The 14th International Seminar on GIS

GI Application Strategies for Realizing SMART KOREA

Korea Research Institute for Human Settlements
Korea Institute of Construction Technology

History of International Seminar on GIS

	Theme	Date	Place	Organizing Committee	
				Chair	Member
1st (1996)	Strategies for NGIS Development	4.18-19	Seoul Education & Culture Center, KRIHS	Young-Pyo Kim, Director, Geospatial Information Center	Woo-Seok Cho, Mi-Jeong Kim Moon-Sub Chung
2nd (1997)	GIS Applications in the Public Sector	10.16-17	Seoul Education & Culture Center	Young-Pyo Kim, Director, Geospatial Information Center	Yong-Bok Choi, Mi-Jeong Kim
3rd (1998)	GIS Development Strategies for the 21st Century	9.10-11	Renaissance Seoul Hotel	Young-Pyo Kim, Director, GIS Research Center	Mi-Jeong Kim, Sung-Mi Park
4th (1999)	GIS in Local Government	9.16-17	Renaissance Seoul Hotel	Young-Pyo Kim, Director, GIS Research Center	Mi-Jeong Kim, Sung-Mi Park, Hong-Jun Choi
5th (2000)	Toward a Knowledge-based Society: NGIS Policy and Technological Development	9.28-29	Ritz-Carlton Seoul Hotel	Young-Pyo Kim, Director, GIS Research Center	Sung-Mi Park, Hong-Jun Choi
6th (2001)	Present and Future of GIS Technologies	5.17-18	Seoul Education & Culture Center	Young-Pyo Kim, Director, GIS Research Center	Sung-Mi Park,
7th (2002)	GIS Workshop & Seminar	11.8	COEX Intercontinental Hotel	Hyung-Min Yeom, Director, GIS Research Center	Dong-Han Kim
8th (2003)	Envisioning Cyber-geospace and Spatially enabled E-government	11.20-21	COEX	Young-Pyo Kim, Director, GIS Research Center	Jung-Hoon Kim, Dong-Han Kim, Seung-Mi Hwang, Ki-Hwan Seo
9th (2004)	Emergency and Disaster Response with GIS	9.8-9	Seoul Education & Culture Center	Young-Pyo Kim, Director, GIS Research Center	Jong-Taek Park, Dong-Han Kim, Ki-Hwan Seo
10th (2005)	NGIS Policy in Ubiquitous Computing Environment	11.14-15	Seoul Education & Culture Center	Byoung-Nam Choi, Director, GIS Research Center	Jung-Hoon Kim, Dong-Han Kim, Jung-Yeop Shin Jin-Hyeong Park
11th (2007)	Collaborative GIS toward the Geospatial Information Society	10.24	KRIHS	Ho-Sang Sakong Director, Geospatial Information Research Center	Jung-Hoon Kim Young-Joo Lee Jae-Il Han
12th (2008)	NSDI Policy for National Spatial Data Integration	10.9	KINTEX	Ho-Sang Sakong Director, Geospatial Information Research Center	Jung-Hoon Kim Chun-Man Cho Mi-Jeong Kim Hae-Kyong Kang
13th (2009)	The World Geospatial: Trends and Prospects	9.10	KINTEX	Moon-Sub Chung Director, Geospatial Information Research Center	Ki-Hwan Seo Dae-Jong Kim Kyung-Hee Kim
14h (2010)	GI Application Strategies for Realizing SMART KOREA	9.1	KINTEX	Moon-Sub Chung Director, Geospatial Information Research Center	Young-Joo Lee Gye-Wook Kim Jae-Sung Choi

Seminar Program

12:00～13:00	Registrations
13:00～13:10	Opening Address(President, KRIHS) Congratulatory Address(President, KICT)
Session 1	**Value of Geospatial Information**
13:10～13:40	Value of Geospatial Information and Future Directions (Alan Smart, Principal Consultant and Marketing Director, ACIL Tasman)
13:40～14:10	The Value Chain of Geospatial Information Convergence and its Implication in National Policy (Byong Nam Choe, Senior Research Fellow, KRIHS)
Session 2	**Smart Application of GI**
14:10～14:40	Modern Concepts and Algorithms for Homogenization and Combination of Cadastral Information in Korea (Wolfgang Niemeier, Professor, Technical University of Braunschweig)
14:40～15:10	Development and Applications of the Interoperable Platform for Disaster Risk Information (Tai Young Yi, Researcher, Japan National Research Institute for Earth Science and Disaster Prevention)
15:10～15:30	Coffee Break
Session 3	**New GIS Trends : GeoWeb & Geosemantic**
15:30～16:00	Building, Maintaining and Sharing 3D City Models - Foundation for a Smarter Korea (Ron Lake, CEO, Galdos Inc.)
16:00～16:30	Semantic Search and Data Interoperability for GeoWeb (Tony Lee, CEO, Saltlux Inc.)
16:30～16:50	Coffee Break
Session 4	**Discussion**
16:50～17:50	Panel Discussion

Profile

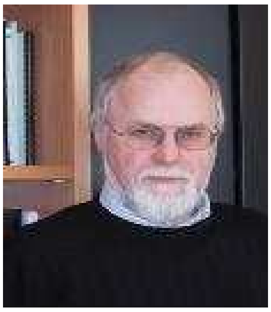
Alan Smart

Alan Smart is a Principal Consultant with ACIL Tasman in Canberra, Australia. Alan consults on economics, policy and strategy in the energy, infrastructure and geospatial sectors. He has directed research into the value of geospatial systems in Australia, New Zealand and the United Kingdom. He is the Vice Chairman of the Spatial Industries Business Association and a member of the Board of the Tasmanian Economic Regulator.

Byong Nam Choe

Byong Nam Choe is a Senior Research Fellow in Korea Research Institute for Human Settlements. He received Ph.D. in Management Information Systems at Korea Advanced Institute of Science and Technology. Major research fields are National GIS policy and analysis, and design of GIS applications. Recent research works include 「Establishment of Korean Spatial Data Infrastructure Model and Study of Globalization Strategy」(2009) 「A Study on the Basic Framework of the National Geospatial Information Systems」(2008), 「A Study on the Basic Framework of the National Territorial Policy Decision Support Systems」(2007), 「Development of Korea Planning Support Systems」(2006~2007).

Wolfgang Niemeier



Wolfgang Niemeier is a professor in Geodesy and head of the Institute of Geodesy and Photogrammetry at Technical University of Braunschweig, Germany. He received Ph. D. in Geodesy from the University of Hanover. He's research interests include data processing, analysis and algorithms, adjustment computations, deformation analysis and satellite positioning techniques, GI applications to technical and cadastral projects. He has published several scientific papers in the field of geodesy.

Tai Young Yi

Tai Young Yi is a researcher in the National Research Institute for Earth Science and Disaster Prevention, Japan. He received Ph.D from the University of Fukui, Japan. He is a member of Disaster Risk Information Platform Project Team. He researches in re-organizing of local disaster prevention capabilities using the disaster risk communication tools for improving risk governance on Disaster Risk Information Platform Project. He's research field is a making a disaster scenario based on risk communication with various independent communities using the tools.

Ron Lake

Ron Lake is the founder and CEO of Galdos Systems Inc., a leading corporation, in the area of GIS interoperability, and a pioneer in the development of software and solutions for the secure, real time and automated aggregation and integration of geographic and geographically related information. He is the original creator of Geography Markup Language (GML) which is now a Chinese National Standard, an OGC (Open Geospatial Consortium) specification and a standard of the International Standards Organization (ISO). In addition Mr. Lake has made significant contributions to key XML and web services standards for interoperability including OGC WFS, CSW-ebRIM, WMS/FPS and KML. Mr. Lake is an active participant in the OGC and the ISO TC/211.

Tony Lee

Tony Lee is the president and CEO of Saltlux Inc. the Knowledge Communication Company, headquartered in Seoul, Korea. He holds a professor's position of Information and Communication Engineering for Inha University of Korea. He is a chairman of the 'Human and Computer Interaction Industry Consortium' and a director of the 'Korea Association for Semantic Information Technology'. He is one of the few pioneers in the field of semantic technologies in Asia and has contributed to Korean Government's R&D plan of semantic web and to the industrial dissemination. He was honored with 'Best Paper Prize' from Samsung and 'Best Software Award' from Korean Government. He has authored more than 50 papers, articles and reports.

Contents

The Value of Geospatial Information

Alan Smart

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1. Introduction

ACIL Tasman has undertaken a number of studies on the value of geospatial information. The most recent have been:

- The value of spatial information in Australia in 2007
- The value of geospatial information in Australia in 2008
- The value of geospatial information in local government in England and Wales in 2010
- The value of earth observation from space in Australia in 2010.

This paper outlines some of the findings of this work. In this paper the terms geographic information, geospatial information and spatial information are used interchangeably.

1.1 What is geographic information and why is it valuable?

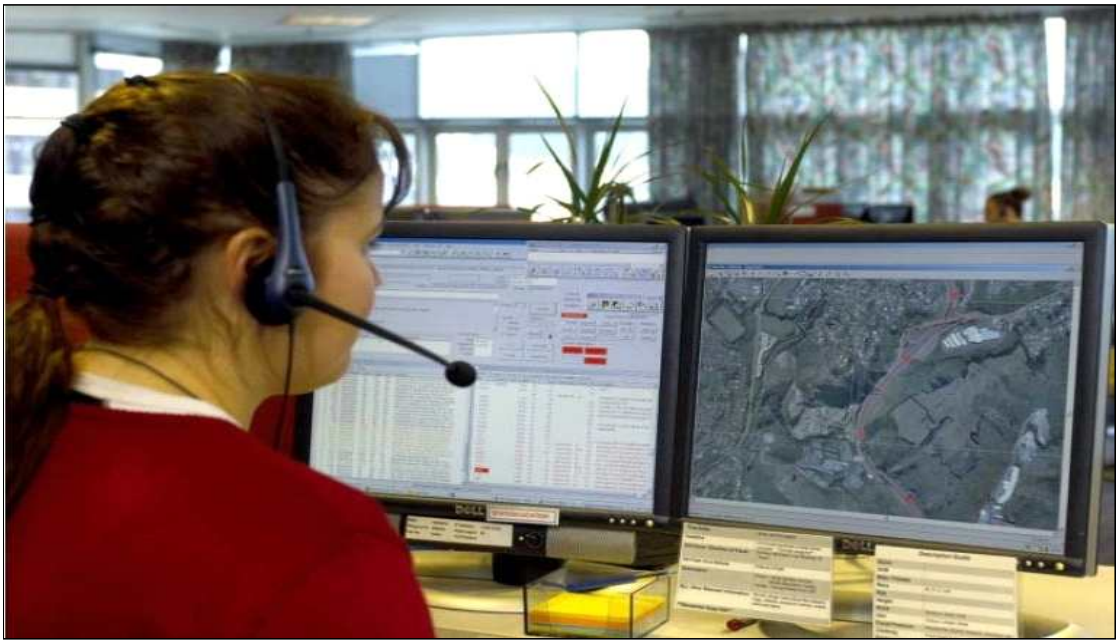
Geographic information, sometimes referred to as geospatial information, is information relating to the location and names of features beneath, on, or above the surface of the earth.

On one level or another all human activity depends on geospatial information – on knowing where things are and understanding how they relate to one another. Having access to spatial information enables key service providers to answer 'Where?' questions in a range of critical situations, such as:

- Emergency response – Where is a distress call coming from (see Figure 1)? Where is a fire or severe weather front moving to?

- Health & biosecurity – Where is the source of an outbreak? Where has an incursion spread to?
- Agriculture – guiding farm equipment or showing where and when to fertilise
- Transport – tracking vehicles, controlling congestion.
- Planning and construction – where to build a road.
- Monitoring and managing infrastructure – managing and monitoring gas and water pipelines and electricity lines.
- Police, ambulance and fire services (see Figure 1).

Figure 1. NZ Police – modern spatial information technology in action



Source: Jill Barclay, Technology Manager, GIS/ICT Service Centre, NZ Police

Spatial information is important to private businesses as well. Knowing where assets and inventories are located, how markets and demand differs geographically, and so on, is critical to running an efficient business – it has been estimated that up to 80 per cent of information managed by business is somehow connected to a specific location (Geospatial Information & Technology Association, 2008).

1.1.1 Modern spatial information technology

Over the past 30 years or so, rapid advances in technology – in particular in data capture, computing and communications – have fundamentally changed the way in which geographic information is be captured, transmitted, displayed and utilised.

Translation of map data into geographic information systems and its digitisation created an opportunity to combine data in layers in a way that was not possible on paper maps. Accurate global navigational satellite systems (GNSS) added the capability to record position accurately. Emerging information technology and web access created the ability to store large amounts of data and to share data between different users. Finally the emergence of search engines, and protocols for registries and meta data created the ability for users to search for and obtain geospatial data from a wide range of sources.

The ability to source data has also increased through technologies such as airborne LIDAR, earth observation created new and expanding applications for monitoring natural resources, planning water resources, measuring emissions as well as planning for infrastructure such as roads, pipelines and telecommunications.

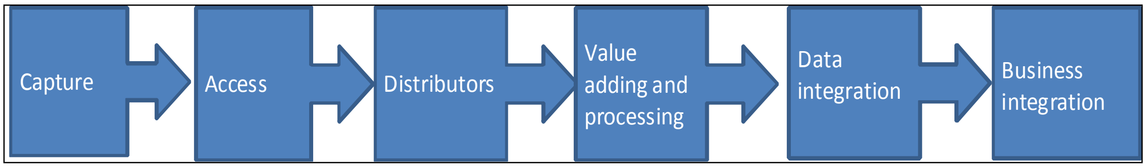
The merging of all these technologies has created capabilities that were not previously available. The technologies are illustrated in Figure 2.

Figure 2. Modern geospatial information

Data source: ACIL Tasman

Value is created along the supply chain the data is processed, improved, merged and integrated into business and other systems (see Figure 3).

Figure 3. The supply chain for geospatial data



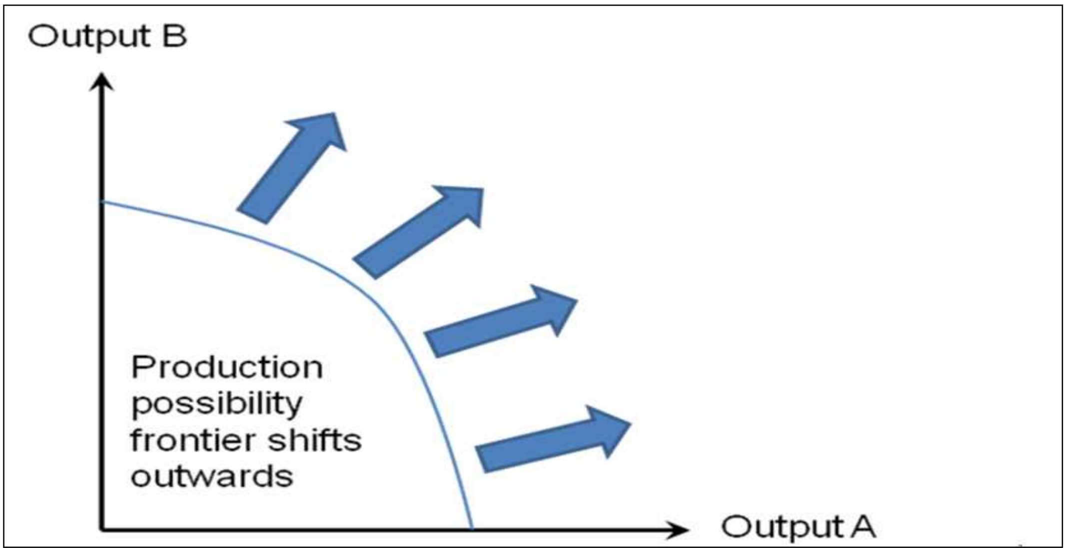
Data source: (ACIL Tasman, 2007)

2. Spatial information and the economy

2.1.1 Increasing productive capacity

The effect of introducing modern spatial information technology on the economy can be summarised as its ability to deliver more with the same resources; this idea is summarised in Figure 4 which shows an economy's so-called production possibility frontier shifting outward as a result of the introduction of modern spatial information technology.

Figure 4. Spatial information & the NZ economy's productive capacity



Source: (ACIL Tasman, 2009)

There will always be winners and losers from shifts in technology – some tasks or jobs may for example become redundant – but the argument is that, overall, society can produce more and better outputs with the same inputs.

A proportion of the 'extra' value to the economy is thus captured by final end users, and some of it is captured by the 'intermediaries' that deliver products and services (and this can include government, non-profit and commercial users). Economic growth in turn means the 'size of the pie' as a whole increases, which feeds back to these organisations as increased demand for their products. This 'size of market' effect is in addition to the effects discussed above.

Improved outcomes in areas such as health and the environment are important non-market benefits from the use of spatial information technology; these will also have longer term impacts on the economy which are harderto estimate than productivity benefits. These long term effects may however be critical to sustainable economic growth and should not be ignored.

2.1.2 Information, data, knowledge and innovation

The terms information, data and knowledge are often used interchangeably. Data refers to information that has been organised so that it can be communicated, reproduced or interpreted (e.g., spatial information stored in digital format). Whilst this is knowledge, it is only of a 'rudimentary' type. As long as it remains unused, its value resides mainly in the options it creates for future analysis and 'value addition'.

Spatial data can aid deeper knowledge creation and enable inventive or innovative activity, thus ultimately contributing to the production of 'useful' knowledge. The 'core' geospatial industry specialises in generating as well as utilising spatial data to create value added products and services.

Value addition does not always occur along a 'linear' path to market. Invention and innovation involve complex knowledge networks that are currently still very much the realm of economic research; however, the role and value of information in determining broad macroeconomic outcomes has been increasingly recognised as industrialised economies shift to what has become known as the 'knowledge economy'. The role of R&D and human capital has been emphasized as influencing levels of long run economic growth (key papers by Grossman and Helpman, 1990, Romer, 1990).

Knowledge is sometimes seen as a kind of 'multipurpose'capital that can be transferred across sectors and applications; however, there is some controversy about this interpretation as there is a distinction between specific knowledge (which cannot be transferred) and other types of knowledge (which are hard to define and measure). The economic literature on knowledge capital, and it links with information, is extensive and increasingly concerned with empirical verification (e.g., Eckwert and Zilcha, 2001, Loof and Heshmati, 2002, Haag et al., 2004, Carlaw et al., 2006, Gibbs and Middleton, 2008)

In a related development, the Nobel Prize winning economist Joseph Stiglitz has referred to the rise of informational economics as a "change in paradigm" (see Stiglitz, 2000b, Stiglitz, 2002). This report echoes the sentiment in the context of spatial information, arguing that full appreciation of the value of spatial information involves a change in paradigm at various levels.

A number of reports in applied economics have scoped economic issues that are specificto spatial information, and given some indications of the value of spatial information and spatial data infrastructures or 'SDIs' (Weiss, 2002, Macauley, 2005, European Commission, 2006, ACIL Tasman, 2008, Almirall, 2008, Barlow, 2008, Park et al, 2008, Mehrtens, 2009).

These all point to potentially high returns from spatial information (and investment in spatial data infrastructure), whilst noting that there is uncertainty about how much money and other resources have already gone into, and are continuing to flow into the maintenance and upgrading of geospatial data infrastructure.

2.2 Technology adoption and diffusion

The economic impact of geospatial information will ultimately reflect the level of adoption as well as the degree to which benefits are reaped by individual adopters.

More broadly speaking, the classic textbook reference by Rogers (1964) identified a five-step decision process involved in technology adoption and diffusion:

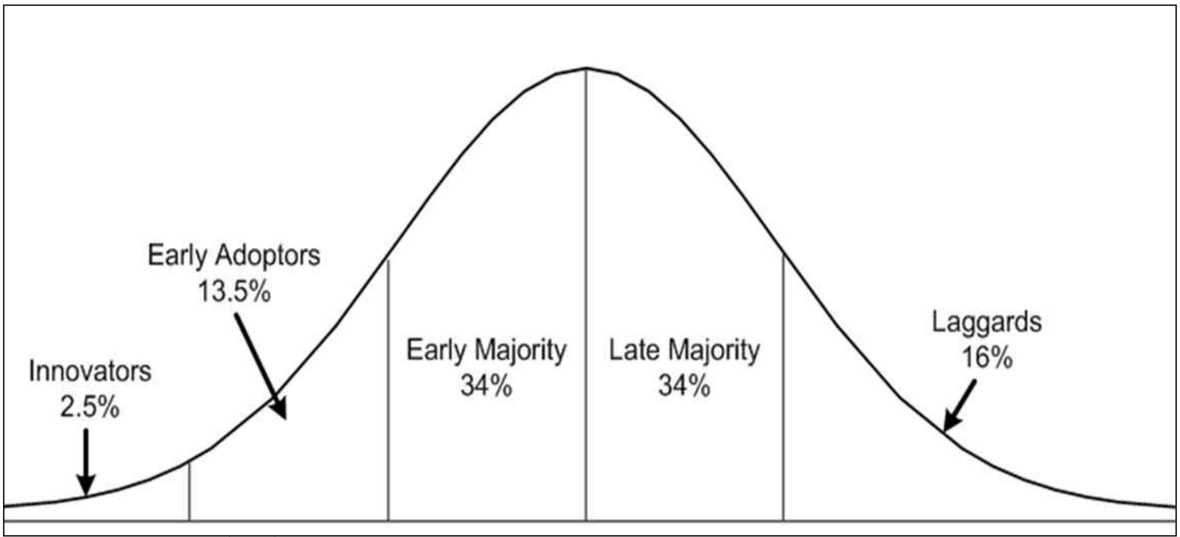
1. **Knowledge** – potential adopter becomes aware of an innovation but has no particular opinion of it (this could be via advertising or through word-of-mouth);
2. **Persuasion** – the potential adopter seeks further information to help form an attitude toward the innovation;
3. **Decision** – the potential adopter engages in activities that lead to a choice to adopt or reject the innovation (the process is internal to the person and can be difficult to measure empirically; however considerations of price and perceived usefulness/necessity will play into this decision);
4. **Implementation** – the innovation is adopted and put into use (e.g., user installs

geospatial data software or uses car navigation aids);

5. **Confirmation** – person evaluates the results of an innovation-decision already made which may affect decisions such as whether to continue using the innovation or return to previous status quo (e.g. remove software or return car navigation aid)

Rogers also estimated the categories of adopters as being innovators (2.5 percent), early adopters (13.5 percent), early majority (34 percent), late majority (34 percent) and laggards (16 percent), see Figure 5. These reference figures are adopted for the current report, as they were based on and have been broadly corroborated by many case studies including those in the original contribution by Rogers.

