18 Navigating the Risks

LEARNING OBJECTIVES

After studying this chapter, you will understand:

- How personal or organizational disasters may befall GI system practitioners or scientists if they behave unprofessionally or communicate badly.
- The various business models used in GI services and their risks.
- Legal and regulatory constraints on actions.
- Privacy issues involving geographic information.
- The importance of public trust, ethics, and the media.
- Spatial data infrastructures.

This chapter assumes knowledge of what is contained in Chapter 17. Here we describe the pitfalls to be avoided in being a geographic information (GI) system practitioner. We start by summarizing the business models that have been adopted in GI-related enterprises and their respective advantages and risks. Then we describe briefly major constraints arising from regulation of GI-based businesses in different countries, including laws on competition, human rights, information access, intellectual property rights, and liability.

We review the role of the nation state in GI-related matters. Examples are given where the state competes with the private sector in the supply of GI and related services and the challenges this can pose to those involved. The past and possible future roles of the state in creating national spatial data infrastructures are discussed, especially in a world of Open Data and national information infrastructures (Chapter 17).

The different concepts of privacy in different countries and hence the focus of its preservation are outlined—especially where data are being comingled. Success in all this is achieved by awareness and conscious mitigation of the risks and by engaging in partnerships whenever appropriate to acquire complementary expertise. An important contribution is to act ethically, actively manage relationships with the media, and foster public trust. Finally, we illustrate the importance of human frailty, showing how some users have ignored risk and managed to misuse GI technology and GI, with unfortunate consequences.

18.1 Clashes Between Scientists and the Judiciary

The Italian Major Risks Committee is an expert panel that advises local governments on risks of natural disasters. The UK *Guardian* newspaper reported that on 31 March 2009, the committee met in the Italian town of L'Aquila, a medieval settlement built on an ancient lake nestled in the Apennines. This was at the request of the Italian Civil Protection Agency to discuss whether a major earthquake was imminent. It has been reported that the minutes of the meeting show that at no point did any of the scientists say that there was "no danger" of a big quake. After the meeting, Bernardo De Bernardinis from the Civil Protection Agency reportedly walked out and told the media representatives: "The scientific community tells me there is no danger because there is an ongoing discharge of energy."

On April 6, an earthquake struck L'Aquila. More than 300 people died, and 20,000 buildings were destroyed (Figure 18.1). A year later, De Bernardinis and six scientists from the committee were indicted for manslaughter. They were found guilty and sentenced to six years in prison (though the six were acquitted on appeal in late 2014). The judge explained his decision on the basis that the committee's members had analyzed the risk of a major quake in a "superficial, approximate and generic" way and that they were willing participants in a "media operation" to reassure the public. This extreme and extraordinary event has profound lessons for any professional involved in analyzing data and providing advice to the public—especially through a third party.

Such clashes between scientists or data analysts and politicians and the judiciary are not uncommon. For example, the International Statistical Institute has reported that statisticians have been prosecuted for some years in two countries. In Argentina, private statisticians and economists working for universities or consulting firms are producing alternative consumer price indices (CPI) to provide users with more reliable data than the official CPI that has allegedly been manipulated by the government. These statisticians have faced fines and threats of imprisonment following prosecution. In Greece, after years of underestimation of the public deficit and debts by the Greek Statistical Office, the EL.STAT agency established since 2010 is now producing figures that are compliant with the high professional standards practiced elsewhere in the European Union. However, the Greek Chief Statistician and two of his colleagues—who were hired to bring Greece's debt statistics in line with European norms—have faced prosecution for producing what are alleged to be inflated budget deficit numbers.

In this chapter we seek to identify and minimize these and other risks and show how best to maximize opportunities.

Figure 18.1 The Governor's offices after the destruction of the city of L'Aquila, central Italy, Monday, April 6, 2009, by a powerful earthquake.

Source: Alessandro Bianchi/Reuters/Landov Media

18.2 Business Models for GI-Related Enterprises

In the beginning (see Section 1.5.1) the GI system world was dominated by big institutional players. In many parts of the world government investment and initiatives played a major role through some private companies, such as utilities that pioneered GI system applications for record keeping and operational efficiency reasons. Since then, the commercial sector has grown to dominance, though the scale of government support via research and military funding remains considerable. Thus, the scale and composition of the private sector in GI systems has changed dramatically over the years. Many new businesses have sprung up, some then bought out by bigger players. Some serious players have all but disappeared, such as Siemens' SICAD system. One common factor has been the continuing success of Esri Inc.; on the basis of estimates published by various market research firms, this company has some 40% of the global market for GI systems, and its professional users top one million.

The market has changed qualitatively as well as quantitatively—many new and global players like Google, Oracle, and Microsoft have changed the nature of what we understand by GI systems and services (see Section 1.5.2.3). As a result, much GI system functionality has been commoditized. Over the period since ca.1995, the delivery vehicle has mutated from large mainframe computers to desktop machines to mobile devices, with Cloud-based Web services playing an increasingly central role (see Chapter 6). And the user base has evolved from a small number of well-resourced governments or commercial enterprises to a diverse one including tens of millions of individuals, each one of whom selects just the particular functionality most useful to them and frequently accesses these functions via a tablet or a cell phone.

As described earlier, many interrelated factors have been responsible for these changes—the introduction of disruptive technologies, cost reductions of computing power, the development of new applications, changing user needs, and the role of education in enhancing geographic information science and systems (GISS) human capital among them. But, however clever and hardworking are the staff of a business, the business model(s) to which they are working will play a major role in determining their market success. Few firms prosper by adhering slavishly to one business model over many years. For example, if a firm is successful and grows, the model must be scalable to be economic. It follows that, to survive and prosper, leaders and managers of companies must seek to anticipate changes in the marketplace and user needs and decide whether to mutate their business model before their competitors have won first mover or other advantage.

Yet any significant change to the business model can be extremely expensive and painful—even fatal. Good judgment, bravery, the right corporate culture, and some luck are also essential for success. Furthermore, in some cases "betting the shop" on the latest development may not be the best solution. This applies especially for organizations with an already large installed base of users. The approach of organizations such as Apple and Esri with mass-market products that ship in large volumes and that have built loyal communities of users is not to seek first mover advantage. Rather they seek to build robust solutions, often improving on the innovation of others. This is not a manifestation of poor management—rather that the business model is continuously reviewed and changes only made when they have long-term benefits.

Being clear about the business you are in—and having the right business model—is the first step to success.

Crudely put, we can distinguish several different families of business model (Table 18.1). None is totally

Table 18.1 Business models used by GI-related enterprises

Nature of business model	Characteristics	Comment
Selling or licensing software (and also sometimes hardware)	Typically involves up-front charge and annual maintenance for updates. Selling content works best where data are updated frequently, e.g., financial, traffic, or meteorological data	Difficult to scale in early days: sales often involved much human interaction. Advent of broadband for delivery of updates helped. The model prospered originally when GI systems were small scale, involved experts, and everyone necessarily had the capacity to collect their own data. Sometimes this was implemented or run by consultants to a business. Now, however, this model is followed by major firms such as Esri, SAS, Adobe, and Oracle. It also serves well when it involves simple systems that are best sold using a one-off business model, i.e., buy software or data once and walk away.
Selling or licensing content (GI) and elements of GI system functionality	Increasingly important through provision as a Cloud service, e.g., routing, store finder, providing embedded mapping in corporate sites.	Often works best where commercial sector adds value to hard-to-understand/poorly packaged datasets provided free by governments. Integration of software tools and data often needed significant expertise in early days.
Advertising-based	Often at no direct charge to end user. Mapping has become a mandatory consumer application even if the end user can't be directly charged—hence use of advertising.	Can work well for large organizations, notably Google, who can tailor advertising and location-based services to personal characteristics of users derived from social media, cell phone locations, and volunteered data. Revenue generation is often indirect, e.g., through number of visitors to Web sites of advertised retailers.

(*continued*)

Table 18.1 (*continued*)

Nature of business model	Characteristics	Comment
Subscription-based	Evolving to a situation where all services are based in the Cloud and a monthly fee enables user to access integrated hardware, software apps, centrally and user-provided data (sometimes shared with others), and sophisticated analytical tools with support services	Developing rapidly. Users can also become service companies on the back of this platform. Mostly hosted on megainfrastructures supplied by Apple, Google, Microsoft, or other major firms so has high fixed costs. Fostering volunteered contributions to content and ideas for new functionality may strongly influence success.
Hybrids	Freemium services form one example: base services are provided free (e.g., open-source software and online map services) whilst "professional versions" (such as Google Maps APIs) are charged, especially if incorporated seamlessly in retailers' Web sites. Some firms offer a mix of software and subscription, e.g., through a desktop and Cloud service	Many smaller developer-based firms offer free tools and map services to consumers, as do major vendors such as Esri and Autodesk.

distinct, some can be run concurrently, and elements of one may be transplanted into another. No one model exclusively characterizes any one size or type of business. All are associated with risks, but the magnitude of these risks often depends on local circumstances. What, for example, happens to your service business if the Global Positioning System (GPS) signal is jammed (as is easy to do locally?). Understanding the options and why successful enterprises have chosen one rather than another is an important management task.

18.3 Legal and Regulatory Constraints

The use of GI can support implementation of the law. It underpins the efforts of many police forces. Examples include planning effectively for emergency responses, creating and testing risk mitigation strategies, analyzing current spatial patterns (e.g., crime), and projecting future ones. But the law also strongly influences the use of GI systems.

