CHAPTER 1

GIS IN THE DIGITAL ECONOMY

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BUSINESS IN THE DIGITAL ECONOMY

Spatial technologies and GIS are impacting the productivity of business and economies. As information technologies have become more pervasive, interactive, mobile, internet-based, and diffused throughout the enterprise, likewise spatial technologies have done so. Information technologies became prevalent for mainframes in the late 1950s and early 1960s, while GIS only appeared commercially in the late 1960s and became widespread in government in the late 1970s. This lag means that information technologies became well established in organizations about fifteen years earlier than GIS. In the business world, the lag is greater because GIS was first adopted by governments, remained largely a public-sector feature for two decades, and only became widespread in businesses in the 1990s.

The reasons that GIS has not caught on until recently in the business sector include its high cost and lack of perceived benefits. Spatial datasets are larger than corresponding non-spatial ones. Often spatial data analysis requires more processing power than similar non-spatial analysis. Thus, computing capacity parameters took longer to provide enough speed and power to adequately support spatial analysis and its applications. Second, business people have had less overall knowledge of spatial principles and applications than their government counterparts. Until recently, exposure to spatial software in industry was limited and fairly expensive. Training is sometimes difficult for the average business person to obtain. Software training is provided by GIS software vendor firms and many community colleges. An example is the GIS

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Education at City College of San Francisco (CCSF, 2007). Universities have not until recently emphasized the business side of spatial technologies. GIS is a prevalent tool in schools of planning and public administration, but is only beginning to take hold in business schools (Pick, 2004). Generally, universities have not understood what is needed to educate and train the geospatial workforce (Marble, 2006). Third, business top management leadership in the 1990s infrequently recognized the importance of spatial dimensions. Today more business leaders do recognize it. As seen in cases in the book, some top leaders in companies that heavily utilize GIS/Spatial technologies do recognize its significance strategically, while others do not.

The Rise in the Internet Platform for GIS

Another set of trends that has stimulated spatial and GIS applications is the rise of the internet, web, and e-commerce applications. The following recap of the development of the internet, underscores how recently web-based GIS has been possible and how it serves as a driver for GIS.

Although the application of the internet started in 1969 at the U.S. Department of Defense Advanced Research Projects Agency (DARPA), the main protocol of TCP/IP was not developed until 1974 and only came into research and academic use at leading centers in the late 1970s. TCP/IP (transmission control protocol/internet protocol) is the protocol that controls internet communications between computers. The management of the internet shifted from Department of Defense (DOD) to the National Science Foundation in 1987 and to international commercial organizations in 1995. At that point, the backbone internet traffic was taken over by commercial telecommunications carriers worldwide such as MCI Inc., AT&T, Sprint, and Nippon Telephone Company. As seen in Table 1.1, the number of internet hosts worldwide increased steadily from the mid 1980s to 2005 (The Internet Society, 2006). An internet host is any computer system connected to the internet from a full- or part-time, direct or dial-up connection (more specifically, a host is any computer with an IP address). Since internet hosts only exceeded 100 million in 2000, this table underscores why widespread GIS and spatial applications on the internet are recent.

The World Wide Web (WWW) was originated in 1989 at the European Laboratory for Particle Physics by Tim Berners-Lee. It allowed a user to jump around the internet by links attached to text and imagery. The first browser, Mosaic, was invented in 1993 at the National Center for Supercomputing Applications at University of Illinois. This browser and others that followed such as Microsoft Explorer (1995) led to standard and user-friendly interfaces that made the web navigation much easier.

Businesses had been able to use the internet to conduct some business transactions in the 1980s through Electronic Data Interchange (EDI), but the control of the interchanges was not user-friendly, so it was mostly specialists in IT departments who developed, operated, and utilized EDI. With the advent of the WWW, a new form of business exchange became available,

TABLE 1.1 Number of Internet Hosts, 1984–2005

Year (January)	Number of Internet Hosts
1984	1,000
1991	376,000
1992	727,000
1993	1,300,000
1994	2,200,000
1995	5,000,000
1996	9,400,000
1997	16,000,000
1998	29,000,000
1999	43,000,000
2000	72,000,000
2001	109,000,000
2002	147,000,000
2003	171,000,000
2004	285,000,000
2005	318,000,000

Source: Internet Systems Consortium, Inc. (http://www.isc.org/).

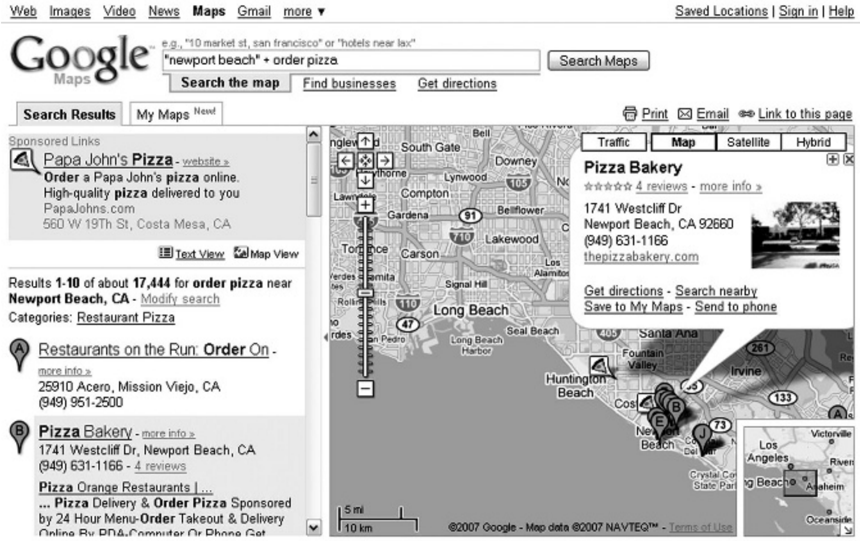
electronic commerce. Electronic commerce is the conduct of commercial transactions on a widespread basis through internet-based exchanges, mostly WWW-based. It grew in the early to mid 1990s and today is estimated to underlie about 5 percent of the U.S. economy, a proportion that is growing. E-commerce can be business-to-consumer (B2C) or business-to-business (B2B). Business-to-consumer e-commerce consists of business transactions and exchanges between a customer and the business; for instance, if a consumer on the web purchases a laptop computer from Dell, or books from Amazon. Business-to-business involves transactions and exchanges between two or more businesses. An example is a B2B website for chemical companies to sell and purchase chemical products with other chemical firms. Often B2B applications provide the basis for market transactions.

The expansion of e-commerce in the United States has been rapid and continues. For instance, e-commerce as a percentage of U.S. retail sales grew steadily from 0.91 percent in 2000 to 2.37 percent for year 2005 (U.S. Census, 2006). E-commerce trends relate to GIS applications, since spatial interfaces are beginning to be involved. This can be through B2C user interfaces with spatial features, marketing of e-commerce, and delivery of goods. For instance, many Google Earth mash-ups, i.e. third party products based on Google code, allow customers to search for business products and services, and conduct online business transactions. The Sperry Van Ness case at the end of the chapter supports spatial features on the web so brokers and their customers can more quickly research, market, and close commercial real estate sales transactions.

Since spatial systems tend to lag information systems (IS) somewhat, web-based spatial applications have only appeared heavily since 2000. Today the shift in spatial applications is steadily towards the web and internet (Sonnen et al., 2004; Sonnen, 2006; Daratech, 2004). Users find the internet platform appealing, easy, and flexible between devices. However, the web protocols and the designs, servers, and software to support these spatial applications are still in development. For instance, the leading spatial web protocols such as GML (Geography Markup Language),WFS (Web Feature Services), and WMS (Web Map Service) are available through a leading standards body, the Open Geospatial Consortium (OGC), but are not yet fully accepted industry standards.

E-commerce applications with spatial components became evident in the Dot.Com boom of the late 1990s with the advent of real estate, transport routing, and other web-based services with map features. The e-commerce with spatial features is growing and particularly relates to B2C in such sectors as real estate, retail, tourism, transportation, and distribution. These spatial advances became evident in 2005 to larger audiences of hundreds of millions of internet users through the milestone advent of Google Earth, Google Map, Microsoft Virtual Earth, and Yahoo Map, and smaller "mash-up" applications. For example, a person ordering a pizza online compares pizza parlors based on their location and the web links describing them, and then ordering online at Pizza Hut (see Figure 1.1).

The breakthroughs in 2005 also swept through the GIS industry and influenced GIS software companies to undertake new strategies of web-based



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Categories: Restaurant Pizza

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B **Pizza** Bakery - more info »
1741 Westcliff Dr, Newport Beach, CA
(949) 631-1166 - 4 reviews
Pizza Orange Restaurants | ...
... **Pizza** Delivery & **Order Pizza** Sponsored by 24 Hour Menu-**Order** Takeout & Delivery Online By PDA-Computer Or Phone Get

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Newport Beach, CA 92660
(949) 631-1166
thepizzabakery.com
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Figure 1.1 Spatial E-Commerce: Ordering a Pizza Online from Google Map Display. *Source:* Google Maps^{TM} mapping service/NAVTEQ 2007 applications that are broadening and changing spatial applications for varied businesses, large and small, across many vertical sectors.

This trend towards the spatial-web is a recurring theme in this book, in the chapters that explain different aspects of GIS in business, and also in many case studies. The Sperry Van Ness case demonstrates how a medium-sized firm can make wise choices of internet platforms and software, not try to do too much, and be highly successful today in the spatial-web space.

Also in the 1990s, large-scale, enterprise-wide software applications became more prevalent (Gray, 2006). These include Enterprise Resources Planning systems (ERP), Customer Relationship Management (CRM), and Supply Chain Management (SCM). The difference from the functional systems available earlier is that these systems apply widely across all locations and many if not all divisions of a business. ERP supports integrated transaction processing systems across wide functional areas including accounting, finance, marketing, sales, production, human resources, and inventory. CRM systems support managing the long-term relationships with the company's customers, from initiation, through building and development and growing breadth of relationships, to transfer, termination, or upgrading of relationships (Gray, 2006). Supply Chain Management (SCM) monitors, manages, and projects companywide flow of raw materials, components, and finished products throughout the manufacturing, distribution, and delivery processes (Gray, 2006). It not only tracks physical items, but also the associated flows of information. If the materials, components, and products moving through the supply chain are geo-referenced at many points in the process, then the supply chain can be better understood, tightened up, optimized, and made more predictable than without geo-referencing.

