GIS Data Sources

(1) GIS Introduction

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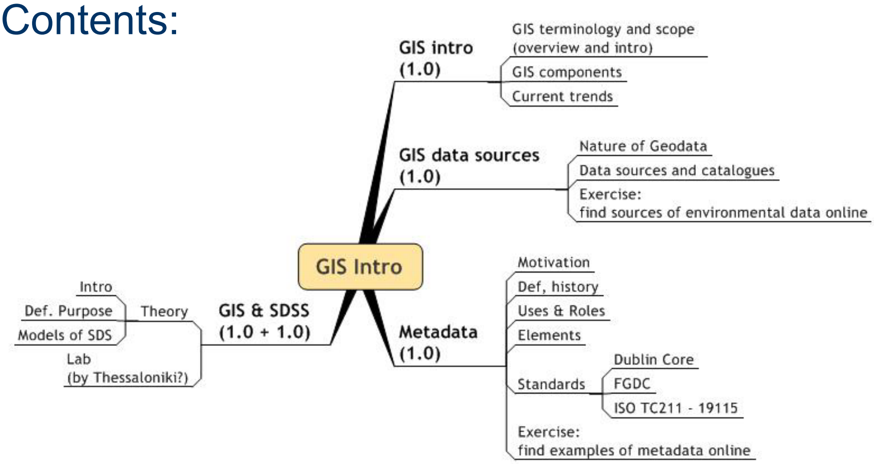
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About these materials

- These materials are part of the UNIGIS MSc Core Curriculum and were developed by **Jochen Albrecht, Wayne Forsythe & Nikolaus Strobel**, and compiled by **Adrijana Car**.
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1 Introduction to GIS Terminology and Scope

- Explain key concepts and terms
- Define and communicate GIS
- Differentiate between
  - GISystems
  - GIScience
  - GITools

Welcome to the introductory lesson of the Summer School here in Brno.

Is GIS a tool or a science? Is it a technology of problem-solving or simply a computer system for making maps? Or is GIS 'just' big business? What is GIS? What is GIS not? In this lesson we will try to answer these questions and focus on the terminology and scope of GIS.

"Good science starts with clear definitions. In the case of geographic information systems, however, definitions have been somewhat hard to nail down. As a result, different definitions have evolved over the years as they were needed. It is no surprise, then, that a geographic information system can be defined in many different ways. Which definition you choose depends on what you seek" (Clarke, 1997, p. 2).

This quote stresses the importance of a lesson on GIS terminology and scope and emphasizes the need for defining the key concepts and terms. On completion of this lesson you should be able to communicate the field of GIS better and to differentiate between GISystems, GIScience, and GITools, etc.

To start with, let's have a look on Clarke's (1997) approach in his book "Getting started with GIS":

•GIS is an information system,

•GIS is a toolbox,

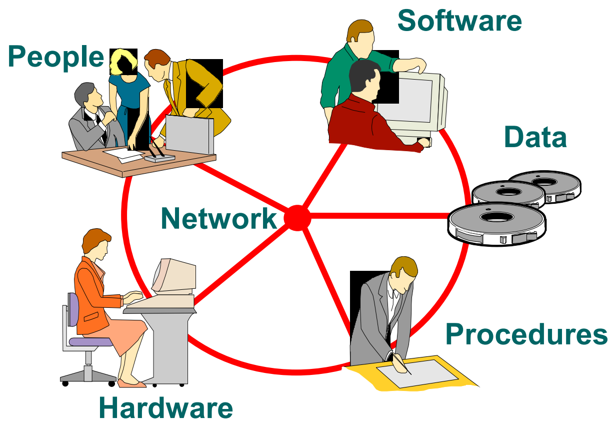
•GIS is an approach to science,

•GIS is a multibillion-Dollar business.

1.1 Information Systems

Systems comprising
- people,
- machines, and/or
- methods

Organized to
- collect,
- process,
- transmit, and
- disseminate data.



Longley at al., 2001, p. 17

The term information system has the following meanings (Wikipedia, 2005):

1. A system, whether automated or manual, that comprises people, machines, and/or methods organized to collect, process, transmit, and disseminate data that represent user information.

2. Any telecommunications and/or computer related equipment or interconnected system or subsystems of equipment that is used in the acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of voice and/or data, and includes software, firmware, and hardware.

The simplest model that describes the structure and behaviour of an information system takes five objects:

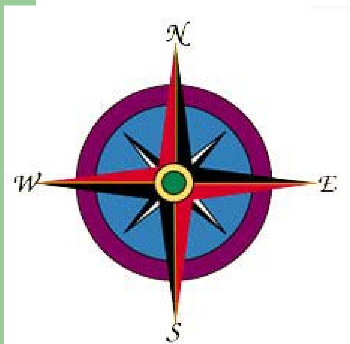
1.Repositories, hold data permanent or temporarily, such as buffers, RAM, hard disks, cache, etc.

2.Interfaces, exchange information with the non-digital world, such as keyboards, speakers, scanners, printers, etc.

3.Channels, connect repositories, such as buses, cables, wireless links, etc.

4.Services, provide value to users or to other services via messages interchange.

1.1 G + IS = GIS ?



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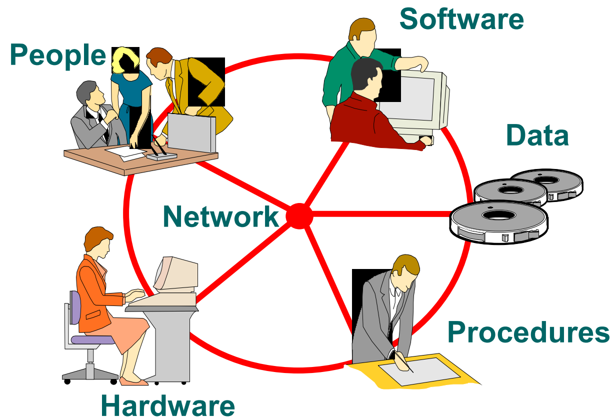


Longley at al., 2001, p. 17

GIS are inherently information systems. But “what exactly is this technology called GIS, and how does it achieve its objectives? In what ways is GIS more than a technology, and why has it attracted such attention as a topic for scientific journals and conferences in recent years – far more, for example, than word processing?" (Longley et. al., 2001, p. 9)

“Many definitions of GIS have been suggested over the years, and none of them is entirely satisfactory, though many suggest much more than a technology. Today, the label GIS is attached to many things: amongst them,

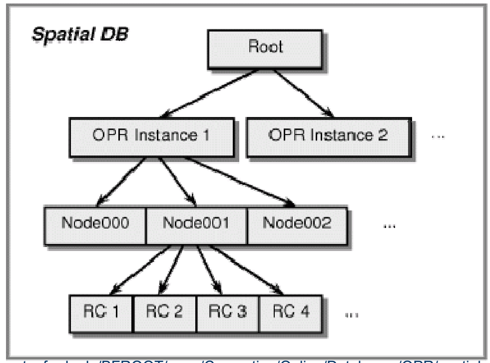
1. A software product that one can buy from a vendor to carry out certain well-defined functions (GIS software);
2. Digital representations of various aspects of the geographic world, in the form of datasets (GIS data);
3. A community of people who use and perhaps advocate the use of these tools for various purposes (the GIS community); and
4. The activity of using a GIS to solve problems or advance science (doing GIS).