During a career in GI services or technology, we may have to deal with many manifestations of the law. These include copyright and other intellectual property rights (IPR), competition law, data protection laws, public access issues enabled, for example, through Freedom of Information Acts (FOIA) and human rights laws, and legal liability issues. As an example of a GI-related—if outdated—law, many countries have long enacted constraints on collecting aerial photography for state security reasons. The Dutch government formally lifted their ban on this in June 2013 as a consequence of the ready availability of maps and imagery from Google, Microsoft, and other sources. The U.S. government has also long restricted the sale of very high resolution satellite imagery. In June 2014 Reuters reported that the government—following support from the intelligence community—had licensed the sale of data at 40 cm resolution rather than the previous 50 cm limit. In addition, it had licensed the sale of DigitalGlobe's WorldView-3 satellite's 31 cm resolution data from early 2015.

Beware! The law touches everything and has direct and indirect effects.

Our contacts with the law may occur through regulators or through the courts. But because laws of various sorts have several roles—to regulate and incentivize the behavior of citizens and organizations and to help resolve disputes and protect the individual citizen—almost all aspects of the operations of organizations and individuals are steered or constrained by them.

18.3.1 Geography and the Law

Laws vary from country to country, and this directly affects us all. For example, the Swedish tradition of open records on land ownership and many personal records dates back to the Seventeenth Century, but much less open frameworks exist even in other countries of Europe. In particular, the creation, maintenance, and dissemination of "official" (government-produced) geographic information are strongly influenced by national laws and practice, though this may be diminishing.

In addition, however, geography can be used to minimize taxes and legal challenges. For example, transfer pricing is alleged to be used within many multinational businesses such as Apple, Starbucks, and Google. This involves the subsidiary being charged for use of IPR or similar held by the parent company. The effect is that revenues are transferred from where they are earned to the enterprise headquarters registered in a lower tax jurisdiction. The obvious result is tax losses to many nation–states of billions of dollars and gains to low-tax havens such as Luxembourg and the Cayman Islands. Such transfer pricing is presently legal in many countries, but this may change.

A second example is that some international organizations argue that the only jurisdiction in which they have to obey the law is that where their headquarters are domiciled. A 2013 example involved Google being sued in Britain for bypassing security settings on the Safari browser on users' iPhones and Mac computers without consent. Google argued that because their software operates from California, the alleged breaches of privacy law should not be heard in a British courtroom. Here we largely ignore such geographic effects of the law, but they are often important.

18.3.2 Three Aspects of the Law and GI

Accordingly, in this chapter we introduce three aspects of the law particularly relevant to GI-related activities. These are protecting innovation, coping with liability, and ensuring access to information. More formal considerations of law and GI are given by Cho and by Obermeyer and Pinto (see Further Reading), focusing especially on the situations in Australia and the United States. *Readers are strongly advised, however, not to rely on textbooks and to take up-to-date legal advice in their own jurisdiction when relevant issues arise.*

Always take legal advice in the relevant jurisdiction if faced with legal challenge.

An important complication in areas such as GI services and technology is that the law is always doomed to trail behind the development of new technology. Laws are only enacted (sometimes long) after a technology appears.

18.3.2.1 Protecting Innovation and Exploitation

Innovation is the key to progress. GI examples include Harrison's chronometer and the Global Positioning System (GPS). Much innovation currently arises from commercial enterprises, but underpinning this is substantial basic research funded by governments. Many of the results from that research are published openly. There is, however, tension in universities and elsewhere between the open scientific approach and the merits of generating revenue and national jobs from the expenditure of government research funds.

Protecting innovation underpins much commerce—and governments.

Central to most commercial activity is protecting the fruits of innovation (at least for a time) from any competition which simply seeks to clone a product (such as a new algorithm, software package, or database), a service, or a process invented by others. Protection from unauthorized cloning is through intellectual property rights agreed on by most countries of the world. There are various categories under which IPR is protected (see Box 18.1), and

Application Box 18.1

Intellectual Property Rights

Intellectual property rights (IPR) are the rights given to persons over their intellectual creations, and they usually give the creator an exclusive right to the use of his or her creation for a certain period of time. The length of time establishes a balance between the individual's rights to benefit from the inventions and the benefits to wider society. There are two main types of IPR:

Copyright and Rights Related to Copyright

The rights of authors of literary and artistic works (such as books and other writings, musical compositions, paintings, sculpture, computer programs, and films) are protected by copyright, for a minimum period of 50 years after the death of the author. The main social purpose of protecting copyright and related rights is to encourage and reward creative work.

Industrial Property

Industrial intellectual property can be divided into two main areas:

- The protection of distinctive signs, in particular trademarks (which distinguish the goods or services of one undertaking from those of other undertakings) and geographic indicators (see following). This protection aims to stimulate and ensure fair competition and to protect consumers by enabling them to make informed choices between various goods and services. It may last indefinitely, provided the sign in question continues to be distinctive.

- Other types of industrial property. These rights are protected primarily to stimulate innovation, design, and creation of technology. Into this category fall inventions (protected by patents), industrial designs, and trade secrets. The social purpose of these rights is to provide protection for the results of investment in developing new technology, thus giving an incentive and means to finance research and development activities. The protection is usually given for a finite term (typically 20 years in the case of patents).

Geographic place-name labels applied to a product may also be protected under World Trade Organization regulations. These indicators denote that the product was—and can only be—created in a particular (usually limited) geographic area. Examples include Champagne, Tequila, Parma Ham, and Roquefort or Feta cheese.

Source: www.wto.org

the type of protection available varies between countries. IPR is in constant flux as a result of changes in the law and challenges facilitated by new technologies.

In some industries, however—notably in the services sector, where innovation often occurs in close association with a particular customer—IPR protection is not sought, and the "first to market" advantage is exploited in products with a short shelf life. Alternatively, developers may choose a nontraditional business model and seek the widest take-up of their products, with few revenue benefits obtained directly from users (e.g., open-source software).

18.3.2.1.1 Patents

Patent wars—notably over how software has been implemented in a user interface on smartphones—have occurred for some time between major technology developers such as Apple, Google, Microsoft, and Samsung. Big changes to the structure of industry sometimes come about because of the desire to secure the patents of others (e.g., Google's $12.5bn purchase of key elements of Motorola's business, bringing them 17,000 patents, some of which involved location capabilities).

A patent is a government-granted monopoly to an invention. An example of patent wars specifically in the GI world featured Facet Technology Corporation and the Dutch navigation device maker TomTom. The businesses reached a settlement after a 16-month legal battle. The case was settled through a patent agreement under which TomTom acquired a limited license to Facet's patents on tools that facilitate capturing road sign and other data needed to underpin advanced driver assistance systems.

18.3.2.1.2 Copyright and Database Protection

How does IPR fit into the world of GI systems and geographic information? The answer is that it mostly involves copyright law, and it is complex, especially when seen from a global rather than a national perspective. There are at least four reasons:

- National or regional IPR laws vary in some elements of substance and in many details.
- The formal relationship between the private-sector and public-sector data suppliers also varies between countries (Section 18.3.2.3).
- Global databases have been built in some domains (e.g., for satellite navigation purposes), whereas many other geographical databases are national or subnational in scope, content, ontology, and reference systems; different legal systems impact on each.
- Many commercial databases incorporate data from multiple sources, sometimes global.

As a result, GI system users must be careful to observe IPR when downloading data or software from the Internet.

Ignore IPR when downloading data or software from the Internet at your peril!

The simplest way to summarize the complex situation is to answer some frequently asked questions:

Can geographic data and information be regarded as property? Normally yes, at least under certain legal systems and under either copyright or database legal protection. Who owns the data is sometimes difficult to define unequivocally, notably in aggregated personal data such as geocoded health data. Some place-name labels may also be property (see Box 18.1).

Can all geographic information be legally protected? There is little argument about copyright where it is manifestly based on great originality and creativity, for example, in relation to a painting or mapping carried out personally using GPS and that is distinctive in content and form. Rarely, however, is the situation as clear-cut, especially in the GI world, where some information is widely held to be in the public domain, some is regarded as facts (see later discussion), and some underpins either the commercial viability or the public rationale of government organizations.

In the United States, the Supreme Court's ruling in the famous *Feist* case of 1991 has been widely taken to mean that factual information gathered by "the sweat of one's brow"—as opposed to original, creative activities—is not protected by copyright law. Names and addresses are regarded widely as geographic facts. Nonetheless, several jurisdictions in the United States and elsewhere have found ways to protect compilations of facts, provided that these compilations demonstrate creativity and originality. The real argument is about which compilations are sufficiently original to merit copyright protection. A number of post-*Feist* instances have occurred in which the courts have recognized maps not as facts but as creative works, involving originality in selection and arrangement of information and the reconciliation of conflicting alternatives. Thus some uncertainty still exists in U.S. law about what GI can be protected by copyright law.

In Europe, different arrangements pertain—both copyright and database protection exists. For copyright protection to apply, the data must have originality in the selection or arrangement of the contents, and for a database right to apply, the database must be the result of substantial investment. It is entirely possible that a database will satisfy both of these requirements so that both copyright and database rights may apply. A database right is like copyright in that there is no need for registration; in both cases it is an automatic right, and it begins as soon as the material that can be protected exists in a recorded form. Such a database right can apply to both paper and electronic databases. It lasts 15 years from making, but if published during this time, then the term is 15 years from publication. Protection may be extended if the database is refreshed substantially within the period. As stressed earlier, geographic differences in the law have potential geographic consequences for commercial GI activity. Protection equivalent to the database right will not necessarily exist in the rest of the world, although all member countries of the World Trade Organization (WTO) do have an obligation to provide copyright protection for some databases.

In some jurisdictions, some GI databases are seen merely as facts and are not protected by law; elsewhere they are protected because of the investment made to create or update them.

Can information collected directly by machine, such as a satellite sensor, be legally protected? Given the need for originality, it might be assumed that automated sensing should not be protectable by copyright because it contains no originality or creativity. Clearly, this interpretation of copyright law is not the view taken by the major content providers, such as satellite imagery companies like DigitalGlobe, because they include copyright claims for their material and demand contractual acceptance of this proposition before selling products to firms or individuals.