Geo-referencing refers to adding X-Y (longitude-latitude) fields to an existing data record. Although less prevalent, this might be in 3-D, i.e. X-Y-Z (longitude-latitude-elevation). 3-D geo-referencing can be used for terrain elevation modeling and other applications. Roughly 80 percent of business data has the potential to be geo-referenced, i.e. have a spatial location attached to it (Bossler, 2002).

Because of its greater prevalence of web-based architecture, GIS is becoming more strategic in its applications, often extending across the enterprise. It is no longer restrained to traditional, 1990s departments that maintained compartmentalized datasets not accessible to the outside. Rather, following a long-term IT trend, spatial systems are beginning to be incorporated as a key part of enterprise-wide business applications such as ERP, CRM, and Supply Chain. The process of its movement into these domains has been inconsistent, bumpy, and sometimes resisted by management and users. Another constraint has been how to seamlessly bridge between the large enterprise business applications, which were originally developed without spatial modules, and the complex GIS software packages. However, vendors of both types of software, such as SAP and ESRI Inc., see the opportunity and are working on smoother and more efficient connecting interfaces. In medium and large firms, the enterprise applications were often implemented by IT specialist groups that were not grounded in spatial principles and often isolated from usually small GIS departments, creating other obstacles that have slowed the pace of development. Of the book's twenty research case studies, few yet have implemented GIS integrated with enterprise applications, and none fully.

Spatial Data

When spatial and GIS applications take place in business, whether traditional client-server systems or enterprise-web-based ones, they are based on business data. High quality spatial data (boundaries and attributes) are critical because they support any spatial application and serve as the foundation for analysis, modeling, and decision-making. Spatial data consists of two parts:

- the *digital map boundaries*, which constitute the map layer or map coverage
- data associated with the map layer, which are commonly alphanumeric but can also be video images, audio, and other forms. The non-spatial associated data are referred to as *attribute data*, and are considered more in Chapter 2.

The role of the two types of data can be seen in the simplified Generic Design of a GIS, shown in Figure 1.2. The digital boundary data on the bottom right are input from the internet, global positioning systems (GPS), satellites, and internal sources, and provide the digital boundaries for each map layer. The attribute data on the bottom left are input from other internal and external sources, and provide the non-spatial attributes associated with spatial features. For example, the diagram's middle boundary layer shows three roads. The non-spatial features of each road (width, materials, date of construction, date of most recent maintenance) are stored in an attribute table associated with the map layer (shown on the left). The model of GIS is explained in detail in Chapter 2, while spatial data are emphasized in Chapter 8. The Model also has analysis and modeling functions, which depend on the boundary and attribute data. This includes functions for statistics, simulation, forecasting, and spatial analysis. Finally the outputs at the top are the processing results of the GIS—maps, graphical displays, tables, and other information that is provided to the user for decision-making.

Important aspects of spatial data are its cost, ownership, security, privacy, data quality, and currency/updating. The need to assure all this makes data acquisition often costly and time-consuming for the following reasons:

- A well-known estimate is that 80 percent of the development costs of a GIS project are data expense (Bossler, 2002). The reasons are that spatial data are often voluminous, come from varied data sources, may have

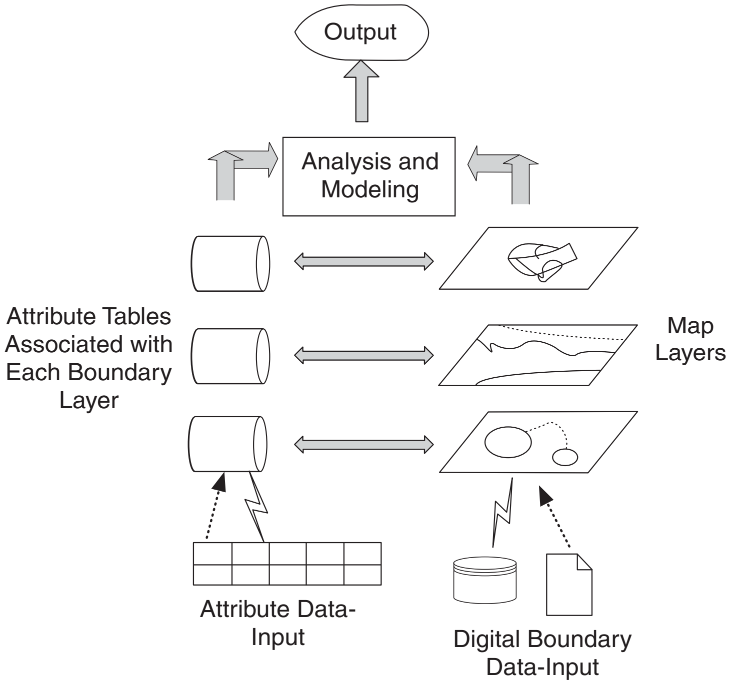


Figure 1.2 Generic Design of a GIS, Showing Attribute Data and Digital Boundary Data

quality issues, and they may not be compatible with each other or with the GIS software. The latter issue stems from the GIS industry's need to update and replace standards, as a consequence of business and technical change, a topic addressed in Chapter 5.

- Data quality is also a problem. Not only are there the usual problems with the attribute data, but in addition serious challenges exist with the accuracy of digital boundary files (Meeks and Dasgupta, 2005). Some of the digital boundary data were originally collected before GPS (Global Positionig Systems) and satellites provided precise locations. A prominent example of this are the base boundary files (TIGER) of the U.S. Census, which have been updated to GPS-accuracy for the 2010 Census. Even with GPS and satellites, errors can occur in the processing and management of the data, as well as in correctly identifying and labeling location. If the user needs exact locations, such as for pipelines or utility lines, then there is a need to do thorough checking for data accuracy. If necessary, accuracy assessments with GPS against physical features in the field may be necessary at extra time and expense to ensure the data quality. Accuracy is also needed to assure the precise connectivity of pipelines with each other.

- The data cleaning, checking, and modifications can exceed ordinary data quality assurances because both the attribute and spatial data need to be individually checked and often modified, but also they need to be compatible with each other and with the GIS software.
- A large proportion of business-generated data are *proprietary*. This means that they are either not released by a firm or only to trusted or partner firms and often at cost. The firm has legal ownership of the data, so in the event of disputes over ownership or data theft, threats or even lawsuits can occur.
- Coordinate systems in boundary layers may be mismatched. Modern software tools can help in achieving matching, but good technical understanding is often needed.

The scope of spatial and associated attribute data is vast and covers the range of business activities in multiple industries. Some of the lead industries that receive attention in this book are utilities, transportation, petroleum, insurance, banking, real estate, retail, environmental consulting, and health care. For just these, the scope of spatial data includes:

- *Utilities*. Attribute and boundary data on economic development, demographic patterns, vegetation, rates, loss evaluation, environmental contamination, maintenance, work-order status, weather, safety, crew and vehicle tracking, outages, transmission lines, land use, metering, labor, materials, customers, and accounting costs.
- *Transportation*. Attribute and boundary data on transport routing, congestion patterns, volume of traffic, vehicle types, loads, maintenance, fuel types, customers, and accounting costs.
- *Petroleum*. Data on geology, drilling, exploration, land use, pipelines, refineries, consumer markets, retail locations, customers, demographic patterns, political patterns, and assets.
- *Insurance*. Data on land use, property damage, vegetation, weather, premium pricing, environmental risks, tax jurisdictions, customers, competitors, natural catastrophe pricing, event loss estimation, population, injuries and deaths, homeless and missing persons, peril zones, and portfolio analysis.
- *Banking*. Data on branch and ATM locations, market areas, spatial diversification of investments, and individual and business customer profiles by location.
- *Real estate*. Data on property locations, layout of land and properties, pricing history, markets—buyers and sellers, taxes, mortgage rates, and customers.
- *Retail*. Data on inventory, supply chain, sales, store sites, customers, transportation networks, demographic profiles and trends, competitors, and purchase patterns.

- *Environmental consulting*. Data on environmental contamination, environmental treatments, management of clean-ups, and customer locations.
- *Health care*. Data on locations and attributes of doctors, other health-care workers, patients, diseases, treatments, facilities, service and regulatory boundaries, transportation, inventory, scheduling, and costs.

These and other data sources are considered in Chapters 9 and 10. Much of the vast reach of business spatial data has existed for many decades, pre-dating the advent of widespread business spatial uses in the 1990s. Since some of the data was not originally accurately geo-referenced, data collection procedures need to be modified so that old locations can now be brought up to the latest precision. For instance, a New York durable goods retailer with thousands of daily deliveries can record and check the X-Y locations of a customer by recording it from the GPS device on the delivery truck, during a home-delivery event. Geo-referenced records have both spatial and non-spatial uses. For example, some companies have geo-referenced their inventory. This can be done through older methods such as adding the location as items are received manually at facilities, or through automatic recording by RFID (radio frequency identification) devices. Knowing precisely where each item of inventory is located helps improve efficiency and timing. Geographically referenced inventory may or may not utilize the spatial referencing, depending on the business process. For example, a chain of grocery stores can calculate, by store, the monthly dollar value of its three current best-selling food items and map those values by store. The map utilizes the spatial location i.e. the point location of each store. Another analysis can do a line graph of the total corporate monthly sales for the three current best-selling items over the past ten years. This line graph is useful for corporate market planning but has no spatial-referencing. This point becomes important with enterprise business systems, which up to now have had minor spatial aspects. For example in the ERP for one large business, over 98 percent of analysis is non-spatial and only 2 percent is spatial. Hence, proportion of the non-spatial uses must be considered in recognizing the perceived importance of spatial data and the priorities given by managers and other stakeholders in utilizing it.