Figure 5. Roger's model of adoption



Data source: Rogers (1964)

Rogers does not indicate a typical 'speed' of adoption or rate of diffusion over time, although the received wisdom now states that adoption typically follows an S-curve path with a 'tipping point' occurring at some stage where rapid uptake in the broader population occurs.

The Bass model, named after Frank Bass whose 1969 paper concerned take up of consumer durables (Bass, 1969), still forms the main mathematical approach to predicting the rate of adoption over time. It follows Rogers'model by differentiating between innovators and imitators, but importantly for the purposes of this report, it differentiates between two coefficients:

- the coefficient of innovation, external influence or advertising effect, and
- the coefficient of imitation, internal influence or word-of-mouth effect.

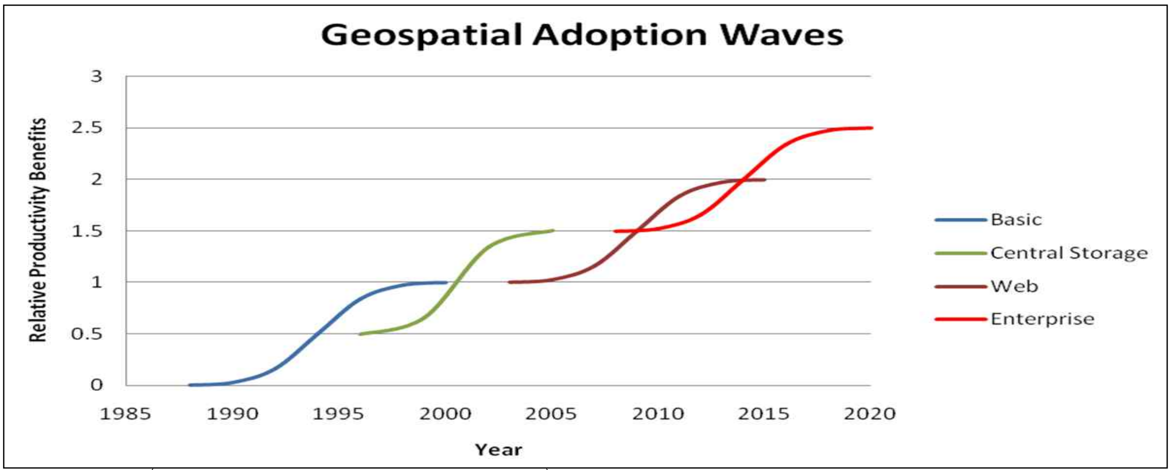
The critical finding which has been widely validated is that the latter coefficient is much more important in determining the rate of uptake over time (by a factor of twenty or more).

This is illustrated for example in our work on the progress of geospatial information in England. Geospatial information has been in operational use in local government in England and Wales for well over twenty five years. There were four interlinked and overlapping waves of adoptionover this period:

1. Basic Implementation: this first wave of implementation was characterised by the introduction of basic desktop geographic information systems (GIS) for specific projects or within a single department. By virtually every local authority had a digital mapping system or GIS.
2. Central Storage: the second wave wascharacterised by the gradual linking of discrete data bases and storage in centralised corporate database management systems. This wave brought with it increased productivity, as users could combine an increasing array of datasets across a number of services, including highways, planning and estate management, as well as managing local issues including providing faster and improved information to the public.
3. Geospatial Web: the third wave is characterised by widespread access to geospatial information by both staff and the public through the web. Although static maps had been available for almost as long as the internet has been in existence, the ability to make queries and to complete transactions over the web, introduced further productivity improvements.
4. Enterprise Geospatial Integration: the fourth wave is the integration of all of these technologies into mainstream enterprise systems where geospatial information becomes as much a part of doing business as email and the internet has become. The enterprise wave is characterised not only by geospatial information being embedded in the corporate information and systems architecture but also a high level of awareness within user departments of its full potential.

These waves are represented in Figure 6showing how each wave builds on the value added by those that have gone before. The Y axis should be conceptualised as a measure of relative productivity improvement, with each wave building on the benefits accumulated from the previous one.

Figure 6. Four waves of innovation in geospatial systems in local government in England and Wales



Data source: (ConsultinWhere and ACIL Tasman, 2010)

3. Five case studies

Our recent work identified many examples how geospatial information systems had improved productivity and added value to the economies of Australia, New Zealand and England. Some examples are listed below.

3.1 Case study – Hazwatch(Australia)

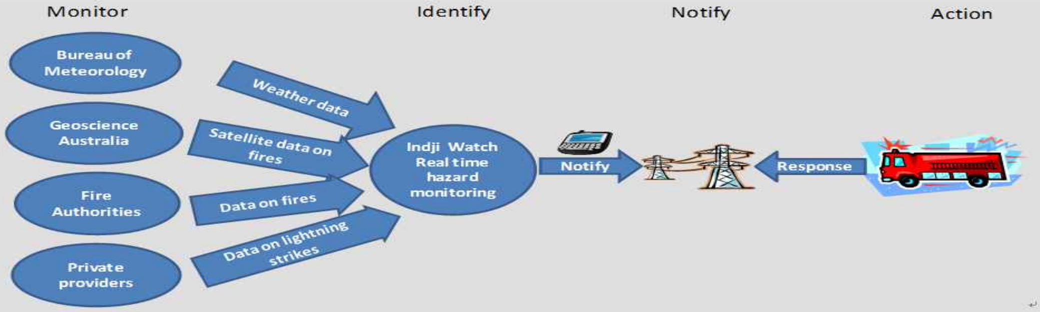
The Hazwatch system was developed by the Cooperative Research Centre for Spatial Information in Australia. It draws on existing data such as maps of infrastructure and provides warnings in the event of fire or bad weather or other impending disasters. The system monitors natural and manmade hazards in real time and identifies threats to assets and people by matching the incidence of hazards against assets and people. The most common natural hazards it works with are bush fires, floods and lightning – though conceivably it could be anything.

It provides a single centralized control system for warnings. This is very important to emergency management organisations. It minimizes the potential for communication problems particularly incorrect communication of warnings to utilities and infrastructure operators.

The system is a hosted solution with data stored at a large data centre. Warnings and alerts are delivered to clients mobile phone messaging and fax. Clients can then monitor the situation by going to a map viewer on the system website.

Data for the system is obtained from a number of sources, both private and public sector. Bushfire information is obtained from Geoscience Australia who download satellite data and run an algorithm to identify hot spots on the earth's surface. Information on lightning is obtained through private sector providers. Information on the incidence of bush fires is also obtained from various fire authorities. Weather information is sourced from the Bureau of Meteorology.

Box 1 ***Indji***



*The **Indji** system integrates data on hazards from a range of sources and notifies clients when a hazard threatens a critical installation or infrastructure. The warnings may be transmitted by SMS or as a digital map warning on a PDA. The marginal cost of accessing and processing the data is small relative to the value of the damage avoided.*

Data source: iintegrate systems

The schematic in Box 1 shows the sequence chain for Indji. The system accesses data from a number of sources, processes it and, when certain conditions are met (such as proximity of a hazard to infrastructure), it transmits a warning to the client.

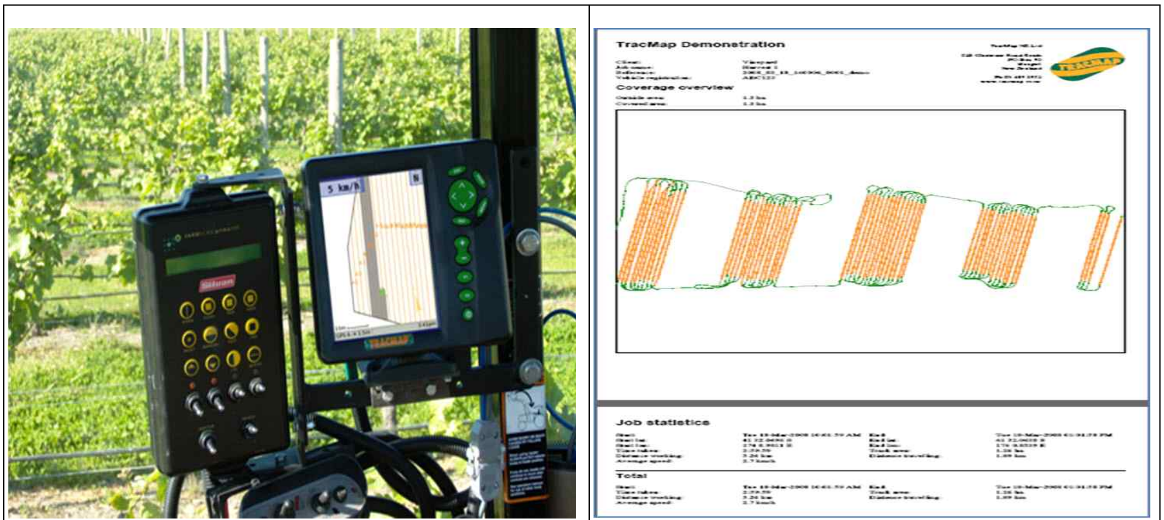
Earlier warnings of hazards can significantly reduce the costs and damage that they cause. Warning systems such as this create value by reducing damage costs to businesses and people from the incidence of hazards.

3.2 Controlled traffic farming or "guidance" (Australia and New Zealand)

Controlled traffic farming (CTF) refers to the use of positioning technology for equipment guidance in horticulture. This technology allows tractors and farm equipment to be self steering. It is at the early adopter stage in Australia and New Zealand.

An example can be found in New Zealand as part of vineyard production; specifically in planning the routes taken by vineyard machinery for spraying and harvesting. GPS guidance units are used to develop on-screen maps that indicate the optimum route to follow along vine rows (e.g. the best turning circles for harvesters or sprayers to take). These optimum routes can then be used repeatedly in each growing season. Units also show which rows have been covered and those that have not in real time, and can record the location of partially completed rows that can easily be returned to later. An example of a GPS unit and the map produced is shown in Figure 7.

Figure 7. Controlled traffic farming – GPS in a vineyard



GPS Unit	Route map

Data source: http://www.tracmap.co.nz/viticulture--horticulture/, Tracmap demonstration map : http://office.tracmap.co.nz

An important commercial benefit is the reduction in overlaps, for example spraying the same row twice. Benefits due to reduced overlap of spraying have been estimated to be in the order of 11% savings on spraying costs.[1] Another benefit is that spraying and harvesting can be undertaken during periods of poor visibility that are affected by weather or the time of day.

1) GPS Equipment Supplier Interview.

3.3 Management of fisheries (Australia and New Zealand)

Fishing is by its very nature an activity that relies on spatial information inputs. The introduction of GPS devices in commercial fishing, coupled with plotters, was a major development for the fishing industry. First experiments began in Australia in the mid-1980s and general technology roll out and adoption began in the late 1980s.

The fishing industry was quick to adopt the technology because it allowed fishing boats to track where the best fishing grounds were, which reduced search costs as well as saving fuel on operations. Some individual fishermen stated that they saw their productivity rise by 50% or more as a result of this technology. Indeed, total industry output increased by around 50%since the late 1980s (from around 180,000 tonnes in 1988/89 to around 270,000 tonnes in 2003-04). However, the composition of output has changed markedly with a large increase in aquaculture.

In the case of a commercial fishing company, for example, a GPS unit attached to a plotter allows recording of tracks, which are a valuable resource in the fishing industry. Tracks increase productivity because vessels can be directed to the most productive fishing locations. For commercial fishing activity, with inputs including crew, fuel and gear, the less time vessels spend looking for the best fishing locations, the less costly is the fishing activity.

Discussions with commercial fishermen suggest that they may now spend less time on the water than they used to ten or fifteen years ago. This difference can however not be solely attributed to GPS as other improvements in technology (e.g., boats, sonar scanning, nets, etc.) will also have contributed to this trend.

The best available scientific evidence in Australia indicated that the fishing power of the fleet increased by around 12%due to the uptake of GPS and plotters (Robins, 1988).

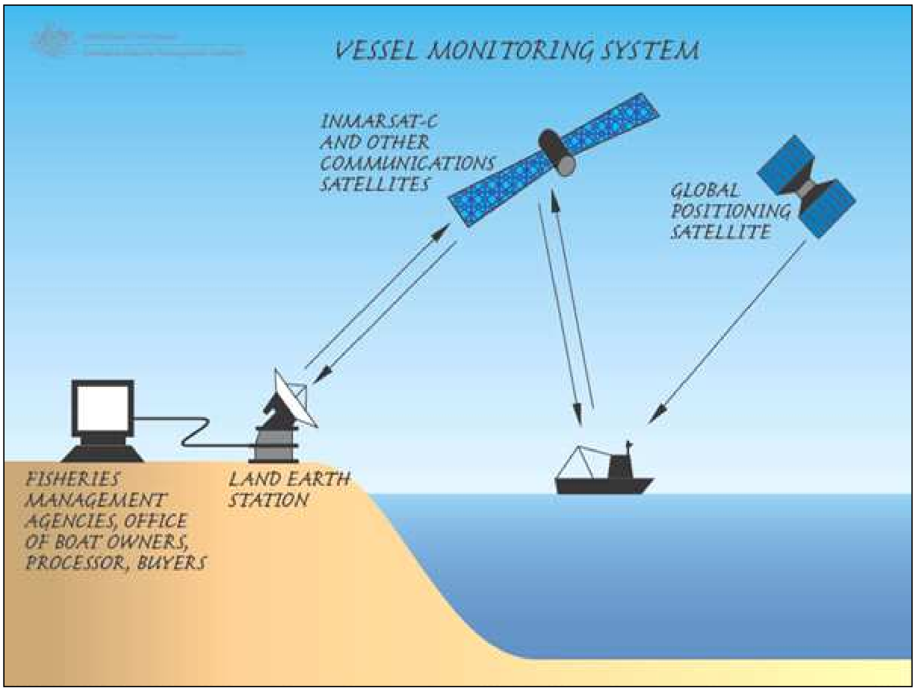
Australian Fisheries Management Authority's Vessel Monitoring System (VMS)

GPS is also used by Australian Fisheries Management Authority (AFMA) part of its Vessel Monitoring System (VMS) to monitor fishing activities in the Australian Fishing Zone. One of the functions of AFMA is to administer compliance monitoring programmes directed towards domestic and foreign fishing vessels and covering licensed and illegal fishing activities. The Vessel Monitoring System (VMS) is one of several programmes used to ensure compliance with AFMA's fishery management measures (see Figure 8). VMS is required on a fishery by fishery basis and consists of three main components:

- the tracking unit on the vessel i.e. the Automatic Locator Communicator (ALC) with built-in GPS
- the transmission medium – Inmarsat C satellite
- the base station.

VMS is used to prevent vessels from fishing in closures (areas with immature fish stock or protected species) and enables compliance with different quotas in different zones. In addition, thefishery itself has adopted the system to track their vessels, which has secondary benefits such as increased communication, safety and productivity.

Figure 8. Vessel monitoring system



Data source: AFMA

ALCs regularly transmit information on vessel position, course and speed via the Inmarsat-C satellite to the land earth station, located in Perth. Information is then sent by land line to a computer base station in Canberra. Automatic reports can be generated for any vessel at any time.

3.4 Highways Inventory Management: London Borough of Islington

In order to streamline and automate its operations, the London Borough of Islington has collected highways inventory information for the entire area of the borough and implemented an enterprise system to store, query and view the data. The overall project, including system design and implementation work, costing circa £2.2 million spread over three years. As part of the project, the highways management team have been equipped with geospatially-enabled systems to allow them dramatically increase the number of maintenance work orders undertaken without increasing the team size.

The system allows officers to provide a more informed customer response, not only to queries but in getting a better understanding of how assets are used so design of schemes is improved. Savings have been generated in several ways including, productivity of response to reactive maintenance up 200% for the same cost, improved repudiation rate on claims from 2 in 10 defended to 9 in 10, back office costs, higher staff satisfaction rates and reduced sickness absence, reduced site visits and reduction in crime and anti social behaviour.

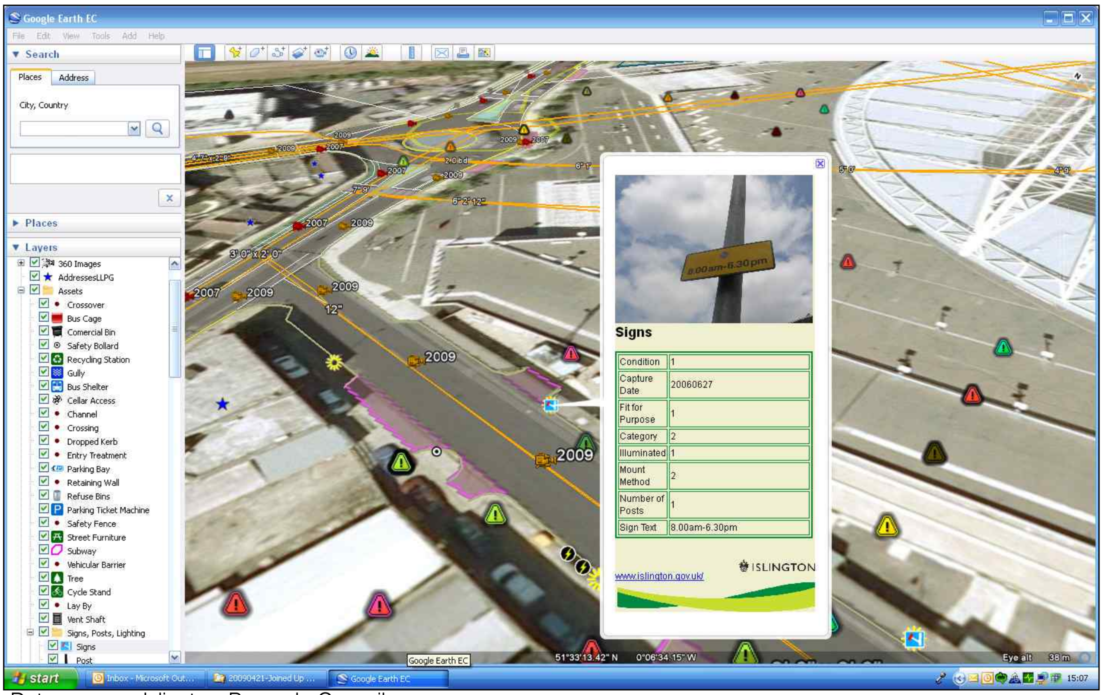
The total savings equate to around £1.2m per annum to the service and a further £1.6m in total costs to Islington as a borough (e.g. in reduced police costs). The cashable element of the saving is around £500,000 pa, making the project pay back in real terms within 5 years.

The biggest benefit is in the increased knowledge the system provides and how that knowledge can be used to make improvements to the experience for residents. Overall satisfaction with the "street scene"has improved since the changes to the ways of working even when the national trend has seen a decline.

Figure 7 illustrates how the team are now deploying the highways information on the backdrop of 3D imagery using Google Earth Enterprise[2)] Islington anticipate further benefits from being able to make this application, overlaid with an extensive array of other geospatial information, available to all staff and the general public.

2) http://earth.google.co.uk/

Figure 9. Islington Google Earth



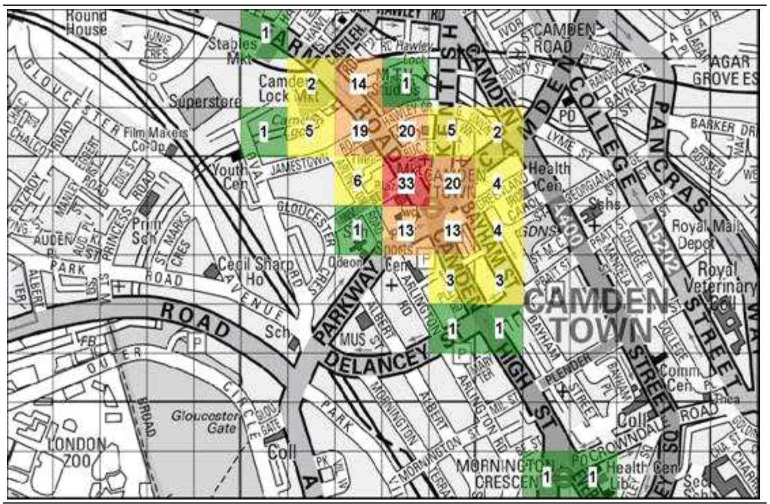
Data source: Islington Borough Council

The authority believes that the benefits can be evaluated simply in the form of time saved. The average fully absorbed cost of an employee to the organisation is estimated at around £45 per hour, so if every employee were able to reduce their information gathering activities by only one hour per annum that would equate to £180k of efficiency saving.

3.5 Performance Evaluation – crime reduction, emergency services and demographic information

The London Borough of Camden has been particularly active in evaluating the success of their crime reduction initiatives. These are reviewed biennially against the targets set by using geospatial information linked to: local crime statistics, fear of crime surveys, demographic information and partner services local information, (such as that from the ambulance service in Figure 9). This has allowed them to more rapidly identify initiatives that are failing and rethink them or close them down. Quantifiable benefits, in terms of time saved by redeployment of resources, are possible from performance data but this has not been undertaken yet.

Figure 10.Incident Locations identified by members of the public



Note: highest incident rate per grid square shown in red, lowest in green.
Data source: Camden CRP Licensing Policy Review. London Ambulance Service records

4. The value of geospatial information

4.1 The approach

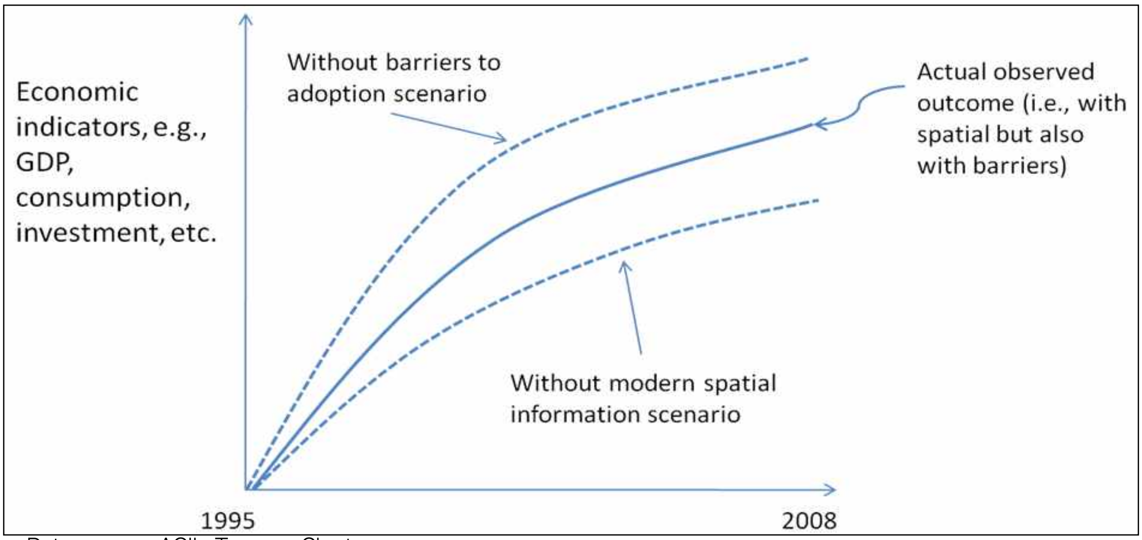
There are various types of economic models and modelling techniques. Many of these are based on partial equilibrium analysisthat usually considers a single market. However, in economic analysis, linkages between markets and how these linkages develop and change over time can be critical. Computable General Equilibrium (CGE) models meet this need.