From the point of view of enforcing copyright, it helps that there are at present only a modest number of original suppliers of satellite imagery—especially that of high spatial resolution. Thus any republication or resale of an image could probably be tracked back to the source with relative ease. This situation is changing as small operators such as Skybox Imaging and Planet Labs launch constellations of small satellites trading off ultra-high spatial resolution for frequent imaging. If the data source can be identified definitively, imagery up to 15 years old would be protected under the EC's Database Directive, at least within the European Union area itself.

How can tacit geographic and process knowledge—such as that held in the heads of employees and gained by experience—be legally protected? "Know-how" can migrate very rapidly. This situation has happened in GI systems/GI organizations—and many others—from the earliest times. The simplest way to protect tacit knowledge is to write some appropriate obligations into the contracts of all members of staff—and be prepared to sue the individual if he or she abrogates that agreement. The most popular "weapon" is the noncompete agreement, which bans an employee from working for a rival for a fixed period, often two years. It has been estimated that 90% of management and technical staff in the United States have signed them. In some countries human rights legislation may complicate winning such action. Keeping staff busy and happy is a better solution!

Who owns information derived by adding new material to source information produced by another party? Suppose a dataset has been obtained that is useful but, by the addition of an extra element or by overlaying data, becomes immensely more valuable or useful. So who owns and can exploit the results in derivative works? The general answer is both the originator of the first dataset and the person who has added value. Without the originator's input, the latter would not have been possible. This is true even if extracted data are only implicit—if, for instance, road center lines are computed from the digitized road casings on the source maps. Moreover, combining datasets may result in deep trouble if permission is not sought from the originator. Where moral rights exist (e.g., in European countries), the author has the right to integrity (i.e., to object to any distortion or modification of his or her work that might be prejudicial to his or her honor). He or she also has the right to attribution as the author, to decide when a work will be published, and to withdraw a work from publication under defined circumstances.

To protect your GI under law, it is wise to watermark and fingerprint it.

How can you prove theft of your data or information? It is now fairly common to take other parties to court for alleged theft of information. To prove theft it is crucial to have good evidence, especially as digital technology makes it easy to disguise the look and feel of GI and to reproduce products to very different specifications, perhaps generalized. The solution is to be both proactive and reactive. The data should be "watermarked" in both obvious and nonvisible ways. It is wise to have a good audit trail to demonstrate that the watermarking was established by management action for that purpose. In addition to watermarking, "fingerprinting" can also be used. At least one major commercial mapping organization has added occasional fictitious roads to its road maps for this purpose (though comparison with satellite imagery normally discloses such practices). In areas subject to temporal change (such as due to tides or through vegetation change), nature's fingerprinting ensures it is very unlikely that any two surveys or uses of different aerial photographs could ever have produced the same result in detail.

How do I seek redress if I have been badly treated? If theft of intellectual property has occurred, go to the police. For other forms of unfair treatment—such as price gouging, unfair competition, illegal restrictions of access, or manifestly inaccurate product descriptions—approach the relevant government regulator.

Do I need a license to use GI or software provided by another organization? In most cases, users of GI explicitly or implicitly have to accept the terms of a license for the information they are accessing and reusing. Even where it is not explicit and use of the information is free, licensing still exists (e.g., under terms and conditions that prevent editing of the data and then misrepresenting the work of the originator or in regard to "creative commons"; see creativecommons.org). Thus it is always wise to read the terms of any licensing agreement with great care before simply clicking on an "I agree" box. Google Maps, for instance, has different licensing arrangements for use of its APIs, depending on whether this is for nonbusiness or business purposes. The criteria for the first purpose require that the service based on your information must be freely and publicly available; strict limits are also placed on the resolution of the maps produced and the number of Web requests made per day. Its use is free, but the professional use version requires payment.

In some cases, licensing is an onerous process and can necessitate signing up to hundreds of pages of contractual details limiting the extent and nature of reuse and even the charging mechanism. In some other cases, however, licensing is now extremely straightforward, at least for Open Data (see Section 17.4). The UK Open Government License (OGL) is a good example of simplicity and is being cloned in some other countries.

Almost all GI is licensed somehow. Read the license before using the GI!

18.3.2.2 Coping with Liability from Use of GI and GI Systems

Liability is a creation of the law to support a range of important social goals, such as avoiding injurious behavior, encouraging the fulfillment of obligations established by contracts, and distributing losses to those responsible for them. It too is a huge and complicated area and covers negligence, fraud, and product liability. Though few jurisdictions seem to have legislated specifically for liability in regard to GI systems and GI use, a number of cases have been reported in regard to air and nautical charts and in boundary disputes (see following discussion and Section 19.6.4).

Nevertheless, the potential for legal action is very real, and two examples may be cited. The first is described by Cho as follows. Four Australian National Parks and Wildlife Service (NPWS) officers were killed from smoke suffocation in a burn-off operation. The officers were given maps that showed two possible escape routes. The maps showed a cleared hilltop, which potentially could have provided shelter from the fire. Unfortunately, the map did not show a 30-m cliff that stood between anyone trying to escape the fire and the cleared area. The map also showed a path known as Wallaby Track running directly towards a local motorway. In reality this path twists into impenetrable bush. It was found by a court that the original botanical map had not been "ground-truthed" to include specific details and did not mark areas with safe refuges should they be required.

A second instance is more general and often relates to historic GI. Disputes over boundaries in land or at sea are common and can have catastrophic consequences. The ongoing dispute between China, Japan, and other South East Asia nations over the sovereignty of the islands known as Senkaku in Japanese and Diaoyu in Chinese is particularly dangerous. Many of these disputes are inflamed because of the understandable but inadequate quality of historical maps and incomplete records. In such cases there is obviously no contractual basis for action—only legal arbitration if all parties agree to it.

In many cases liability in data, products, and services related to GI will be determined by resort to contract law and warranty issues. This assumes that gross negligence has not occurred. If it has occurred, the situation can be far worse, and individuals as well as corporations can be liable for damages. Other liability burdens may also arise under legislation relating to specific substantive topics such as intellectual property rights, privacy rights, antitrust laws (or noncompetition principles in a European context), and open records laws.

Clearly, liability is a serious issue for all GI practitioners. Minimizing exposure to risk is achieved primarily through performing competent work and keeping all parties informed of their obligations. Any contract to provide software, data, services, or consultancy should make clear the limits of your responsibility, though disclaimers rarely count for much. And you should adhere to well-recognized professional codes of conduct (sometimes called Codes of Practice or Ethics; see Section 18.5.2).

18.3.2.3 Access to GI and the Role of the State

Access to GI provided by commercial suppliers is relatively straightforward and usually involves a contract and some payment or exposure to advertising (Section 18.2). Data available from the private sector generally reflects the sector's ability to monetize it. Hence car guidance systems based on digital mapping are now almost ubiquitous: Major commercial players such as Apple, Google, and Microsoft have all bought their way into accessing or owning the relevant GI as an essential part of their normal business. In some cases roads have been newly surveyed to avoid copyright infringements and other restrictions associated with using data from governments.

It might be thought from Box 17.2 and Table 1.2 that because we are now "drowning in data" and the Open (government) Data movement is growing worldwide, access to GI held by the public sector would be routinely easy, cheap or free, unencumbered by bureaucratic hurdles, and defined by law (as in U.S. states' public record laws). Notwithstanding many impressive national visions for the use of GI systems—such as that for India, the world's second most populous country, set out in moes.gov.in/national_gis.pdf—nothing could be further from the truth.

National security concerns limit the availability of some GI in a surprising number of countries.

In India there are numerous examples of impressive GI system applications: The tsunami warning system has been built around GI systems and is capable of providing information within minutes about travel time and run-up heights at 1600 locations along the coast of the Indian Ocean. Yet, despite this sophistication, there has been a long history in India of preventing access to topographic mapping of coastal and border areas on security grounds. This was relaxed somewhat in the 2005 Indian National Map Policy, but the terrorist attacks on Mumbai in 2008 made the situation difficult again. For example, the Survey of India lodged a complaint with the Delhi police against Google India's plans for a Mapathon in 2013. This was a competition open to all to map their neighborhoods, with the data then being uploaded to the Google server in the United States. This contravened the 2005 policy, which said that maps intended for publication must be sent to the Ministries of Defense and of Housing and to intelligence agencies for security checks. To those in Europe and North America, this may seem strange. But such security concerns still exist in various areas of the world.

In summary, the reasons why access is not universally straightforward include the following:

- National policies or statutes like India's National Map Policy contain restrictions, often legitimated on security grounds.
- The lack of appropriate technology in government bodies, which are the traditional custodians of the GI.
- The costs of preparing data to be made available, including creation of metadata.
- A lack of incentives to make such GI available, especially in the face of other government priorities.
- A wish in some countries to ensure that the taxpayer manifestly benefits from revenues generated by any GI made available to the business sector—often international, rather than national, and in some cases accused of not paying reasonable levels of tax (see Section 18.3.1). One approach to this is for the government to become an information trader.

18.3.2.3.1 Governments as Information Traders

Governments have been and remain major collectors (and sometimes providers) of many types of information, some of it collected under a statutory monopoly. We should recognize that the normal remit of government departments is to implement government policies, and few of them are specifically funded as data providers. What data they hold may generally be characterized as "exhaust data," created as a by-product of the department's core functions. There are, however, some special-purpose government bodies, such as mapping and meteorological agencies. Their rationale is to collect and, increasingly, to exploit data for the nation. A number of them, incentivized by government policy or reductions in funding, have become information traders.