CASE STUDY: GLOBAL INTEGRATED OIL

Global Integrated Oil (GIO) is a world giant, with over 50,000 employees, more than $100 billion in revenues, and business conducted in 180 nations. Spatial technologies are applied enterprise-wide, including in exploration, leasing, transportation and storage, environmental, refining, pipelines, marketing, distribution, supply chain, and business planning. These areas can be better conceptualized with a picture of its Energy Value Chain, shown in Figure 1.3, from exploration to production through to distribution and marketing to customers.

These steps are supported by a mixture of technologies that includes information systems, e-commerce, mobile technologies, and GIS.

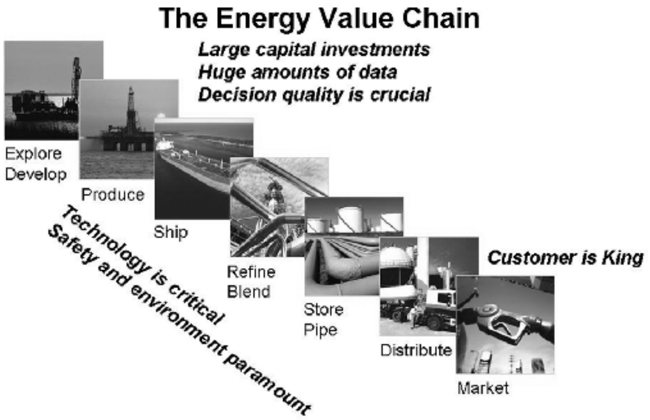


Figure 1.3 GIO's Energy Value Chain

Some notable examples of GIO's spatial activities are the following:

Upstream GIS uses are the heaviest. In *exploration and development*, geologists analyze the subsurface using 3-D modeling software, mostly purchased from outside vendors. This is a competitive aspect, since the global petroleum firms compete strongly on strategic knowledge of where petroleum reserves are located. In determining where to explore, the upstream GIS groups model the global petroleum basin formation from 500 million years ago to present. For instance, Figure 1.4 shows the location of subsurface oil and deposits,

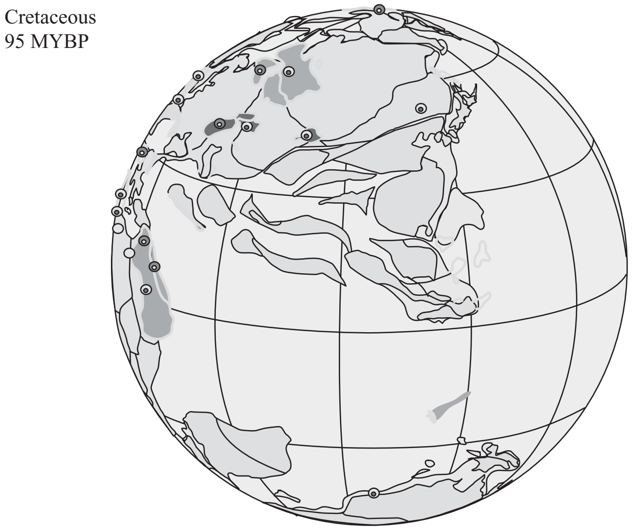


Figure 1.4 Geologic Model of Oil and Gas Deposits in the Cretaceous Period

as well as certain related fossil deposits in the Cretaceous Period that occurred earlier than 95 million years ago. The darker the shading, the larger the deposit.

Global discoveries by GIO over the past ten years of oil and natural gas are mapped, along with locations of dry holes and tar sands. This helps to strategically appraise the size and locations of exploration projects. The benefits are knowing not only where to explore, but also which zones to avoid. Once exploration has commenced, maps of seismic profiles can be produced and overlaid on exploration fields, to determine both the geologic properties and the risk of equipment damage from earthquakes once a production site is active. The exploration fields can be given in one map layer, shown on the left in Figure 1.5, that overlays another layer on the right which shows proposed locations of well sites and pipelines. The full GIS incorporates both terrestrial (topography, well sites, pipelines) and subsurface features (earthquake fault zones, oil deposits).

Another upstream application displays the leasing of exploration land areas held by GIO and its global competitors. It is crucial to know precisely the boundaries of what land is leased compared to competitors' leases and new blocks that might be bid on.

Once drilling starts, 3-D map images can show how the exploration field is laid out, both above and below the surface. These 3-D map images can be used to plan, monitor, and evaluate the construction, regulation, and environmental impacts of *pipelines*. Pipelines constitute GIO's second largest spatial use after geologic modeling.

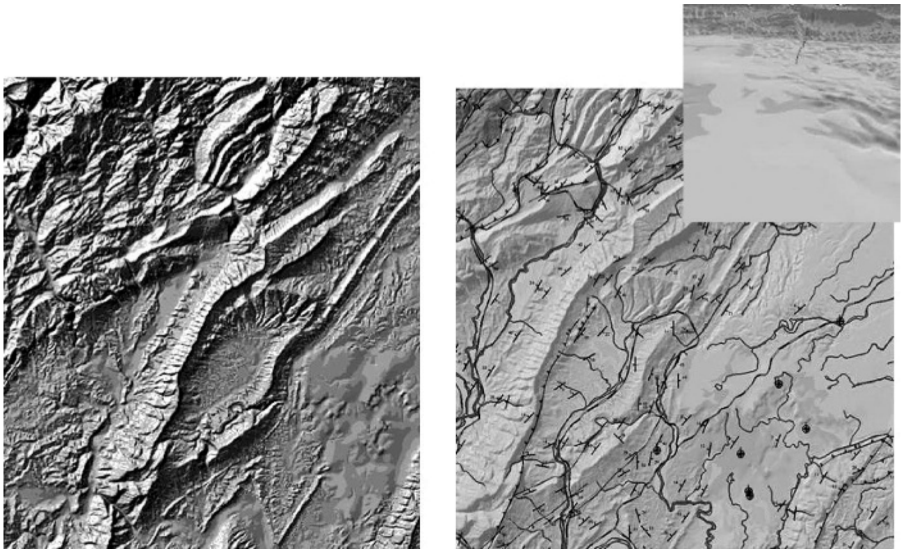


Figure 1.5 Map Overlay of Exploration Field Topography and Locations of Proposed Pipelines and Well Sites

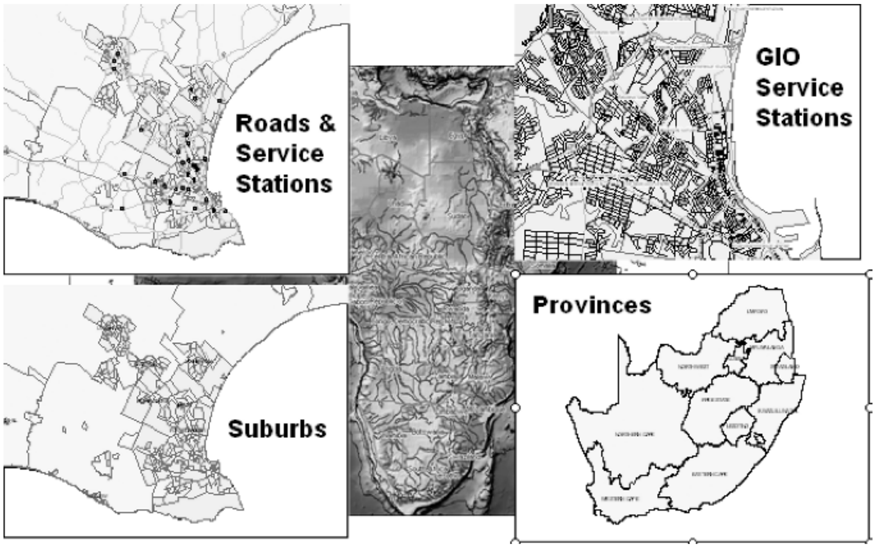


Figure 1.6 GIS in GIO's Retail Market Planning in Africa

For transportation and storage, multi-layered maps show routes, depots, and associated supply districts. For marketing, service station locations are analyzed relative to retail markets, price zones, urban and population areas from the census, and trade area maps.

An example of retail market planning is given in Figure 1.6 for a retail area in Africa. Map layers show major roads and service stations in a suburban area, suburban boundaries, service stations in a denser urban area, and provincial boundaries. Based on these, GIO managers can make improved decisions on locations of retail stations that take maximum advantage of traffic flows, and population proximities, and distribution of existing stations.

GIO has critical supply-chain models and information systems that support the planning and movement of items worldwide. The company has begun to add spatial analysis and mapping to its supply chain system. Figure 1.7 indicates routing pathways between plant and container locations for Europe, Africa, South Asia, and Australia. Questions can be answered such as what are the distances to ship items, how expensive are routes, and how can shipments be best timed and coordinated over space-time to create the most efficiency.

In the environmental realm, GIS is applied upstream and midstream to model layers of physical topography, hazards, and social impacts. Strategic planning uses include spatial analysis of global new ventures and merger proximities of production facilities and office locations. These applications spatially compare data on GIO's facilities, workforce, and assets to those of new-venture or merger candidates. Is there a fit geographically between GIO and other entities? Can the proposed consolidations be beneficial? What are the savings from proximities?