Tasman Global a large-scale computable general equilibrium model which is designed to account for all sectors within an economy and all economies across the world. ACIL Tasman uses this modelling platform to undertake industry, project, scenario and policy analyses. The model is able to analyse issues at the industry, global, national, state and regional levels and to determine the impacts of

The model estimates relationships between variables at different points in time. In applications of the Tasman Global model, a reference case simulation forms a "business-as-usual"basis with which to compare the results of various simulations. The reference case provides projections of growth in the absence of the changes to be examined. The impact of the change to be examined is then simulated and the results interpreted as deviations from the reference case.

In CGE analysis, the outcomes of the policy simulation modelled are reported as deviations from the business as usual reference case (see Figure 10). To eliminate the impact of price movements in the results, economic variables such as the change in Gross Domestic Product (GDP) are reported as deviations from their real rather than nominal values.

Figure 11. Scenario description



Data source: ACIL Tasman Chart

For the studies undertaken the business-as-usual reference case is the situation where the economy grew as per historical records (the Base Case). This reference case is then compared to the alternative policy scenarios:

- Without spatial information scenario. In this scenario, the quantifiable productivity benefits identified from the case studies (see Figure 10) have been removed. The difference between this scenario and the base case with spatial information scenario provides an estimate of the economic benefits that access to, and use of, spatial information has had on the New Zealand economy.
- Without barriers to adoption scenario. In this scenario the potential unrealised productivity benefits identified from the case studies (see Figure 10) have been added. The difference between this scenario and the base case with spatial information scenario provides an estimate of the economic benefits that could have arisen if barriers to the uptake of current spatial information technologies had not existed across the identified opportunities.

4.2 Results for Australia and New Zealand

Our research found that geospatial technologies had made significant contributions in many sectors of the Australian and New Zealand. At the time the research was undertaken, it was estimated that most sectors were at the early adoption stage. Some sectors however exhibited higher levels of adoption and higher direct productivity impacts.[3)]The productivity impacts in selected sectors are shown in Table 1.

Table 1. Selection of productivity impacts by Sector in New Zealand and Australia

Sector	Productivity impact	
	New Zealand	Australia
Agriculture	1.25%-1.9%	0.93%-1.5%
Forestry	5.25%-5.71%	1.93%
Fishing	3.40%	4%-5%
Manufacturing	0.25%-0.35%	0.02%
Transport	2.1%-3.15%%	1.4%-1.5%
Communications	0.82%	0.98%-1.32%
Utilities	0.70%	0.7-1.25%
Property and business services	0.23%-0.46%	0.47%
Construction	0.75%-1.13%	0.25%-0.5%
Trade and retail	0.77%-1.15%	0.08
Recreation	0.23%-0.46%	~
Resources	~	0.9%-10%
Government	0.77%-1.15%	0.34%-1.05%

Data source: ACIL Tasman research

The following sectors showed significant productivity impacts in both countries

- Property and construction
- Transport
- Agriculture
- Forestry
- Fisheries
- Security and search and rescue.

3) This included areas such as meteorology, defence and national security for example. These areas were not explored in detail for these studies.

However the relative size of the impacts was not uniform between the countries. For example Australia exhibited higher productivity impacts in the resources, fisheries, communications and business services sectors while New Zealand exhibited higher impacts in the agriculture, forestry, construction, tourism and retail sectors.

The results for Australia are shown in Australia in Table 2. We found that the spatial information industry contributed to a cumulative gain of between $6.4 billion and $12.6 billion in Gross Domestic Product in 2006-07. Consumption was between $3.57 billion and $6.8 billion higher, investment between $1.7 billion and $3.4 billion higher and wages were between 0 .6% to 1.1% higher.

Table 2. Results for Australia

Factor	Increase	Increase as a percentage of total
Gross domestic product	$6.4 billion - 12.6 billion	0.6%-1.2%
Consumption	$3.5 billion - 6.8 billion	0.6%-1.1%
Investment	$1.7 billion - $3.4 billion	0.6%-1.2%
Exports	$1,3 billion - $.3 billion	
Imports	$1.2 billion - $2.2 billion	
Wages		0.6%-1.1%

Data source: (ACIL Tasman, 2007)

The results for New Zealand are shown in Table 3. We found that for New Zealandthe accumulated aggregate impact of the productivity benefits from geospatial information was $1.2 billion in 2008 which was 0.6% of GDP. Consumption was higher by around 0.6 % of total consumption and investment was also higher by around 6% of total investment. Wages were also 0.6 % higher.

Table 3. Results for New Zealand

Factor	Increase	Increase as a percentage of total
Gross domestic product	$1.2 billion	0.65%
Consumption		0.6%
Investment		0.64%
Exports	$362 million	0.66%
Imports	$333 million	0.65%
Wages		0.63%

Data source: (ACIL Tasman, 2009)

In both studies we found that additional non quantifiable environmental and social benefits also accrued - possibly at a multiple of the productivity benefits.

4.3 Results for public service delivery in the UK

The study in the United Kingdom was more focused on local government services. In England local government services include police, ambulance, social and primary health care as well as local government services. This sector makes up around 32 % of total public administration.

Our study found however that geospatial systems had delivered significant productivity improvements to those services as well as additional benefits to certain sectors of the broader economy.

Key areas of impact included:

- improved productivity through use of web mapping systems to help local government and the public in reducing the costs of transactions
- improved transport efficiency through route optimisation and street works
- better decision making using geospatially enabled local information systems
- reduced data duplication
- more efficient front line workers
- better management of social problems and crime.

The direct productivity impacts were of course much narrower and are summarised in Table 4. Many of the benefits came from improved efficiency in local government. However the construction, transport and business services sector's also benefited from improved service efficiency which enabled them to save time and money as a result (see Table 4).

Table 4. Productivity impacts in selected sectors from use of Geospatial systems in local government

	Direct productivity impact in 2010	Possible impact in 2015
Local Government	0.233%	0.311%
Primary care trusts	~	0.023%
Construction	0.06%	0.08%
Land transport	0.009%	0.012%
Business services	0.0026%	0.0035%
Increase in labour from more efficient use of time	1,500	2,000

Data source: (ConsultinWhere and ACIL Tasman, 2010)

The aggregate impacts on the economies of England and Wales that resulted from the CGE Modelling were:

- GDP for England and Wales was £323 million higher in 2009 as a result of geospatial information
  - Representing around 0.02 % of GDP
- The average annualised benefit cost ration of using geospatial information was around 2.5 to 1
  - That is net benefits of £2.5 were realised from every £1 spent on geospatial information systems.

5. Conclusions

The research in Australia, New Zealand and the United Kingdom confirmed that geospatial systems have delivered substantial economic benefits to their respective national economies. This arose despite the fact that the level of adoption was still at the early adopter stage in most sectors.

The most prominent areas where economic benefits had arisen as a result of geospatial information were in agriculture, fishing and forestry, construction, transport, communications and resources in the case of Australia.

Important benefits also occurred in areas such as tourism and recreation.

Local government services had benefited in England which had been of benefit to other sectors notably construction, transport and general business services.

It was expected that as levels of adoption increased, so would the benefits.

In these studies we did not quantify social and environmental benefits or benefit to national security and defence. These benefits are potentially orders of magnitude greater than the productivity benefits.

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The Value Chain of Geospatial Information Convergence and its Implication in National Policy

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1. Introduction

The ubiquitous spatial computing environment being pervasive enable anyone to access easily geospatial information in anywhere at anytime. In such an environment, the geospatial information as data presenting location, attribute of an object or event contributes to the value creation for governments, businesses, and citizens. For instance, governments improve the administrative efficiency. Companies explore niche markets with new business models based on the geospatial information. Citizens achieve smart convenience in a daily life with low cost such as location service.

The current geospatial environments making geographic data more publicly accessible and becoming part of our daily lives are fundamentally different from the past when paper maps were used mainly. People now enjoys new information service which comes out as a result of combination of geospatial information and others such as IT technologies, and IT data. The convergence bring us much more values which have never been in the digital era.

This is why many governments emphasize geospatial information as one of the national infrastructures and invest to build a national spatial data and so on. A government is an actor producing and managing geospatial information like other geospatial providers in the geospatial market. Therefore, appropriate intervene of a government may need, for instance, to facilitate the convergence of the national geospatial data, or to encourage its sharing.

However, it is difficult for the government to decide when and how to intervene in the market due to the lack of knowledge about geospatial convergence mechanisms. The government needs to make sure what kinds of policy requirements can be made before it starts to intervene in the market.

The purpose of this research is to analyze value chains of geospatial convergence in the geospatial markets based on value chains of information theories, and to clear its implication in terms of national policies. For this, we investigated geospatial information business models, value chains, and business environments of the geospatial information market by interviewing 18 organizations belongs to the geospatial industry fields such as aerial survey, content production, navigation, web portal, system integration, and LBS.

The value chains of governmental organizations describing the production and application of the geospatial information were summarized based on relevant references as well as experiences of the authors in public GIS applications development.

2. Geospatial Information Market

In general, the market has a meaning of abstractive place where the trade of product and service is made. In terms of components of this place, there are suppliers who produce (or provide) the products and services and demanders who consume these commodities. The definition of this kind is based on the business activity which pursues profitability maximization.

The geospatial information market is divided into nine areas based on the relationships between government, company, and individual as suppliers and customers (Byongnam Choe, 2008). According to the general definition of the market, the geospatial information market corresponds to B2G, B2B, and B2C markets. However a definition of the geospatial information market is significantly different from that of the market in economics.

First, customers use geosptial information without being charged in many cases. This is possible because the company set the two-sided market strategy so that it can provide geospatial information for free while earning profits from something else. For example web portals such as Naver and Daum provide high resolution geospatial information for free. Nevertheless, these companies definitely make profits.

Second, government and individuals who have been demanders of the geospatial information recently become the suppliers, which eventually contribute to the geospatial information market expansion. Government change itself into the supplier since the geospatial information has characteristic of public goods and it also contributes to the company's profit. Individuals are also able to provide self-oriented geospatial information.

Moreover, South Korean geospaital information market has been expanded. First, the market has been focused on B2G market in which demands create supplies. However it is now B2C market where the supplies create demands. The environment is changing from the one-way geospatial information service by the suppliers to the customer-oriented service with variety of options.

Second, major geospatial information provided by the suppliers were simple locational data. However, now there are new types of information which grows from the convergence between the geospatial information and professional knowledge. g-CRM, planning support system, and trade area analysis are only a few examples. It is expected that the further convergence of geospatial information in many fields appears with various applications.

3. Geospatial Information Convergence Value Chain

3.1 Definition of the Geospatial Information Convergence

The word "covergence" from "Digital Convergence" has the meaning of showing a trend of making new products or services by combining different unit technology from information & communications. Therefore, the digital convergence is considered as the chemical and physical convergence between diverse fields such as information & communications technology and media, commodity and service, between hardwares, and softwares, hardware and softwares, human and machinery, and virtual and physical space.

Such convergence becomes very important strategy of generating new value. The research defines the geospatial information convergence as an activity which produces or adds value on the geospatial information. In other words, geosptial information convergence is a combination between different geospatial information or the information and other elements which adds new value. The new value is generated or added in the process of convergence by using new technology through geospatial information sharing, providing the information to the demanders regardless of time and space, and developing and applying the information (Byongnam Choe, 2008).

3.2 Elements of Geospatial Information Convergence

Geospatial information convergence consists of many elements from different categories. The research suggests list of elements below by studying geospatial information business model and value chain through the interviews.

- ○ S/W : Development tool(GIS, 3D, CAD, and navigations) and information service S/W
- ○ H/W : Individual devices such as PC, laptop, navigation, cell phone, PDA, GPS
- ○ Platform : Web, communication, and broadcasting platforms
- ○ Knowledge : Solution development and consulting (ISP, g-CRM, and trade area analysis)
- ○ Content : Producing and processing of geospatial information

3.3. Geosptial Information Convergence Value Chain

Information value chain is a process of producing final information started from acquiring source data (Spataro and Crow, 2002; Oelschlager, 2004; Phillips, 2001). Geospatial information is processed and achieves new value through the series of step which ranges from an initial producer to the consumer. These steps eventually create a value chain of input-converge-output.

Such successive transformation relationship is called geospatial information convergence value chain in this research. <figure 1> is written based on the value chain elements and their relationship of production and consumption. This is the highest level of geospatial information convergence value chain in national context.

4. Implication of Geospatial Information Convergence in National Policy

4.1 Geospatial Information as a Content Platform

Geospatial information value chain starts from the production of geospatial information and the new value is added during the convergence processes. The information service which is delivered to the consumers is based on the geospatial information. Geospatial information works its role as the content platform of the value chain.

The term, Spatial Data Infrastructure (SDI), is made based on the recognition that the geospatial information is public goods. This corresponds to the idea that common geospatial information should be constructed and shared by many people from various fields. SDI may be considered as the key of the geospatial information platform, but it is not large enough to be used as the content platform.

Therefore, geospatial information should be identified as a content platform larger than SDI. It should also be standardized and achieve good quality to become the platform.

4.2 Effects of Administrative Geosptial Information on the Market Expansion

Among the diverse elements of the geospatial information convergence, the key element is the geospatial information. The start of the geospatial information value chain is production and process of the information. In other words, the producing process of the geospatial information impacts the entire value chain.

Government works as an important supplier of the information since it produces and manages many kinds of geospatial information (Consumer(Government)→Geospatial Information Content Provider in the <Figure 1>). Hence geospatial information distribution policy of government has absolute impact on the value chain.

In order to facilitate the geospatial information market, change of the distribution policy is needed. Current Korean distribution policy of the geospatial information is ambiguous. Not only the information production of the company is restricted but also the information provision by the government is limited. It is necessary to release the level of the restriction and to change the relevant policies into the open ones. Size of the American geospatial information market is ten times larger than that of the European market although the economic scales of the two regions are similar (Peter Weiss, 2002)

4.3 Cooperation Between Small and Big Businesses

The nodes (supplier) which includes the big business in the geospatial information value chain (<Figure 1>) are some SI Vendors and Platform Vendors. Big SI Vendors are provided the geospatial information and the development tool by the small Geospatial Information Producer and Basic S/W Developers. Also the Platform Vendors, which are usually big businesses, acquires processed geospatial information and service S/W from the small Geospatial Information Providers and Service S/W Developers.

Therefore, the small businesses are positioned before the big businesses in the value chain. Furthermore, recent life cycle of the information technology has been shortened and the market requires customer-oriented geospatial information service from the suppliers.

In this situation, the small businesses are stronger in reacting such environment than the big ones are. The small businesses has more capability in developing technology in specific area. They also have ability to correspond rapidly to the changing environment. Therefore, it is important to have more competitive small businesses to expand the geospatial information market. For expansion of the market, cooperation between the big and the small businesses is essential. Initial step for this is to build up the capability of the small businesses. In other words, government needs policy which can remove weaknesses of the small businesses and reinforce the strengths of them.

4.4 Appropriate Policy Institution for the New Geosptial Information Market

Geospatial information market in the 21st century which is based on the digital convergence shows different characteristics from the paper map market. In the analogue geospatial information market, the business model was very simple since only some suppliers and demanders from specific fields participated. However, the current market based on the geospatial information convergence consists of variety of suppliers and any person who demands the information. In the near future, the scope of the suppliers will be expanded into almost everyone. To fit into this environment, it is extremely crucial to develop various business models.

In order to support such market environment, the government needs to reorganize the relevant policies. By making clear policies about copyrights, the right of using, and property ownership for geospatial information application, healthy market is formed and development of new content is facilitated. It is also important to eliminate public ontion spat the geospatial information is always free of charge by placing intellectual property rights. Moreover, it is necessary limie gee the recognition and regulation of information security. Domestic web portals such as Naver or Daum cannot provide certain geospatial information because of the security policy while Google can provide such information.

5. Conclusion and Further Study

Geospatial information convergence is a process of adding new value by combining various elements. It is complicated to categorize the convergence elements and to set the relationship among them. So it is possible to write the different geospatial information convergence value chain from the different point of view.

The research study suggests the Korean geospatial information convergence value chain. It provides important points of understanding the geospatial information market and also the implications for the relevant national policies. First, it provides a framework of identifying the entire market and its sub-categories. Through this frame, people can attain simple view of the complicated geospatial information market. Second, it shows the successive relationships between the elements of the value chain. With these elements, it is possible to recognize relevant policy leverage which would achieve low cost and high efficiency.

The development of the geospatial market is affected by many causes such as policy, economic, technology, and social contexts. This research study only suggest a little segment of the implication of such information in national policy. Additional studies are necessary for further development in geospatial information convergence. Especially, characteristic of the added value is changed through the value chain process and by different purposes of sub-markets. It is important to identify such phenomena. The next study will be about analyzing impact of geosptial information convergence. This further study will be using system dynamics to analyze the impact, based on the geospatial information convergence value chain.

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Modern Concepts and Algorithms for Homogenization and Combination of Cadastral Information in Korea

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Abstract

At present there are strong efforts to improve quality and completeness of cadastral information in Korea. The actual situation is characterized by digitized, but inhomogeneous maps in different scales. To make this information suitable for uniform use and for general access e.g. via internet, the existing data have to be homogenized (unified) and to be transformed into a modern, globally useable coordinate frame.

In this paper some algorithms for this homogenization process and concepts for the transformation into a global coordinate frame are presented.

In addition, it is recommended to complete the cadastral information, which is by now restricted to parcels of land, by adding the location and extend of buildings, the most important topographic items and a Digital Elevation Model.

Key words: Cadastral information, homogenization of maps, global coordinate frame, aerial laserscanning

1. Introduction and Background

Basic element for economic development in communities worldwide are legally guaranteed property rights. An essential part of this confidence in land titles is a modern, high standard cadastre, which guarantees the existence of the property, its location, its size and form and depicts the neighborhood.

Actual projects within the Korean administration are oriented towards an integrated national GI-Data-Structure. An important part of this will be a modern, complete and actual cadastral information, which might be usable via online access for selected private and public users.

As the original Korean cadastre was developed in about 1910 in close relation to the former Prussian cadastre in Germany, it seemed to be meaningful to orient the upgrading process to recent developments made in Germany during the last decades, but – of course - with a broader look to actual developments worldwide.

The focus of this paper are modernization aspects for the digitized cadastral maps, not for the analog information (register, book), which has to be integrated in digitized form into a combined, modern cadastral information system.

2. Existing Situation for Cadastral Information in Korea

2.1 Historical Developments

Due to historical reasons, two types of analog cadastral information exist in Korea. One group are the so-called Cadastral Maps (Sie Seok Do) which cover all areas with settlements and go back to the years 1910 – 1918. These maps have scales of 1 : 600, 1: 1200 and 1 : 2400.

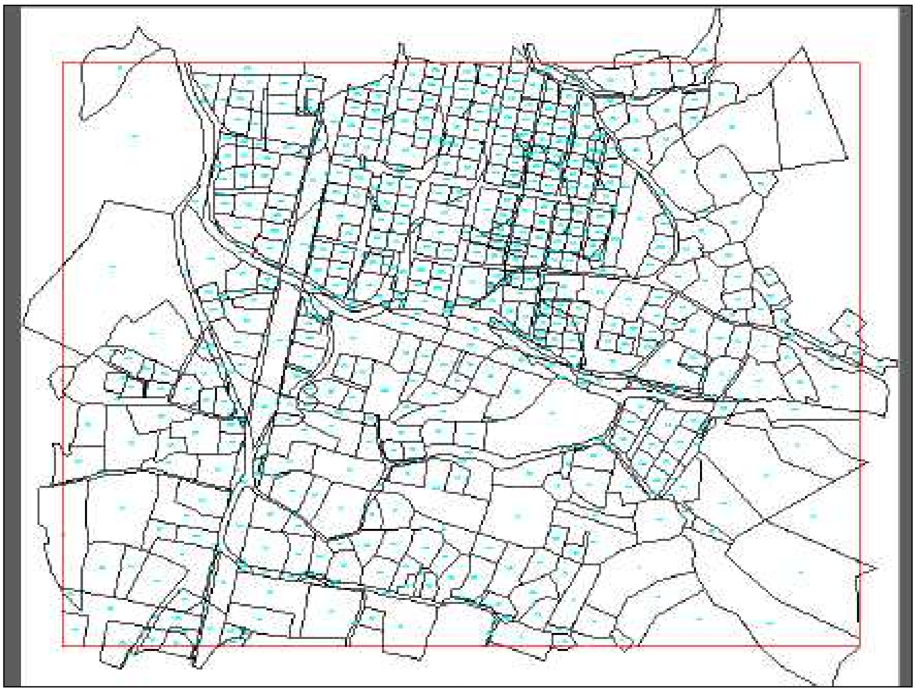
The second group are so-called Forest Maps (Im Ja Do), covering the forested areas, in former days about 2/3 of the complete area of Korea. These maps go back to the years 1916 –1924 and have scales between 1 : 3000 and 1 : 6000.

During a first modernisation, starting about 1975, among others the metric system, new scales of 1 : 500 and 1 : 1000 and new map formats were introduced.

In 1990 the digitalization of existing maps started. An example is depicted in Fig. 1. Still these maps are mainly singular (insular) maps and have different scales.

Further problems are related to the reference system of this information. The original cadastral system was derived within Tokyo Datum. Aside the National Datum with 3 different zones and 11 Regional Systems exist. Nowadays the objective is to have all information available within a global coordinate frame, which is suitable e.g. for GPS-applications, resp. navigation purposes.

Figure 1. Actual digitized cadastral map in Korea



A further objective was and still is a seemless information in a uniform scale with actual, most complete information. Only if all these objectives are fulfilled, it is worth to go to online-availability and online-exchange of this information.

2.2 Digital Cadastral Maps and Problems Encountered

During the process of digitizing existing maps and putting together these mainly isolated maps to form seemless information, severe discrepancies were found, which let to a closer look to the origin of this information and initiated the here presented work to homogenize and unify the available cadastral information.