Despite many research studies, there is no unambiguous economic demonstration of which of the following options is in the best interests of a country:

- To pay for the creation and essential processing of data needed for a government's purposes, then make it freely available in the hope that this will stimulate the economy and provide greater transparency (see Section 17.4), or
- To pay for the first stage, then for the government to seek to generate revenues by leasing the data to end-users or value-added resellers.

Option 1 places immediate costs on the taxpayer with the possibility of large but unpredictable future economic and social benefits. There is much evidence that the level of use of some government data—notably GI—expands substantially when made readily available and at marginal cost or less. However the use/accrued revenue relationship is complex. Option 2 internalizes costs and benefits. Its success depends on the organs of the nation–state being efficient and entrepreneurial, having possibly competitive advantage through access to superior data and skills funded by sunk costs, and being able to deny access to those who cannot or will not pay for the data. All that has to be achievable under national laws.

But this is more than a matter of economics: It involves a matter of principle about the role of the nation–state. What should the state do, and what should be left to private enterprise? In some cases in some countries the answer is uncontroversial, such as the state providing and guaranteeing definitive information about parcels of land and houses upon them. Elsewhere these issues are controversial. There are practical concerns as well: If a government body starts to trade in information, how is mission creep averted; for example, if it then begins to provide added-value services (education and training, data linkage, and analysis of data from their own and other sources), thereby competing with national and international businesses?

All this also ignores important external factors. An obvious one is the international agreements to which a nation–state is committed by its government. These include commitments made under international treaties (such as the agreements on data sharing that emerged from the UN 1992 Rio treaty). The 28 European Union member states have obligations to convert EU directives, such as that on reuse of public-sector information and the INSPIRE Directive (see Section 18.6.2), into national law. Perhaps the best example of how this complex of time-varying factors has played out in one country is that of the UK. Box 18.2 summarizes the oscillations of government

Application Box 18.2

Mutations in UK Information Policy

Following the policies of the British government, the Ordnance Survey (OS)—the national mapping agency—first took action as early as 1817 to prevent "free riding" or illegal use of the government's maps. The OS expressly warned anyone infringing their copyright that this would lead to legal action. In the 1930s world of mapping, public policy was on a "charge only for ink and paper" basis; in the 1960s it changed to charging users a fraction of the total costs of operations. In 1999, the move to a Trading Fund status effectively led to the OS having to become profitable and thus meet their full costs and interest on their capital employed.

In 2008, the UK government was seeking to nurture the use of the Web for social, economic, and educational purposes (Section 17.4). Over the next four years rapid developments occurred under two different administrations, stimulated by Sir Tim Berners-Lee (see Box 17.6) and others. The Open Data concept was elaborated and around 20,000 datasets have been made available via data.gov.uk. These included many sets of GI; notably all bar the most detailed mapping of the UK produced by Ordnance Survey. They also included large numbers of statistical datasets and administrative ones designed to support "armchair accountants" keeping a watch on how national and local governments were spending taxpayers' money. All these were made available for free under a new and simple Open Government License.

In some areas the changes were rapid—notably in apps being created for a multiplicity of location-based services, especially those making available real-time travel data on air, rail, and bus services and congestion data. The new technologies helped make possible a variety of new services, such as a national road works register, created and constantly updated by a commercial body.

All of this was powered by a direct interest taken by two successive Prime Ministers. This and President Clinton's endorsement of the U.S. National Spatial Data Infrastructure (NSDI) illustrate the importance of having support from the highest political level in any public sector initiatives.

Austerity associated with the financial crisis from 2007 onward, however, has ensured that four government bodies (Ordnance Survey, the Meteorological Office, Land Registry, and Companies House) have all been required as government Trading Funds to continue to generate revenue to cover their costs though income from Parliament is now counted in that figure. Continuing debates revolve around the regulation of these Trading Funds and their ability to compete with the private sector and how strategic a view government should take on which datasets held by departments should be prioritized for "freedom." In early 2014 the UK government consulted publicly on privatizing the Land Registry but drew back. In summary, policy oscillations evident over 200 years continue.

policy over a 200-year period, with particular reference to the official mapping of Britain.

Some core reference GI form perhaps the most valuable data in any national information infrastructure. These typically form the framework to which other data are linked. All the datasets using this framework will then be spatially congruent. This has both theoretical and practical advantages. But the longer governments delay in making such data freely available, the more users turn to alternatives, and the opportunity for congruence may be lost. The growth of use of Google Maps, thanks to its sophistication, low or zero cost, ease of use, and global coverage, has been remarkable and is outflanking the use of government official data for many applications.

Finally, it has been argued that access to certain information—largely about oneself—is a basic human right and therefore subject to human rights law in jurisdictions where these are enacted. It can, by extension, be argued that access to many other government data (such as how it is performing against its own targets and what its branches spend our money on) is a basic democratic right. We touch on this in part in Section 17.4.

18.4 Privacy and GI Systems

Privacy in regard to personal information is a matter of law in many countries. Here we discuss it separately because of the breadth of factors involved.

Our personal privacy has in practice become sharply undermined since the bombing of the Twin Towers in New York in 2001. This led to a global increase in surveillance and the development of new technologies for capturing the movements of people.

Privacy considerations are germane to both the private and public sectors: Loss or theft and subsequent publication of private information can cause great reputational damage. Personal information collected by government bodies is often mandated by law: Citizens have no right to refuse but benefit from government using the data in planning facilities or supplying social services (as well as collecting income-based taxes). In contrast, individuals voluntarily—and often happily—provide personal information to many private-sector bodies (e.g., retailers: see Section 17.3.1.3 and Box 17.5) for gain of some form. The explosion of use of social media has multiplied the personal information being used semipublicly; the more geotagging becomes common, the wider is the possible GI use, but the greater are some threats to privacy. New technologies that permit locating individuals within buildings may well exacerbate the threats.

Some commentators are resolutely opposed to the tracking of position of individuals via cell phones or other mechanisms. Jerry Dobson and Peter Fisher have coined the term *geoslavery* for it. Another term is *geopiracy*, used to describe when personal GI is allegedly being seized without consent.

Attitudes to privacy may be time dependent. Some people abhor any broadcasting of their location. Others welcome having locations shared for social reasons. Parents concerned about the safety of their children might well contemplate giving them a smartphone with a location-reporting app. An injured hill walker or a wounded soldier would be happy for the rescue services to know his or her location. In these latter examples, an element of privacy is being traded to ensure enhanced safety at some moment in time. Thus privacy is a complex concept, varying between individuals and at different moments in time.

Privacy is a complex concept, varying between individuals and at different moments in time.

What information is considered appropriate for the state to hold varies greatly between different countries. Nordic countries operate a series of linked registers to provide large amounts of administrative data about individuals for multiple government purposes. In general, three base registers exist containing details of each "data unit." These are a population register; a business register (enterprises and establishments); and a register of addresses, buildings, and dwellings. A unique identifier for each unit in the base registers, and links between them, is used. The unique identifier is also used in many other administrative registers for these units (see Figure 18.2), such as educational registers and taxation registers. An extract from the population register serves as a basic document that is needed when applying for a passport, when getting married or divorced, or when a funeral is held or an estate is distributed; this is provided free of charge. It is thus in the interest of the individual to make sure that all the data within administrative register systems are accurate. Most important, although the purpose of the registers is primarily for government bodies, the public can access some registered information via a terminal. From these registers a wide variety of aggregate-level data are spun off and analyzed and mapped using GI systems. Such an intricate and largely public infrastructure of linked personal data would not be acceptable in some other countries with lower levels of trust in government than in Scandinavia.

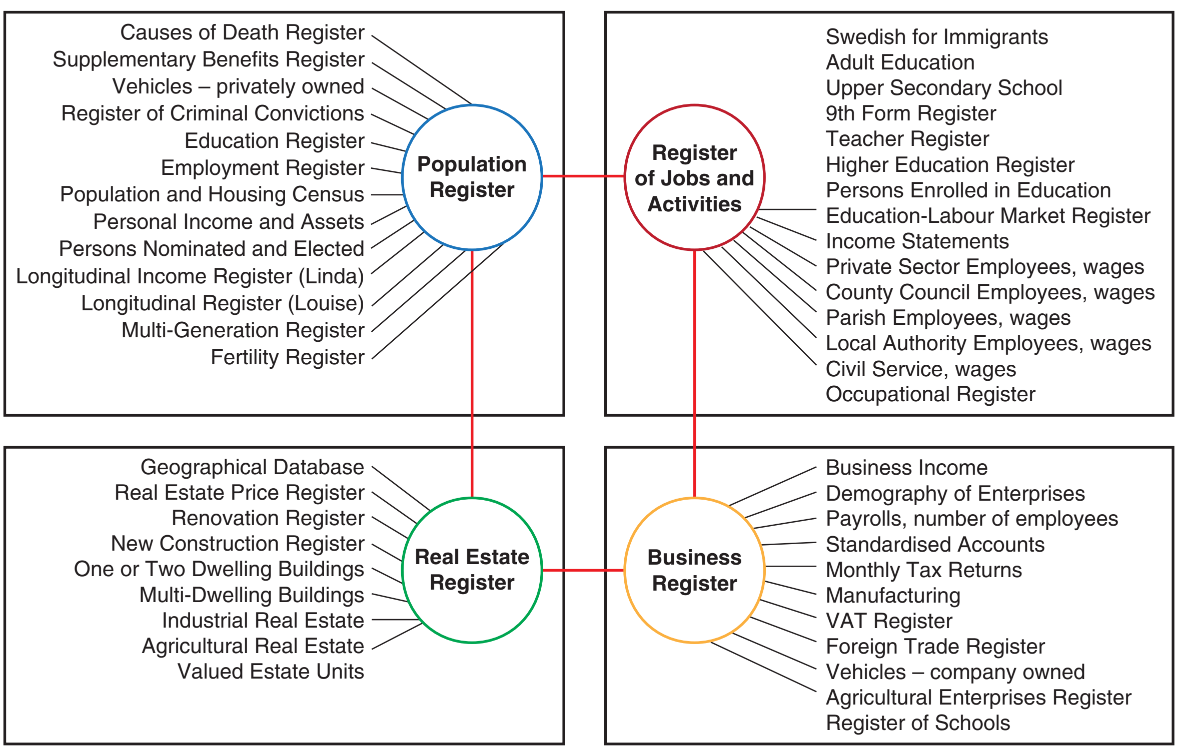
Google's introduction of car- and tricycle-based imaging to produce Street View in 2008 led to many concerns worldwide about its impact on privacy. The Greek data protection agency, for example, banned Street View's expansion in the country until it obtained acceptable commitments on how long the images would be kept on Google's database and what measures the firm would take to make people aware of privacy rights. The initial furor about deployment of Street View has largely subsided, as it has become part of the taken-for-granted information infrastructure and as its currency has declined.