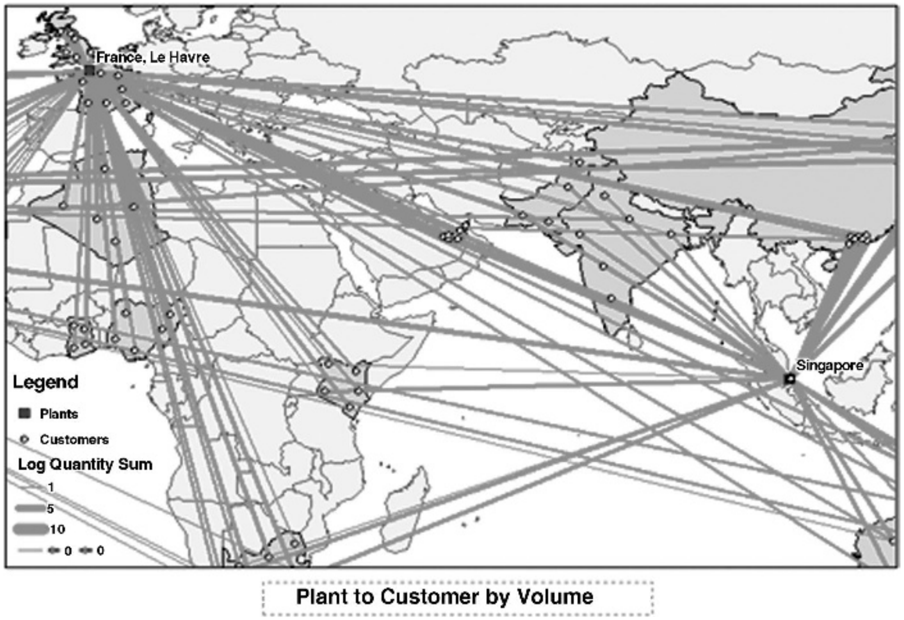
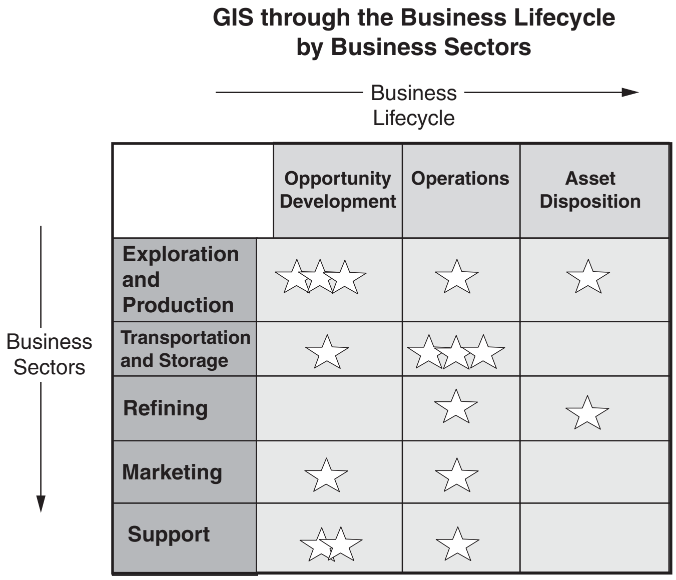


Figure 1.7 GIO's Supply Chain Routing of Containers from Plant to Customer in Africa, South Asia, and Australia

Application of GIS to company strategy at GIO can be analyzed through matrices, such as the simple one illustrated in Figure 1.8 categorizing certain parts of the holding company and its many subsidiaries where GIS/Spatial is applied. In this matrix, the life-cycle stages are the columns, while the rows represent functional business sectors. The number of stars reflects the amount of GIS application. It's clear that GIS finds its way into most cells. At GIO, GIS has moved far from a "silo" and diffused widely into most of the business sectors, life-cycle stages, and subsidiary companies.

Given GIS's prevalence, the company has a surprisingly small GIS Central Group of a dozen experts, located in one of the subsidiary technology companies. That group interacts with twenty-five other GIS employees who are scattered in many of the dozens of GIO operating companies. The GIS Central Group does management, planning, and provides the expert spatial consulting for all the companies, as well as coordinating with the spatial employees worldwide.

The company is pushing the technology limits, in areas such as sub-surface geologic mapping, web-based applications, 3-D maps, data warehousing, and advanced spatial analytic tools for business planning. Overall, GIS is considered by GIO top management to be very strategic in taking on GIO's competition at many levels.



	Opportunity Development	Operations	Asset Disposition
Exploration and Production	☆☆☆	☆	☆
Transportation and Storage	☆	☆☆☆	
Refining		☆	☆
Marketing	☆	☆	
Support	☆☆	☆	

Figure 1.8 Matrix of GIS Applications at GIO by Business Sector and Life-Cycle Stage

THE SPATIAL RE-EVOLUTION

In the past few years, GIS and spatial developments in business have come at a rapid pace, leading to "re-evolution" of earlier business paradigms for GIS. This section looks back at key milestones and then considers several waves of new developments sweeping across GIS and spatial technologies that include RFID, sensors, Lidar, spatial web services, open source software, and event-driven architecture. This section sets the basis for some technology themes of the book.

Historical Antecedents

The history of GIS and spatial technologies in business goes back only about fifty years and only in a major way since the 1990s. However, antecedents go back to non-computerized map overlays in the early twentieth century. A *spatial overlay* is the process of exactly superimposing of several map layers such as terrain, hydrology, geology, and agriculture. The layers can be viewed together, and the relationships of their features analyzed (Wade and Sommer, 2006). Using exact scales to match up layers, Jacquiline Tyrwhitt did this in her *Town and County Planning* textbook in 1950 (Clarke, 2003). Waldo Tobler's article in 1959 conceptually foresaw using a computer to accomplish cartography from inputting data to producing maps (Tobler, 1959). In the

Figure 1.9 ESRI Inc. Founder and President, Jack Dangermond. *Source:* Copyright © ESRI. All rights reserved. Used by permission

1960s early computer programs such as SYMAP and CALFORM could overlay layers and produce maps using mainframe computers and on bulky, crude printers. The Canadian government was an early adopter in 1964 of primitive GIS and continued in subsequent decades to be a lead user. An academic milestone was the book *Design with Nature* by Ian McHarg, a professor at University of Pennsylvania. McHarg included plastic overlay sheets that demonstrated how overlays could shed new light on environmental design (McHarg, 1969).

In the mid to late 1960s, substantial progress was achieved on computer algorithms for GIS at the Harvard Laboratory for Computer Graphics and Spatial Analysis, including the use of arcs and nodes to build up boundary files (Clarke, 2003). In the late 1960s, Environmental Systems Research Institute (ESRI) was formed as a company and headed since its founding by Jack Dangermond (see Figure 1.9). Its mini-computer product ArcInfo, based on Harvard concepts, became the leading commercial GIS software package. Although ESRI's early markets were predominantly in government, this also marked the beginning of GIS and spatial applications for businesses. Later other software companies entered the markets, including MapInfo Corporation and Intergraph Corporation. During the Cold War, there were parallel and often secret developments in mapping and satellite technology by U.S. military planners who were reacting to the threat of nuclear war (Cloud, 2002; Charles, 2005). This stream of military R&D eventually led to the first development and deployment of satellite systems for GPS in the 1980s. The military history is less well known and was largely detached from the academic developments of those decades.

For the 1970s through the 1990s, GIS platforms progressed from bulky mainframes to mini-computers, pcs, and handheld devices. User interfaces changed from command-driven to Graphical User Interfaces (GUIs) in the 1980s. These transformations were driven by advances in the computing

TABLE 1.2 Moore's Law. Transistor Capacity of Intel Processor Chips, 1971–2006

Year of Introduction	Chip	No. of Transistors per chip	MIPS*
1971	4004	2,250	0.06
1972	8008	2,500	
1974	8080	5,000	0.64
1978	8086	29,000	0.75
1982	286	120,000	2.66
1985	386	275,000	5.00
1989	486	1,180,000	20.00
1993	Pentium	3,100,000	66.00
1997	Pentium II	7,500,000	1,000.00
1999	Pentium III	24,000,000	1,354.00
2000	Pentrium IV	55,000,000	9,700.00
2002	Itanium	250,000,000	
2003	Itanium 2	600,000,000	
2006	Dual-Core Itanium 2	1,100,000,000	27,000.00

*millions of instructions per second
Source: Intel, 2007.

power of the underlying component technology. There was a 450,000-fold increase in chip capacity and in processing power from the 1971 through 2006 (Intel, 2007) (see Table 1.2).

The expansion in power allowed GIS to run on much smaller devices or to run thousands of times more powerfully on the same device. Other technological advances impacting GIS were vastly improved monitor screens, higher-resolution printers, expanded networking lines and bandwidths, and more advanced telecommunications design and protocols.

GIS software, most of which was originally written in FORTAN, progressed in the 1990s to object-oriented (OO) languages such as C++ and Visual Basic. Object-oriented design emphasizes interchangeable components, interactive GUI interfaces, and greater ease of use. OO design also allowed GIS software to be more portable across computing platforms. As a result today's GIS software can be implemented as a family of products with the similar user interfaces extending from handheld devices to large-scale servers.

Networking changes in the late 1980s and 1990s transformed the distribution and reach of GIS. For large-scale applications, client-server architecture was introduced on conventional lines (non-internet). Most of the processing takes place on the server(s), which connect and share processing with the client's local system. Data can be stored on the central server, on specialized database servers, and/or on the client's system. Also, during this period, versions of all the leading software packages such as ESRI's ArcInfo and Intergraph's Geomedia were introduced for client-server platforms. Today, powerful client-server versions support advanced departmental applications often for specialized purposes. Client-server architecture was not designed for the internet whereas enterprise web services is. As the latter has become more prevalent, the client-server environment can be referred to as "traditional" (Sonnen and Morris, 2005), even though it is still in widespread use. The distinction of "traditional" versus enterprise/web-based will carry through the book as a theme.

Coupling Technologies

Coupling technologies such as GPS, RFID, and portable wireless devices became prevalent in the 1990s. A *coupling technology* is one associated with GIS that makes the combination more productive and efficient (see Table 1.3). For example, GIS by itself can produce maps based on existing datasets, but does not have the capacity to gather data in real-time. However GIS coupled with GPS can gather geo-referenced data, input it, combine it with existing datasets and produce real-time outputs. As another example, GIS in a field location formerly functioned on a desktop computer with dial-up networking. It is replaced by GIS coupled with a light, flexible, and physically transportable wireless device that is networked at higher bandwidth. The handheld computer in Figure 1.10 is supported by the ArcPad software from ESRI. It provides features for map viewing, data query, distance measurement, GPS navigation, data editing, limited spatial analysis functionality, and wireless communications. Data can be transferred back and forth between the ArcPad mobile device and a networked workstation with GIS by wireless, Bluetooth connections or a physical cable.