Some of the found discrepancies are depicted in Fig. 2. In Fig. 2a maps with different scales are put together, where differences of several meters are found; in Fig 2b much larger discrepancies are encountered, as administrative boundaries are crossed. The detected gaps in the data sets are that large that they cannot be neglected in a GI-data-base.

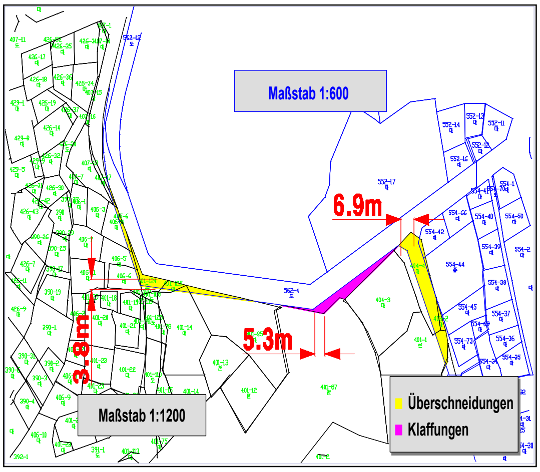


Figure 2a. Discrepancies between maps of different scales

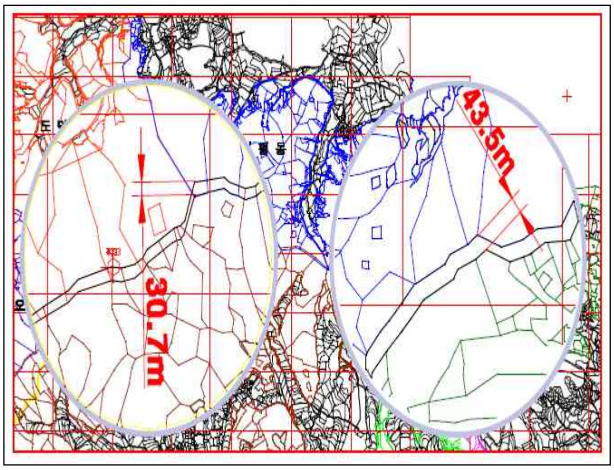


Figure 2b. Discrepancies between maps of different administrative districts

3. Homogenization of Digital Cadastral Maps

Homogenization of digital data are always necessary, if analogmaps are digitized and then put (knitted) together to form a seemless data set. Homogenization is a widely used concept and several numerical strategies and algorithms are developed for this process (e.g. Dreesmann et. al. 2001, Kampshoff 2005).

In general the following steps have to be followed for the process of homogenization :

I. Search for identical points in adjacent maps

II. Apply sequential transformations (variable in number of parameters, introduction of scales and rotations, …) to combine different maps

III. Eliminate remaining discrepancies by so-called neighborhood-matching

3.1 Homogenization Strategy for Korea

The found situation in cadastral maps in Korea can be characterized as follows:

- Main information is boundary line and not the parcel with its area
- Different scales (1: 600 till 1 : 6000)
- No coordinates available for edges
- No point numbers exist

- No buildings, i.e. no conditions regarding orthogonality, parallism, etc. have to be fulfilled

This specific set of information let to the development of a new concept and subsequent algorithms for forming a seemless cadastral information in Korea. The main difference to common solutions is to detect identical points without any point identifier and variable scales.

Our concept and solution is based on features, which are unique for a specific geometric situation, but not sensitive to aging effects of maps (paper distortion), unprecision of information, etc. We used so-called datum-invariant elements, which can be derived in each map individually but allow to find identical points and locations in different, but adjacent maps. Starting point is the assumption that identical locations can only be located on the outer edge of a map. For all points on the perimeter the following datum-invariant quantities are computed: - distance to previous point- distance to subsequent point-enclosed angle.

In Fig. 3 these criteria are depicted for two typical situations. In Fig 3a for two adjacent parcels of land, existing at the beginning in separate maps, the 3 datum-invariant elements are computed. The result are 2 identical distances and 1 identical enclosed angle. This is a strong hint for these locations to belong to each other. The enclosed point will be identified as being identical. In Fig 3b in the left map a further parcel of land occurs in the vincinity of this location. The result of these first computations are just one identical distance and identity for the enclosed angle.

To decide on identity of location the requirement of strong congruency is too strict. It has to be allowed that a) only 2 criteria fulfill the requirements of being identical and b) due to limited precision of the information certain differences between the datum-invariant parameters are allowed. The final decision on identity is based on FUZZY rules, which have to take into account "normal" deviations.

The remaining steps are sequential transformations to combine the digitized maps and finally to apply neighborhood-matching to eliminate remaining discrepancies. The algorithms for these steps mainly follow established concepts and can be found in Kim (2009).

Figure 3a. Two identical distances and identical enclosed angle

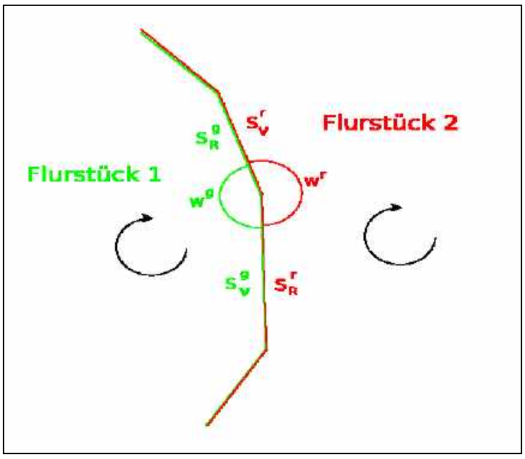
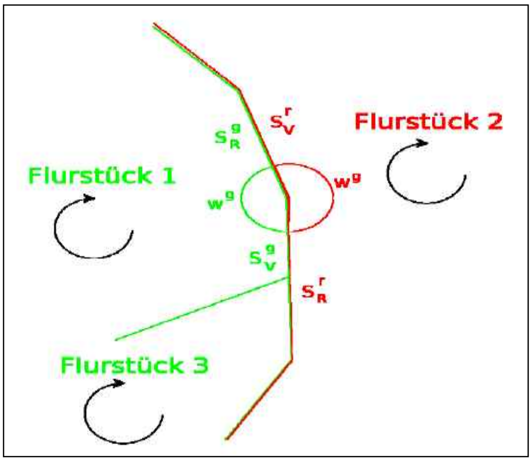


Figure 3b. One identical distance and identical enclosed angle



3.2 Pilot Area YoungTong Gu

As test area for the new homogenization strategy a 3 km^2large section of the pilot area YoungTong Gu was selected. For this section 4 maps are available with scales of 1 : 1200 and 3 (forest) maps have a scale of 1 : 6000.

In Fig 4a these different maps are depicted where the perimeters of each map are colored. In Fig. 4b the results of the sequential transformations between these sheets are depicted. The green dots indicate the detected identical points. At least for this test area the new algorithm was able to identify a sufficient number of identical points for robust transformations.

The development up to now can be considered just as first step, various improvements and extensions might be necessary to derive a universal solution for homogenization of all types of cadastral information, which exist in Korea.

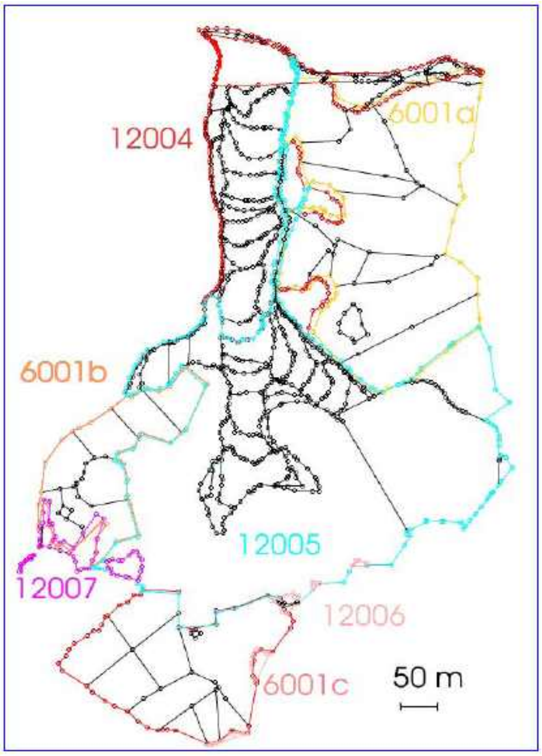


Figure 4a. Used maps for test area in YoungTong Gu

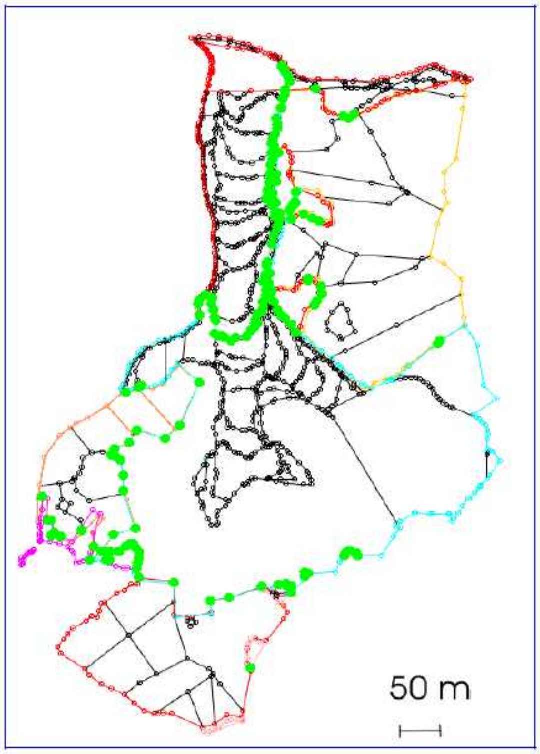


Figure 4b. Identified identical points (green dots) and results of transformation

4. Uniform New Datum

A second problem to be discussed here is the necessity to transform all cadastral information into a new, global coordinate system. As outlined in section 2.1, at present various mainly local or regional datum definitions form the basis for the spread cadastral information.

Nowadays there is a need to have all GI-data available in a well defined global coordinate system, e.g. to be able to use this information for navigation purposes or for national and international data exchange.

4.1 Tectonic Situation in Korea

Before defining a new datum , a look at the actual tectonic situation for Koreais meaningful. In Fig. 5a the basic plate tectonic structure of East Asia is sketched and actual movements rates for 8 GPS stations within Korea are depicted, based on the analysis of GPS campaigns in 2002 and 2004 (Song & Yun 2006). In Fig 5b the actual movement rates for 53 permanent GPS stations within Korea are depicted, derived from National Geographic Information Institute (NGII 2007).

Figure.5a. Tectonic situation of Korea and movement rates from GPS campaigns

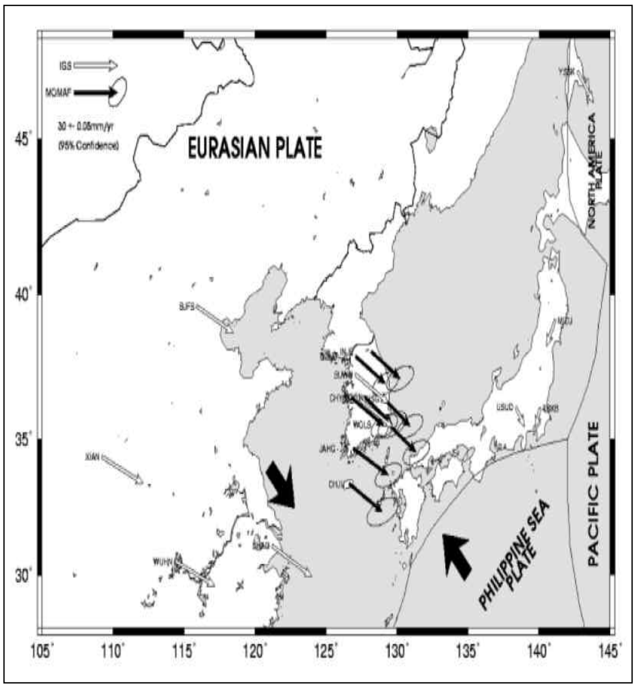
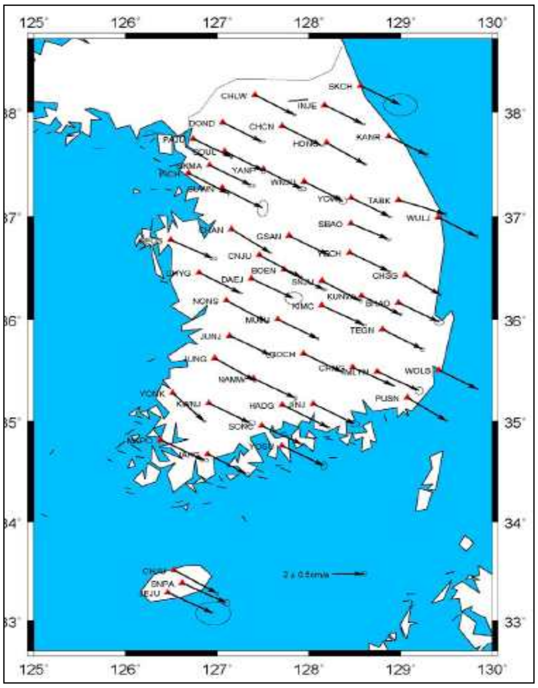


Figure 5b. Velocities for 53 permanent GPS- stations



One can state that the movements rates of Korean stations in relation to a worldwide system, like the International Terrestrial Reference Frame (ITRF 2005), are in the order of 25 to 30 mm and oriented to South-East. To our knowledge more detailed information on variations of movement rates within Korea are not known and analysed yet in detail.

4.2 Concept for Defining a New Geodetic Datum for Korea

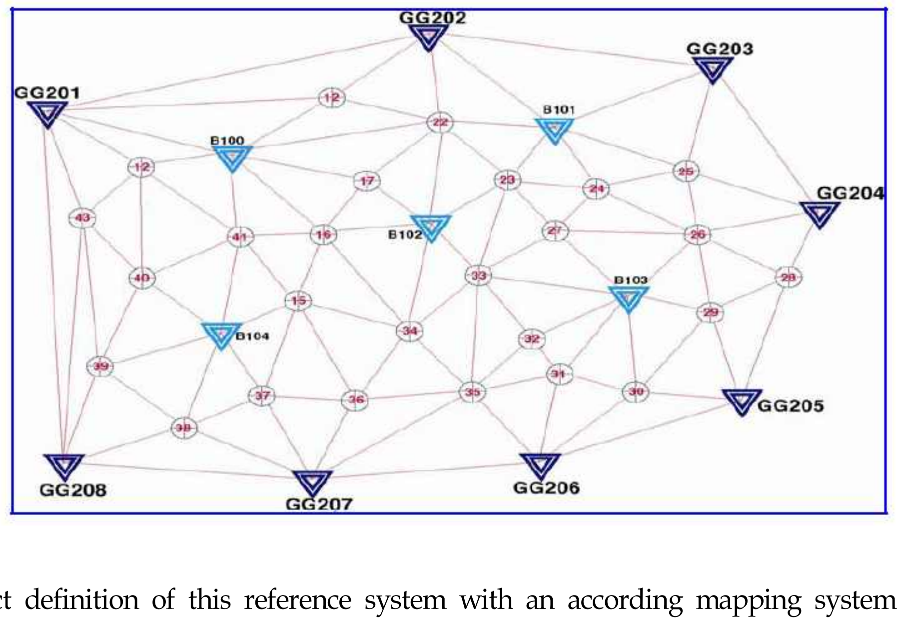
The above given information on actual movement rates within a global coordinate frame was neglected up to now, as the various geodetic reference systems were defined locally. At least for a limited time span of 10 to 20 years it will be possible to define a fixed datum in the future, e.g. for ten years the shift of the country is in the range of 30 cm, what might be neglected in most applications. For longer time spans a more general – dynamic - datum definition will be necessary, where this plate kinematics is taken into account !!

At present a new, but – static -datum definition seems to be an adequate and sufficient solution for defining a new uniform geodetic datum, named e.g. Korean Terrestrial Reference System 2010. Two steps seem to be necessary to define this KTRF 2010:

i) Determination of selected permanent GPS stations within the global ITRF, more specific by connecting Koreato ITRF stations in the surrounding countries. This could be done by a special campaign or at least by a thorough analysis of existing GPS data sets for a longer time span. This coordinate set will be the fundamental information for the new KTRF 2010.

ii) Determination of a sufficient number of stations of the existing control networks by GPS in relation to the stations determined in KTRF2010. It will be necessary to have global 3D-coordinates for well spread stations, known in the cadastral system everywhere in the country. In Fig 6 this densification of the GPS network is depicted. It results in a number of stations with coordinates in the old and new system, named identical stations. The density and spreading of these stations is depending on the zones of existing control and knowledge on real distortions and break lines.

Figure 6. Connecting cadastral (control) stations with KTRF2010 stations via GPS observations



The exact definition of this reference system with an according mapping system cannot be discussed in this paper. Here we assume, that such a new, uniform coordinate frame exists.

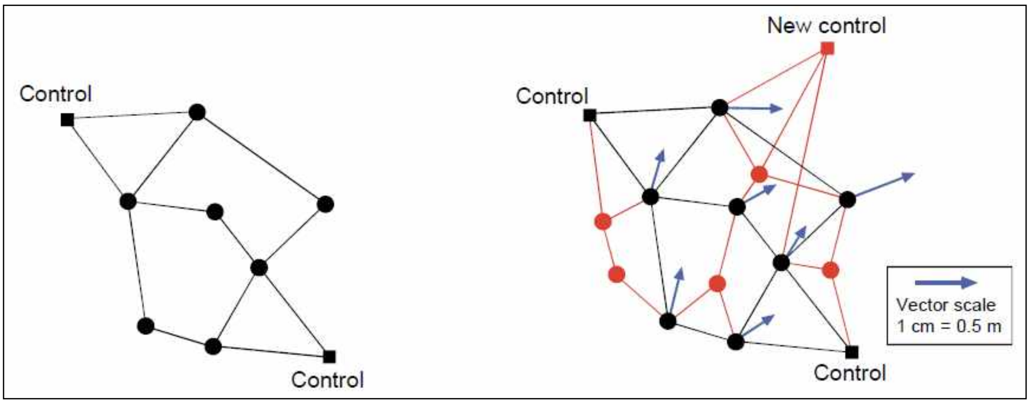
4.3 Grid Based Transformation

The normal way to transform local or regional coordinates into a new coordinate system is a 7 or 4 parameter similarity transformation, depending whether the coordinates are defined in 3D or 2D. But these similarity transformations, which can cover the main part of the differences between the two coordinate systems, are not sufficient, the remaining discrepancies are in general to large.

Therefore as second step for transforming the existing cadastral information into a new, homogeneous cadastral information system a so-called "Grid Based Transformation"has to be applied. This type of transformation was developed and tested extensively in Canada and Australia (Collier 2002) and nowadays is used in Germanyas well. Driving impact are the remaining distortions within the existing coordinates. Such distortions exist everywhere in geodetic networks or cadastral information due to the process of generating, maintaining and extending the data during their lifetime.

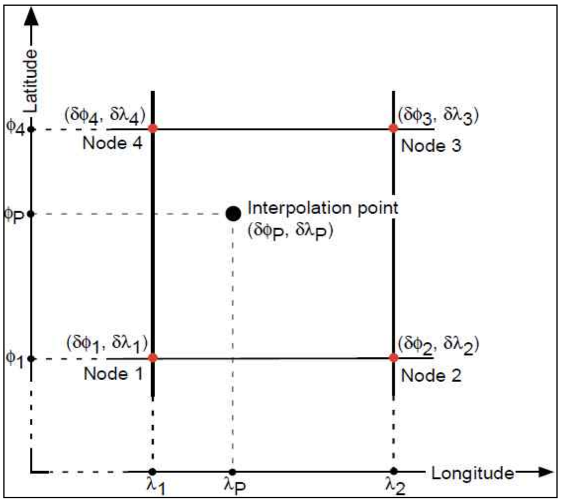
In Fig 7 a typical example for such distortions is given. On the left the original information, here coordinates of points, are depicted. We all know that the absolute accuracy of this information is limited. After a second campaign, may be with new control points, with new observations or after extended adjustments or computations one receives new coordinates for the existing points. Aside real point movements can occur. Anyway, the existing cadastral information, being analog or digital will have a certain pattern of distortions. During the transformation of this information into a new, homogeneous system it will be necessary to account for the existing distortions, but sometimes also to maintain certain features, e.g. the parcel size, rectangularity, parallelism, etc.

Figure 7. Distortions in existing coordinate sets can be caused by new observations, new higher order control, extended adjustments and point movements



The concept of the Grid-Based-Transformation is to realize a detailed approximation of the distortion pattern that exists within the given data sews. Prerequisite is that for a sufficient number of identical stations coordinates in both systems (old and new) have to be known. Then the discrepancies, determined at these identical stations will be transfered to a regular grid structure, see Fig. 8. This transfer will be made by applying some stochastic modeling, e.g. using collocation (see Niemeier 2008). The model behind this approach is that the distortions behave like a stochastic process, more precisely, the distortions change slowly and their variability can be approximated by an adequate covariance function.

Figure 8. Interpolation for each point in relation to surrounding grid points



Once the grid, resp. the distortions for the grid points are determined, the distortion for each position inside the grid can be computed by a given interpolation rule, e.g. bi-linear or spline interpolation. Normally the 9 surrounding cells with 16 nodes are used to determine the valid distortion for each point. The computed distortion for each point is then applied as correction term within the complete transformation process.

The advantage of this concept is that this transformation is unique, reversal and easy to implement. Each user can have access to a software tool to go from one system to the other and vice versa.