The basic label works in all of these ways, and its meaning surely depends on the context in which it is used” (Longley et. al., 2001, p. 9).

1.1 Definitions of GIS

Toolbox-based definitions,

http://www.epa.gov/waterinfrastructure/pricing/images/toolbox.gif



http://www.slac.stanford.edu/BFROOT/www/Computing/Online/Databases/OPR/spatial.gif

Database definitions,

Organization-based definitions.

There are many definitions of geographic information systems. The one here is a very general one that was developed by consensus among 30 specialists (Chrisman, 2002, p. 12):

"A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth."
(Dueker and Kjerne, 1989, pp. 7-8)

Chrisman (2002, p. 13), for example, defines GIS based on the activities performed. According to him, GIS is the organized activity by which people

1. Measure aspects of geographic phenomena and processes;
2. Represent these measurements to emphasize spatial themes, entities, and relationships;
3. Operate upon these representations;
4. Produce more measurements;
5. Discover new relationships by integrating disparate sources; and
6. Transform these representations.

Burrough (1998, p. 11) provides and overview of definitions based on the three categories toolbox, database and organization. Here are some examples of his list:

Toolbox-based definition:

"A powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world" (Burrough, 1986).

Database definition:

"A database system in which most of the data are spatially indexed, and upon which a set of procedures operated in order to answer queries about spatial entities in the database" (Smith et al., 1987).

Organization-based definition:

"An institutional entity, reflecting an organisational structure that integrates technology with a database, expertise and continuing financial support over time" (Carter, 1989).

1.1 Defining GIS

Different definitions of GIS have evolved depending on different perspectives:

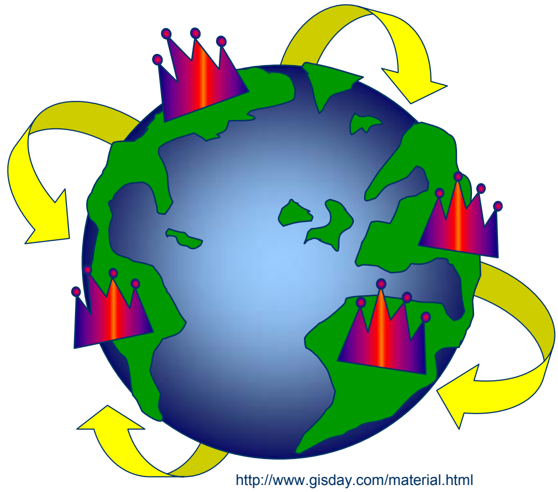
- Spatial analysis perspective,
- Database perspective,
- Functionality perspective,
- Information systems perspective,
- Applications perspective, etc.

In addition, GIS can also be defined depending on the groups who find them useful (Longley, 2001, p. 10):

1. A container of maps in digital form (the general public),
2. A computerized tool for solving geographic problems (decision-makers, community groups, planners),
3. A spatial decision support system (management scientists, operations researchers),
4. A mechanized inventory of geographically distributed features and facilities (utility managers, transportation officials, resource managers),
5. A tool for revealing what is otherwise invisible in geographic information (scientists, investigators),
6. A tool for performing operations on geographic data that are too tedious or expensive or inaccurate if performed by hand (resource managers, planners, cartographers).

1.1 Common Denominator

- Spatial data and
- Spatial perspective
- Geography matters!



http://www.gisday.com/material.html

"Common to all the definitions is that one type of data, spatial data, is unique because they can be linked to a geographic map. Spatial means related to the space around us, in which we live and function." (Clarke, 1997).

1.1 GISystems vs. GIScience

GISystems

- Emphasis on technology and tools to solve geographic problems

GIScience

- Fundamental issues raised by the use of GIS and related technologies, for example:
  - Accuracy,
  - Basic principles,
  - Spatial analysis,
  - Map projections,
  - Scientific visualization, etc.

We have seen that a GISystem is an organized collection of hardware, software, network, data, people, and procedures. From a systems point-of-view, GIS is a technology that provides tools to collect, store, retrieve, transform, and display spatial data.

On the other hand it is also very important to know the science behind the technology. Goodchild (1992) has shown that "the handling of spatial information with GIS technology presents a range of intellectual and scientific challenges. This … leads naturally to a proposed definition of GIS research: research on the generic issues that surround the use of GIS technology, impede its successful implementation, or emerge from an understanding of its potential capabilities".

Geographic Information Science is research both on and with GIS, "because these are issues that are both fundamental to the technology of GIS, and also issues that must be solved before the technology can be successfully applied" (Goodchild, 1992).

1.1 Contributing Disciplines to GIScience

Geography
Remote Sensing
Cartography
Surveying
Geodesy (GPS)

Statistics
Mathematics
Computer Science
Information Science
Operations Research
Management Science

- Psychology
- Sociology

GIS has been called an "enabling technology" because of the potential it offers for the wide variety of disciplines which must deal with spatial data. But many of these different disciplines also contribute to the field of GIScience.

Geography, for example, provides techniques for conducting spatial analysis and a spatial perspective on research. Cartography provides methods for digital representation and manipulation of cartographic features and methods of visualization.

Statistics is important in understanding issues of error and uncertainty in GIScience. Mathematics, especially geometry and graph theory, are used in GIS system design and analysis of spatial data.

And psychology contributes on issues like people's perception of space, spatial cognition and spatial behaviour.

1.1 What GIS is not

- GIS is not simply a computer system for making maps
- GIS is not a general purpose computer graphics system
- GIS offers a lot more than a CAD system
- GIS is not just a route planner
- GIS does more than simply retrieve existing information

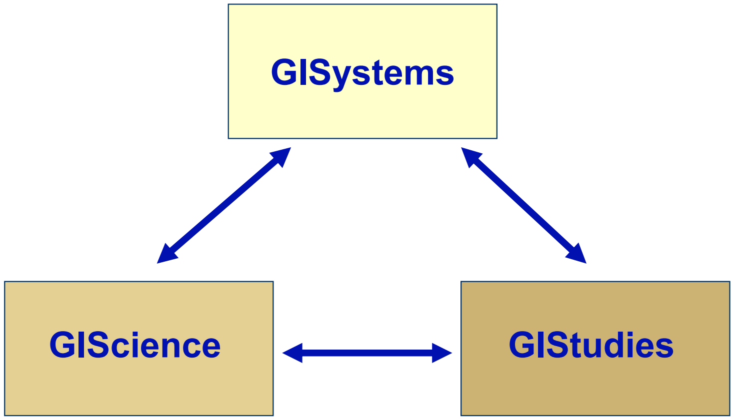
"GIS can produce impressive, professional maps with myriad symbols, at different scales and projections. But they can do much more than that. In fact a true GIS never holds maps in the conventional sense, but as a database of coordinates or collections of grid cells. From this geographical database we can produce maps as and when required. In addition to producing and storing our map data, a GIS can manipulate them, since the data are stored as a model of the real world, rather than as maps in the conventional sense.