Most socioeconomic data are collected for individuals, and so privacy matters.

18.4.1 Preserving Privacy without Losing the Use of Personal Information

In many cases, the resolution of GI pertaining to an area of land or the altitude of a point on the earth's surface is not a matter of contention over privacy. Central to privacy concerns are information about identifiable human individuals or small firms. We have

Figure 18.2. A visualization of how many Swedish registers are linked using unique identifiers for people, businesses, and buildings; those without lines are not linked at present.



Source: Carlsson F. and Holmberg A. Statistics Sweden after Wallgren, A. and Wallgren, B. 2006. *Register-Based Statistics—Administrative Data for Statistical Purposes*. New York: John Wiley & Sons

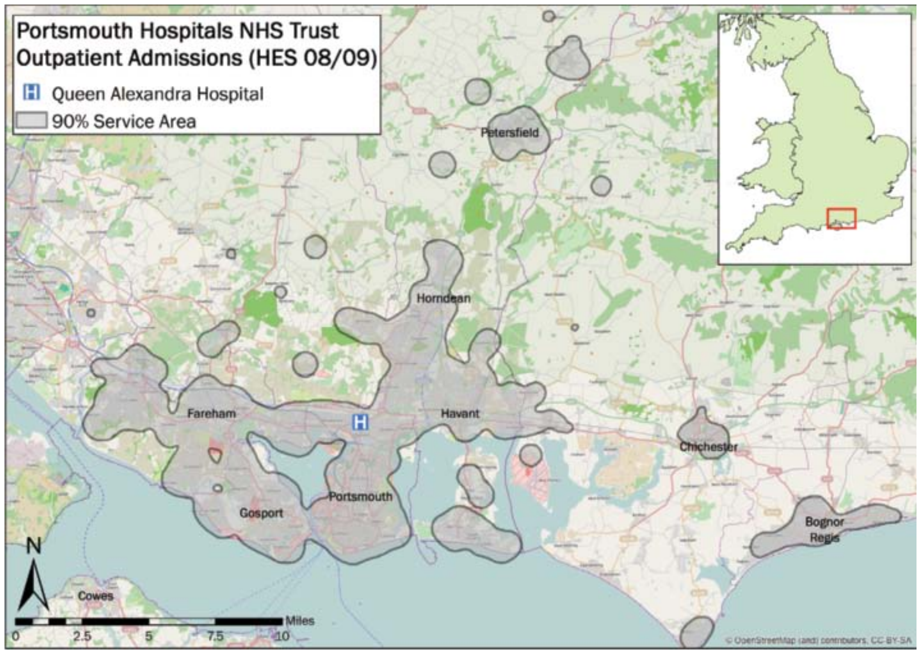
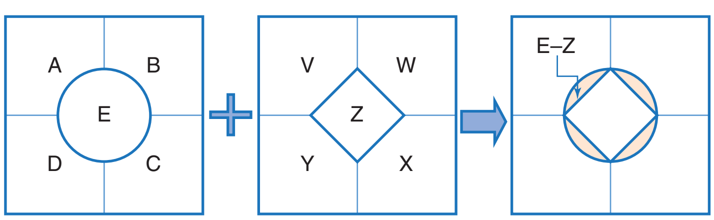


Figure 18.3 The “market footprint” of Portsmouth Hospitals based upon analysis of annual Hospital Event Statistics for one class of morbidity in the UK. The shaded areas include 90% of all outpatients treated in the year; a percent volume contour associated with a kernel function has bounded these 90% to ensure no individuals with a particularly sensitive disease are identified in rural areas or very small settlements.

already highlighted the numerous benefits from being able to analyze personal data, notably for research into causes of poor health (Section 17.3.1.2). But five issues need to be addressed:

- How to avoid compromising privacy when mapping any individual data. This is particularly sensitive when displaying the incidence of some medical conditions. Fortunately there are well-established GI system tools for doing this (Figure 18.3) and tuning the level of privacy desired—albeit at the price of losing some valuable information.
- How to avoid disclosure of information generated by the “mosaic effect” when overlaying GI (Section 5.4.4). In creating added value, small differences in the boundaries of different datasets may result in details about individuals being identifiable (Figure 18.4).
- How to persuade members of the public that their data are safely held and their privacy is not compromised. In Britain the tax authorities lost a CD containing 25 million records of individual taxpayers in 2007, which strongly influenced public opinion against the holding or sharing of personal information.
- How to cope with any legislation—such as that under discussion in the European Union at the time of writing—that would require every individual data subject to give explicit permission for their records in databases to be used for any purpose other than the original public one, for example, for subsequent research purposes (i.e., the “opt-in” requirement). Demonstrating that very robust data anonymization procedures are effective and that there are large public benefits from carefully organized research may be the best solutions in the longer term to build public acceptance.
- Making routine and easy the process by which those who wish to remove their existing records from a database run by a commercial entity (e.g., Facebook or Google) can do so. It is not always easy to retreat into anonymity and reestablish privacy, especially if that involves wiping criminal records.

Figure 18.4 Diagrammatic representation of the problem of disclosure of information about individuals or small groups through the “mosaic effect” (overlay, in GI system terms). If population details are known for areas A to E and V to Z, then overlay will compute the counts of the sliver areas in pink.



18.5 Public Trust, Ethics, and Coping with the Media

18.5.1 Public Trust

Public trust is essential to the effective running of civil society, to maintaining the success of a business, and to preserving reputations. If the public distrusts what is being done, big problems arise. These could be expensive in money or new business terms. High levels of trust minimize time-wasting debates and facilitate the implementation of policies.

Normal levels of public trust vary greatly for different institutions and groups of people—between governments of different levels, physicians, politicians, scientists (e.g., those engaged in nuclear power or stem cell research), in banking and other businesses, journalists, and those in professional bodies (Figure 18.5). In many Western countries there have been significant falloffs in the past three decades to the public's acceptance of some expert scientific advice. This more generally is the "death of deference." But too high a level of trust is also bad: Mindless acceptance of what governments, scientists, or businesses propose is bad for democracy. The question is: how much trust is appropriate?

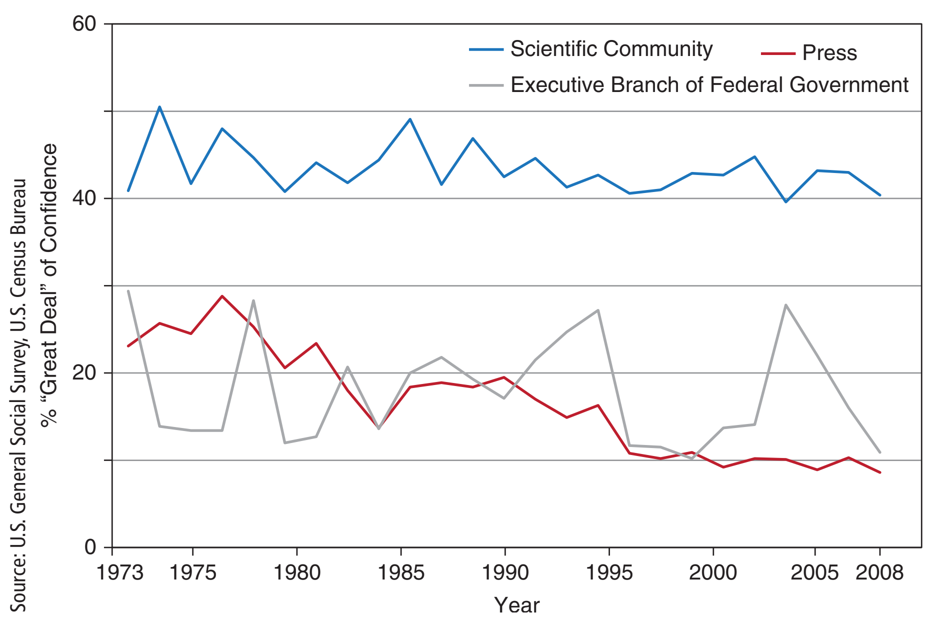
This has significant implications for those working in the GI domain. Insofar as the GI system-based analyses are illustrated by maps, we have an advantage over cost/benefit studies that simply produce tables of numbers; maps are often regarded (incorrectly) as easy to understand and convincing. Widespread acceptance of embedded GI system functionality in telephones, satellite navigation, and Web sites providing "where is" factual-type information have also produced a positive spillover effect on other GI system functionality. The common GI system practice of drawing together data from multiple sources can also be seen as an advantage in suggesting we do not rely solely on one view of the world. And the stunning capabilities of GI technology driven by skilled experts dazzle the onlooker into acceptance and trust.

The GI community seems to enjoy high public trust—but it could evaporate.