5. Objective: Integrated Information System

If one looks to international developments, e.g. given in the declaration of the FIG "Cadastre 2014", actual developments in Germany, named AAA (AdV-online, Knoop 2004, 2008, Ueberholz/Christ 2007) and similar concepts in other countries, the objective of any administration always is the development of an integrated, actual data set. The following information therefore should be merged with the cadastral information:

i) Building information

The knowledge on the location of buildings is in most countries an essential part of basic Geo-Information-Systems. Not only the location, but also the real size (extension) of the structure and the utilization could be included into an integrated system.

ii) Topography

To give a more complex view, important for planning purposes and decision making, the most important topographic items, like roads, water lines, bridges, vegetation type, usage, etc should be available in an integrated data set.

iii) Digital Elevation Model

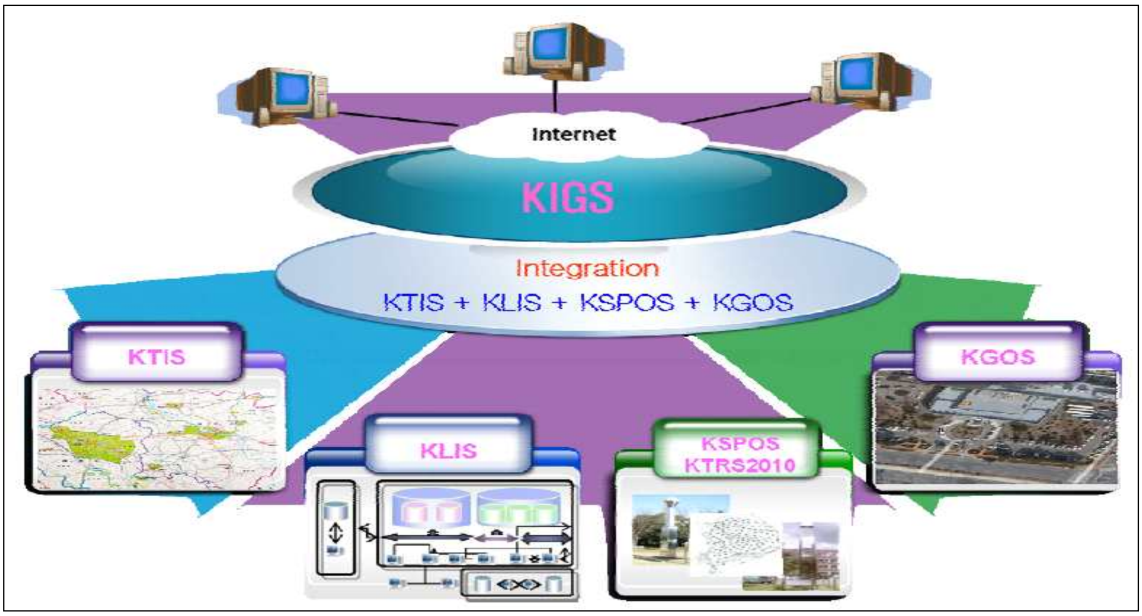
For a complete information the third dimension has to be included. For purposes of property evaluation or planning the exposition to the sun, the inclination of the landscape etc. is an important information.

For the complete integrated system Kim (2009) made a proposal to develop an innovative Korean Intregrated Geoinformation System, named KIGS, which is depicted with its main elements in Fig. 9.

The main elements of this integrated KIGS are:

- Korean Topographic Information System (KTIS),
- Korean Land information System (KLIS), i.e. the combined graphical and registered cadastral information, both in digital form,
- basic elements of the new Korean Terrestrial Reference Frame (KTRS2010) combined with the Korean Permanent Satellite Positioning Service (KSPOS),
- data base with building information (KGOS).

Figure 9. Architecture of a new integrated Korean GI-System, named KIGS (Kim 2009)



This could be the future. Many of this information does exist, at least in preliminary form. But not everything is available in digital form and even then several adjustments have to be made to the data, see the previous chapters.

If more information is needed, e.g. for buildings, topography or even for the digital elevation model, nowadays a adequate and efficient technique to capture geometry related information is aerial *laserscanning*. This remote sensing technology, where the scanner is based under an aeroplane for many tasks almost replaced classical aerial photogrammetry and should be seriously considered to support the setup of an integrated information system for Korea.

Summary

This paper focuses on concepts and algorithms to establish a uniform cadastral information for Korea, using the existing cadastral maps. The here presented strategies and methods for homogenization have been tested in real surroundings and have proven its potential for renewal of cadastral information.

For a development towards an integrated information system for Korea the set-up of a new, global reference system is proposed.

Finally, the content of such an integrated information system is outlined. Here besides cadastral data the buildings and the topography including a DTM is necessary.

Several important questions could not be discussed, e.g. any checks of the correctness and actuality of the available information as well as concepts for maintenance and renewal have to be developed. Further on all the questions of data formats and data exchange for online access have been left out.

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BIOGRAPHICAL NOTES

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Development and Applications of the Interoperable Platform for Disaster Risk Information

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Abstract

Disaster risk information, such as hazard maps, helps at-risk stakeholders to understand the risks and take action to reduce them. Our research into an interoperable platform for disaster-risk information focuses on the following three areas: the advancement, interoperability, and utilization of information. The purpose of our project is to help people become better prepared for disasters by providing them with a way to utilize specific disaster-risk information. In this paper, we introduce the concept behind our project and some applications.

Keywords

Disaster risk information, Risk evaluation, Risk management, Interoperability, Coping capacity

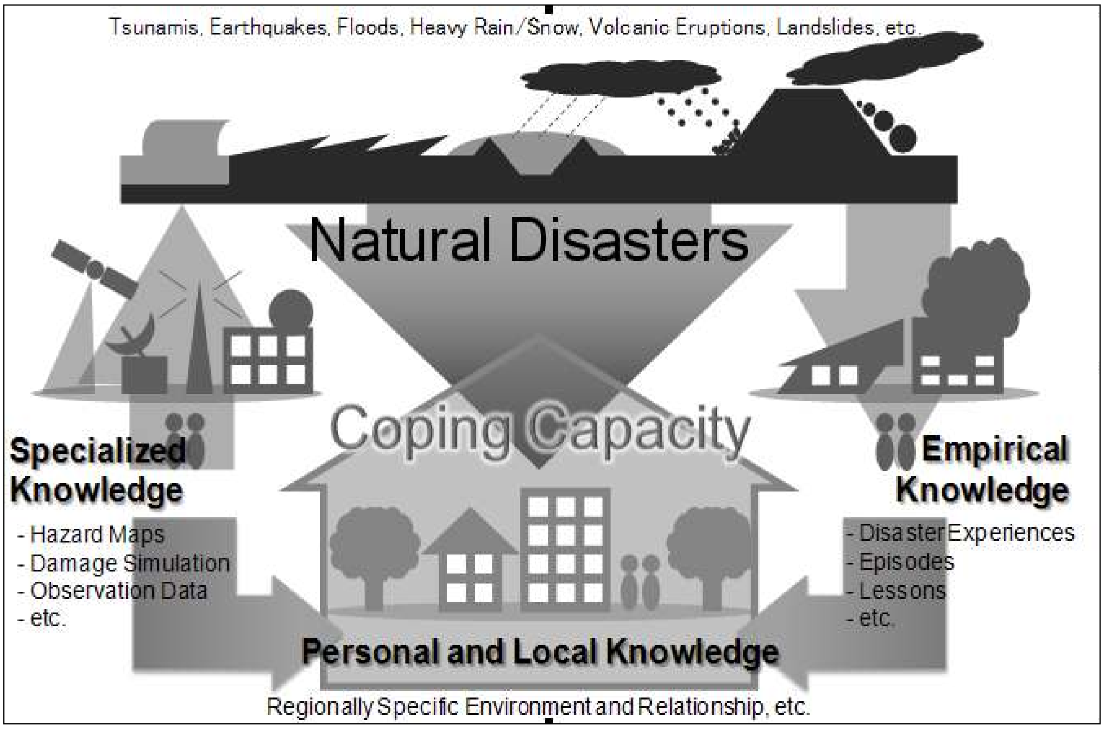
1. 'BOSAI-DRIP' for Disaster-risk Governance

In 2008, the National Research Institute for Earth Science and Disaster Prevention (NIED) commenced a new research project named the "Disaster Risk Information Platform,"based on the concepts of governmental science research tactics called "Innovation 25". The long-term strategy initiative "Innovation 25" will be designed and executed by the year 2025 in the fields of medicine, engineering, information technology, etc., for the creation of innovation contributing to growth. This strategy concerns returning benefits to society, based on advancements in science and technology, to create a safer, more comfortable, and sustainable society by means of decreasing the population and aging and the globalization of risks. (http://www.cao.go.jp/innovation/en/index.html)

1.1 The background and purpose of the Bosai-DRIP (Disaster Risk Information Platform)

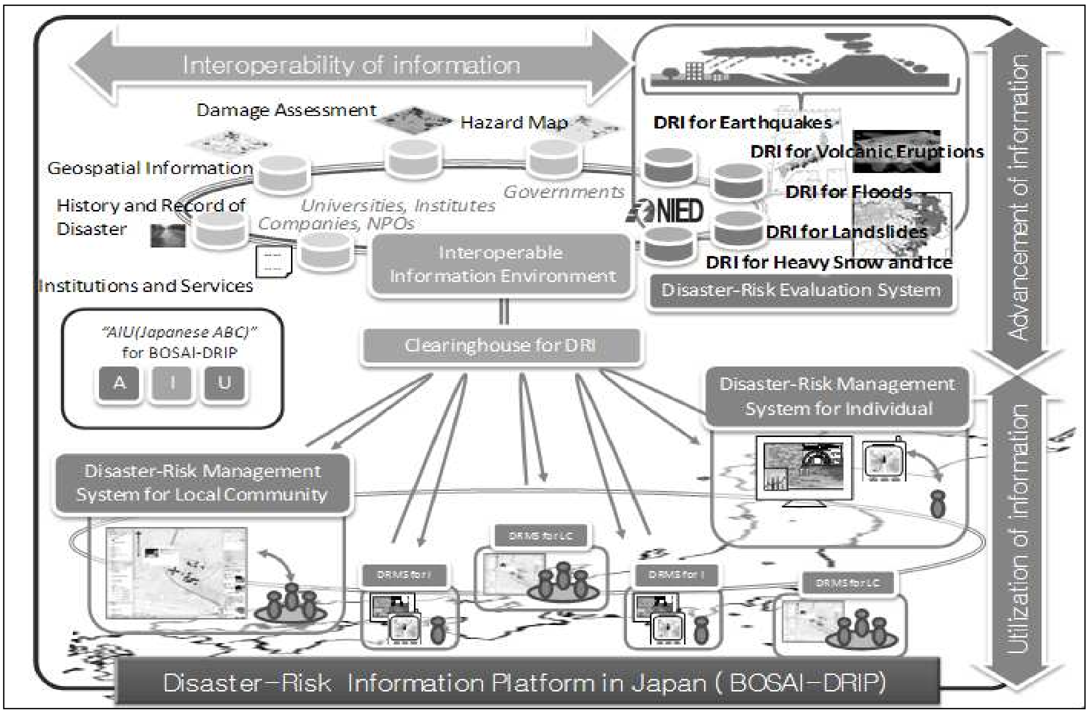
In order to mitigate the damage caused by natural disasters, every person must increase their awareness and promote preparations. No common optimum disaster prevention measure exists among all people and all local communities. Therefore, every person and local community should acquire specialized knowledge and empirical knowledge and develop the ability to cope with natural disasters. (Figure 1)

Figure 1. Improving the coping capacity using various types of knowledge about disaster risks



To achieve this objective, we are researching an interoperable platform for disaster-risk information called "Bosai-DRIP." "Bosai"means disaster prevention in Japanese, and "DRIP" is the acronym for "Disaster-Risk Information Platform". Disaster-risk information is visualized knowledge, such as hazard maps, damage simulations, and disaster episodes. Figure 2 shows the overall scope of our project. The project focuses on the following three points: advancement, interoperability, and utilization. "Disaster Hazard and Risk Evaluation Systems"deliver various types of disaster-risk information in the form of specialized knowledge. To provide information interoperability, we have proposed the "Interoperable Environment of Disaster-Risk Information,"which integrates various types of information and interlocks the distributed simulation systems utilized by various users. Regarding information utilization, we are developing a disaster-risk management system for individuals and local communities, as well as methodologies for improving their capacities to cope with disasters. These three points are the basic components of "Bosai-DRIP". This platform will be useful for enhancing not only each person's decision-making capabilities during emergencies, but also the preparations for disasters of both communities and individuals.

Figure 2. Overall scope of "Bosai-DRIP"



1.2 Key concept of the BOSAI-DRIP

The disaster risk information platform provides solutions to some of the current problems in our society.

(1) Problems-Why do we need the disaster risk information platform?

a. Lack of clarity with regard to access point, owing to scattered information

There are too many organizations providing useful information such as that related to natural disasters, for example, the structure of the ground, soil conditions, location and activities of faults, and the possibility of heavy rainfall, as well as information pertaining to housing, the population, etc. The main entity providing risk information is the national government. However, even in the national government, there are numerous ministries and governmental agencies, as a result of which it is difficult for people to determine which among these are the appropriate information resources with respect to risk.

b. Failure of residents/recipients to use hazard/risk information owing to low reliability

Although a considerable amount of research has been conducted by experts, there still exist too many uncertainties with respect to risk information on natural disasters. Additionally, the data on hazards/risks is not reliable, which leads to dissatisfaction among the residents. As a result, the general public is unable to implement rational countermeasures for disaster risks, such as retrofitting and/or diagnosis of people's houses.

c. Failure of mere publication and distribution of risk information to lead to disaster prevention.

Following the Great Hanshin-Awaji earthquake in 1995, there was a significant economic and social change in risk communication. Although various hazard maps and disaster evaluation reports were published by the local government, this information and knowledge was not practically used by the residents. Typically, almost the entire general public does not comprehend the seriousness of disaster risks. We believe that the problem lies in the risk information.

(2) Solutions-How will the information platform contribute to our society?

The disaster risk information platform is a system that enables everyone to easily access their own risk information in the manner that they desire. This system is characterized by information decentralization and mutual operations among various organizations related to natural disaster. The system has standardized not only the interface for spatial information data but also the clearing house functions through which the meta-data pertaining to risk information can be retrieved.

In addition to geographical information, this system provides solutions with respect to disaster prevention planning, including financial consideration, to residents and local communities. The implementation of this system will enable decision-making for various stakeholders such as the national government, local government, research organizations, nonprofit organizations, private companies, communities, families, and individuals.

To achieve these objectives effectively, the information platform has three types of action programs, which are described in the next chapter.

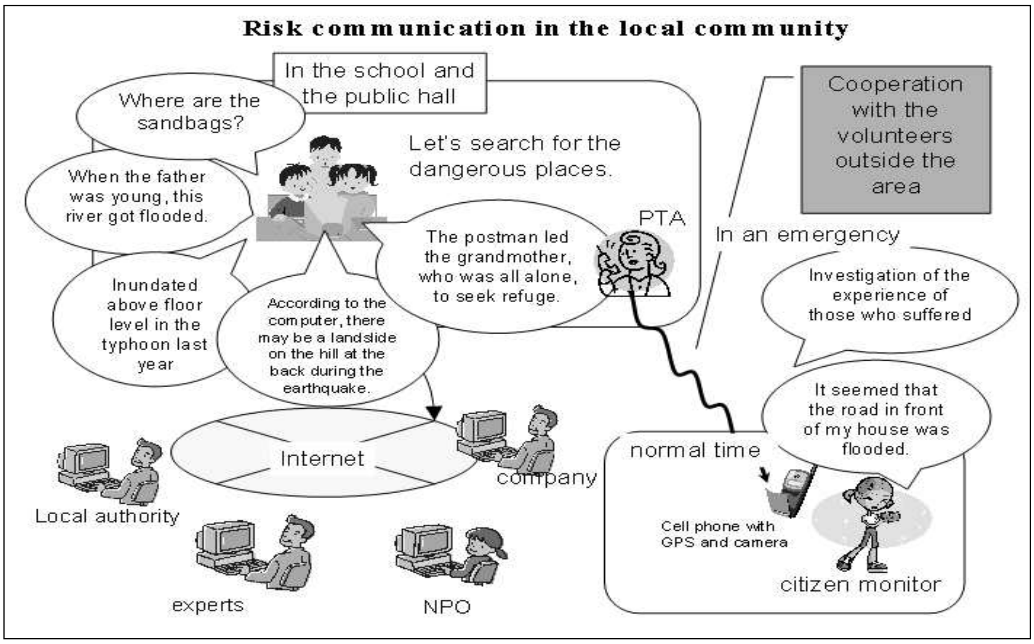
1.3 Developing disaster risk information appreciation systems

Our project involves creating two types of risk information appreciation systems. The first type is the nationwide overview type of system, which is useful for national agencies and similar enterprises.

The other type is the detailed community type of system, which is useful for local governments, communities, families, and individuals. With respect to the latter, we have experience in creating an e-community platform on the Internet in limited districts.

An e-community platform recreates local relationships with respect to risk communication by using the Internet. For example, fieldwork and a workshop with respect to local disasters were conducted with the participation of school children in the city of Tsukuba. Participants used cellular phones to communicate with each other in order to identify the locations with natural disaster risks. The culmination of this activity was the publication of hazard maps in specific areas, which proved to be highly useful.

Figure 3. Images of risk communication in the local community on the Web



1.4 Basic policy of disaster risk governance

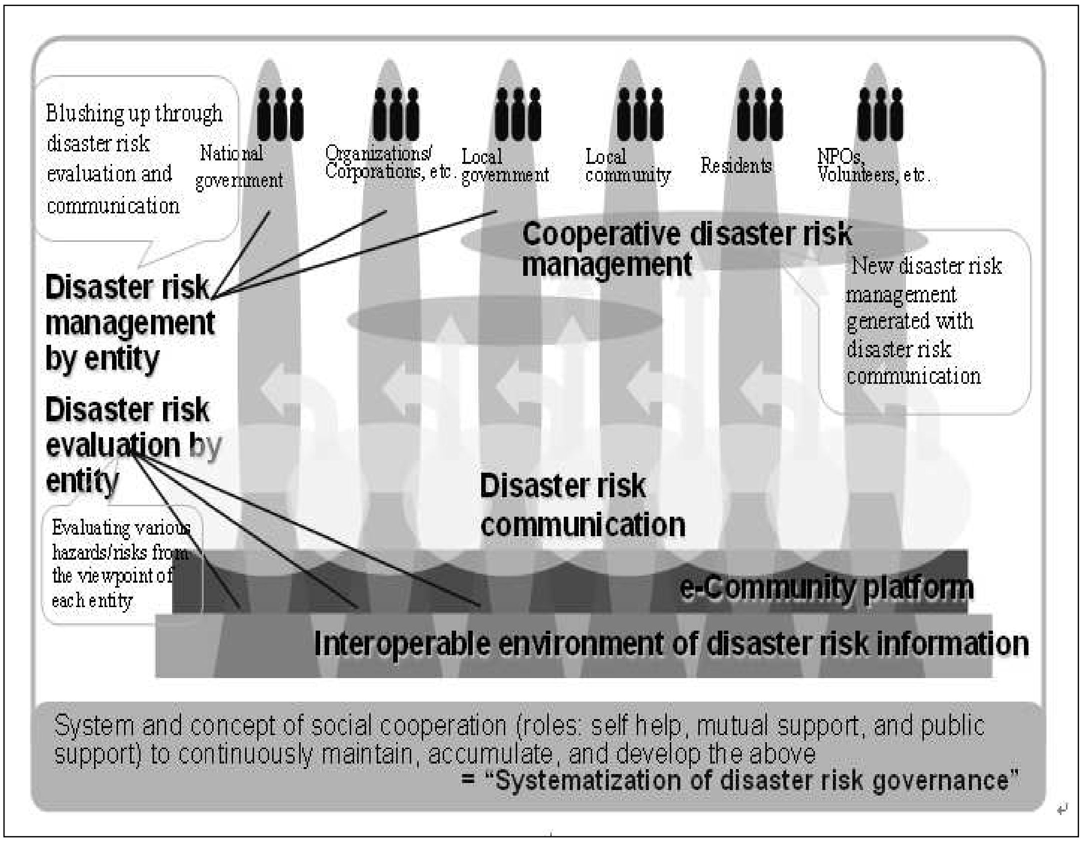
There was a significant change in the strategy of the Japanese disaster prevention system following the Hanshin-Awaji earthquake in 1995. In particular, everyone recognized the importance of the balance of hard/soft countermeasures with respect to natural disasters. Three years ago, we proposed a conceptual framework named "disaster risk governance"as a participatory and interactive approach for disaster risk management. It called for the enhancement of collaborative efforts among a variety of stakeholders in terms of self-help and mutual assistance through informal activities and social networking in communities. We believed that this was more important rather than formal and institutional assistance by the government. We also propose three basic requirements to implement the policy of risk governance in communities. They are as follows:

(1) The sharing of basic risk information such as scientific expertise and/or folk knowledge/wisdom among stakeholders in local communities

(2) The customization of risk communication with the analytical deliberation of risk information and informed choice of acceptable levels of disaster risk

(3) The creation of an informal setup of collaboration among stakeholders by enhancing social networking and non-regulatory/non-market incentives

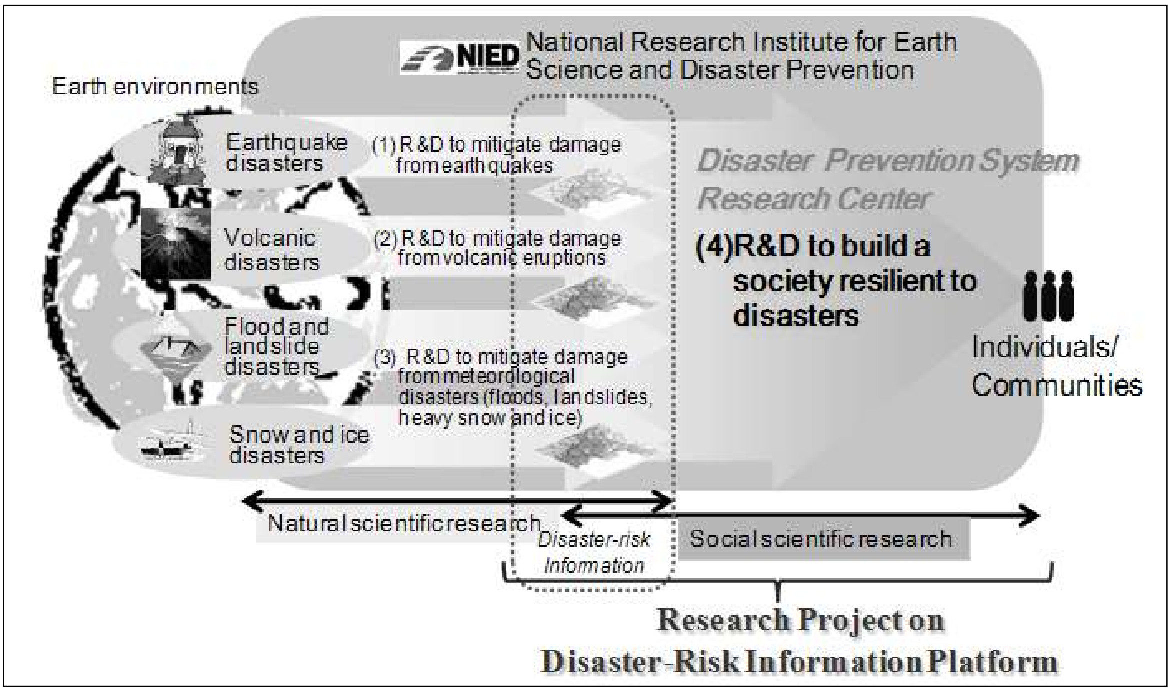
Figure 4. Goal of project: Systematization of disaster risk governance