A list of some of the coupling technologies is given in Table 1.3.

Global Positioning Systems (GPS) technology, developed in the U.S. military beginning in 1973 and utilized for the first time in combat during Operation Desert Storm in 1991, was not made available for commercial use until shortly after the end of the Cold War in 1993 (Pace, 1995). However, the military at first broadcast a civilian signal that was only accurate to within 100 feet (NAS, 1997). In 1996, the Clinton Administration approved a higher level of GPS accuracy within several feet to be made available to anyone (NAS, 1997). GPS is based on a system of twenty-four Navstar satellites that were constructed by the Rockwell Division of Boeing (originally Rockwell International) and completely deployed in 1993. Each satellite completes a full low earth orbit every 12 hours. They are arranged in an orbiting formation so every point of the earth is in radio communications with at least four satellites at all times (NAS, 1997). GPS devices receive signals from four of the satellites that enables the device to determine its position anywhere in the world with a very high accuracy, commonly under one meter. Military GPS have even higher accuracies as low as a centimeter.

Radio Frequency Identification (RFID) technology started earlier than GPS. Invented by Léon Theremin in the Soviet Union in 1945, it was presented conceptually in a paper by Harry Stockman in 1948 (Landt, 2001), and

Figure 1.10 Handheld Computer Running ArcPad Software. *Source:* ESRI Inc.

further developed and tested in the 1970s and 1980s. RFID allows automatic identification of physical items which have tags (active or passive) that connect with RFID readers. Passive tags can be read within about twenty feet, while active tags can be read within several hundreds of feet and have larger memories. Its first commercial applications were in the late 1980s. It became widely deployed the 1990s after standards were developed and agreed upon (Landt, 2001). In the past few years, lead organizations such as the U.S. Department of Defense and Wal-Mart Inc. mandated its use for suppliers, and their “clout” has speeded up business adoptions. An RFID reader records the data on an item at a particular time and place, resulting in geo-referencing to the reader. It is not continually referenced, as with GPS devices, but occurs at discontinuous points when a tag goes by a reader. The advantage of RFID is that huge numbers of items can quickly be geo-referenced, inventoried, spatially analyzed, and mapped.

An RFID device has a processor, memory, and a radio antenna. Passive RFID devices do not transmit but can be read by radio signals in range of up

TABLE 1.3 Technologies Often Coupled with GIS

Technology	Importance for GIS in Business
GPS	Global Positioning Systems (GPS) is a technology that can determine exact point locations anywhere on the earth by communicating signals with four of the twenty four GPS satellites in an orbiting system. GPS combined with GIS allows real-time locational information to be mapped for business purposes.
RFID	Radio Frequency Identification (RFID) allows portable products of any type to be spatially registered and to carry data that can be accessed and updated remotely by RFID readers. Its use in business is that supply chains and inventory items can be RFID-tagged and their positional locations tracked and stored for GIS access (Richardson, 2003).
Sensors	Devices implanted into buildings, transport vehicles, inventory items, the landscape, and even people provide physical measurements of the environment, such as temperature, lighting, radiation, noise, heat, etc.
Mobile wireless communications	Allows field deployment of GIS technologies in mobile commerce. Useful in supporting the real-time field operations of businesses (Mennecke and Strader, 2003). Combines GIS, GPS, and wireless technologies.
Handheld Devices	Portable handheld spatial devices, such as Personal Device Assistants (PDAs), cell phones, handheld computers, and other mobile devices. For spatial purposes, it contains a GPS device and scaled-down versions of standard GIS software. Gives businesses field flexibility in inputting, outputing, modifying, analyzing, and utilizing data. Important in business sectors such as retail and utilities that have substantial field forces.
LIDAR	LIDAR (Light Detetion and Ranging) can estimate precisely the distance to a surface or object by bouncing laser pulses. The time delay from transmission to receiving the light signal determines the distance. Utilized in aircraft and ground stations for high-precision distance measurements.

to about 20 feet from an RFID reader. Active RFID devices actively transmit radio signals so the readers can be located at more distance—up to 300 feet. The costs of the tags and readers are falling rapidly. Readers have become quite affordable, many models at less than $1,000, and are widely distributed.

As an example of the importance of RFID, Wal-Mart in 2006 required its largest 300 suppliers to have RFID tags on its shipping crates and pallets. Each RFID tag stores an Electronic Product Code (EPC), which provides more information than the traditional bar code. In particular it provides codes not only for product description but also a code for the production lot at the time of manufacturing. This means that an item being shipped or stored can be associated with its detailed production, transport, and storage history. The transport and storage is the accumulated history of movements through readers, which is transmitted and stored in a database. Wal-Mart will track crates and pallets from the point of entering the Wal-Mart supply chain through distribution centers to individual stores (Williams, 2004). Whenever the item passes an RFID reader, not only the EPC but also the coordinate location of the reader is recorded. This supports mapping and spatial analysis applications in order to better plan and optimize the spatial movement and storage of inventory and improve transportation and optimal locating of inventory items.

Portable wireless devices were introduced for widespread commercial use in the 1990s and continue to expand in functionality and market penetration. They include handheld computers, mobile phones, PDAs (personal device assistants), and combined devices such as Blackberries. They support users in the field for data input and display, for instance utility field maintenance staff who need to view maps to locate and repair pipelines, control boxes, and underground facilities.

Wireless LANs are used to provide networking in a flexible local environment without cabling. It allows personnel to capture or update spatial information into devices often portable ones, unfettered by cabling restrictions.

LIDAR creates vivid earth imagery that may be used for weather forecasting and analysis, regardless of whether there is spatial analysis. Its displays are useful for viewing earth events for business and government analysis and decisions.

Networked sensors collected a variety of environmental information, usually at a fixed location. They can measure the magnitude and volume of of environmental or human events at the sensor's location. For instance, climatic data from a network of weather sensors in a region can be input in real-time into a GIS to produce continuous weather maps. Sensor-based data can be used for supporting decisions in business and government (Meeks and Dasgupta, 2005). In short, many of the Geo-location devices share spatial and non-spatial uses.

Broadband as the Foundation for Web Services

Another shift was the advent of web services and service-oriented architectures over the past decade (see Table 1.4). The shift is supported by the expanding internet capacities shown in Table 1.1 and by the widening bandwidths of internet transmission (Austin and Bradley, 2005). Larger bandwidth implies that greater volumes of information can be transferred per unit of time (Dodd, 2005). An important bandwidth division point occurs between narrowband and broadband, which generally means bandwidths higher than that of T1 transmission lines (Dodd, 2005). The dividing point is at 1.54 million bits per second (mbps).

TABLE 1.4 Broadband Penetration Rates by Country

Rank	Country	Broadband Subscribers Per 100 Persons (1/2004)	Households Using Broadband as Percent of Total Households (12/2003)	Percent of Population with High-Speed Internet Access (2002)
1	South Korea	24.0	70.5	21.3
2	Hong Kong	17.0	50.3	14.6
3	Canada	15.0	36.2	11.5
4	Iceland	14.5	NA	8.6
5	Taiwan	12.5	43.2	9.4
6	Denmark	12.0	25.7	8.6
7	Belgium	11.5	24.7	8.4
8	Japan	11.0	28.0	NA
9	Netherlands	11.0	NA	6.5
10	Switzerland	11.0	23.1	NA
13	United States	10.0	22.5	6.5

Source: Reprinted by permission of Harvard Business School Press. From The Broadband Explosion by Robert D. Austin and Stephen P. Bradley (eds.), Boston, MA 2005.

Today's broadband has capacity much higher than that, for instance cable modem services support 6 mbps. T3 lines have capacity of 44.7 mbps, more than the average individual user can take advantage of (Dodd, 2005). Broadband is rapidly becoming more prevalent, including several nations that had more than 50 percent of households connected to broadband in 2003. Many advanced nations had over 20 percent (see Table 1.4).

The growth rates of conversion to broadband are high, so it can be expected within several years to be the dominant transmission mode in developed nations. This trend favors spatial web services, which require rapid and high volumes of information transfer, i.e. in the broadband range.

Spatial Web Services

Spatial web services are those that can be delivered to the user over the web. They are delivered over the Internet Bus, which refers to the high-speed internet or intranet available throughout the enterprise. As seen in Figure 1.11, the organization can put its spatial software on an enterprise server, which creates maps, performs spatial analysis, and sends outputs across the Internet Bus. Also, database servers with data stores are connected to the Internet Bus. Spatial web services managed by outside service vendors are linked to the bus. The maps and other spatial output are transmitted over the Internet Bus to reach users who have access to thin client systems, i.e. ones without much of their own capacity, or thick client systems, ones that have their own software packages and databases. At the lower left of the diagram is a connection to business enterprise systems such as ERP, CRM, and Supply Chain.