Many GIS have developed from CAD (Computer Aided Design) systems. CAD allows the modelling of entities such as a circuit board, or buildings. But, CAD does not usually require the same volumes of data as GIS, nor does it attempt to model geography.

For the Fleet Manager, GIS is not just a route planner. It may also hold information on the destinations the drivers head for, their business needs and characteristics. It may allow the manager to target businesses and people as well as places.

A GIS can produce new information by combining existing information in new ways. This value added information can be used to help support decision making. The representation of results from a GIS in map form is just one method of output, other methods can be used to suit decision makers“ (Poiker, 1999).

1.1 Summary

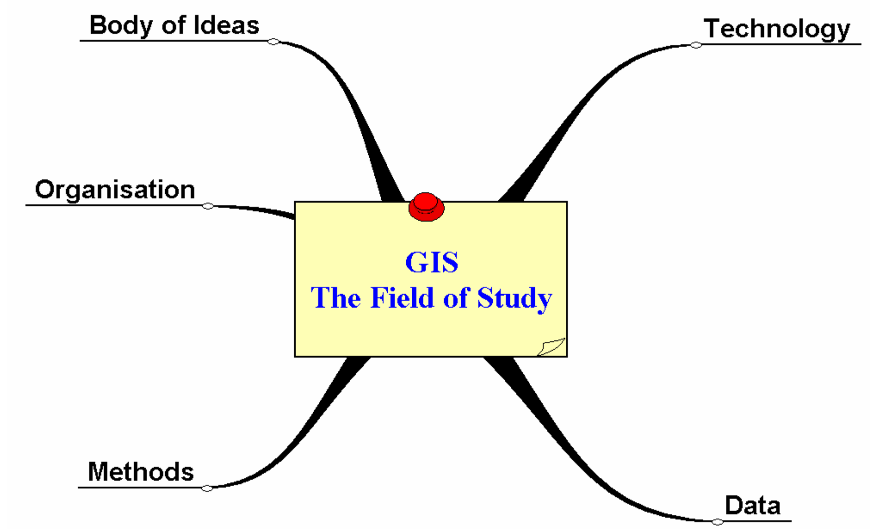


Longley at al., 2001, p. 438

Understanding GIS requires the consideration of science, systems and studies. GIS as an integrating technology provides a framework to manage the world. GIS is fundamentally a problem-solving science. Understanding the science behind applications will help to interpret the results and to understand the weight that these results carry.

In essence, GIScience addresses the fundamental scientific issues arising from the use of GISystems. In GISystems the store house of GIScience knowledge is implemented. And GIStudies is concerned with the way how systems and science are embedded in a societal context (Longley, 2001).

1.2 GIS Components



There are many different approaches to define the major components of a GIS. ESRI, for example, lists six component parts: hardware, software, data, people, procedures, and network (Longley et al., 2001, p. 17). Depending on the point-of-view, certain parts will be highlighted and regarded as crucial, others will be merely named to complete the list.

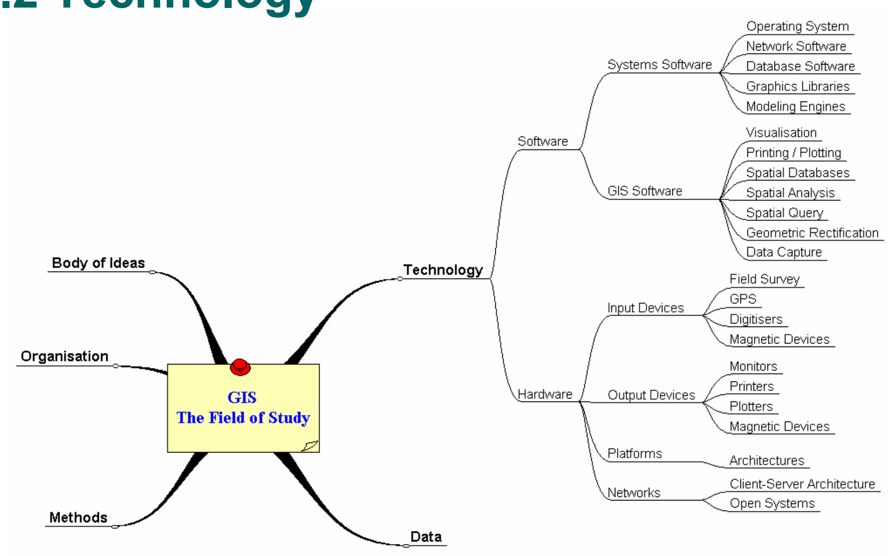
A software vendor obviously focuses on the functionality of his GIS package and tries to convince you that “Product X” is a GIS and the best one available on the market. GIS training people will tell you that whatever package you purchase it will be useless without having skilled personnel at hand to run the whole thing. And the hardware guy will try to sell you the fastest and most expensive equipment.

In this part of the materials we would like to focus on all the components that are necessary to design, create and run a GIS.

This mind map displays the main components of GIS. As you can see, the following five parts are regarded as fundamental: Technology, Data, Methods, Organisation and Body of Ideas.

According to Petch (2002) “these are not merely branches of the field of study, however. If you think about it, any use of GIS must of necessity include each of these components. They are not components of a field of learning but components of the activities of designing, creating and running a GIS. We will argue that each deserves conscious consideration. Our education in GIS should deal with each and we need to develop some skill in and appreciation of each area”.

1.2 Technology

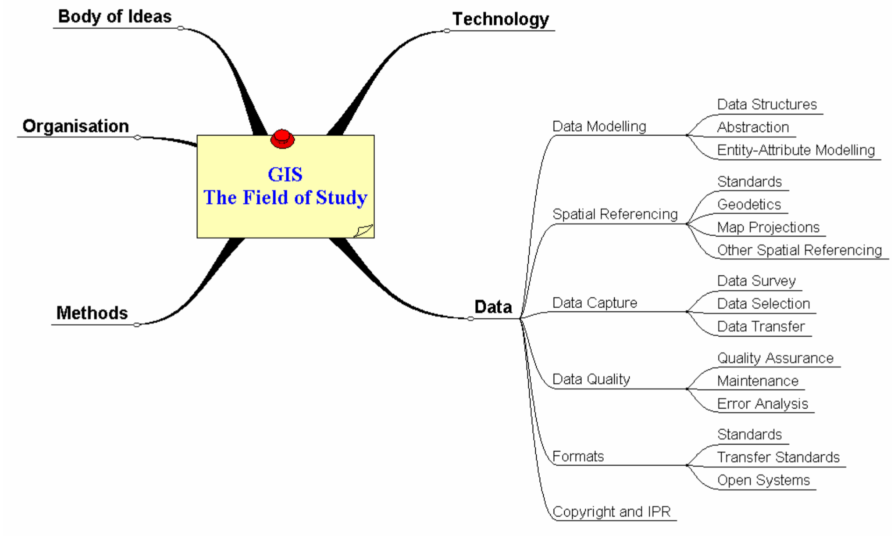


Adapted from Petch, 2002

“There is the technology of GIS, which is the software and hardware. It includes the set of software processes at the core of which is a set of algorithms for accessing, presenting, analysing and synthesising data with reference to their spatial as well as non-spatial attributes. Linked to these programs are others for data management, for extraction from databases, for visualising data and for undertaking other tasks such as import and export. These sit on some particular operating systems and are used with other programs in the normal suite of computer software that deal with systems administration.