2. Research and Development of the Disaster Hazard and Risk Evaluation System

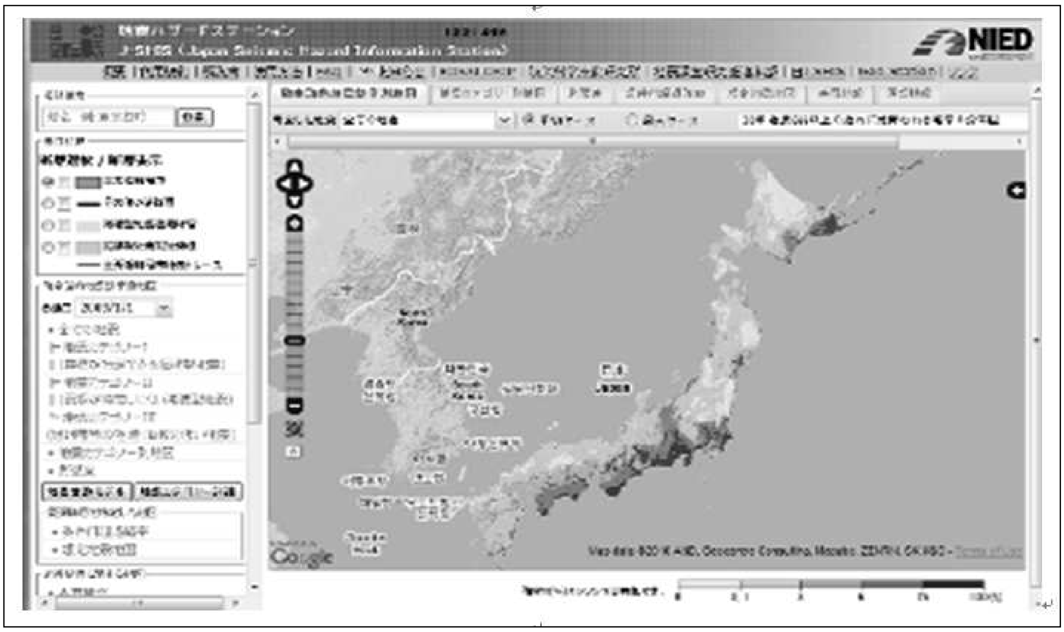
All of the researchers at NIED are working on research and development projects related to various types of disasters, such as earthquakes, volcanic eruptions, floods, landslides, heavy snowfalls, and heavy ice buildup, in order to help society become resilient to disasters. We develop systems that disseminate expert knowledge in the form of the disaster-risk information created by researchers. (Figure 5)

Figure 5. Disaster-risk information as specialist knowledge of natural disasters



Currently, we are focusing on earthquake disasters. We are developing methodologies for modeling subsurface structures in order to improve the accuracy of ground motion predictions and seismic hazard evaluations, and examining the methods for important target areas. We also are developing a practical system for predicting strong ground motions that make use of advanced simulation techniques. The methodologies are capable of simulating both large-scale earthquakes and local ground motions. In order to provide highly accurate real-time seismic information during massive earthquakes, we are developing methodologies for real-time estimations of the earthquake source parameters using the new K-NET real-time strong-motion observation system as well as other seismograph networks. We also are developing methodologies for estimating real-time strong-motion distributions and damage. In order to increase the reliability of probabilistic seismic hazard evaluation methods, we will develop a methodology that integrates such information with strong motion simulations for scenario earthquakes. We will establish a Japan seismic hazard information station to distribute our research products and other information to the public through the internet and other means, and produce detailed hazard maps for local regions in collaboration with local authorities. (Figure 6)

Figure 6. J-SHIS (Japan Seismic Hazard Information Station)

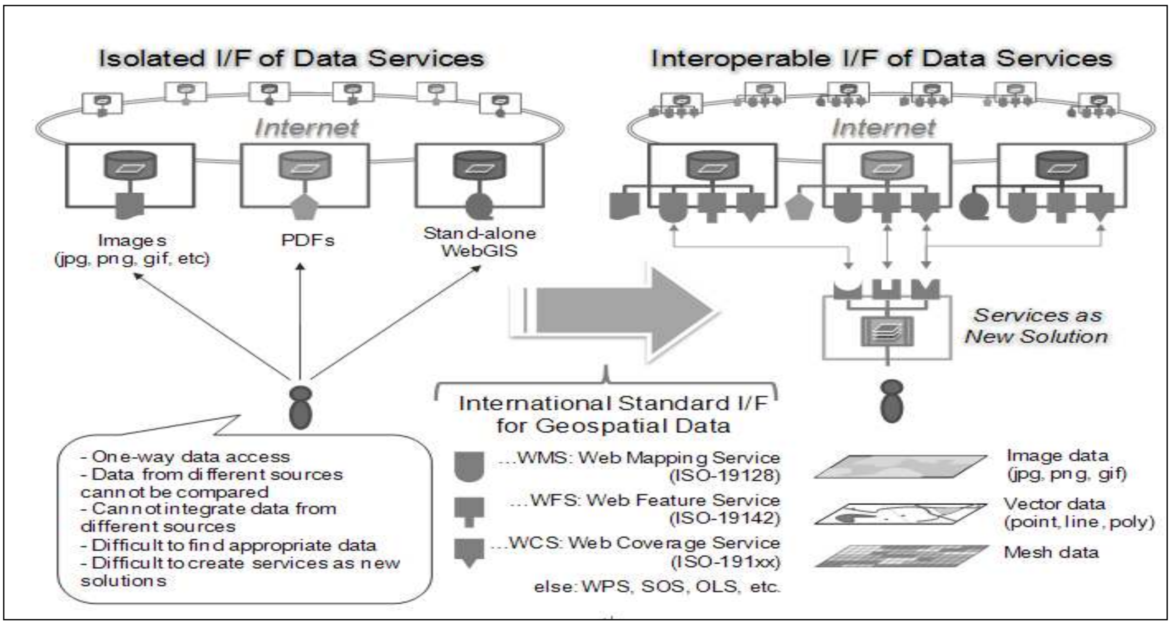


We are making a map of past natural disasters in Japan and collecting hazard maps made by national and municipal agencies. These maps are combined with relevant seismological data to create data for experiments in disaster-risk management system for individuals and local communities.

3. Research and Development of the Interoperable Environment for Disaster-risk Information

Recently, various types of information have been published on the internet in the forms of images, pdf files, and stand-alone WebGIS. Therefore, users see and use the information discretely and are not able to compare or integrate the various forms of the information. To solve this problem, we have proposed compliance with international standard interfaces for geospatial data. Examples of such interfaces include WMS (Web Mapping Service), a format for exchanging images, WFS (Web Feature Service), a format for exchanging vector objects, and WCS, a format for exchanging numerical mesh data. Data compiled in these formats can be dynamically transmitted in real time between different systems. Users can then integrate these various forms of information into their utilization systems. (Figure 7)

Figure 7. International standard I/F as a basic infrastructure



We developed the "Interoperable G-Server" as a data delivery system and have delivered the system as open source software. We verified the system and its interoperability by applying it to aid efforts for the Haitiearthquake, which killed more than 200,000 people and destroyed the homes of many more. Just after the quake, several agencies and institutes around the world published on the internet, such as, satellite images, earthquake intensity maps, and damage assessment maps. In Japan, JAXA, the Japan Aerospace Exploration Agency, gathered remotely sensed data after the earthquake using the ALOS (Advanced Land Observation Satellite) and published the first images of the aftermath. Although we can see the data on each distributor's web site, the data cannot be combined and dynamically used because their formats differ (jpeg images and pdf files). Under such circumstances, thedata cannot lead to new solutions for the user. Therefore, we proposed to JAXA that we reformat the ALOS images in order to enable interoperable utilization. We were given the approval to distribute ALOS images from our "Interoperable G-Server" based on an international standard interface. Therefore users all over the world can access ALOS images using software that incorporates the international standard interface. For example, Google Earth incorporates the WMS I/F, so ALOS images can be viewed and utilized using the Interoperable G-Server.

After the Haiti earthquake, none of the maps available on the internet were sufficient for the aid efforts in Haiti. OpenStreetMap, a Volunteered Geographic Information project, is a rights-free map of the world being created by volunteers using various sources and GPS tracks. It, too, had been insufficient. The OpenStreetMap Editor software, however, has an interoperable I/F, and many volunteers around the world traced roads in Haiti using various images, including JAXA/ALOS images, by means of the WMS I/F. As a result, only a few days after the earthquake, a highly detailed map had been created, and the locations of refugee camps and severely damaged buildings had been plotted. Many dynamic services also were created by mashing up OpenStreetMap and other services, such as a route search service, photo-sharing service, rescue needs map, etc. An application service for smart phones also was developed. When internet service was available, rescue parties could download into their smart phones all of the data for roads, damaged buildings, and refugee camps, and then access the data in the field, even when internet service was unavailable.

In this way, information interoperability can dynamically create new utilizations and solutions. We verified the validity of the environment. In the future, multiple disaster prevention information systems and related services and programs will be dynamically linked and data dynamically updated. In the past few years, free and simple API (Application Programming Interface) services (e.g., the Google Maps API) have been developed, allowing users to combine various new services and data. This trend in user innovation allows anybody to design a method for outputting information using any system, not just the source that controls the data. This point is very important for providing disaster prevention/mitigation information in the future. The key to successfully creating an interoperable environment is to motivate each institute and organization to circulate specific information. It is important to further promote measures to actively provide information and ensure interoperability by setting clear standards for compliance through appropriate discussions and studies on how to effectively use information.

4. Research and Development of the Disaster-risk Management System for Individuals and Local Communities

The primary goal of this project is to develop a variety of approaches for utilizing disaster-risk information that can help the general public and local communities evaluate their own disaster risks as well as develop and implement preventive measures in their local interoperable environments. Among the systems targeted for the general public is one that helps individuals design their future lifeplans in the event of a disaster by considering their socio-economic circumstances, life stages, and life events. The system draws on public aid, private-sector services and products, and official information on disaster relief and recovery activities during emergencies.

Another goal of this research is to develop a system for disseminating essential hazard and risk information, as well as the diverse information needed for implementing risk-reduction actions at anytime and anywhere according to their own day-to-day living activities.

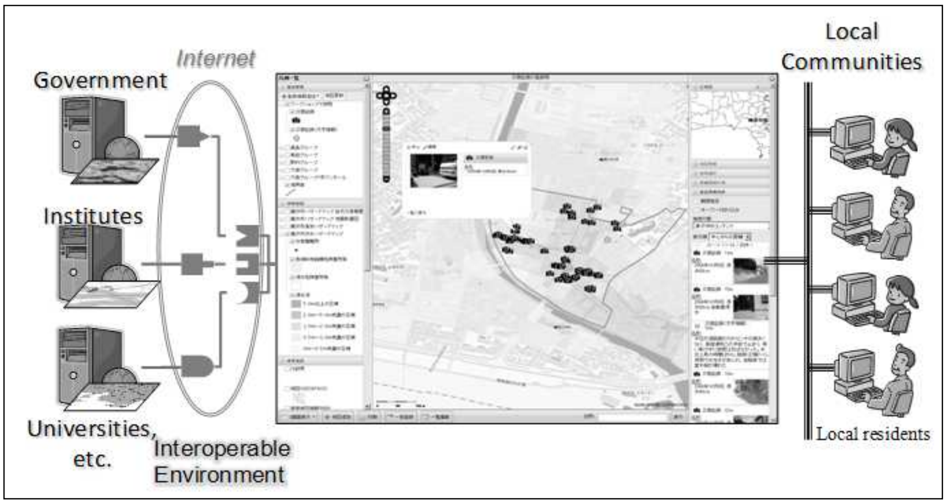
For local communities, a system will be developed that allows them to create disaster prevention maps tailored to their local conditions. The system will allow local voluntary disaster prevention associations, evacuation areaoperation councils, and other parties to add information to official hazard and risk maps published by governments and specialists. Such information includes the life safety resources in the community, the locations of potential danger, shared experiences of disaster damage, and information about near-miss disasters.

Also to be developed is a system that will produce a set of possible scenarios for emergency measures, restoration works, reconstruction efforts, etc., ordered by time and based on the damage anticipated in the community's area. The system will use as references past disasters and people's accounts of them from around Japan. The intent of the research is to 1) use the operation of these systems to encourage local communities to reorganize their problem-solving and risk management approaches and capabilities in terms of utilizing both local resources and social networks and/or relationships among local actors (residents, public and private organizations), and 2) reinforce their abilities to manage disaster risks based on the collaborative networks among the various local actors.

Figure 8 shows the "e-community map" participatory web mapping system that we developed and will deliver as open source software. Participatory mapping for disaster prevention is considered effective for identifying disaster risks and the resources for preventing disasters. Geographic Information System (GIS) technology is essential for the various phases of risk assessment and communication (acquisition, creation, presentation, and distribution of information). Most disaster risk information contains location (spatial) information, which means that it is typical geospatial information. The advantage of a web mapping system over conventional paper maps is its superior ability to provide dynamic spatial information. Local residents can search maps that include their region using the system’s clearinghouse function. For example, if they input "liquefaction"and a map showing liquefaction in this region exists, the map will be displayed on their "e-community map." The important point to remember is that these maps don’t exist on this "e-community map." These maps are obtained from interoperable servers at various agencies, institutes, universities, etc. Moreover, they can automatically add their own data to the map by simply copying and pasting the data, such as a list of addresses. They can input not only character data and numerical data but also any file they have, including photographs, sounds, and movies. Then, when they search for a hazard map of their region and open it on their "e-community map,"they can compare their disasters experiences with those on the hazard map. They can also input line and polygon data and use this map on their cellular phones or smart phones. Offline functions, especially printing, have been strengthened so that paper maps can be printed by the software for use in fieldwork or workshops.

Accordingly, the interoperability of the disaster prevention information systems for both administration and the residents led to a synergistic effect on sharing hazard information, which was insufficient for both hazard maps and the mapping efforts of the administration or residents. This effectiveness in the interoperability of the system was expected.

Figure 8. e-community map a participatory web mapping system



4.1 An informed decision-making support system for personal disaster preparedness

The concepts of the proposed system are as follows: (1) decision-making by the users with regard to their actions, (2) determination of the criteria by the users to support their own actions, and (3) utilizing the interoperable information infrastructure.

(1) Decision-making by the users with respect to their actions

Providing the necessary information for decision-making on the basis of the time at which users should act is very effective. Therefore, it is necessary to deliver information to the media that is always associated with the users'action. Furthermore, we assumed that we used the cellular phone as an information transmission media. Recently, the cellular phones in Japanhave been enabled with the GPS (global positioning system) function; therefore, we can provide disaster risk information of the location where the user resides through their cellular phones.

(2) Determination of the criteria by the users to support their actions

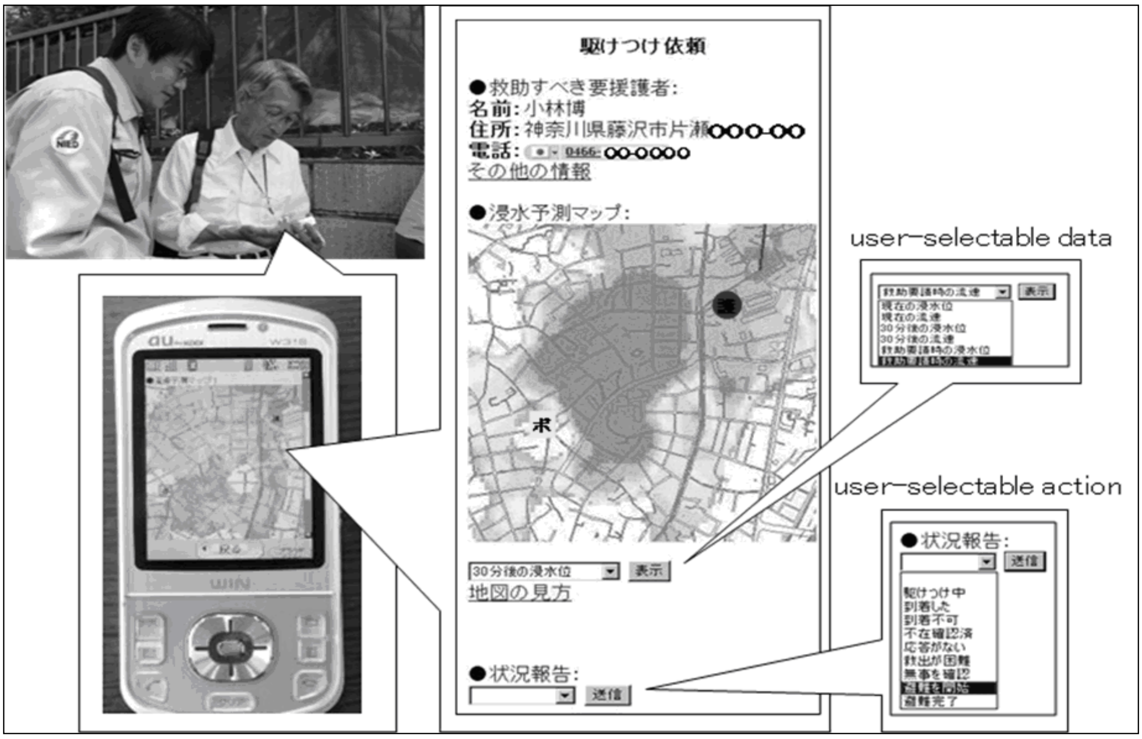
Decision-making implies that the user has to take decesions with regard to their actions on the basis of some criteria. The criteria vary from user to user, and we cannot set one general criteria that is appropriate for all the users. Therefore, we provide a function to the users for deciding their own criteria on the basis of his/her attributes.

(3) Complete utilization of the available information

For a disaster risk that involves uncertainty, it is necessary to take a general decision by completely utilizing all the available information. We propose the interoperable information infrastructure for completely utilizing the available information. This information infrastructure is an environment in which we can mutually share the data managed by using a dispersed data server. We can also dynamically use the data completely by setting an international standard interface.

For the case study, we developed a prototype system for supporting volunteers who help people in need of social aid by using the real-time flood risk mapping system. We performed the demonstration experiment by using this system for some volunteers. Figure9 shows the prototype of this system and the schematic of the demonstration experiment. Volunteers could receive flood risk information in their cellular phone and take decisions with regard to their actions. In an interview after the experiment, they said, "I was able to get the security by receiving information among actions" and "It is necessary for volunteers to rescue those who need social aid."

Figure 9. Prototype of the system and a schematic of the demonstration experiment

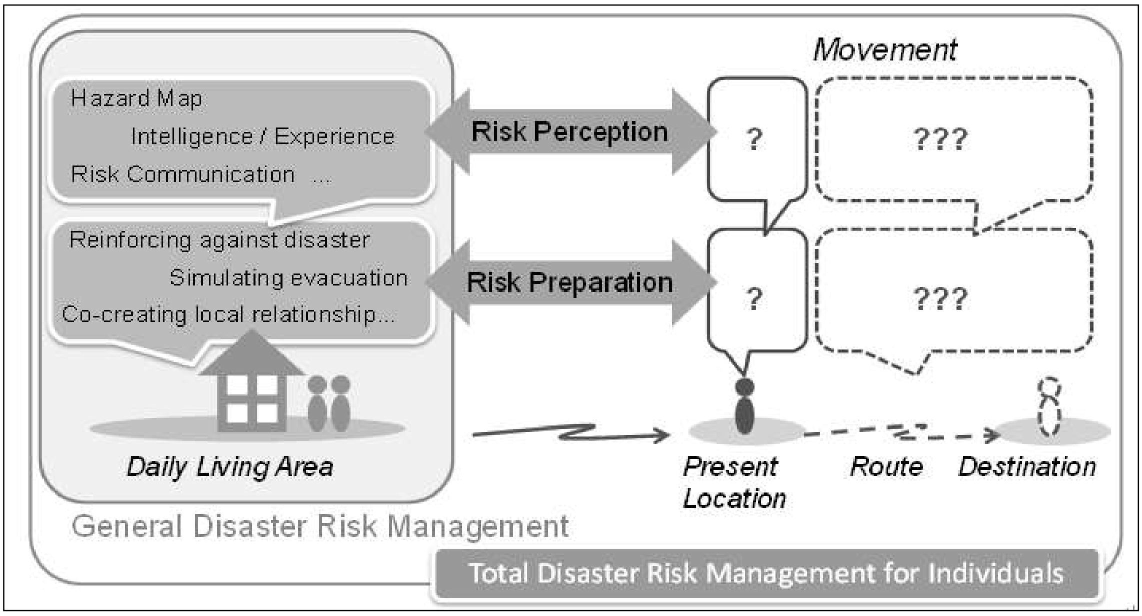


4.2 Mobile disaster preparation support system for individuals i-bosai

Do youknow what kind of disaster-risk exists at your current place? It is important for every individual to prepare for natural disasters that could strike where he/she is now standing. The purpose of our study is to develop the on-site support system for disaster-risk preparation. We developed "I-Bosai" as a mobile disaster-risk recognition support system for individuals. "I" stands for individual and "Bosai" means disaster prevention in Japanese. "I-Bosai" is operated based on a cellular phone or smartphone as follow

1) It obtains the position information of the current place by using GPS (Global Positioning System)
2) It obtains disaster-risk information from various geospatial-servers by using WMS/WFS/WCS protocol
3) It represents the information effectively to make us understand the disaster-risk at the place. It is especially effective on Smartphone to indicate the risk by using AR (Augmented Reality).

Figure 10. Total Disaster Risk Management for Individuals



Recently, government agencies and researchinstitutes publish a variety of disaster-risk information. Also Local communities make disaster-risk information as their own maps for disaster-risk preparation and information sharing of disaster-experience and disaster-risk. Disaster-risk information that helps people in reducing the risks associated with natural disasters. This can be effective for the stakeholders to deal with the risks by improving their understanding and to act properly. We believe that disaster-risk information should be shared on the interoperable network for improving disaster-risk preparation and coping capacity for every individual and local community. We call this network "Bosai-DRIP", Disaster-Risk Information Platform for "Bosai". "I-Bosai" will enable every individual to obtain various disaster-risk information on site through "Bosai-DRIP".

There are three key points for supporting personal disaster preparedness as follow

(1) Informed Decision using the interoperable information infrastructure

As the disaster risk includes uncertainty, it is essential to make a decision by considering various information which can be used.

(2) Action Support using the mobile phone with GPS function

It will be most effective for user to get necessary information for decision-making in the exact moment of the action. Therefore, means of information propagation should be focused on the media which is always possessed by the user.