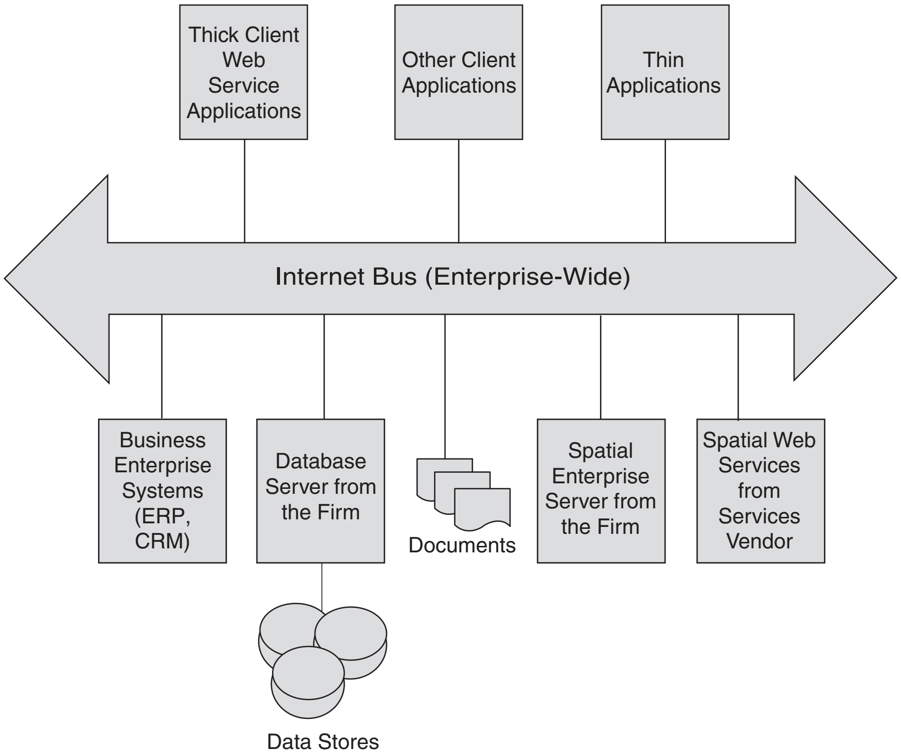


Figure 1.11 Spatial Web Services Provided by Enterprise-Wide Internet Bus

This framework utilizes the protocol of *Service Oriented Architecture* (SOA). SOA differs from traditional client-server protocols in supporting a set of loosely coupled and interoperable application services that are independent of the hardware platforms and programming languages. The most common web services version of this is based on Simple Object Access Protocol (SOAP). It supports SOA as a web service based on the Extensible Markup Language (XML) web protocol. SOAP allows application programs to coordinate with each other across the Internet Bus, even though they utilize different operating systems, programming languages, and technologies. Thus it supports the integration of business applications, allowing sharing of resources and lower cost.

Open Source Software

Another important trend is *open source* software, which has grown since the late 1990s. Open source refers to software development by a community of developers who contribute to publicly available software code. It may or may not have copyright or patent protections, but if protected, the licensing makes the software freely available. Probably the most famous open source software is the Linux operating system, which has entered the mainstream pc operating system market with a small but growing share. Open source development is becoming more important for spatial and GIS software, although no Linux-like software has yet become a leader. An example is MapServer software, developed at University of Minnesota, which allows development and rendering of maps for the web (MapServer, 2007). It's not a full GIS software but has many basic spatial features and tens of thousands of users.

The open environment was also stimulated by the product and legal approach taken by the internet companies Google, Yahoo, and Microsoft when in 2005 they released their free spatial software, Google Earth, Yahoo! Maps, and Microsoft Virtual Earth. The firms opened up their code for outside development, by releasing the APIs. An *Application Program Interface* (API) is a group of protocols, tools, and code modules that allow developers to build applications consistent with the original software, although the firm may retain some limited controls. The outside programmer can use the API elements as a set of building blocks to develop applications that enhance or expand the original software. An example for GIS is a property development company in Portland, Oregon, that utilizes the Google Earth API, combined with its own property database to display satellite imagery of its properties along with their value, tax status, square footage, and year built.

Event-Driven Architecture

Along with SOA and open source, another web trend for GIS/Spatial is event-driven architecture. *Event-driven architecture (EDA)* refers to developing applications in which software events in certain combinations or sequences trigger sending of messages in an asynchronous manner to software modules at remote sites that are unaware the messages are coming (Silwa, 2003). Asynchronous refers to transmission of messages at different times, while synchronous is at the same time. It is "de-coupled," in the sense that the event, sender, and recipient are not previously connected. Middleware serves as the intermediary to which event-messages are sent and allocates the messages to software programs that have subscribed to be notified (Silwa, 2003). EDA is a decoupled, asynchronous architecture that complements SOA's loosely coupled synchronous architecture.

In GIS and spatial business applications, an example of EDA is for a transportation firm that sends out notifications when a vehicle is errant from its course. It can set up a combination of event criteria that define an errant vehicle, e.g. it is more than 5 miles outside its travel buffer zone and at a speed more than 10 miles per hour above the speed limit for more than a half hour. If the vehicle goes errant, the notification is automatically sent to a subscription list of office managers, customers, and security personnel. A current weakness of EDA is lack of widely accepted standards, which means that it runs best where all the programs involved are linked to the same middleware (Silwa, 2003).

In summary, GIS and spatial technologies have advanced tremendously over the past fifty years. Not only have capacities of the underlying component technology increased vastly and the internet revolutionized approaches to transmitting information, but new coupling technologies such as GPS, RFID, LIDAR, and Sensors have extended the combined functionality. Many of the key developments for business took place since the web's advent in 1989, so widespread adoption of spatial technologies in business is fairly recent. Even if a technology diffuses rapidly, companies and their people are often slower to adopt it due to prior investments, measured adoption approaches, and resistance to organizational change.

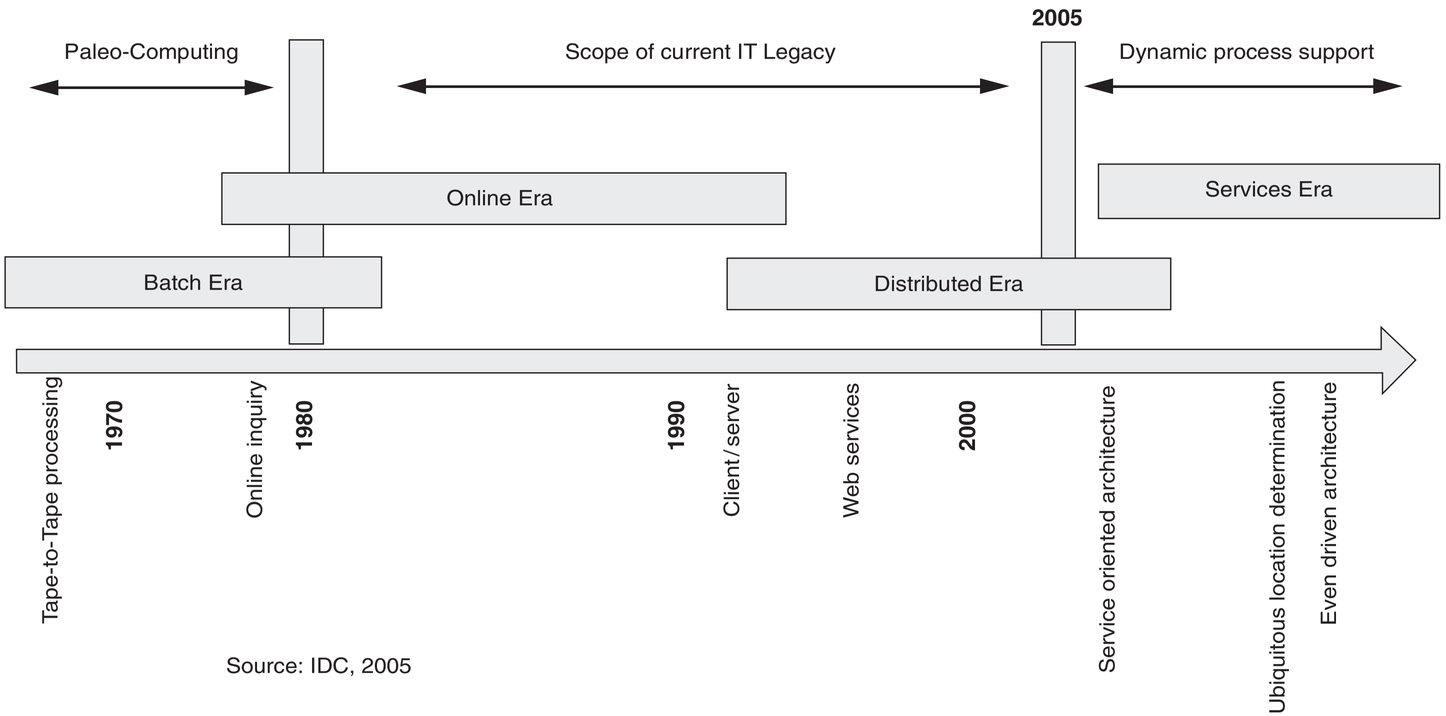
The overall changes in the IT context of the evolution of GIS and spatial technologies are summarized in Figure 1.12.

GIS parallels this IT timeline. It commenced in the Batch Era in the late 1960s and progressed through the Online Era of the 1980s and Distributed Era of the 1990s and into the first decade of this century (IDC, 2005). The year 2005 was a key turning point in GIS history, marking the start of the map services era, with free dynamic online processes for the general public, as typified by Google Earth and Microsoft Virtual Earth.

In summary, spatial technology trends have transitioned from mainframe to client-server to web services and event-driven architectures; from larger to smaller computing devices; from batch processing to interactive, real-time processing; from command-driven user interfaces to user-friendly GUI ones; from separated departmental data to data shared enterprise-wide or multi-enterprise-wide; from lower to higher quality standards of spatial information; and from traditional, stand-alone GIS software to GIS coupled with a group of associated technologies.

THE SPATIAL INDUSTRY

This section considers the spatial industry, which.comprises GIS vendor firms, distributors, data providers, spatial service providers, firms for the associated technologies (GPS, RFID, LIDAR, sensors), consultants, and integrators. Overall, the industry revenues are estimated in the range of $20 billion, with a further estimated $40 billion in government spatial data collection (based on Sonnen et al., 2005; Daratech, 2005; and Longley et al., 2005). The main components of the industry may be divided into (1) GIS software and add-ons, (2) geolocation technologies, (3) web-based enterprise-wide applications and infrastructure, and (4) spatially-enabled enterprise database products.



Source: IDC, 2005

Figure 1.12 Evolution of the IT Context for GIS, 1965–2005. *Source:* Sonnen et al., 2005

TABLE 1.5 GIS/Spatial Software Worldwide Revenues from Leading Vendors

Vendor Firm	GIS/Spatial Revenues, 2004, in millions of dollars	Percent of Market, 2004	Annual Growth Rate 2002–2004
ESRI	445.0	22.6	2.0
Intergraph	376.9	19.2	−0.3
Autodesk Inc.	261.3	13.3	24.1
MapInfo	97.7	5.0	15.4
AOL - Mapquest	67.0	3.4	6.1
Microsoft	56.0	2.9	16.7
GE Energy	18.8	1.0	−53.1
Group 1 Software Inc.	11.7	0.6	9.4
ObjectFX	10.0	0.5	11.1
PCI Geomatics	8.1	0.4	53.0
Other	612.2	31.2	5.6
TOTAL	1,964.7	100.0	5.6

Source: Sonnen et al., 2005

(1) GIS Software and Add-Ons

GIS revenues from the ten leading core software vendors in 2004, shown in Table 1.5, reflects that four companies, ESRI, Intergraph, Autodesk Inc., and MapInfo control 60 percent of the market.