The hardware part of the technology is centred on the computer platform and has peripheral devices related to input and output. These include conventional read devices which allow file transfer, as well as network devices, together with output devices such as printers. In addition there are specific devices widely used in GIS applications for input and output of maps to and from analogue formats” (Petch, 2002).

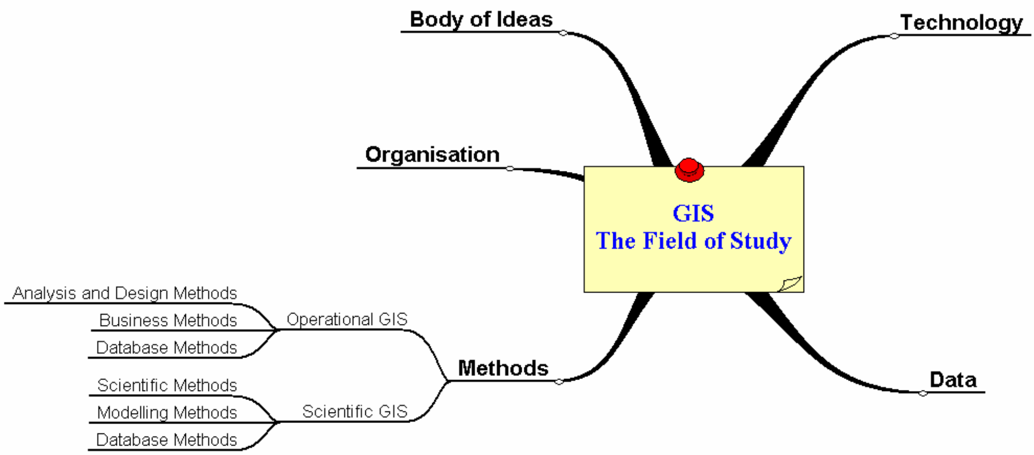
1.2 Data



Adapted from Petch, 2002

"The second main element of a GIS is data. All information systems are based on data and rules for using data in some form or other. The main components of the data part of the system are inputs, spatial and other forms of databases, data maintenance systems and quality assurance systems. You should note here that in GIS we are beginning to include not only technological entities but also human systems" (Petch, 2002).

1.2 Methods

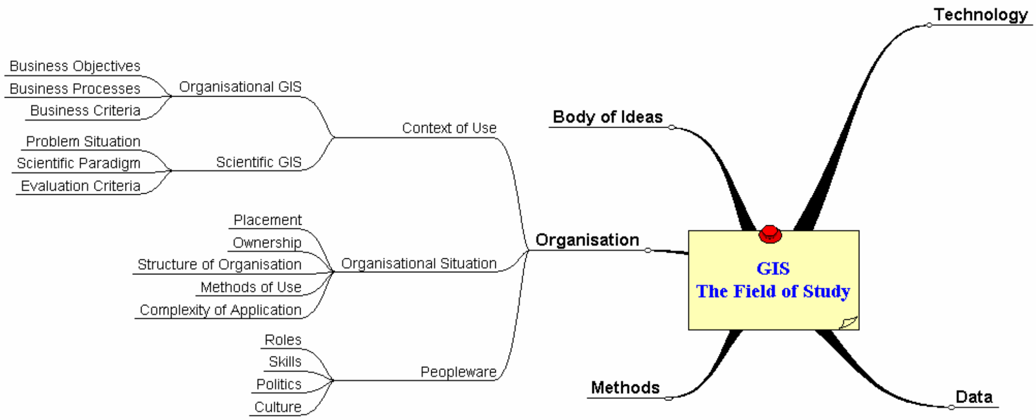


Adapted from Petch, 2002

“The third component of GIS is the set of methods. They are neither hardware, nor software, nor indeed are they specific to people. They are independent procedures or rules for undertaking the various tasks involved in the design, creation and operation of GIS.

A method contains the logic for a procedure and the specification for the actions. There are methods for spatial analysis, for data manipulation, for database design, for user needs analysis, for map interpretation and so on and so on. Each activity has a method. And the method is what determines the meaning or quality of the outcomes of that action. Method is the key to everything in GIS operations” (Petch, 2002).

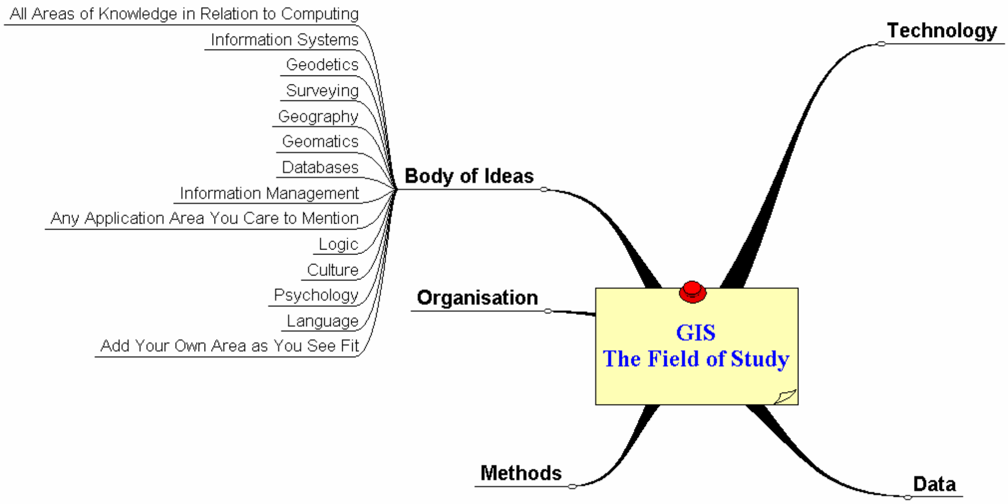
1.2 Organisation



Adapted from Petch, 2002

"The next part of the GIS is the organisation. Any information system makes sense only in the context of an organisation. The organisation consists of many complex and subtle parts but we will consider it here to consist of a set of business objectives, a set of business processes, management, operators and the general overarching component, people. Particular sub-components of the management, operators and people are those concerned with system design, implementation and monitoring since they have a particularly important role in defining what a GIS is" (Petch, 2002).