(3) Self Management providing the function that every user can manage their own criteria according to their own attribute and circumstances

Decision-making is to decide the appropriate action through consideration among some criteria. However, criteria is different among every users, and it is impossible to set single criteria which is appropriate for all users.

Figure 11. Introduction and Extension of Smart Phone and Augmented Reality

5. Conclusions and future plans

This paper described how the interoperable platform for disaster-risk information plays a significant role in developing disaster prevention and mitigation measures. It should be noted, however, that such systems and the interoperable environment are not the final goals of the scheme. The desired outcome for a disaster prevention information system is to effectively and efficiently implement disaster prevention and mitigation measures by using the disaster-risk information that is already available in the society. The interoperable environment and disaster prevention information system are only basic tools for achieving the goal. Therefore, the keysto success are promoting the interoperable environment, and providing opportunities for citizens to study and promote disaster prevention and mitigation measures by sharing disaster risk information among administrations, companies, and NPOs under a policy of self-reliance, cooperation, and public assistance.

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Building, Maintaining, and Exploiting 3D City Models

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Introduction

The dominant global challenges of the past two generations were related to human conflict, its avoidance, and its resolution or execution. For the next several generations, the challenges are going to shift towards the preservation and hopefully enhancement of our physical environment, dealing with climate change, maintaining bio-diversity, and the prevention of ecological decline. Meeting these challenges will require that human societies become "smarter"in providing for our existence, somehow achieving equity and economic prosperity, while reducing our impact on the world around us. This will be especially true in cities - where most people live, and where these challenges must be confronted head on.

These challenges are going to be made that much more difficult because of the unprecedented rate of world urbanization. Urbanization is one of the dominant demographic trends of our time. In 1900, 150 million people lived in cities. By 2000, that number had climbed to 2.9 billion people, a 19-fold increase. By 2007, half the population of the world lived in cities—making us, for the first time, an urban species.

In 1900, there were only a handful of cities with a million people. Today, 408 cities have at least that many inhabitants (over 100 of these are in China alone); and there are 20 megacities with 10 million or more residents. The city of Tokyo's population of 35 million exceeds that of the country of Canada. Mexico City's population of 19 million is nearly equal to that of Australia. New York, São Paulo, Mumbai (formerly Bombay), Delhi, Calcutta, Buenos Aires, and Shanghai follow close behind.

The situation in Korea has been similar. In the 19thcentury, the population of Seoul was only 190,000 people; whereas today, it is a world megacity of some 10 million people. As of 2008, 81% of the population of South Korea was living in urban environments with an urbanization rate of 0.6%/year.

To be smarter about our environment will require that we plan, design, and maintain our cities in a more holistic and integrated fashion than ever before. This will require a better and deeper understanding of the structure, function, and organization of our cities. It will require that we think of cities in relation to the natural world around them, and the natural world within them. It will require that we plan on a larger scale, and maintain rich and detailed models of our cities that incorporate not only building geometry and internal structural information, but also information about the nature of the building surfaces (e.g. for sound, light, heat), biological ecosystems, and the location and movement of people.

Many cities in the world are developing 3D models of their buildings. Although the majority to date are little more than eye candy – and insufficient, in terms of richness and accuracy, to support planning, design, and the provision of urban services – nonetheless, these are promising starts. More and more people are beginning to understand the challenges of maintaining and using such models in real world applications, which is the real and present challenge for city modeling.

This paper focuses on evolving standards and technologies for the creation, maintenance, and exploitation of 3D models of our cities.

What is a City Model?

A City Model is a complex set of information that describes every aspect of a city in such a way as to enable the past, present, and future of that city to be analyzed, simulated, and visualized. Ideally, such a City Model should incorporate everything that is known about the city, from the details of building geometry, to its utility infrastructure (both above and below ground), transportation systems, parks and internal ecosystems (which will increasingly be integrated with building infrastructure), its systems for cooling, heating, power generation, and power distribution. This information should be integrated in a manner as close as possible to that in the real world.

City Models must be more than just pretty pictures. They must be more than accurate geometry. They must facilitate shared design, and simulation of current and future events (e.g. flood, earthquake), activities (e.g. world conference), and structures (e.g. impact of a new building on the efficacy of adjacent building green roofs). They must assist us in the adaptation to, and the limitation of, changes in the local and global climate.

City Models must be maintained. Ideally, they will change as the physical structures comprising the city are changed, and as the demographics of its citizens change. City Models cannot be static; they must not be regarded as documents, but as working models used to support all manner of collaboration and decision making. To make such usage and maintenance possible, we must find ways to integrate the maintenance of the City Model into the business processes of the government and the private sector. Maintenance of the model must be an organic consequence of urban development.

Semantic Models – BIM and CityGML

It should be apparent that City Models must be semantic models; they must encode what is known about the city, and they must embed the known constraints – from the development policies to the laws of physics and ecology. Only in this manner can City Models truly assist in the more efficient planning, design, construction, and operation of our cities.

While meeting these objectives is still somewhat in the future, the development and adoption of BIM based computer assisted design standards – in particular, the Smart Building Alliance's IFC (Industry Foundation Classes) and the OGC's CityGML (City Geography Markup Language) – shows that things are moving in the right direction.

BIM, or Building Information Model, is an object- or feature-oriented approach to capturing design information about a building, or about any other piece of physical infrastructure. It is more an approach to computer assisted design (CAD) than a standard. In conventional CAD, acomputer stores geometrical elements (such as points, point coordinates, B-splines, and arcs) together with attributes (such as text and names), but it does not encode the meaningful objects that comprise structure (such as walls and windows) nor the geometrical and topological relationships between those objects (e.g. "this window is in this wall"). In a BIM model, the user works with specific object types, and modifies and connects these together to create a computer based model. The computer representation thus explicitly represents structural components such as walls, beams, girders, rooms, and windows, and the relationships between them.

OGC (Open Geospatial Consortium) CityGML is based on the OGC Geography Markup Language (GML) and is formally an application schema of Version 3.1.1 of the latter. It makes use of GML geometry primitives such as surfaces and solids, and uses these to create a specific vocabulary for the description of buildings and other structures. This vocabulary is the core of CityGML, and includes objects such as buildings, roads, railways, roofs, rooms, water bodies, and walls.

A unique feature of CityGML is its support for multiple levels of detail. In the current version there are five such levels of detail (LOD) as shown in the following table.

Level of Detail	Area of Applicability	Utilization
0	regional, landscape	Urban and regional planning. Demography.
1	City, Region	Urban planning
2	City, Districts	Building impacts – shadow mapping, solar loading, illumination. Public safety & security.
3	Architectural (exterior)	Building cooling, heating, ventilation. Building design in its environment. Public safety & security.
4	Architectural (interior)	Building cooling, heating, ventilation – public safety/security.

In CityGML, a particular structure can have multiple geometric realizations (each at a different LOD), or completely different models related through a "generalization" or other relationship.

CityGML is based on GML and hence is inherently extensible. A specific extension mechanism is provided in CityGML, called an ADE (or Application Domain Extension). An ADE is, effectively, a specialized GML Application Schema that extends existing CityGML types, either by inheritance or composition, using substitutions for generic properties. ADE's are expected to be developed for a variety of applications, and may become standards in their own right, just as CityGML is. Some existing ADE's, like the one for Noise, already have some generic software support. One can anticipate other ADE's to be developed for solar or green roof mapping, for flooding, and for many other applications.

Industry Foundation Classes (IFC) is another BIM data encoding, and one which complements CityGML. While CityGML concentrates on modeling entirecities, IFC focuses more on the fine grained details of the building structure. In IFC, there are building and wall objects, but also much more fine grained ones such as girders, beams, panels, and so on. An IFC encoding describes the detailed connection of these building components to one another. IFC also incorporates details like electrical circuits, plumbing fixtures, and elevators. IFC is supported by most of the major CAD vendors, and there is increasing understanding of the importance of IFC to minimizing fit and interference problems through better information sharing.

IFC and GML complement each other by dealing with different ends of the detail spectrum. In the future, this complementariness can be expected to be more and more important with more holistic design at the city level driving down to constraints on detailed design at the building level, while building design impacts are assessed at the city or district level. CityGML and IFC need each other.

Of course, much more needs to be done. We still don't have the standards that enable ready integration of City Models into simulation systems. It can be done, but the integration is still too case-specific or city-specific.

Maintaining the City Model

City Models are, by definition, rather large –100's of gigabytes today, and most certainly terabytes and even petabytes in the very near future. Such large sizes preclude the use of manual or semi-manual procedures for bulk analysis, copying, updating, and distribution. Furthermore, the sheer complexity and richness of these models will require their automated assembly and update, and the ability for communities or organizations to subscribe to those specific portions of the model that are of interest to them. This type of "SDI-like" information infrastructure will be essential if we are to be able to maintain these models in practice. Taking this point further, maintaining these City Models will require that we integrate the business processes of the city (most of which are already in place) with those supporting the maintenance and exploitation of the City Model.

Consider the following example. Most cities in the world require the submission of drawings when a building is proposed, and a resubmission of "as-built"drawings when it is completed. Today, these drawings are just part of the permitting process, and do not feed into the construction and maintenance of the City Model. This will have to change. The permitting business process must be integrated into the process for City Model maintenance. Since most modern CAD systems are able to export data in IFC-BIM, and since there are at least some tools for IFC-BIM to CityGML conversion, the maintenance of City Models based on permit drawing submission is a now a feasible proposition. I believe that this will revolutionize the construction of City Models, and greatly increase their usage in all forms of design and decision making. Changes to a city are first known when an application is submitted to a planning review board or similar authority. Here, it can enter the life cycle of the City Model, and be again updated as the building (or other piece of infrastructure) is reviewed, developed, and completed (when "as built" drawings are submitted).

Of course, we will still need to make other measurements and surveys, beyond what is required to explicitly support new construction. There is a huge legacy of existing structures which will not be going away. At the same time, however, the above process can be exploited to know exactly where changes have occurred and thus where to acquire additional aerial, spacecraft, or ground-based imagery, or other sensor data. This will make the data collection process far more efficient and effective than it is today.

Sharing the City Model

The size and complexity of City Models, combined with the geographic and topical diversity of their user base, demands a new approach to the sharing of this type of information.

Even with the greatly increased bandwidth on the Internet, the cost and delays associated with moving 100's of gigabytes or petabytes of data are prohibitive. Furthermore, for model users to be able to access the most current information, fine grained publishing of model changes will be essential. Of course, we will continue to use imagery and visually-optimized renderings from the model, but these will need to be integrated with fine grained publication-subscription data access mechanisms to guarantee that a given user always has the latest information for their domain of interest. Moreover, many users will need more than visualizations, and more than just model geometry. They will need to know specific properties of wall surfaces such as colour, IR reflectance/transmission/absorption, noise reflection/absorption and a host of other quantities that they will use in simulations and other design models. The geographic distribution of the user base will further enforce the requirement of being able to select specific model subsets that are then automatically synchronized with changes to the model on a fine grained basis. This will need to be accomplished easily, and as transparently as possible. This is not a task for ETL and bulk file copy.

Information infrastructures will be a key component of the City Model, both for aggregation and integration ofdata into the model, as well as sharing with the local community of citizens, and the world community of design, engineering, and other professionals.

Collaboration

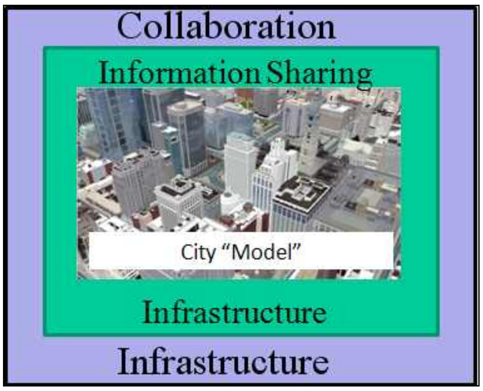
Cities are evolved by collaboration. Developing a new building complex in Vancouver may involve an urban planner in Toronto, an architect in Tokyo, an engineering firm in Korea, and a construction company in the United States. As the project proceeds, dozens and dozens of other firms and individuals will be involved from local contractors to specialized manufacturers around the world. A consequence of this interaction of multiple persons and agencies, combined with a record of poor information sharing, and limited IT resources and systems to support information sharing, and possibly a culture that inhibits information sharing leads to frequent "fit and interference"problems on construct job sites. This rarely happens in the manufacturing sector, but is endemic in the construction sector.

To improve the efficiency and effectiveness of urban planning and development, future city model information infrastructures will need to support active collaboration amongst their users. For example, a new building is proposed by a developer. For a period of time this building proposal might be viewable in the city model, but only to members of an architecture review board. They may suggest changes or extensions to the proposal, and these changes are then only shareable amongst the board members, and the architecture and developer firms. Over time the building project converges (or diverges) and is finally approved. The building may then be shared with engineering firms to perform more detailed engineering studies, or with interior designers to further refine the building as it proceeds towards construction.

Collaboration requires information infrastructures that support the notion of a project (or project sequence) as this is a basic concept for collaborative information sharing. Projects have a defined extent in time and space, and have specific objectives (e.g. build a new opera house).

Collaboration will often require shared visual interaction. This may be just for visual presentation (e.g. "look at the building from this side" … "see the dramatic opening on the garden space". Each participant should be able to see the model, and each in turn take control of the view point for the other participants. Collaboration with respect to other aspects of city design, development and decision making (e.g. public safety planning, large scale urban planning, urban biodiversity assessment) will become a significant component of future city model infrastructures.

Figure 1. City Model and Supporting Information Sharing & Collaboration Infrastructures



City Model Exploitation

The purpose of a unified city model is to support a wide variety of applications from urban planning and design to public safety and security.

Urban Planning

How cities develop and evolve is poorly understood. Many of the world's great cities such as London, Paris and Tokyo developed for centuries with little more than sporadic periods of planned development. With the increasing pace of change, however, this approach became untenable, and the idea of planning regions of cities took hold. Initially urban planning was a very top down process, typically driven by government that provided the regulatory framework for land assembly, zoning and even the financing for development or redevelopment projects. More recently we have seen the emergency of community driven (bottom up) planning processes either managed by planning professionals or driven by community members themselves. We have also seen the emergence of large developers that assemble land, design new structures, finance the development and carry it to completion, usually within a broader regulatory framework (e.g. interface agreements for electricity, cooling) provided by government. Today, most urban planning is a mix of these various components.

How can city models help?

To begin with, urban planners need to understand the context for the proposed development. Typically this is a primarily a visual issue, but in a deep sense. Planners want to understand the feeling and visual impact of an urban space. This requires seeing the space in question at multiple levels of detail and possibly at multiple levels of abstraction. 3D City models can help, but must be provided with more than aerial views, as the planner needs to see the landscape from a viewer's perspective. Immersive head gear or glasses can help to give the planner a much better sense of being on the street.

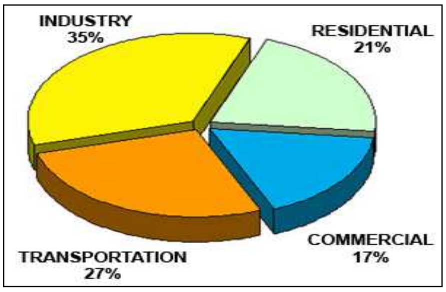
For the planned area itself, the planner must integrate multiple competing objectives related to housing, recreation, transportation, water and air quality, while keeping within specified constraints such as those for energy consumption and waste management. It must be easy to construct "what if"scenarios by adding new buildings, modifying existing buildings, adding or changing roadways, pedestrian walkways, and parks. Furthermore there must be the facility to connect these visual elements with their physical realization – geometry, surface physics, air movement, emissions, and energy consumption so that changes in planning elements are reflected in terms of the parameters that define the design goals of the urban plan.

Cities are not static. They change. They may undergo times of almost explosive growth driven by new economic or government forces, and they may go through periods of prolonged decay, as these same forces wane, and shift to other economic drivers or areas of the world. City models can provide the planner with the tools to more effectively understand and respond to the natural dynamic of a city.

Emissions and Energy Management

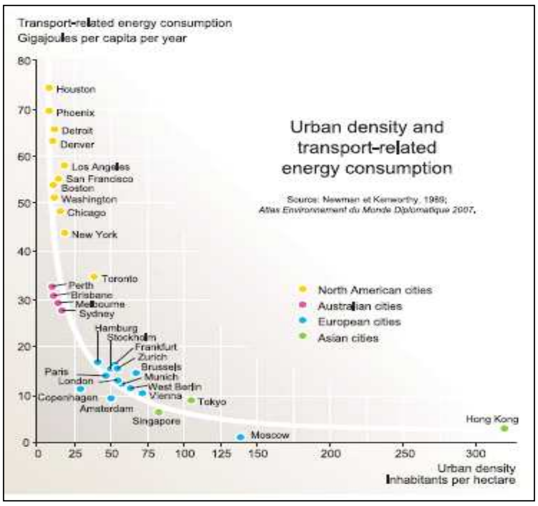
Increasingly a key component of all urban plans is sustainability. While there is disagreement on the exact definition, most would agree that sustainability is now a requirement, and most would incorporate in that understanding a reduction of the city's environmental footprint (i.e. reduction in waste, emissions, energy and water consumption), together with more local production of energy, food, oxygen (i.e. more plants), and spaces for recreation (nature within the city). Today, cities are major consumers of energy., in fact for the United States, the largest single contributor to global warming. If one looks at electricity consumption the numbers are even more dramatic, with more than 70% being consumed by buildings for heating, lighting, cooling, the operation of mechanical equipment.

Figure 2. U.S Energy Consumption by Sector



One approach to the reduction of the transportation component of energy consumption is to make cities more dense, as there is well established correlation between density (people/sq km) and transportation energy consumption per capita.

Figure 3. Correlation of urban density and per capita energy consumption for transportation



Increasing density may have, however, adverse consequences for air quality in general, and causing very severe conditions in areas of the city with limited air movement due to building placement.

Energy consumption can be reduced further by the use of smarter building technologies such as green roofs and wind driven ventilation, however, both of these require a comprehensive understanding of each building in relation to those buildings around it. City aerodynamics and thermodynamics need to be understood and city models can make a major contribution. This is equally true for the local production of electrical energy for cooling and lighting. Shadows can severely restrict the natural light available in a given building and of course the efficacy of solar (or green) roofs. One might see future situations where a tall building (taller than its neighbours) must have a solar roof to provide electricity not for itself but for the surrounding buildings in its shadow whose electrical costs for lighting have been increased by the new buildings presence. All of these sorts of analyses require 3D models of cities.

Public Safety and Security

Major global events such as the Olympics, World Cup, or a G20 meeting require significant investments in security. They require the placement of hundreds or thousands of special police and security forces, and the analysis of potential threats and their means of entering, attacking and exiting the city. Again city models can help. In the planning stage, they can provide maps of intervisibility, showing the areas visible from a given vantage point ("what will a police offer stationed here be able to see?"), or all the areas that are able to view a given site ("where could a sniper have a clear view of the parade route or stage?"). In the operations phase they can assist with the tracking of vehicles and personnel. Again the visual elements must be connected to models of physical reality to enable the impact of road closures, building closures etc to be assessed.

Augmented Reality and Other Information Services

Augmented reality applications which superimpose information about the real world onto real time camera views, depend on substantial information about the real world, and in particular the placement of services, businesses, and other objects. Furthermore, for many such applications the business, service etc. must be located with a high degree of absolute accuracy, or at least high accuracy relative tothe buildings or other infrastructure. In many cases this can only practically be achieved by incorporating the business/services etc within the city model. Again, the location of such businesses is known when a business registers for a business license, and known to a higher degree of accuracy (e.g. room number).

We can anticipate greater use of such facilities, not only for the general public, but also for service personnel. The integration of electrical, telecommunications, water, sewage and other utilities within the city model will enable site workers to operate with "X-ray" glasses and see the utility infrastructure without having to dig. This will improve service calls and reduce accidents.

A information rich city model will likely give rise to a host of information services that we can only guess at today, from aids to the blind and elderly, to optimal multi-modal routing from one place to another, and advanced housing and business placement services.

Summary

Rich unified models of cities are an essential component of planning, operating, and living in the urban world. They can enable a more holistic approach to urban design that can reduce our impact on the environment while providing a better quality of life for the cities inhabitants. To gain these benefits we require models that are more than visualizations - that are geometrically accurate and which incorporate key elements of the basic physics of our environment.

Modern city models are complex. The world is complex. This complexity requires that the model be supported by information sharing infrastructures that support both the model's automated assembly and integration, and its distribution and maintenance on a fine grained basis to users around the world. The models must be easy to useand easy to maintain, using existing and intrinsic business processes (e.g. permitting), as well as crowd source inputs. Rather than thinking of delivering a model to a city, we should be thinking of the model as the city, changing and growing as the city changes and grows.

Model sharing must also incorporate model collaboration, with ability for widely distributed participants to view, navigate and modify the model together. Collaborative information infrastructures are thus a key component of city models.

City models seen in conjunction with sophisticated information sharing and collaboration infrastructures can help shape the future of our cities, making a smarter Korea and a smarter world.

Semantic Search and Data Interoperability for GeoWeb

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Abstract

As mobile service technology is getting advanced and smart phones become more popular, demand for geospatial data utilization is drastically increasing. This trend goes beyond mobile application of the existing GeoWeb service to expand into various areas such as geo tagging and intelligent local search. Such demand promotes intelligence of geospatial data and technologies for intelligent applications, while Semantic Technology and Geo Ontology become the core axis of this foundation. Particularly, Geo Semantic Technology is evaluated as the core technology for supporting interoperability of geospatial data and building Semantic Search. For building practical ubiquitous computing environment in the future, more investment would be required for study of building Geo Ontology and connecting with Linking Open Data (LOD).

1. Introduction

Geospatial information technology including GIS has been greatly advanced for the last 10 years. While this technology was limited to map creation and specific purpose application for state and army in the past, today it is used in our daily lives beginning with popularizing car navigation system. Particularly, as smart phones become more popular, most mobile applications adopt GPS and geo tag to provide a variety of services which have never imagined in the past. For the last several years, global research that endeavors to apply Semantic Technology to geospatial information processing has never been more active than before. Particularly, led by the U.S. and the U.K. it is, encouraged to convert to geo semantic data based on the existing geospatial data and Semantic Web standard to open in connection with various Geo Web applications.

This paper introduces concept of Semantic Technology and semantic geospatial information, especially the procuring method for interoperability of geo data for Geo Web, and the best practice of building the Geo Ontology. Finally we will forecast how Geo Web service would be prospective with Semantic Technology and Semantic Search.

