know what to do and where to go for help.

- Evaluating the scope of an event or disaster in the first 24 hours is critical to success.
- Getting information to people who make decisions - when they need the information - is critical to a successful Red Cross operation.
- Both national level and local level decision makers need real time info

4. During a disaster or emergency, how do you get information to the people who need information - when they need it?

Let us quickly just remind ourselves of the unfortunate disasters that can occur.

This leads us to the American Red Cross Solution, but what problems have the Red Cross already experienced?

- GIS / Mapping technology has not succeeded for Red Cross in past
- Unable to get data to decision makers
- Technology difficult to use

- Expensive
- Required powerful computers
- Proprietary nature prevented using other data formats

Now the American Red Cross is able to manage information on a national level from disparate data sources from around the country.

They are able to view an operation with local detail, combine intelligent vector with raster information, adding satellite and digital ortho photography. Query databases for statistical and demographic information, all across the web.

"GIS technology and the Internet create revolutionary new opportunities"

5. So what is this new technology?

- Autodesk MapGuide is breakthrough technology providing critical information to decision makers
- Delivers important map and map-related content (data) over an Internet or Intranet
- Maps
- Satellite images
- Aerial photos
- Spreadsheets

MapGuide offers multiple server technology

- Simultaneously link servers from:
- Red Cross offices nationwide
- Local government
- National government
- Emergency services
- Suppliers
- No geographic restrictions
- Internet and Intranet capability with strong security

5.1 Red Cross Solution Components

Data -- no longer a problem!

- Today data available from many sources:
- Telcos, utilities
- Government
- MapGuide GIS and CAD data in many file formats:
- Autodesk
- ESRI
- Intergraph

Information when and where it is needed--Real Time!

- Inter-net for communicating with general public
- Intra-net for communication
- Strong security
- No training required
- Low cost
- Small computers

Red Cross applications

- Verification of victim need
- Link maps with database of local community
- Contact names, local agencies, emergency services
- Publish location of resources
- Info for citizens and Red Cross mgmt.
- Input damage information from field
- GPS input
- Field access to map and database information
- Overlay historical data
- Disaster welfare inquiries

Red Cross Mapping Volunteer Program

- Selected Autodesk Map/GIS partners
- Assist in creation and management of local map database
- Partner with Autodesk training centers

- 1,000,000+ students/year trained on Autodesk products
- Red Cross GIS/Mapping volunteers
- Know the technology
- Moveable assets/expertise

MapGuide and the Internet overcome technology problems of the past
- Makes it easier to get information to decision makers quickly regardless of their location
- Quick to implement
- Inexpensive to create and operate due to Internet
- No or low training costs
- Works with existing data from many sources

New Horizons for the New Millenium

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ABSTRACT

The GIS market is undergoing some of the most radical changes seen since its inception, as spatial technology moves into the mainstream Information Technology world. As it does, all of the trends and directions in broader IT suddenly become applicable to spatial technology, with some remarkable results.

The Internet, for example, has had a profound impact. It is already extending access to spatial information to a much wider, global audience. As a result, applications are being implemented today, that would have been impossible to imagine, and certainly to construct, only 5 years ago.

New Horizons for the New Millennium looks at the future of Spatial Systems and how they will change and evolve in order to meet the growing needs of a broader and in many ways very different user community.

The session will also profile some innovative applications for spatial technology, applications made possible by other changes taking place in technology and communications that will affect the way we will live our lives in the years beyond 2000.

The session will discuss visions, virtual realities and veritable realities, providing food for thought for doer and dreamers.

요 지

GIS시장은 공간기술이 정보기술세계를 주도해감에 따라 가장 빠르게 변화해왔다. 괄목할만한 결과와 함께 공간기술의 응용에 다양한 정보기술이 이용되어 왔다.

예를 들어 인터넷은 큰 영향을 미쳤다. 공간정보에 대한 접근은 더 널리 지구적으로 접근이 가능하게 되었다. 따라서 불과 5년전만 해도 상상하기에 불가능했던 것이 오늘날 실행되고 있다.

다가오는 2000년에는 공간 시스템에 대한 미래와 이 공간 시스템이 전세계적으로 팽창하는 수요와 다양한 사용자의 욕구를 충족시키기 위해 어떻게 변화하고 발달해 가는가 하는 문제가 새로운 지평을 열것이다.

이 논문은 2000년 이후 우리가 살아가는 방식에 영향을 주는 기술과 통신측면에서 일어나는 변화들이 공간 기술을 어떻게 혁신적으로 응용할 수 있는가에 대해 소개할 것이다. 또 행동가와 공상가의 생각에 지식을 공급할 비젼과 가상 현실, 그리고 사실에 대해 논하고자 한다.

Current Status and Future of GIS Technology

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ABSTRACT

Today's GIS is built on a relational database platform, enabled with version management, which accommodates both spatial and aspatial data in a like fashion, with object-oriented extension languages. These systems are capable of being scaled to very large database sizes accessed by hundreds or thousands of concurrent users.