1.2 Body of Ideas



Adapted from Petch, 2002

"Finally, there is the body of ideas, which lie behind the use of GIS. The field is too vast to describe adequately but we can illustrate the scope and complexity of these areas. They include areas of engineering concerned with computing including mathematics and physics, which lie behind the computer hardware systems. Behind software systems are bodies of knowledge concerned with geomatics, data processing, databases, spatial analysis and in any applications area bodies of theory such as from agriculture, ecology, sociology, transportation and endlessly on.

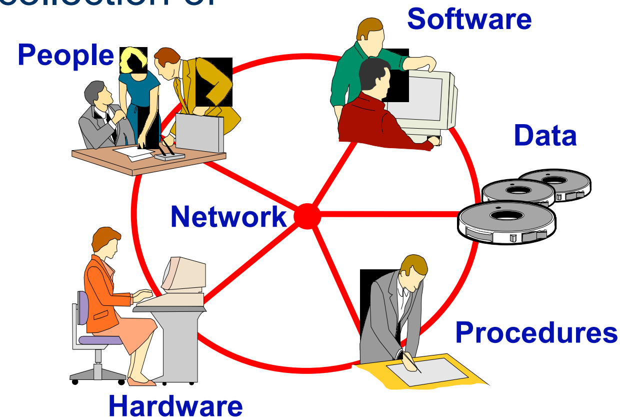
Behind organisational issues are theories of management, systems design, business economics, sociology, psychology, psychophysics and ergonomics. Methods stand on bodies of theory from every conceivable branch of science, sociology, management and commerce. Even the most superficial consideration of these bodies of ideas reveals a picture of Arabian richness" (Petch, 2002).

1.2 Summary

GIS is organized collection of

- Hardware
- Software
- Network
- Data
- People
- Procedures

© Longley et al., 2001



We have seen that GIS does have its well-defined components. GIS is an organized collection of hardware, software, network, data, people and procedures. But we have also seen that there is much debate over these components and the discussion is linked to the way how we define GIS in general.

From a toolbox perspective we will mainly focus on the functional components of our GIS, for instance, which different tools are available and which procedures can be performed. From a broader point-of-view, entire organizations including the management structures, people and human knowledge are part of and have an impact on an operational GIS.

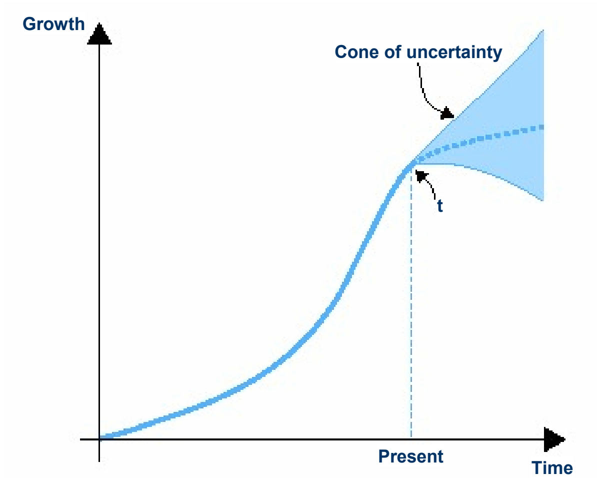
1.3 Current Trends

- Anticipate the likely future development of GIS
- Appreciate possible future roles of geospatial information
- Reflect on changes in the geotechnology industry
- Better plan your involvement within GIS

The development of GIS started in the 1960s and 1970s. Since then lots of things have changed and GIS still is in a continuous state of flux. In this lesson, we offer some predictions about the future of GIS and we will try to anticipate the way GIS is likely to develop in the next few years.

Questions about the future of GIS are not that easy to answer. Looking forward is always linked with predictions and speculation. When last has the weatherman been right? Nevertheless, forecasting and the projection of trends is central to all business areas. Therefore the GIS industry, GIScientists, and everyone involved in GIS have to look to the future to identify trends, to specify basic research areas and to foresee possible customer needs.

1.3 GIS Futures

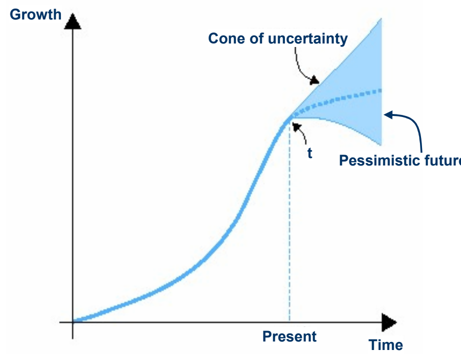


Just as GIS forecasts are characterized by uncertainty, so is the future of GIS itself uncertain. This slide illustrates the way in which the uncertainty of outcomes is often represented. The activity under study, e. g. the growth in GIS usage, has been observed to grow until point t. Data points beyond this represent predictions or forecasts of the future. Our predictions about future growth are bound by upper and lower limits that define a zone of uncertainty.

One of the ways to begin anticipate changes in GIS is to break a problem down into its constituent parts, in our case the component parts of GIS as hardware, software, network, data, people, and procedures. Of course there are limits to this form of analysis, since progress in all facets is neither constant nor proportional at all times (Longley et al., 2001, p. 443).

1.3 Constraints to GIS Development

- Lack of awareness and trained staff
- Continued high cost restrict use
- Limited availability and high cost of data
- Legal restrictions
- Networks become clogged
- Critical theorists dominate
- GIS loses its identity



Adapted from Longley et al., 2001

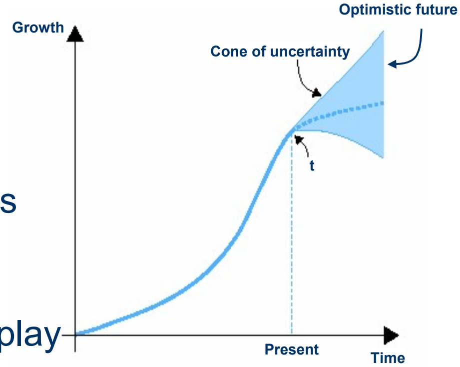
Here we offer two contrasting scenarios about the future of GIS. One scenario is pessimistic; the lower bounds of the zone of uncertainty in our figure.

In our pessimistic scenario we focus on the major constraints that could hold back the development of GIS. Even though GIS is now taught in many universities, colleges and schools around the world, there remains a shortage of well-trained staff and users. The high cost of both software and data could restrict the use of GIS. Legal issues like data ownership, copyright, and software patents, etc. could hamper growth.

If network bandwidth improvements fail to outstrip demand, users will turn away from using online GI services. In addition there are critical theorists who do not value the linkage to the scientific mainstream that GIS provides for human geography. And last but not least, as GIS technology increasingly becomes embedded into specialist areas, there is a danger that some may lose sight of the core GIS values (Longley et al., 2001, p. 444).