Yet we are not totally in control of our reputation. For instance, distrust spills over from what people think of their government (or business) into products (like statistics) produced by it. This is particularly true where the statistics are used to buttress government claims of progress; economic and health statistics are typically trusted less than are transport ones, presumably because the public thinks governments have little to gain by manipulating transport statistics!

Such lack of trust does not in general occur with producers of reference mapping (such as government national mapping agencies) or in regard to some major commercial providers of software or data. Yet we know that the quality of such data varies considerably across the globe and that many of the data series are as difficult to collect as good-quality statistics. Soil maps, for instance, have typically been based upon field sampling principles and estimation techniques as much as are population statistics (see Section 2.4). Greater

Figure 18.5 Changes in public confidence in US institutions 1973–2008



awareness of this complexity could lead to a diminution of public trust; that would be extremely dangerous for the continuing success of GI-related activities.

We minimize the risk of loss of trust by following a published Code of Practice (or Ethics: see following section); by being transparent about the inputs, processes, and algorithms underlying any decisions we make; and by running sensitivity analyses as part of any "what-if" analysis (see Section 15.5), describing as best we can what levels of uncertainty remain in the results and being prepared to answer questions from those affected or interested (e.g., the media).

18.5.2 Ethics

Professional competence and acceptance of contractual and other responsibilities are readily understood as being essential for any GI system, service, or technology professional. The Association of American Geographers posits that there are at least four reasons why ethics should also be essential to any GI professional:

- Geographic technologies are surveillance technologies. The data they produce may be used to invade the privacy, and even the autonomy, of individuals and groups.
- Data gathered using geographic technologies are used to make policy decisions. Erroneous, inadequately documented, or inappropriate data can have grave consequences for individuals and the environment.
- Geographic technologies have the potential to exacerbate inequities in society, insofar as large organizations enjoy greater access to technology, data, and technological expertise than smaller organizations and individuals.
- Georeferenced photos, tweets, and volunteered (and unvolunteered) geographic information can reveal private information. Those data that are increasingly publicly available and used to study societal phenomena raise significant privacy concerns.

More prosaically, technology in general, and GI system technology in particular, is neither good nor evil, and it certainly cannot be held responsible for the sins of society. But technology can empower those who choose to engage in either good or bad behavior.

Ethics matter in operating GI systems safely.

Ethics refers to principles of human conduct, or morals, as well as to the systematic study of such human values. An act is considered to be ethical if it agrees with approved moral behavior or norms in a specific society. GI technology provides ample scope for unethical behavior, notably to produce results that knowingly benefit one individual or group rather than another or society as a whole. As described earlier, this behavior is facilitated by the apparent simplicity and believability of map outputs—despite the high complexity of the assumptions made in combining data, the various different algorithms that might be employed, and well-known ways of misleading the eye by use of map scale, color, projection, and symbolism (see Chapter 11).

How do we know who to trust? How do we know, for instance, that the person who has offered to forecast environmental risk or provide disaster management at a microlevel is appropriate for the job? The simplest way to find out is to review candidates' educational attainment and track record and to use only registered professionals who have gone through an extensive formal qualifications process and who can be disbarred for unethical conduct.

GI systems are a field where until recently few directly relevant professional certification programs existed, and many GI system practitioners operated on an ad hoc basis. Fortunately various helpful Codes of Ethics have now been established. Valuable early work was done by the Urban and Regional Information Systems Association. Contemporary Codes of Ethics include those published by the GIS Certification Institute and the Association of American Geographers. The former, an independent not-for-profit organization, has been particularly active. A short summary of their code is given in Box 18.3. Much greater detail on what it includes is given by Obermeyer and Pinto and on various Web sites (see Further Reading). Such codes can never be perfect because they cannot legislate for every possible eventuality. The essence of a true professional, however, is that he or she abides by the spirit of the Code, even when it does not proscribe a questionable action.

There is now scarcely a major university around the world that does not have some form of GI systems education program, and many include a module on ethics. It is also becoming commonplace for GI system professionals to attend certification courses within their own domains. In these, individuals who demonstrate possession of specified competencies through some combination of education, experience, examination, and study of ethics gain certification. For example, the U.S. intelligence community has been mandated to provide certification processes for the entirety of their professional employees, and the Open Data Institute in London is providing certification in Open Data exploitation.

Applications Box 18.3

An overview of the GIS Certification Institute Code of Ethics

This is a high-level summary of the document at www.gisci.org/code_of_ethics.aspx:

I. Obligations to Society
The GIS professional recognizes the impact of his or her work on society as a whole, on subgroups of society including geographic or demographic minorities, on future generations, and inclusive of social, economic, environmental, or technical fields of endeavor. Obligations to society shall be paramount when there is conflict with other obligations. Therefore, the GIS professional will:

1. Do the Best Work Possible
2. Contribute to the Community to the Extent Possible, Feasible, and Advisable
3. Speak Out About Issues

II. Obligations to Employers and Funders
The GIS professional recognizes that he or she has been hired to deliver needed products and services. The employer (or funder) expects quality work and professional conduct. Therefore, the GIS professional will:

1. Deliver Quality Work
2. Have a Professional Relationship
3. Be Honest in Representations

III. Obligations to Colleagues and the Profession
The GIS professional recognizes the value of being part of a community of other professionals. Together, we support each other and add to the stature of the field. Therefore, the GIS professional will:

1. Respect the Work of Others.
2. Contribute to the Discipline to the Extent Possible

IV. Obligations to Individuals in Society
The GIS professional recognizes the impact of his or her work on individual people and will strive to avoid harm to them. Therefore, the GIS professional will:

1. Respect Privacy
2. Respect Individuals

18.5.3 Coping with the Media

The print and electronic media are a crucial influence on public trust. Very different legalities and practices characterize the media in different countries: some are under state control and thus invariably supportive of the government. Others—such as the print media in the UK—can be extraordinarily aggressive and combative, determined to seek out what they see as wrongdoing and humiliating those whom they believe should be blamed. Redress against false accusations is often difficult and expensive. The story told in Section 18.1 illustrates just how important the media can be.

In an ideal world, only one person in any organization—with the right skills and experience—should be allowed to talk to the media. Any briefings must be available in written form as well as spoken; otherwise some invented or misconstrued report is not plausibly denied. Yet minimization of contact with the media and other key influencers is also a mistake. Building relationships through keeping in touch regularly with journalists and politicians and keeping the latter informed about how better services are being provided, new jobs are created, or the quality of their constituents' lives is being improved is part of a manager's role. It is a mistake to become too cozy with the media, but their drivers (e.g., to sell newspapers) must be understood and supported where possible and ethical.

18.6 Partnerships, Up-Scaling Activities, and Risk Mitigation

We live in a competitive world. But there are many occasions when the GI system user finds it best to collaborate or partner with other institutions or people. In principle, partnerships can bring missing skills, know-how, technology, finance, and better branding to the enterprise. Because the need for partnerships applies at the personal, institutional, local area, national, and global levels, there is great scope for different approaches. The form of the partnerships can range from the enforced (e.g., through legislation) and the highly formal based on contract to the informal where participation is entirely voluntary. Some partnerships result from short-term events that span national boundaries (such as the Chernobyl nuclear reactor accident in 1986 or the Asian tsunami of 2004). Others arise from long-term relationships like membership of NATO—which has had a profound effect on the standardization of GI within the military (and beyond) in those nations that participate.

Technological change makes it possible to achieve partnerships between geographically dispersed organizations. But technology does not resolve all difficulties. Rarely are partnerships trouble free and totally successful. It simplifies matters if someone is in overall charge (such as the Department of Homeland Security, in charge of counterterrorism in the United States). This facilitates setting clear project milestones, monitoring of risk and progress, and providing enforcement action when things go wrong. In contrast, ad hoc partnerships tend to be created on the fly in the case of an unexpected disaster.

We begin with an extraordinary success story: the Open Street Map (OSM) project. The resulting global database of mapping information can be used for many different purposes with very few restrictions (www.openstreetmap.org). It is licensed under the Open Database License. In essence, OSM mapping and data may be used for any purpose without charge subject to two conditions: that proper attribution is given and that users agree to share any corrections or other changes they make with the project so all other users can benefit. The entire database may be downloaded and held on local servers, but for many purposes the OSM servers provide good facilities.