1. *ESRI*, the long-time and largest general-purpose software and services vendor, introduced ArcGIS 9 in 2005 as its new lead product family.The family offers GIS software ranging from enterprise applications at the high end to software for portable devices, and including map server options. The products are built in object-oriented components that allow them to function in a variety of environments. It licenses web server software software to firms as ArcGIS Server. For enterprise-wide architecture, ArcGIS is provided as component libraries residing on the ArcGIS Server. Outsider developers can gain licensed access to the ArcObjects components through ArcGIS Desktop, Engine, and Server. ESRI also has divisions that provide selective and large-scale applications consulting as well as management of a client's web services under ArcWeb Services and other offerings. ESRI has been a technology leader in GIS software design. ArcPad software is offered to mobile users, and Business Map and Business Analyst Online to medium- and small-sized enterprises.
2. *Intergraph Corporation* provides software to middle- and large-sized government organizations and businesses. It also sells hardware to support the software. It focuses on vertical markets including homeland

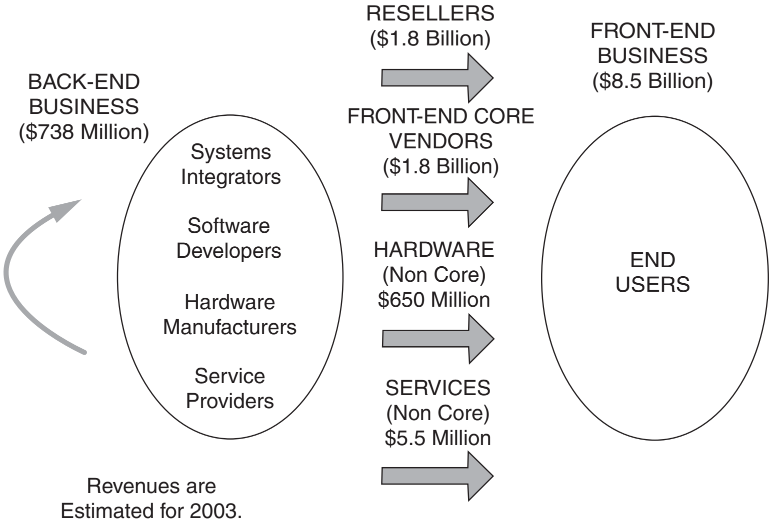
security, government, power and utilities, manufacturing, and transportation. Its leading product family, Geomedia, is offered in web, client-server, and desktop versions.

3. *Autodesk Inc.* especially serves the utility, manufacturing, building, and infrastructure sectors, and partners with Oracle for enterprise-based applications. Its software has tools for engineering, design, planning, and managing large land-based assets. Autodesk heavily serves the utilities industry, where engineering exactness and asset tracking is essential. It extended its products into location-based services to support small and middle-sized businesses in their mobile workforce and field operations. Its major client base comprises government organizations and large infrastructure-related firms. Autodesk grew rapidly from 2002 to 2004, the result of its emphasizing the areas of homeland security and government infrastructure that benefited from the post 9/11 build-up.
4. *MapInfo* markets software to users ranging from individuals to medium-sized organizations. Its lead product is the full-featured GIS software package, MapInfo Professional. Other products are in enterprise applications, geodemographics, and street mapping data. Mostly it sells to medium-sized businesses and emphasizes marketing, banking, insurance, utility, and government applications. MapInfo, which since 2007 is a division of Pitney Bowes, has not yet introduced data management engines, map servers, or mobile device products. It is sometimes known as PB MapInfo.

The GIS software industry also has hundreds of smaller, more-specialized firms that often work in partnership with leading vendors. An example is PCI Geomatics (number ten in the Table 1.5), a Canadian firm that offers services in remote sensing, digital photogrammetry, terrain analysis, radar analysis, and data visualization software development, as well as mapping products to support these areas.

All told the GIS software industry in 2004 totaled about $2 billion in revenues (IDC, 2005). IDC estimates that the segment of industry that provided associated services in 2004 was $8 billion (IDC, 2005). These firms provide design, development, consulting, facilities management, and outsourcing to implement, manage, and enhance the core software.

The industry also includes a segment of systems integrators, software distributors, and software retailers. There are many partnerships and interrelationships among these enterprises (Daratech, 2004), as seen in Figure 1.13. Daratech estimated the total GIS industry and services in 2004 at $8.5 billion, with a somewhat lower services component of $6 billion. It includes specialized spatial hardware vendors with revenues in 2004 of $650 million (Daratech, 2004). An example of a specialized hardware vendor is Trimble Inc. which manufactures and markets a variety of small- to large-sized GPS devices.



Source: Daratech Inc., 2003.

Figure 1.13 Model of the GIS Marketplace, 2003

Systems integrators support the planning and integration of the groups of spatial and other technologies. They establish processing flows, data flows, and software and networking coordination, when varied hardware and software products are applied in combination. This is often in conjunction with data providers and networking platforms. Systems integrators are especially valuable for large-scale projects, which must realize complex configurations of hardware, software, and applications. Here, the systems integrator will be present throughout the project to advise management. Among the steps in a large project that the integrator consults on are the feasibility study, conceptual design of hardware and software, requests for proposals (RFPs), specifications, quality assurance, developing, and building interoperability between different vendors, implementation, and training (Daratech, 2005). In sum, the integrator acts in a high-level technical and management consulting role.

If the project management is fully delegated to an outside party, then outsourcing occurs. Although not yet prevalent for GIS, outsourcing is on the rise and is covered in Chapter 10. The integrated arrangement of GIS and associated components, human resources, and processes needs to be stressed, and will be seen throughout the book and its cases.

(2) Geolocation Technologies

These technologies, GPS, RFID, wireless LANs, cellular networks, Lidar, Sonar, and networked sensors (Sonnen et al., 2005) have already been introduced. They advanced greatly in the present decade and new ones are likely to be introduced (Sonnen et al., 2005). Many smaller, specialized firms in the spatial industry and some larger ones provide and support these devices. Since these technologies are heavily utilized in military and intelligence, this side of the spatial industry is allied with the defense industry.

(3) Web-Based Enterprise-Wide Applications and Infrastructure

Many businesses have already developed IT infrastructures that support enterprise applications such as Enterprise Resource Management (ERP), Customer Relationship Management (CRM), Data Warehousing, Supply Chain Management (SCM), and Electronic Commerce (Gray, 2005). The development of these systems was stimulated by the Year 2000 necessity to re-design large legacy systems to avoid the feared failure of built-in clock algorithms in many of them. Another stimulus to such systems was the more robust web and the trend of the underlying networking towards higher bandwidths.

Vendors of many of these large-scale business systems are adding spatial modules or interfaces to GIS software. An example is the ERP leading vendor SAP, which has introduced spatial connectors. In 2006, there were five technical interfaces that connected ESRI ArcGIS and ArcIMS software with SAP (ESRI, 2006):

(1) SAP remote function calls (RFCs) between SAP and ArcGIS
(2) third-party connectors
(3) the SAP GIS Business Connector
(4) enterprise application integration from both SAP and third parties
(5) direct connections in prototype stage between SAP and ESRI software

Each of the connectors has pluses and minuses. For instance, the Belgian utility firm Pidpa uses ArcIMS to create a website called GeoLink that connects ERP and GIS data. The application is for utility monitoring and maintenance applications known as SCADA. Pidpa is examined as a case study in Chapter 4.

(4) Spatially-Enabled Enterprise Database Products

Enterprise database software has spatially-enabled versions that create a platform strong on database functionality, yet providing extensive spatial functionality as well. This approach to GIS emphasizes seamless incorporation of spatial functions into the backbone databases of the enterprise (Lopez, 2005). It is particularly suitable for large-scale applications involving extensive data and huge user bases across large organizations (i.e. millions of concurrent users). Since that profile is already being well served by enterprise databases for many corporate functions, using the same database with a spatial extension is appealing. These large scale databases tend to be supported by the IT department, not a separate GIS department. It is spatial with an IT flavor to it, emphasizing huge processing and efficiency (Francica, 2005; Lopez, 2005).

Two major database providers, Oracle and IBM, have spatially-enabled database products. In the general database software marketplace in 2004, Oracle had 34 percent of the market, followed by IBM at 29 percent (Standard and Poors, 2006). Since the database market leader is Oracle, it is not surprising that the firm has led in introducing versions of the database software with spatial functionality.

The recent version of the Oracle database enhanced with spatial functions is Oracle Spatial 10g (Francica, 2005; Lopez, 2005; Oracle, 2005). This database has moderate GIS functionality. Although the GIS functionality is somewhat less than for mainstream GIS software, Oracle Spatial 10g offers potentially greater integration with enterprise software and applications, especially for firms that have already adopted Oracle as a standard. However, for certain areas such as business intelligence and ERP, Oracle Spatial 10g's functionality may exceed standard GIS software (Francica, 2005). The mainstream IT connectivity in the enterprise arena makes Oracle Spatial 10g competitive with traditional GIS software offerings for high-volume, huge-user-base applications. Companies can even have both, Oracle Spatial 10g underneath for generalist applications and one or more traditional GIS software packages running on top for particular specialties (Lopez, 2005). There are also service and consulting firms that provide software add-ons, services, and integration for the web-based Enterprise Applications. The architecture of spatial database applications are compared further in Chapter 8.