1.3 GIS Drivers

- Hardware advances continue:
  - Performance continues to improve
  - Hardware diversity increases
- Continued improvement of Software functionality
- Economies of scale come into play
- GIScience becomes the norm
- More GI is created and accessible
- GIS plays a pivotal role in New Science

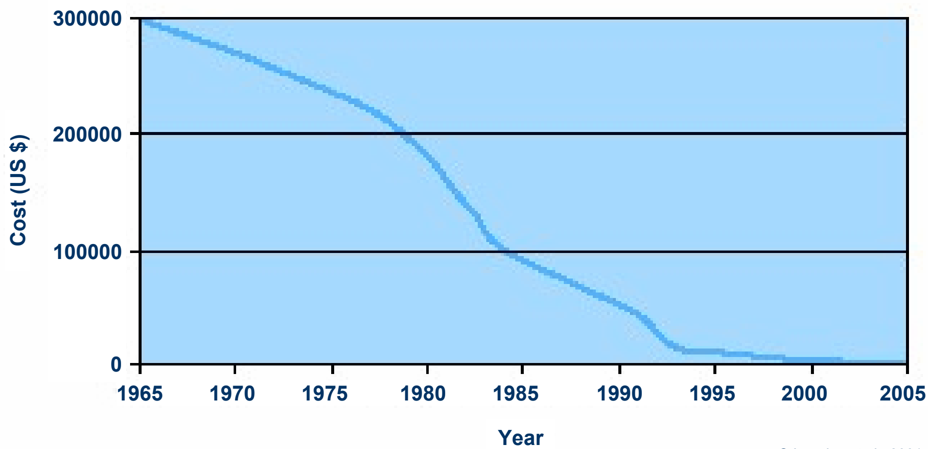


Adapted from Longley et al., 2001

In our optimistic scenario we envisage that solutions will be found to many of the potential problems highlighted before. We will now focus on some of the main drivers that are likely to fuel GIS growth.

Many of the major advances in GIS have been stimulated by rapid breakthroughs in hardware development (improvements in hardware performance, developments in screen and storage technology, etc.). And also software functionality becomes richer, easier to use and lower cost. For GIS to gain critical mass for economies of scale in consumer markets it must become more widespread. And also a widespread adoption of substantial advances in GIScience is critical to the future of GIS (Longley et al., 2001, p. 445).

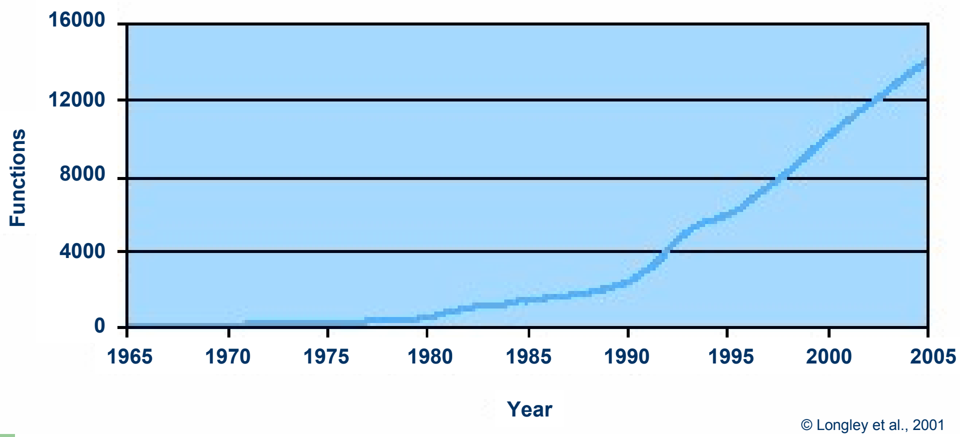
1.3 Falling Cost of GIS



© Longley et al., 2001

The cost of GIS (hardware, software, data, and customization) have fallen drastically in the past four decades. “In the early GIS days of the 1960s and 1970s when commercial-off-the-shelf (COTS) solutions did not exist and GIS ran on mainframe computers, the cost of a GIS was $ 250 000 or more. With the COTS software and minicomputers in the late 1970s and early 1980s the price fell quickly to around $ 100 000. The next major period of rapid price fall resulted from the advent of personal computers and desktop GIS in the early and middle 1990s. Since then prices have continued to fall and in the year 2000 the price for a GIS was around $ 3000” (Longley et al., 2001, p. 444).

1.3 Increase in GIS Functionality



“At the same time as prices have continued to fall the functionality has increased dramatically. There were major jumps in functionality in the early 1980s, with the release of general-purpose workstation COTS GIS software products, and again in the 1990s when desktop GIS came to market” (Longley et al., 2001, p. 444).

“Optimistic extrapolation of the existing situation suggests that GIS software will continue to advance in the areas of capability, usability and affordability. All the major GIS software vendor development teams are currently hard at work adding new features to the next releases of their products” (Longley et al., 2001, p. 446).

1.3 Ubiquitous GIS (UbiGIS)

> "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."
>
> (Weiser, 1991, p. 94)

The computer as we know it has not vanished as Weiser (1991) predicted when speculating about the future of computers in the 21st century. But "recent advances in ubiquitous computing (ubicomp) have accelerated the pace toward the disappearance of computers, as more and more embedded computers are found in mobile phones, car navigational systems, gas pumps, ATM machines, electronic road/bridge tolls, precision agricultural products, retail point-of-sale systems, etc." (Sui, 2005, p. 361).

"Undoubtedly, digital computing technology has influenced and will continue to influence the development of GIS. Ubicomp will embed more conventional GIS functions in various kinds of enhanced location-based services. Location-aware computing, or more broadly ''context-aware'' computing, respond to a user's location, either spontaneously (e. g. a friendly reminder of approaching a favorite restaurant, or warning of a nearby hazard) or when activated by the user's request (e.g. is this area prone to traffic jam or accidents?)" (Sui, 2005, p. 363).

1.3 LBS/GIS

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“Geospatial Information (GI) technology continues to be application or service oriented in serving our modern society, hence location-based services (LBS) arisen out of convergence of GI technology, the Internet, mobile wireless telecommunication and positioning technologies. The convergence of GIS and various technologies has been existing since the widespread availability of the Internet, and it is reflected in a series of GIS terms such as Internet GIS, web GIS, wireless GIS, and mobile GIS. Nowadays it appears that all the “GIS” come to a pot with a more fashionable term – LBS” (Jiang, et al., 2004, p. 89).

“LBS/GIS service is considered another killer service after SMS. It has a great market scale and a favorable profit potential; however, the real development is slow. Along with the perfect of industry chain, the LBS/GIS market is expected to become larger and larger. The global LBS/GIS market started to accelerate in 2005, and the revenue is expected to reach 11.7 billion USD by 2008” (MarketResearch.com, 2006).

1.3 Wearable GIS

One example of a mobile GIS-solution application area is disaster management. "Since major accidents usually have a spatial extent, the beneficial use of geoinformation technology is obvious" (Giger, 2005).