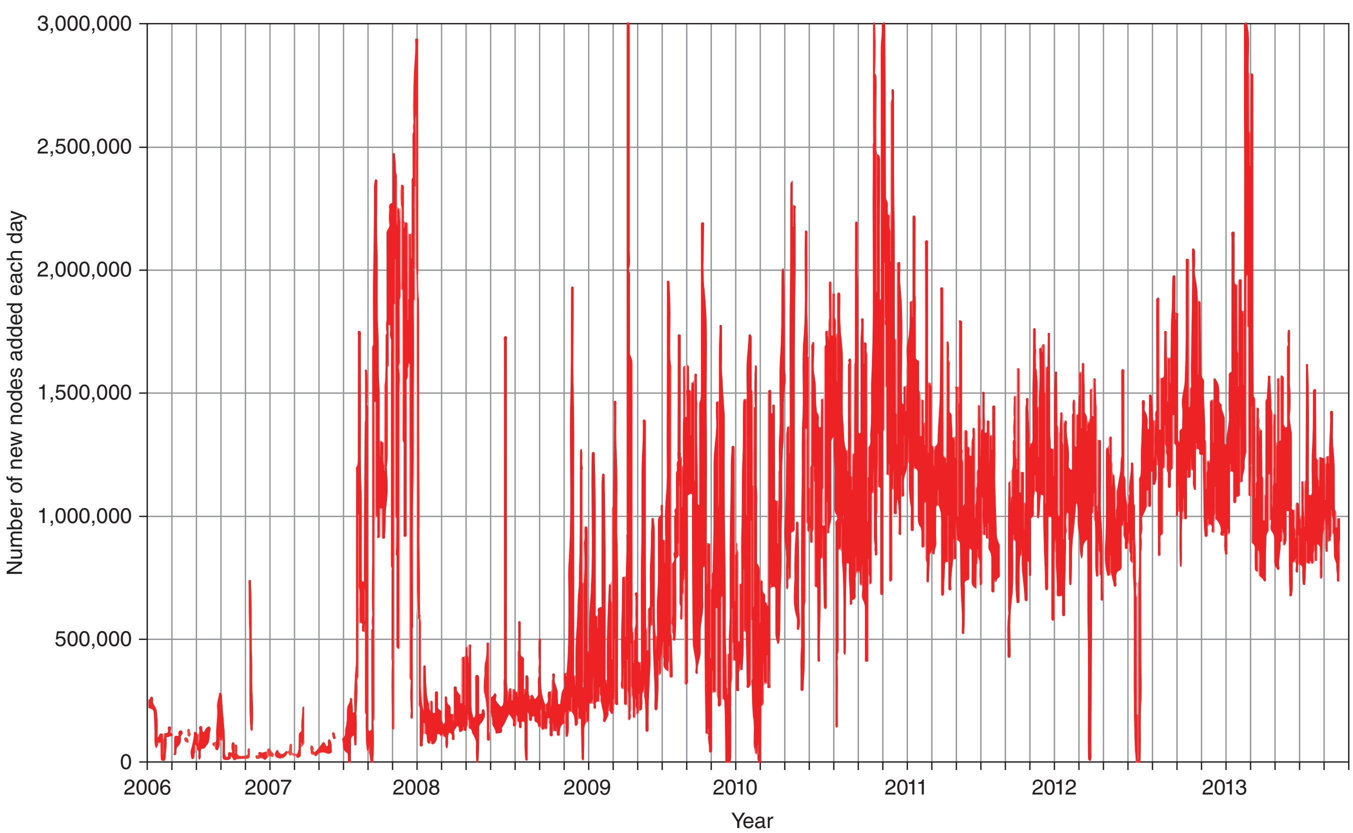
Launched in 2004 by Steve Coast, it operates through thousands of individuals collecting and volunteering copyright-free data (see Sections 1.5.6 and 17.3.1.3 on volunteered geographic information [VGI] and Figures 17.7 and 18.6A). The tools used are also open source. The growth in use of OSM has been spectacular (Figure 18.6B), including that by businesses, governments, and nonprofits as well as individuals. Underpinning the OSM project is the OpenStreetMap Foundation, a not-for-profit organization. The OSM Foundation owns and maintains the infrastructure of the OpenStreetMap project.

We now draw lessons from more official contemporary partnerships focusing on national and supranational ones. Broadly, many of these large-scale collaborations are encompassed within the collective title of spatial data infrastructures (SDI).

18.6.1 Spatial Data Infrastructures: The U.S. Experience

The U.S. NSDI is far from being the only one worldwide; important SDI developments occurred even earlier in Australia and some other countries. There has even been an organization set up to take forward the concept of a global spatial data infrastructure (GSDI). Moreover, many other developments have occurred at

Figure 18.6A Number of nodes added to the OpenStreetMap database each day.



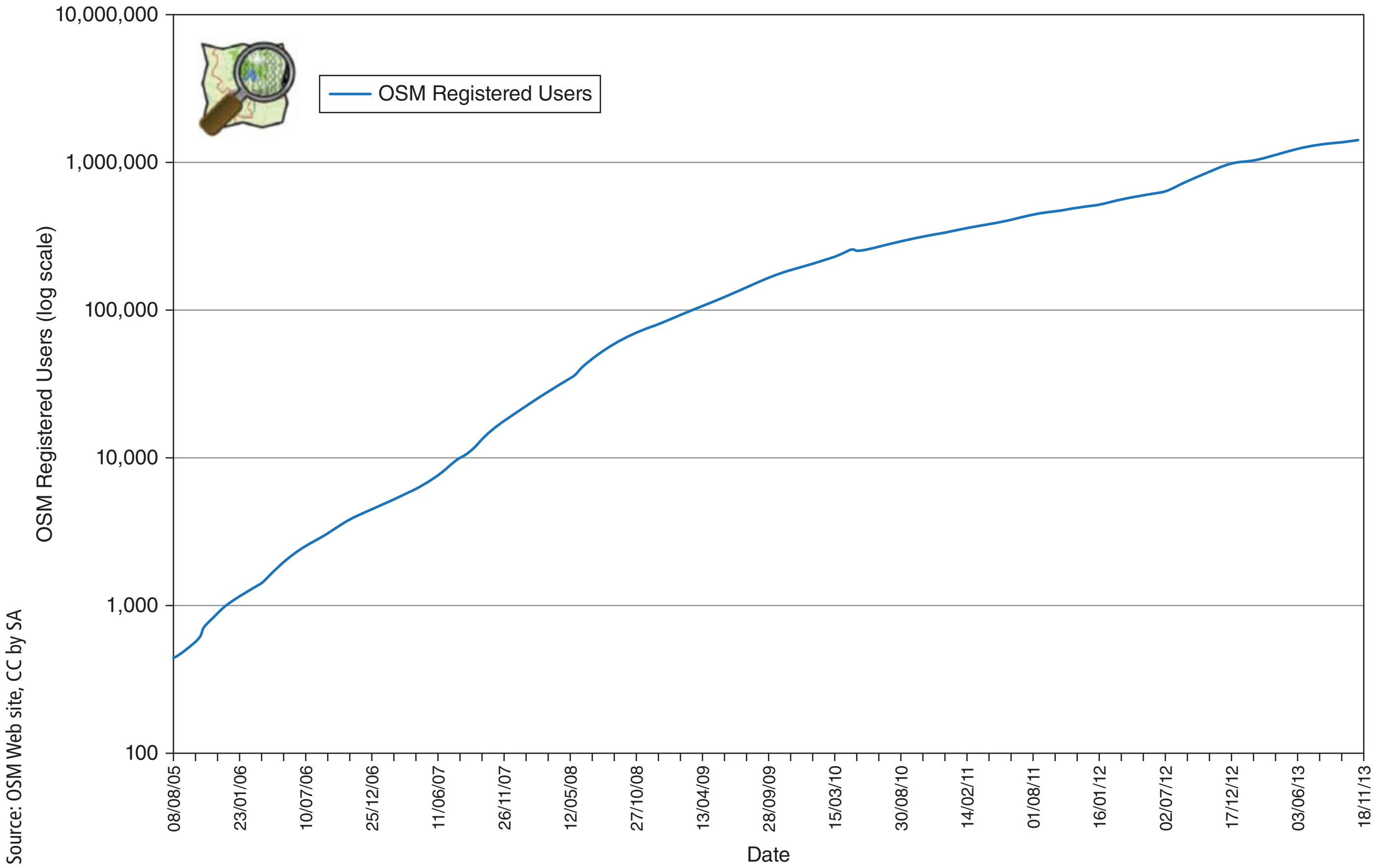


Figure 18.6B Number of registered users of OSM (log scale).

state and local levels in the United States and at various levels in other countries (Figure 18.7). For practical purposes, however, the NSDI concept and reality originated in the United States in 1994 with President Clinton's *Executive Order 12906—Co-ordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure*. This order directed that federal agencies, coordinated by the Federal Geographic Data Committee (FGDC), carry out specified tasks to implement the NSDI; it created an environment within which new partnerships were not only encouraged but also required of federal bodies. This was all embedded further through the contents of the Office of Management and Budget's (OMB) Circular A-16 and the U.S. E-Government Act of 2002.

The original concept of an NSDI was as a national endeavor: it was viewed as a comprehensive and coordinated environment for the production, management, dissemination, and use of geospatial data, involving the totality of the relevant policies, technology, institutions, data, and individuals.

The potential value of an NSDI in the United States was demonstrated by disasters like 9/11 and Hurricane Katrina.

A substantial impetus for the NSDI and local SDIs was provided by a number of emergencies in the United States such as 9/11 in 2001 and the destruction wrought by Hurricane Katrina in New Orleans in 2005. The 9/11 experience in which the New York City Emergency Operations Center was located in a destroyed building, and data and mapping support had to be provided initially by staff from Hunter College, was particularly telling. Among the lessons learned was the need to duplicate and geographically distribute data and metadata, to have wide-area access to them, and to have better arrangements in place to circumvent bureaucracy in emergencies. Subsequent changes in technology have facilitated meeting the first two of these needs.

At the outset, the role of the private sector was scarcely factored into the NSDI concept—this was to be a federal government–led endeavor. Yet private-sector developments—many involving commercial products and partnerships—such as Google Maps and Google Earth, the availability of fine-resolution satellite imagery and SatNav systems based on road data—plus increasing activity by the states and local government and much else made the original concept seem very out of date.

Source: Web sites of responsible agencies

Figure 18.7 Some examples of SDIs and portals to them.

Nevertheless, governments still have a role to play because of their data holdings (Section 17.4) and because of their control of relevant laws and regulations (Section 18.3).

> **The biggest changes in GISS since the NSDI launch are due to commercial organizations—and yet these played minimal roles in the original vision.**

In late 2012 the U.S. Government Accountability Office (GAO) issued a strongly critical report on the progress of NSDI. The report concluded that "While the President and the Office of Management and Budget (OMB) have established policies and procedures for coordinating investments in geospatial data, government-wide committees and Federal departments and agencies have not effectively implemented them . . . because these efforts have not been a priority. FGDC's strategic plan is missing key elements, such as performance measures for many of its defined objectives." Six months later the FGDC issued a new draft strategic NSDI plan for public consultation.