Overall, the emerging spatial market includes desktop uses of GIS, traditional client-server GIS software, and web-based enterprise applications (Sonnen et al., 2005). As seen in Figure 1.14, the established GIS market has a high spatial focus and medium to high integration complexity (Sonnen et al., 2005). "Integration complexity" refers to how complex it is to integrate GIS with other systems and applications. Established GIS is an older segment that is informed by a lot of geographical knowledge and a strong and

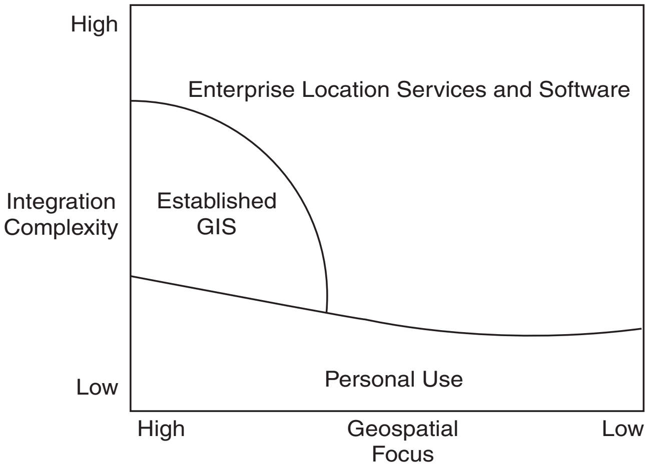


Figure 1.14 Model of Geospatial Markets in 2004. *Source:* Sonnen and Morris, 2004

dedicated workforce of GIS professionals, but less expansive architecture. A second part of the GIS market consists of spatial software for personal use that may be implemented on desktops, laptops, and PDA devices. Its spatial focus varies from high to low. Users range from traditional GIS experts to emerging business users. Its integration complexity is low, but it offers user convenience and flexibility. The emerging market for web-based enterprise applications, seen in the upper right, serves users with mostly middle to low spatial focus, and the applications are medium to high in integration complexity. The most rapid growth in businesses is for the latter group of users, as a number of the case studies will demonstrate.

STRATEGY, COMPETITIVE ADVANTAGE, AND GIS

Companies are successful or unsuccessful in IT depending on how they set up business models, deploy strategies to take advantage of their core competencies, and move ahead of the competition (Applegate et al., 2007). Successful firms need to understand and plan for (1) strategic opportunities and (2) strategic risks (Applegate et al., 2007). Opportunities exist at all times, but are accentuated when firms and industries are undergoing rapid changes, such as happened in the Dot.Com era of the late 1990s. Earlier sections of the chapter have indicated that the early twenty-first century is a time of rapid change and innovation for GIS and spatial technologies in business. The current pace of change is seen by the advent in the past five years of the enterprise web platform for GIS; the advent of widespread RFID uses in firms and industries, often combined with spatial analysis; the appearance of free consumer web packages such as Google Earth; and the increasing sophistication of the large-scale spatial databases such as Oracle Spatial. As in earlier times of change, successful firms will spend time to assess risks and come up with strategies that move the company forward versus its competition. Although the details of strategic and competitive GIS/Spatial are covered in Chapter 12, this section briefly considers the strategic grid and spatial strategic alignment models, and examines them in the context of GIS. The latter is a spatial strategy model for the current period of rapid change and innovation. It underscores why the web integration platform is important in understanding spatial strategies. Sperry Van Ness, a commercial real estate firm, exemplifies as a case how a competitive web strategy for GIS can be successfully implemented.

Two models of strategy are considered.The McFarlan Strategic Grid, seen in Figure 1.15, encompasses the two dimensions of (1) impact on operations, and (2) how strategic it is for the business. The grid can be applied to GIS applications, which may or may not impact business operations and strategy. For instance, Global Integrated Oil's GIS depends on spatial analysis to model its upstream exploration, especially the geological aspects of petroleum deposits and exploration. For GIO's geologic spatial analysis, it's highly strategic and it has a strong impact on operations, i.e. the firm's global explorations could

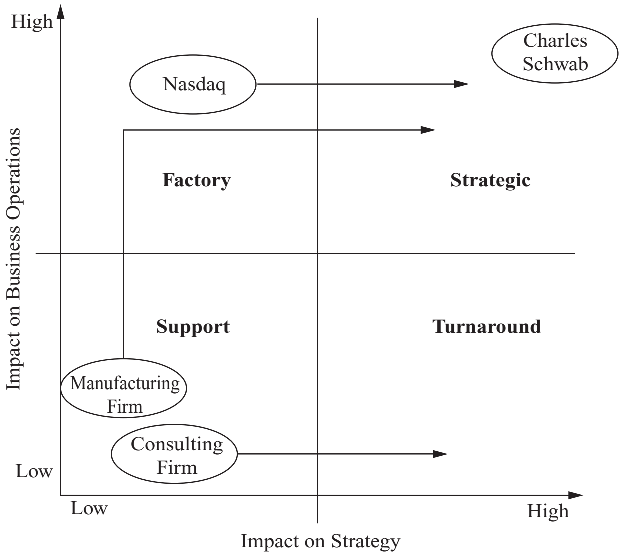


Figure 1.15 McFarlan's Strategic Grid. *Source:* Reprinted by permission of Harvard Business Review. This article was originally published under the title, "Information Technology Changes the Way You Compete," by F. Warren McFarlan in May/June 1984. Copyright © 1984 by the Harvard Business School Publishing Corp.

not be done well today without it. It's clear that GIO's application falls into the Strategic Grid's upper-right cell, i.e. GIO can't get along without it. This model is returned to in Chapter 12.

The second model (Hagel and Brown, 2001) offers a way to organize thinking about spatial strategy. It reasons that the web services architecture increases strategic competitiveness. Firms that have tended to shed their former proprietary and closed approaches to the internet and instead developed interaction with multiple other firms through the web and internet can realize net benefits. Web services can be accessed globally, to combine the best data and software applications available that are affordable and function well together (Hagel and Brown, 2001).

The final chapter will demonstrate through testing with all twenty research cases in the book that the presence of a web integration platform is strongly associated with how strategic GIS is to the company. The implication is that management of firms that can deliberately champion and effectively move forward in the new spatial web environment will tend to do better competitively.

SPERRY VAN NESS: GAINING COMPETITIVE ADVANTAGE FROM GIS

Sperry Van Ness, a private firm founded in 1987, is a rapidly growing commercial real estate brokerage firm with over 1,200 employees and commercial projects throughout the United States. It advises clients and brokers on over a billion dollars annually in retail, industrial, office, multi-family, and land sales transactions. The company has deployed web-based spatial applications that support marketing and sales efforts by its national sales force of 800 people, who are referred to at Sperry as "Advisors." Sperry's Advisors represent the sellers and buyers of commercial properties that range in price from $3 million to $50+ million. Usually the owners are sellers but sometimes are buyers. The top Advisors are hard working, highly paid at often well into six figures, and critical to Sperry's success as a company.

The GIS was developed over the past four years by a manager and team of three technical specialists, a group also responsible for Sperry's IT. The team followed a non-traditional approach for GIS, adopting Microsoft software including MapPoint and MS Virtual Earth on a web platform available both on the company's internet and intranet. GIS user training was emphasized and offered online through the commercial Raindance Conferencing service, which provides combined web and phone training conferences to the Advisors and Advisor Support Center (ASC) staff that can be flexibly deployed across time zones.

The goal of the GIS was to provide the Advisors and Brokers with maps, photos of properties, property sales descriptions, and relevant demographic information in a very user-friendly format. This allows them to showcase online or in person the properties for sale and "tour" prospective investors on the web around sets of prospective properties. For face-to-face meetings with clients, Advisors can use the system to very quickly prepare fancy printed sales material in person. Sperry Van Ness is unique among national brokerage firms in implementing a broker marketing plan along with its investor marketing plan. Its ethos is to encourage cooperation of parties engaged in commercial real-estate transactions. Its three main spatial systems are the following:

1. General public viewing website. A publicly accessible part of the corporate site that lists the firm's properties for sale nationwide, it enables the user to locate properties on a map, see a photo of the property, get basic sales data and the building history, and examine supporting demographic data. An example of the property description and mapping web pages for a similar service is shown in Figure 5.4.
2. Online Publisher, a proprietary and fully featured software package that serves the Owners, Advisors, and the Advisor Support Center (ASC) staff, includes all features from the public site, plus report generation in a highly polished look. Further, it allows the Advisor to "see" out of the property at oblique views, i.e. at 30-degree angles. For any one property, the user can select five viewing angles, a capability called "immersive, birds-eye imagery." The multi-view perspective allows the broker, prospective buyer, and Advisor to imagine themselves inside the property and get a sense of surrounding views, obstructions, and

> surrounding neighborhoods. This unique feature, as well as the 1-hour speed in putting together finished packages, sets Sperry apart from the competition. In commercial real estate, speed of response is often of the essence, especially for sought-after properties.

This case demonstrates a firm that is located in the upper-left strategic cell of the McFarlan Strategic Grid, i.e. highly operational and highly strategic. Since Sperry's approach is totally based on an enterprise-web platform, it is correlated with strategic competitiveness as postulated by Hagel and Brown (2001). The firm's top management is enthusiastic about the use of GIS, even though they maintain a practical one- to three-year planning horizon on all facets of the company including GIS.

CHAPTER SUMMARY

Geographic Information Systems emerged as an important factor in the business world over the past ten years. The GIS trends are towards smaller devices, coupling of GIS with associated technologies, web platforms, and enterprise-wide applications. Some huge firms have adopted GIS across their enterprise, as illustrated by Global Integrated Oil, which uses it throughout its value chain and strategically in the upstream exploration and pipeline stages.

GIS and spatial technologies can be strategic and advance firms versus their competitors. Some background on strategy is presented, including the strategic IT grid and web services strategy. The strategic importance of GIS is linked to use of enterprise-web platforms versus traditional client-server. The case study of the medium-sized Sperry Van Ness commercial real estate firm illustrates how well-conceived, user-friendly design in a web environment can be very strategic in providing crucial maps and multimedia sales information to top sales people much faster than the competition.

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