2. Semantic Web and Semantic Technology

Semantic web was proposed by Tim Berners-Lee, who invented the World Wide Web in 1999 [1]. Like Geo web, the core technical elements of the Semantic Web standards such as triple, ontology and description logic have been established and advanced regardless of the web. Tim Berners-Lee drew Semantic Technology which seemed unrelated with web into the enormous world of the World Wide Web in connection with URI and HTTP.

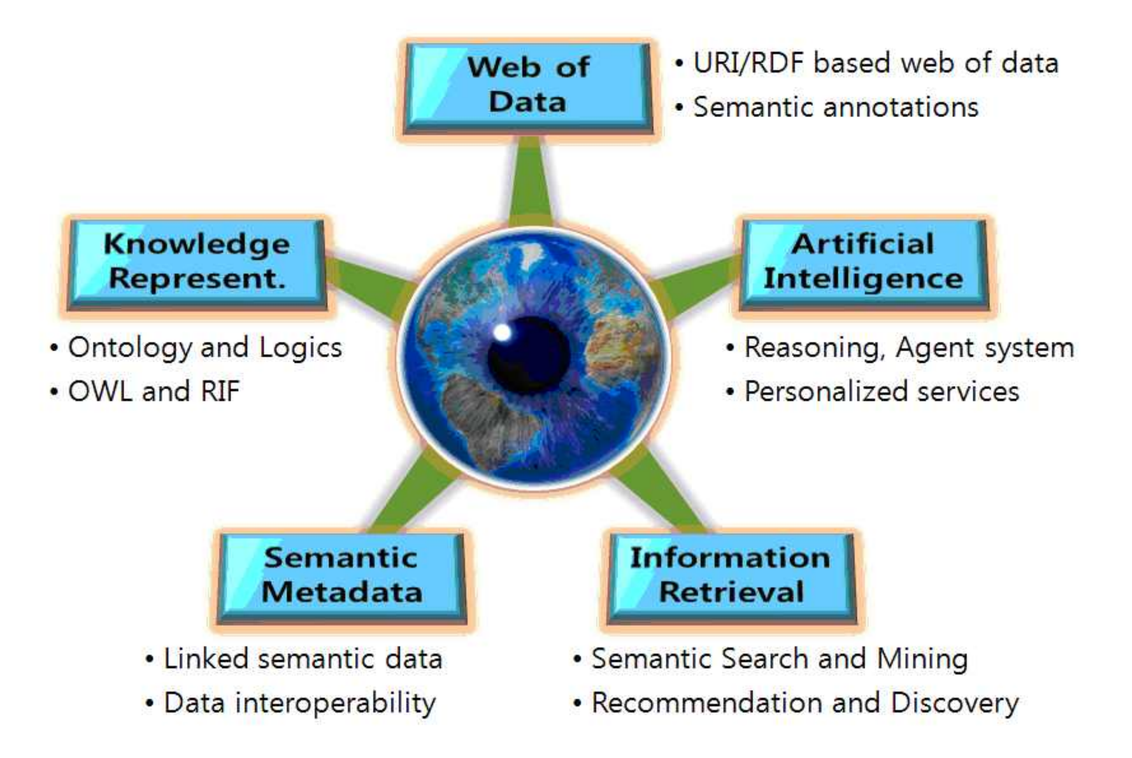
The first standard of the Semantic Web was established by W3C in 2004. The first recommendation based on RDF(S)[8] and OWL[9] describes how data can have graph structure in a triple form and how such data can be connected with semantic concept via schema and ontology. The most important advancement is that semantic data in a triple form can be queried with SPARQL, and decidable reasoning is guaranteed with soundness and completeness within OWL DL expressivity.

Semantic Technology has showed great advancement since the standard establishment was made in 2004. It means sufficient level of commercial procurement not only for reasoning performance but also for scalability. Recently, the existing standards such as OWL and SPARQL are advanced into more elaborated and practical phases [10].

Figure 1 shows five different viewpoints for the Semantic Technology. Semantic Technology is like an apple tree grafted from mutually different technical roots. For this reason, there may be some different understandings and applications for the fruit of an apple depending on the viewpoint.

The first, Semantic Web viewpoint is to view Semantic Technology from the point of the World Wide Web. It is related to defining Semantic Web as a web of data. This viewpoint means that ontology and semantic data are expressed by URI and should be accessible and distributable via web. This viewpoint provides the core concept that asserts Geo Semantic Web can be advanced with Geo Web Technology. Namely, geo data acquires semantic interoperability and allows freedom of expression with intelligent service on the web. Linking Open Data (LOD) project based on SPARQL EndPoint including GeoNames may be a pretty great example of application in this viewpoint [7].

Figure 1. Five different viewpoints for the Semantic Technology



Knowledge representation viewpoint is the subject which has been studied for more than 2,000 years since Aristotle. This viewpoint is connected with philosophical subjects of how to express human knowledge explicitly and share it one another. Knowledge representation viewpoint shows tendency of concluding with ontology containing logical rules after all. To express, share and utilize for geospatial knowledge beyond geospatial information expression, challenge is encountered with semantic level expansion of expressivity for the existing geo data. The researchers with such viewpoints tend to focus on how to build and utilize Geo Ontology effectively.

The researchers with artificial intelligence viewpoint focus on how machine can show its intelligence and behavior. Reasoning becomes the most essential technical study subject in this viewpoint and focuses on how it becomes intelligent and personalized, and how proactive service can be built. Recently, research is being processed for building intelligent location based service specific to smart phones. Particularly, utilizing Semantic Technology for building personalized service is being reviewed in various ways.

Achieving data interoperability and storing/managing semantic metadata expressed in graph structure become an essential study subject in a metadata viewpoint. In the past, many enterprises including Oracle and other research institutes have studied about how to store and manage geo data effectively and achieve high performance with data query and calculation based on ER model [6]. If geo data is advanced into Geo Ontology-based semantic geo data, an effective technology to handle such data should be advanced as well. Recently, huge volume of semantic metadata processing technology that can store and manage over 10billion triples is being developed.

At last, let's take a look at the Semantic Search-basedinformation retrieval viewpoint. Semantic search does not have to be based on semantic metadata with triples because Semantic Search based on text mining and machine learning is recently being developed as a very important area as well. It will be described more in chapter 4 of this paperthat real-time intelligent search for geospatial information and map-based mash-up for heterogeneous data is becoming more important as the mobile service environment is generalized. Geospatial information basically has semantic ambiguity including POI. In addition, it will be essential to use semantic metadatafor the expanded search of the connected information based on geography.

3. Data Interoperability

The authors are playing roles as common researchers for LarKC project, one of important FP7 projects in Europe. In this project, we made semantic integrations of LOD's Linking Open Data (LGD) and Open Street Map (OSM) with POI data set which was built in Korea, and have researched for building an urban computing platform which allows semantic query and reasoning on sensor's and geospatial data set. The largest problem the authors found was to procure interoperability for the heterogeneous geo data.

Particularly, it is very difficult to make some relationships when the labels of the same geo objects are marked in different languages, notations, and synonyms. Geo semantic approach connects with the heterogeneous geo data sets as in figure 2 and procures data interoperability among those sets. In this case, OWL's owl: same As axiom may become a powerful tool. Complexity and accuracy of the geo data being considered, study of providing ontology-based geo data interoperability is merely the first step

Figure 2. Semantic interoperability for heterogeneous data sets

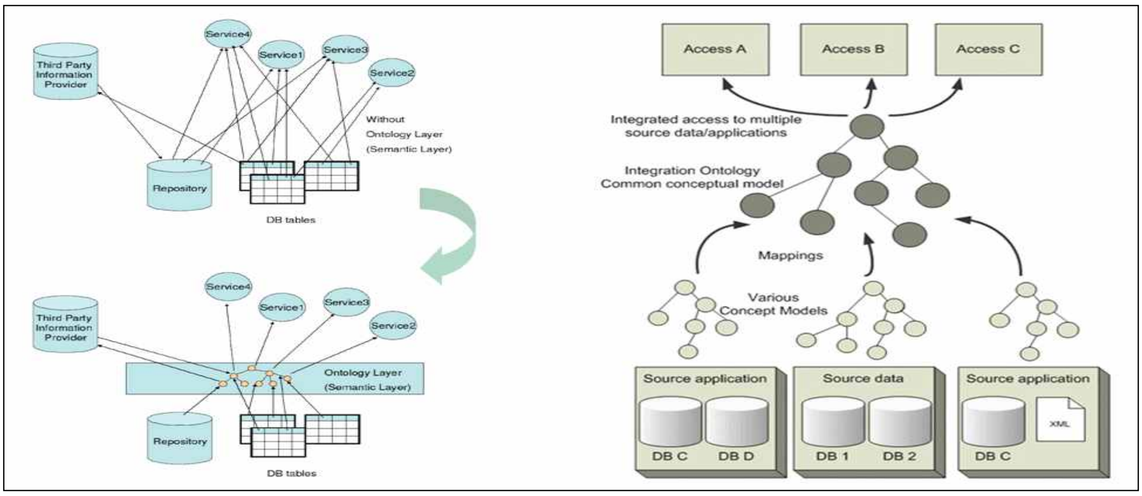
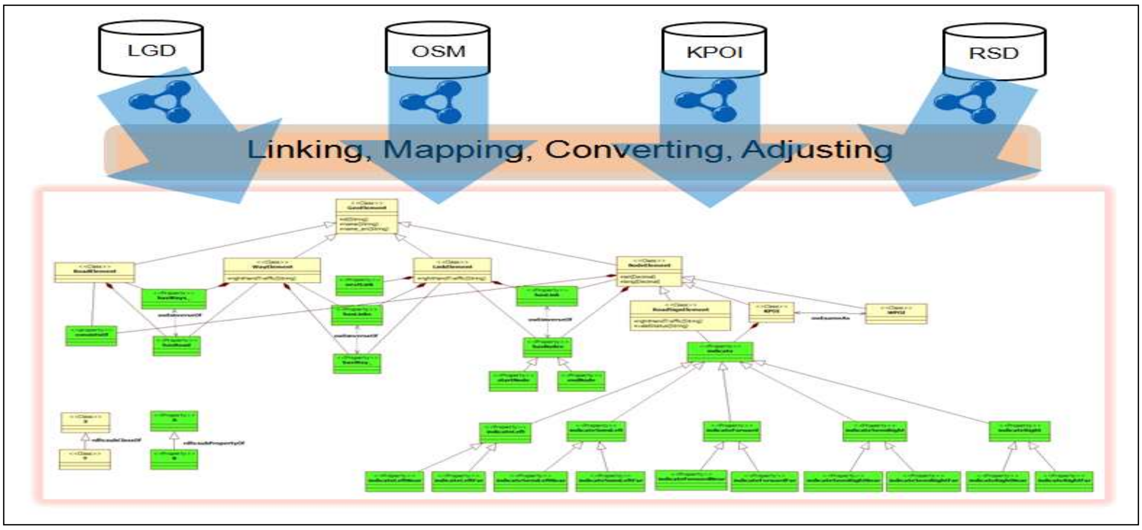


Figure 3 is the actual mediate Geo Ontology built by the authors. The authors design and utilize Geo Ontology integrated with LGD, OSM, and Korean POI in LarKC project, one of important FP7 projects in Europe [13]. This Geo Ontology procures interoperability by connecting with POI based on ontology based on the entire road information. In addition, using axims such as rdfs:subClassOf, rdfs:subPropertyOf, owl:inverseOf, owl:sameAs allows more powerful SPARQL query via reasoning. This ontology has 1 billion triples of the linked geo data with 4 millions of POIs within Korea, and the entire road information of the open street map to make interconnection and semantic compatibility.

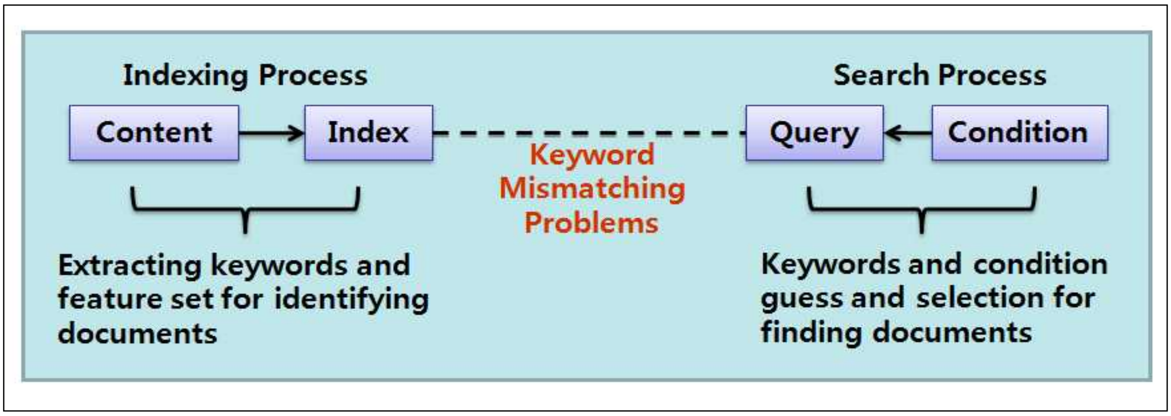
Figure 3. Example Geo Ontology for data mediation



4. Semantic Search

Conventional information retrieval system indexes keywords in an inverted file and the document with the relevant keyword is searched and listed when a user queries with the same keyword. It is relatively easy to build such a conventional IR system, which brings high performance for a large volume of data. F1-measure is generally used for quality evaluation of the information retrieval system. As the volume of information increases explosively, so does recall while precision decreases drastically. There have been numerous studies to resolve this problem. The typical best practice would be Google's pagerank algorithm. This technology improves relative precision by placing more accurate information on the top of search result for the same recall. However, the existing IR technology does not satisfy customers enough, especially in local search of the recent mobile service.

Figure 4. Conventional IR system – keyword mismatching problem



Search for the geospatial information is more complicated and delicate than that for a general document. Each geo object is interconnected with one another in complex relations such as part-of, linked-with, and boundary-of on the geospatial system, and has large semantic ambiguity of various expressions such as Seoul National University, Seoul University, and Seoul Univ. Furthermore, User's desire of search is more definite and the search condition also tends to be very complicated. For example, a user wants to search "finding address and phone number of a famous Korean restaurant available for parking space of more than 5 cars and reservation within 300m radius in coordinate 38.1345, 102.9523."

In a technical viewpoint, type of Semantic Search can be summarized as the following advanced Semantic Search system for geospatial information should be capable of the 5 types proposed.

- **World Sense Disambiguation(WSD)**: Performs semantic classification in indexing and searching by classifying semantic terms such as 'Shijang' in Korean (mayor, market, and hunger) and 'Mal' in Korean (speech, horse, checker, and end) the relevant applications are name entity recognition, semantic annotation, terminology gathering and ontology technology etc.
- **Semantic Query Expansion**: Searches by expanding conceptual parent/child relation, synonym/assonant relationship, and instance such as "Seoul = Capital City of Korea = The Largest City in Korea" or "Commercial Building ⊃ Department Store ∋ Hyundae Department Store". Namely, searching by "City" also searches for documents with a keyword, 'Seoul' it is possible to deduct from the implication relationship using thesaurus (word net) and ontology. Automatic build such as ontology population is available via automation technology.
- **Object Property Navigation**: A feature to make expansion search for specific properties of the targeted search objects such as address of Saltlux, coordinate of Saltlux, and category of Saltlux. In the triple viewpoint, this is a form of information navigation via predicate it is possible to make automatic extraction of the relevant information by using the ontology built or partial parsing from texts.
- **Related Subject Expansion**: A feature to make expansion search for the related subjects such as Seoul Station-Train-KTX and HanRiver-Flood-Typoon. It is purposed to understand contexts and trends surrounding the specific subjects Application made here is analysis method such as co-occurrence analysis, LSA, and TopicRank.
- **Intension-Based Search**: Search for proposing objectives by user's desire of search for Nengmyon-DeliciousRestaurant/Receipe/History and Chungdamdong -Traffic/Restaurant/Café search for user's intension and index by subject via search pattern analysis such as user logs.

Building a semantic network for geospatial information, furthermore, building Geo Ontology will make it possible for more complete Semantic Search in geospatial services.

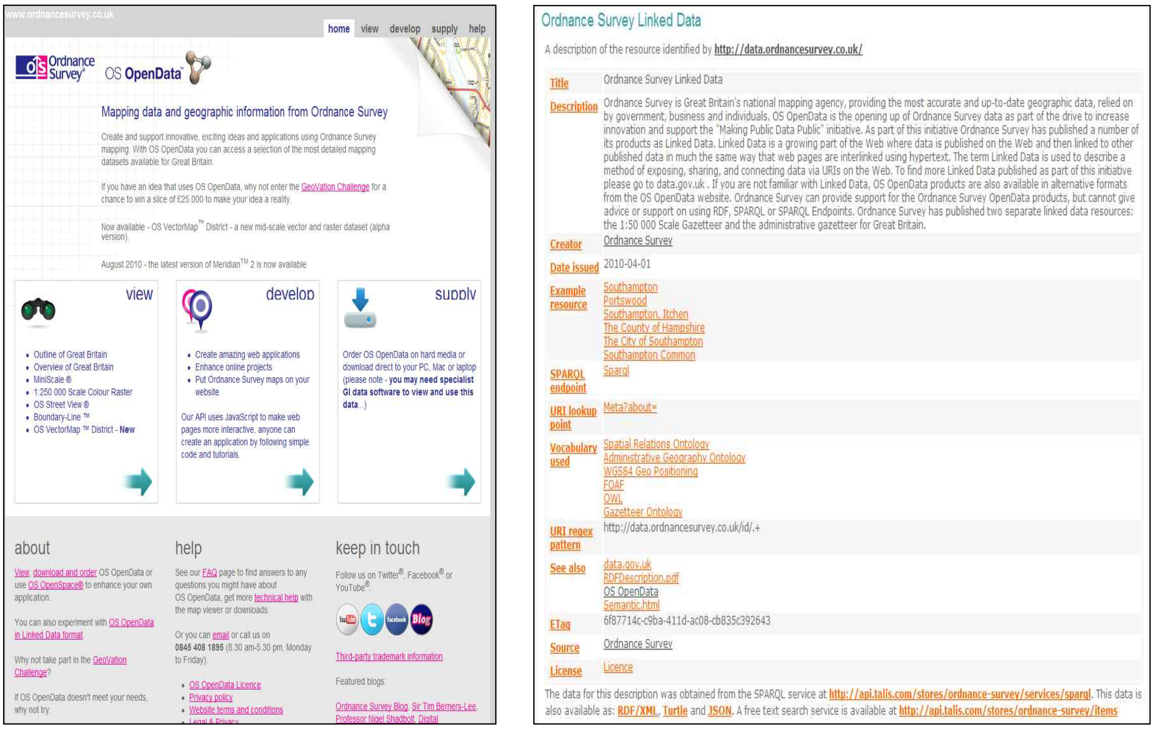
5. Geo Semantics and Geo Ontology

At the end of 2009, Obama declared an open government policy which allows all government data opened to public in order to reconsider transparency of the U.S. government. Data.gov site became the core axis of the U.S. government [4]. Data.gov provides the critical data in RDF for public data utilization and related service, and more than 400 data sets of the critical public data are already provided in RDF. Figure 5 shows the geospatial data provided by data.gov and the various applications associated. Geospatial data has a nature that increases its value when connected with a large volume of statistical and anthropological information. In addition, as open to public as SPARQL Endpoint form, it allows outstanding scalability in direct connection with LOD and provides connection with other data in various application systems with easy mash-up.

Figure 5. Semantic data and geospatial services in Data.gov

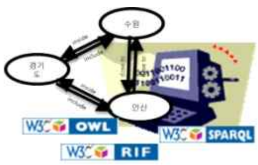
Another example is data.gov.uk and Ordnance Survey in the U.K. [5]. Like in the U.S., U.K. government opens and provides public information service on Semantic Web. Particularly on data.gov.uk, a large volume of public information is provided by SPARQL EndPoint. The most wonderful attempt was that Ordnance Survey started to provide geospatial information with OS Linked Data based on SPARQL EndPoint [11]. Tim Berners-Lee personally joins and supports this project. OS Linked Data refers to and connects with Spatial Relations Ontology, WGS84 Geo Positioning, FOAF, and Gazetteer Ontology, and a tremendous amount of investment is poured to build Geo Ontology [12]. Ordnance Survey supports it to build more intelligent location-based service not only by providing data and SPARQL EndPoint but also by interconnecting the existing RDB-based geo data with semantic geo data to apply reasoning technology. The current OS Linked Data started to be used in connection with OnplelyLocal and Dbpedia as well as LOD's GeoNames, and will motivate to develop various Geo Ontologies in the future.

Figure 6. Ordnance Survey and its Linked Data service



Working group activities for W3C's Geospatial Ontology increased interests in building and utilizing Geo Ontology. Building Geo Ontology becomes more essential for procuring interoperability of geo data, integrated service implementation, and service intelligence. It is forecasted that geo Semantic Technology will start with simple geo semantic tagging and grow as Geo Ontology integrated with reasoning rules. Proper methodlogy for knowledge engineering is required for building the effective Geo Ontology; consideration should also be made for re-use of upper Geo Ontology, domain Geo Ontology and application Geo Ontology.

Figure 7. Level of Geo Semantics

	**Geo Tagging** - GPS based POI processing - Connecting location coordinate with the relevant information
	**Geo Feature** - Applying classification system by domain - Referring to major geographic classification system such as GeoNames
	**Geo Ontology** - Building/Applying ontology-based spatial information - Expressing Point/Line/Shape information
	**Geo Ontology + Rule** - Utilizing Geo Ontology and rule-based inference engine - Applying deduction rules for intelligent spatial information processing

Geo Ontology allows interconnection with heterogeneous geo data, performs mash-up of various data collected from enormous statistics, anthropological information and sensors, and also allows various queries with powerful reasoning via SPARQL. It means intelligence of geospatial data, intelligent personalized mobile service as well as the advent of practical ubiquitous computing world including agriculture, astrology, military, and aerospace.

6. CONCLUSION

Google Earth and Google Map became evangelists which led map and geo information to the connected and open world of the web. During Web 2.0 era, various web services were developed and opened to the public. Google Map became the unrivaled open API and developed as one of the most mash-up services in the world.

In the hot wave of the smart phone, services based on the mobile web browser and mobile web are developed as killer applications. Geo tagging and local search placed their core position in most of the mobile apps for simple photography as well as memo creation, Twitter, Facebook, Foursquare and etc.

Geo information is currently utilized as an optional function based on GPS, however, semantic processing for geo data becomes very important in the world where geo mobile web is generalized beyond geo web. Semantic Search for geo information has already been the core study subject and the relevant market is also growing dynamically. Eventually, Geo Semantic Web or Geo Semantic Mobile Web will become the centralized infrastructure of the ubiquitous computing world.

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