In the project 'Location-based Information Systems and Applications', for example, it is intended to combine the four technologies mobile GIS, Location-Based Services, mobile Positioning and Augmented Reality in order to develop a prototype of a location-aware, dynamic-adaptive wearable GIS (Baldegger et al., 2003).

"A member of a professional fire brigade is equipped with a wearable, dynamic-adaptive and location-aware GIS. This system allows him not only navigation and communication with the missions headquarters, but provides also different information about the objects as well as the possibility of analysis. Furthermore, the system assists its wearer in his mission and warns him if a dangerous change of the overall situation is occurring. The system is easily wearable and does not reduce the fire-fighter in his liberty of action since he needs both his hands for handling the situation" (Giger, 2005).

"GIS therefore is moving towards real time control. Cartography develops into a human-computer interface discipline for spatial views supporting interaction with current processes" (Strobl, 2005, p. 41).

1.3 Joining the Mainstream

- GIS has become less special
- GIS technology is now closer to the IT mainstream
- Reasons for developing specialized technology are less valid
- Cost of specialization are no longer worth incurring
- Massive economies of scale in computer applications
- Adoption of technologies developed for generic applications

Strobl (2005) also argues that “GIS is increasingly becoming an integral part of mainstream ICT". And in his keynote address to the Scandinavian Research Conference on Geographical Information Science 2003, Michael Goodchild (2003) explores the benefits that being part of the information technology mainstream would bring.

“GIS began as a highly specialized application of information technology, with its own hardware devices for input and output, its own data structures, and its own algorithms for data processing. Through time more and more aspects of GIS have become mainstream, and more and more standard approaches have been adopted to replace earlier specialized ones, taking advantage of the economies of scale inherent in the mainstream” (Goodchild, 2003).

1.3 Arguments against Wholesale Adoption

- Unique needs of GIS
- Large volume of data
- Uncertainty in geographic information
- Vast number of GI applications
- Specific production arrangements
- Impacts on society

On the other hand, however, “there are many reasons for treating geographic information as special, and for educating specialists in GIS concepts, principles, and use” (Goodchild, 2003).

Many things are special about spatial data:

•A typical remotely sensed image occupies hundreds of MB, and the EOS series of satellites generates in excess of 1 TB of data per day.

•It is impossible to measure position on the Earth's surface exactly, and attributes of geographic features are often uncertain, because of limited measurement accuracy, vague definitions of classes, errors introduced during processing, etc.

•Geographic information has a vast number of uses, in virtually all areas of human activity.

•In many countries, it has been traditional for geographic information to be produced by the national government, through a national mapping agency.

•GIS is unique in its ability to threaten individual privacy, through the creation of massive, high-resolution databases and their linkage through street address and other geographic keys, and in its importance to surveillance (Goodchild, 2003).

1.3 Towards Consensus

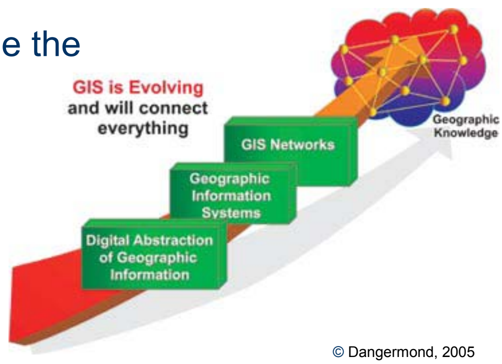
- Some applications of GIS are more compatible with the mainstream, others are much less compatible
- Economies of scale will continue to pull GIS into the mainstream
- GIS data sets require highly specialized approaches to search and retrieval
- The special characteristics of GIS will continue to foster an emerging GIScience.
- Difficulties to bound and regulate the field

“In summary, there are major benefits to joining the mainstream, but there are also major reasons why GIS is special, and why the specialized knowledge, concepts, and skills of the Spatially Aware Professional are essential to its continued health and success” (Goodchild, 2003).

Therefore “the future health of the GIS industry depends on knowing when to generalize and when to specialize” (Goodchild, 2003).

1.3 Summary

- GIS is evolving on the Internet and will connect everything
- Individual systems will be connected into a system of systems – The GeoWeb
- GIS Web Services will provide the framework
- Movement towards a Geo-data rich Society



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To conclude, let's see what Jack Dangermond predicted at the 25th Annual ESRI User Conference 2005:

"We are moving into a data-rich society, with more geospatial information and more access to that information. For example, there are indications that within the next few years we will have a hundred times more satellites beaming back to earth than today, as well as a huge increase in GPS data, real-time monitoring, and greatly expanded data portals throughout the world with georeferenced information that will be used for discovery and analysis.

This will cause an exponential increase in the geospatial literacy of people throughout the world. GIS Web services will provide the framework for this information network, with GIS servers providing the content. Other information will come from sensor networks and the location-based services environment of wireless communication. All of this knowledge will be integrated into our government and business enterprises, providing the benefits of spatial referencing and analysis to these organizations. Over time, we will have rapidly expanding GIS services on the Web, allowing more synergetic relationships between unrelated groups and agencies, with data and services going back and forth between them. Once initiated, the GeoWeb concept will evolve rapidly, and will be driven by the needs and demands of millions and millions of participants" (Dangermond, 2005).

•Burrough, P. A., 1986. *Principles for Geographical Information Systems for Land Resources Assessment*. Oxford University Press, Oxford, 194 pp.

•Burrough, P. A., and McDonnell, R. A., 1998. *Principles of Geographical Information Systems*. Oxford University Press.

•Carter, J. R., 1989. *On defining the geographic information system*. In W. J. Ripple (ed.), Fundamentals of Geographical Information Systems: A Compendium. ASPRS/ACSM, Falls Church, Va., pp. 3-7.

•Chrisman, N. R., 2002. *Exploring Geographic Information Systems*. 2nd Edition. John Wiley & Sons.

•Clarke, K. C., 1997: *Getting started with GIS*. Prentice Hall, Inc.

•Dueker, K. J., and Kjerne, D., 1989. *Multipurpose cadastre: Terms and definitions*. Falls Church, VA: ASPRS and ACSM.

•ESRI. *Geography and Gis.ppt*. PowerPoint Presentation. GIS Day Materials. Available from: http://www.gisday.com/material.html. URL last validated 2006-03-02.

•Eastman, J. R., 1999. *IDRISI32 - Guide to GIS and Image Processing*, Volume 1. Worcester, MA: Clark Labs, Clark University.

•Goodchild, M. F., 1992. *Geographical information science* [online]. National Center for Geographic Information and Analysis, University of California, Santa Barbara, CA 93106, U.S.A. Available from http://dusk2.geo.orst.edu/virtual/goodchild1992.pdf. URL last validated 2006-02-02.