However, now that the GIS technology is there, customers for that technology have moved on from only requiring departmental solutions, to requiring enterprise-wide deployments in every department of their businesses. This has now changed the focus to one of being able to integrate seamlessly with other corporate systems. Integration technologies such as CORBA and Microsoft COM will be the underpinnings of these integrated systems. The use of web technology will enable widespread access to data held in large corporate GIS databases. GIS is moving from being a niche departmental solution to taking its proper part in the ERP (Enterprise Resource Planning) market place, complementing the solutions of such major players as Oracle, SAP, Baan and PeopleSoft. Today, ERP does not embrace spatial data and so we could call this new market place Spatial Resource Planning (SRP). SRP is focused on enterprise-wide applications of GIS technology. It is both part of and complementary to ERP. Finally, GIS takes its proper place in the MIS infrastructure.

요 지

오늘날의 GIS는 공간데이터와 비공간데이터를 동시에 변형할 수 있는 관계형 데이터베이스를 기초로 만들어졌다. 이러한 시스템은 수천명의 이용자들이 동시에 접근하였을 때 데이터의 크기가 매우 커지게 된다.

그러나 현재 GIS기술은 단지 요구하는 분야에서만 사용하는 것이 아니라 각 분야에서 다양하게 사용할 수 있도록 발전하고 있다. CORBA와 Microsoft COM과 같은 통합기술은 이러한 통합시스템을 뒷받침하게 될 것이다. 웹기술의 이용은 많은 통합GIS데이터베이스를 가지고 있는 데이터에 접근할 수 있게 해준다. GIS는 정확하게 맞는 문제만을 해결하기 위한 것 뿐만 아니라 앞으로는 ERP(기업자원계획)시장의 적절한 분야와 Oracle, SAP, Baan, PeopleSoft와 같이 중요한 위치의 솔루션을 제공하게 될 것이다. 오늘날 ERP는 공간데이터만을 다루는 것이 아니라 공간자원계획의 새로운 시장을 요구하게 될 것이다. SRP는 GIS기술의 전기업적인 이용에 초점을 맞추고 있다. 마지막으로 GIS는 MIS체계에도 적절하게 이용될 수 있다.

Current Status and Future of GIS Technology

Early GIS either evolved from CAD systems, or from a simple model of the world based on layers. Both approaches emulated the paper map approach in that spatial databases were tiled. The CAD-based systems were quite good at emulating the manual drawing approach to maintaining maps and the layered, geo-relational model was appropriate for performing efficient spatial analysis of data organised in themes or coverages. In both these early approaches the focus was on spatial entities with a connection to attribute data held in a relational database.

More modern systems have changed the emphasis to one of modelling objects in the real world. Such real world objects have attributes, both spatial and aspatial. Spatial attributes are manifested as areas, lines or points as well as other things. Taking this approach means that modelling for GIS is much closer to conventional relational modelling, but extensions are needed to handle the modelling of topology. These systems go even further, enabling many different views of the same data, allowing scale-dependent drawing-styles, multiple geometric representations of the same object and multiple representations in geographic, schematic and internal views. An object-centred approach fits very well with the use of object-oriented development environments and extension languages. Code reusability in an object-oriented programming environment leads to large reductions in cost and time in implementing a customised system. The barriers to successful deployment are much lower.

At the same time as moving to an object-centred approach, modern systems have eliminated tiling from their databases and they handle the data as a seamless carpet of connected geometry to accommodate objects that cross the spatial boundaries of tiled systems such as rivers, gas-pipes and electricity-cables. Major users of GIS technology, such as utilities and communications companies, have a compelling requirement for modelling large connected networks, which would frequently span many tiles in a tiled system. Many of the business benefits for these users stem from the ability to trace their networks without stumbling across tile boundaries. For example an electricity outage management system cannot perform predictions without access to the entire network nor can a water company find the valves to close to isolate a leak.

However, a seamless database introduces a new problem of how to handle large numbers of concurrent users who wish to update the database. This has probably been one of the most expensive problems to overcome for the GIS vendor community. Most base their solutions on the ad hoc approach of check-out/check-in with locking. This is because today's relational databases do not support long transaction management in their core engines. An approach based on version management to overcome this difficulty has many benefits. Version management not only allows each user to have access to the whole database at all times, but also provides the basis for building highly scalable solutions so that large numbers of users can be supported, with good performance, on a single GIS database server.

So, in summary, today's GIS is built on a relational database platform, enabled with version management, which accommodates both spatial and aspatial data in a like fashion, with object-oriented extension languages. These systems are capable of being scaled to very large database sizes accessed by hundreds or thousands of concurrent users.

However, now that the GIS technology is there, customers for that technology have moved on from only requiring departmental solutions, to requiring enterprise-wide deployments in every department of their businesses. This has now changed the focus to one of being able to integrate seamlessly with other corporate systems. Integration technologies such as CORBA and Microsoft COM will be the underpinnings of these integrated systems. The use of web technology will enable widespread access to data held in large corporate GIS databases. GIS is moving from being a niche departmental solution to taking its proper part in the ERP (Enterprise Resource Planning) market place, complementing the solutions of such major players as Oracle, SAP, Baan and PeopleSoft. Today, ERP does not embrace spatial data and so we could call this new market place Spatial Resource Planning (SRP). SRP is focused on enterprise-wide applications of GIS technology. It is both part of and complementary to ERP. Finally, GIS takes its proper place in the MIS infrastructure.

21세기를 향한
GIS 발전전략에 관한 국제세미나

3rd International Seminar on GIS Development Strategies for 21 Century

GIS Exihibition

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