•Hughes, J., 2001. *Definition of Geography* [online]. Available from http://srufaculty.sru.edu/james.hughes/100/100-1/defingeo.htm. URL last validated 2006-01-29. (http://srufaculty.sru.edu/james.hughes/100/100-1/images/defingeo.gif)

•Longley, P. A., Goodchild, M. F., Maguire, D. J. and Rhind, D. W., 2001. *Geographic Information Systems and Science*. John Wiley & Sons.

•Longley, P. A., Goodchild, M. F., Maguire, D. J. and Rhind, D. W., 2001. *Geographic Information Systems and Science*. John Wiley & Sons. Teaching Material / Powerpoint Slides. Available from http://www.wiley.com/legacy/wileychi/gis/powerpoint.html. URl last validated 2006-03-02.

•Petch, J., 2002. *Introduction to GIS* [online]. Unit 1 Intake 12. UNIGIS UK. Available from http://www.unigis.org/UNIGIS/RegisteredArea/intake12/default.htm (Password protected).

•Poiker, T., Cornelius, S., Heywood, I., Jordan, G., 1999. *GIS: An Overview*. UNIGIS Course Notes, Simon Fraser University, Manchester Metropolitan University, 3rd Edition.

•Slippery Rock University. Images. Available from http://www.sru.edu/images/compass3.jpg. URL last validated 2006-02-14.

•Smith, T. R., Menon, S., Starr, J. L., and Estes, J. E., 1987. *Requirements and principles for the implementation and construction of large-scale geographic information systems*. International Journal of Geographical Information Systems, 1: 13-31.

•Strong, W. R., 1998. *WHAT IS GEOGRAPHY?*[online]. Available from http://www2.una.edu/geography/statedepted/definitions.html. Department of Geography, University of North Alabama. URL last validated 2006-02-14.

•U.S. Environmental Protection Agency, 2003. *Water & Wastewater Pricing*. Available from http://www.epa.gov/water/infrastructure/pricing/images/toolbox.gif. URL last validated 2006-02-14.

•Wikipedia, 2005. *Information system* [online]. Available from http://en.wikipedia.org/wiki/Information_system. URL last validated 2006-01-29.

References

•Baldegger, J., and Giger, C., 2003. *Wearable GIS: A smart assistant in disaster management*. Proceedings of the 6th AGILE Conference on GIS, April 24-26 2003, Lyon [online]. Available from http://www.geoit.ethz.ch/staff/PDF/Joachim/2003_agile_baldegger.pdf. URL last validated 2006-02-26.

•Bolstad, P., 2006. *GIS Fundamentals: A First Text on Geographic Information Systems, 2nd edition* [online]. Chapter graphics available from http://www.paulbolstad.net/gisbook.html. URL last validated 2006-02-08.

•Dangermond, J., 2005. *GIS: Helping manage our world* [online]. Available from http://www.gisdevelopment.net/magazine/years/2005/dec/26_1.htm. URL last validated 2006-02-27.

•Giger, C., 2005. *LISA (Location-based Information Systems and Applications)* [online]. Available from http://www.geoit.ethz.ch/research/lisa_en.html. URL last validated 2006-02-25.

•Goodchild, M. F., 2003. *Finding the Mainstream* [online]. Available from http://www.scangis.org/scangis2003/papers/goodchild.pdf. URL last validated 2006-02-26.

•Jiang, B., Zipf, A., 2004. *An Introduction to the Special Issue on LBS and GIS*. Geographic Information Sciences, Vol. 10, No. 2, December 2004. The International Association of Chinese Professionals in Geographic Information Science (CPGIS) [online]. Available from http://www2.geoinform.fh-mainz.de/~zipf/specialIssue.Jiang_JGIS.pdf. URL last validated 2006-02-26.

•MarketResearch.com, 2006. *Location Based Services (LBS)/Geographical Information Systems (GIS)* Market Research, 2005. Published by: Research in China. Published: May. 16, 2005 - 91 Pages [online]. Available from http://www.marketresearch.com/map/prod/1170123.html. URL last validated 2006-02-25.

•OrdnanceSurvey, 2006. *GIS Files: Expert GIS concepts. 6.6: Mobile GIS (2) Location-based services (LBS)* [online]. Available from http://www.ordnancesurvey.co.uk/oswebsite/gisfiles/section6/page6a.html. URL last validated 2006-

•Baldegger, J., and Giger, C., 2003. *Wearable GIS: A smart assistant in disaster management*. Proceedings of the 6th AGILE Conference on GIS, April 24-26 2003, Lyon [online]. Available from http://www.geoit.ethz.ch/staff/PDF/Joachim/2003_agile_baldegger.pdf. URL last validated 2006-02-26.

•Bolstad, P., 2006. *GIS Fundamentals: A First Text on Geographic Information Systems, 2nd edition* [online]. Chapter graphics available from http://www.paulbolstad.net/gisbook.html. URL last validated 2006-02-08.

•Dangermond, J., 2005. *GIS: Helping manage our world* [online]. Available from http://www.gisdevelopment.net/magazine/years/2005/dec/26_1.htm. URL last validated 2006-02-27.

•Giger, C., 2005. *LISA (Location-based Information Systems and Applications)* [online]. Available from http://www.geoit.ethz.ch/research/lisa_en.html. URL last validated 2006-02-25.

•Goodchild, M. F., 2003. *Finding the Mainstream* [online]. Available from http://www.scangis.org/scangis2003/papers/goodchild.pdf. URL last validated 2006-02-26.

•Jiang, B., Zipf, A., 2004. *An Introduction to the Special Issue on LBS and GIS*. Geographic Information Sciences, Vol. 10, No. 2, December 2004. The International Association of Chinese Professionals in Geographic Information Science (CPGIS) [online]. Available from http://www2.geoinform.fh-mainz.de/~zipf/specialIssue.Jiang_JGIS.pdf. URL last validated 2006-02-26.

•MarketResearch.com, 2006. *Location Based Services (LBS)/Geographical Information Systems (GIS)* Market Research, 2005. Published by: Research in China. Published: May. 16, 2005 - 91 Pages [online]. Available from http://www.marketresearch.com/map/prod/1170123.html. URL last validated 2006-02-25.

•OrdnanceSurvey, 2006. *GIS Files: Expert GIS concepts. 6.6: Mobile GIS (2) Location-based services (LBS)* [online]. Available from http://www.ordnancesurvey.co.uk/oswebsite/gisfiles/section6/page6a.html. URL last validated 2006-02-25.

•Strobl, J., 2005. *GI Science and technology - where next?* GIS@development, August 2005, Vol. 9, Issue 8 [online]. Available from http://www.zgis.at/team/strobl/gisdev_js_0805.pdf. URL last validated 2006-02-25.

•Sui, D. Z., 2005. *Will ubicomp make GIS invisible?* Editorial. Computers, Environment and Urban Systems, Volume 29, Issue 4 (July 2005). Pages 361-367 [online]. Available from http://geog.tamu.edu/~sui/publications/UbicomCEUSeditorial.pdf. URL last validated 2006-02-26.

•Weiser, M., 1991. *The computer for the twenty-first century*. Scientific American, September 1991.