The new FGDC strategic plan in response proposed three goals—to "develop national shared GI services . . . ensure accountability and effective development and management of Federal geospatial resources . . . and . . . convene leadership of the national geospatial community." These are backed up by nine objectives and underpinned by 27 specific actions. Responses to the public consultation on this plan included fierce comment by a national association of private-sector geospatial firms, which complained this was not a strategy and did not address performance management. The commentary further argued that major elements were missing such as a critical part of the framework data (Section 17.2.1.4)—a national land parcel system.

The NSDI implementation difficulties highlighted by the GAO report are scarcely surprising for an activity where no one is really in charge, the activity was not adequately prioritized, and inadequate finances were ring-fenced for the activity. In a country with over 80,000 different public-sector governing bodies (e.g., counties, school boards)—perhaps the most complex geographical structure anywhere in the world, with some different jurisdictions overlapping in space—and a vigorous but neglected private sector, the task was huge. That said, the pioneering U.S. NSDI made some significant impacts; these are discussed in Section 18.6.4.

18.6.2 INSPIRE

Probably the most ambitious SDI-like scheme in the world is the INSPIRE (INfrastructure for SPatial InfoRmation in Europe) project (inspire-geoportal.ec.europa.eu/). This is based on a legal act set up by the European Council and the Parliament and covering the 28 member countries and some 508 million people of the European Union (in 2013). There is no European Union (EU) equivalent to the data collecting federal bodies like the Bureau of Census in the United States; all EU-wide data is sourced nationally and coordinated by agreement within the legal structures of treaties.

The purpose of INSPIRE is to support environmental policy, and overcome major barriers still affecting the availability and accessibility of relevant data. These barriers include

- Inconsistencies in spatial data collection
- Lack or incomplete documentation of available spatial data
- Lack of compatibility among spatial datasets that cannot therefore be combined with others
- Incompatible SDI initiatives in the Member States that often function only in isolation
- Cultural, institutional, financial, and legal barriers preventing or delaying the sharing of existing spatial data

The solutions to these problems involved creating metadata; harmonizing key data themes; building agreements on network services to provide discovery, viewing, and downloading of information; and policy agreements on sharing and data access. The scale of the enterprise is awesome: The U.S. NSDI covers seven data themes but INSPIRE covers 30; the internal heterogeneity in the EU is greater than the United States—Germany, for example has 17 SDIs, one for each of the lander (states) and one federal one, each requiring a separate legal act. All this has to be accomplished through working in 23 languages.

It was not possible to ask the Member States and their national and local organizations to reengineer all their existing databases. This ensured it was necessary to develop not only translation tools to help overcome the natural language barriers, but also agreed reference frameworks, classification systems and ontologies, data models, and schemas for each of the data themes. It took seven years of work to develop an agreed methodology (the Generic Conceptual Model) and tools, mobilize hundreds of experts in different domains, and deliver and test the specifications for the datasets falling in each of the themes. Thousands of pages of specifications and tens of thousands of comments had to be addressed individually during the stakeholder consultations. No less than 491 Spatial Data Interest Communities and 295 Legally Mandated Organizations were created, 259 experts were involved in drafting teams and working groups, and over 3000 user organizations have registered on the INSPIRE website. The scale of the task and work has been described by Italians as Herculean and by Russians as Stakhanovite!

INSPIRE may well be the most complex GI program yet enacted.

INSPIRE is coming to the conclusion of all this work at the time of writing, so its success cannot yet be judged. It has, however, certainly provided valuable insights, which we describe in Section 18.6.4.

18.6.3 UN Initiative on Global Geospatial Information Management

GGIM is a very different form of partnership. It comprises a group of experts drawn from the national mapping and charting agencies (NMCAs) of over 60 UN member countries. They seek to gather case study evidence from around the world of GI system– and GI-related activities and share ideas about future developments and experiences. Case studies on Egypt's use of GI to help grow its economy and deliver better public services, on Brazil's GI use to reduce crime rates, and Korea's use of GI systems to enhance its cadastral system and manage land systems are examples of what the group has produced.

Perhaps unsurprisingly, this group is particularly fascinated by the future needs of governments and the future roles of mapping and charting bodies. A 2013 report produced for the group recognizes the changing relationship with private-sector GI providers and users and the growth of volunteered GI. It even speculates that the future role of NMCAs might well be in setting standards and operating more in a policy, advisory, and procurement role, rather than a production one.

18.6.4 Have SDIs Worked?

The SDI movement was *the* big development of GI in the 1990s. Two decades after its launch it is now possible to make an assessment of whether the many SDI schemes have worked effectively.

Not surprisingly, implementation of many NSDIs (and SDIs more generally) has not gone smoothly. Anything so broadly defined and forming such an intangible asset, whose creation involves huge numbers of different organizations and individuals—each with their own views, values, and objectives—and having no one in overall charge was always going to have difficulty achieving universal approval. In the United States, the post-Clinton administration had different priorities. There was also internal dissension within the federal government about who led on what; some shortcomings in agreements between federal, state, and local government and with the private sector on how to progress; and budget constraints, plus a host of other, competing new initiatives demanding staff and resources.

At a high level, few would dispute the merits of achieving data sharing, reduction of duplication, and risk minimization through the better use of good-quality GI. But how to make it happen for real, how to avoid excessive bureaucracy while being accountable to stakeholders, and how to measure success are different matters. A number of external-to-GI researchers have, for instance, criticized the way evaluations of SDIs have been carried out for not focusing on governance matters and for using only qualitative measures of success.

Craglia (see Further Reading and Box 18.4) has provided an example where the traditional NSDI approach did not work well initially but was then fixed. The Global Earth Observation System of Systems (GEOSS) was set up by the G8 countries to provide a framework for integrating the Earth observation efforts of the Group on Earth Observation, comprising 60 countries. GEOSS was a voluntary, "best efforts," multidisciplinary, and cash-limited enterprise. Three years after its launch only a few hundred datasets and services had been made available. However a step change was achieved by changing the operational model to one in which brokering was used to build bridges between different disciplines. It introduced a new middleware layer of service offerings in the SDI that achieve the necessary mediation, adaptation, distribution, semantic mapping, and even the quality checks required to address the complexity of an interconnecting multidisciplinary infrastructure. The approach is claimed to have resulted in discovering 28 million datasets in a few months!

Biographical Box 18.4

Max Craglia

Max Craglia (Figure 18.8) has been at the center of spatial data infrastructure developments for many years. He is no uncritical enthusiast: In addition to helping to nurture such infrastructures he has been a constructive critic, drawing lessons from many developments across the world and applying them in his own work. That work has extended across many areas of geographic Information.

Since 2005 he has worked at the Digital Earth and Reference Data Unit in the European Commission's Joint Research Centre in Ispra in Italy. The Unit is responsible for the technical coordination of the INSPIRE Directive, aimed at creating an infrastructure for spatial information in Europe. Within the Unit he has been responsible for the development of the INSPIRE Implementing Rules for Metadata and for research on the impact assessment of SDIs and INSPIRE.

Courtesy: Massimo Craglia

Figure 18.8 Max Craglia.

In addition, Max was the technical coordinator of the EuroGEOSS project developing INSPIRE–compliant GEOSS Operating Capacity in three thematic areas of drought, biodiversity/protected areas, and forestry. He is currently the scientific coordinator of the GEO Weather, Ocean, Water project (GEOWOW). Between 2010 and 2013 he also led projects on citizens' science in the area of forest fires and the use of civilian drones to collect environmental information.

Max was initially trained as a civil engineer in Milan and then obtained MPhil and PhD degrees in Planning and GIS from the Universities of Edinburgh and Sheffield, respectively. After a spell as an urban and regional planner for the United Nations in Saudi Arabia, he took up information management teaching posts. In that role he coordinated the GISDATA scientific program of the European Science Foundation and the EC-funded Geographic Information Network in Europe. He was one of the founders and served as chief editor of the *International Journal of Spatial Data Infrastructures Research.* One of the founders of the Vespucci Initiative for the Advancement of Geographic Information Science, Max has been a major contributor to scientific meetings across the globe and brings an unrivaled range of experience in and breadth of understanding of science, GI technology, and social science.

Drawing on numerous reviews worldwide and particularly that of Craglia, we can conclude that:

- SDIs are more complex than many first thought. They are more about building social networks and reaching agreements on the semantics of data than technologies and standards. Applied social science is a crucial element in making SDIs work.
- The context has changed: SDIs have remained a relatively niche affair for public administrators and policy analysts, whereas a few large private-sector companies have come to dominate the global GI systems and services activities. This has enabled the dissemination and use of spatial information to an extent that could not be foreseen in the 1990s.
- There will always be different standards and practices across different communities, and it is better to accept diversity than trying to impose uniformity that is unlikely to work.
- There are multiple models for an SDI. In many countries such as Italy, Spain, Belgium, and Germany, the regional level of SDIs often forms the key building blocks of the national SDIs, with the national level providing a thin layer on the regional infrastructures. Others are rather more centralized, reflecting the institutions and history of the state.
- Adequate and continuing funding is crucial. In many SDIs this support has been lacking, in part because so many organizations are involved, and all see themselves as contributors rather than taking lead responsibility and/or providing significant funding. A widely agreed business plan with measurable targets and a clear statement of which organizations will benefit is vital.
- Inter- and intraorganizational conflict is inevitable in implementing an SDI. Thus successful SDIs build and maintain networks of people and organizations, in which technology only plays a supporting but nevertheless important role.

Curiously another contextual change may actually nurture SDIs in future—the growth of the Open Data movement and the recognition by G20 leaders that this has potentially major benefits for governments, businesses, and citizens (Section 17.4). Thus we may come to see SDIs, focused on spatial data or GI, as precursors to the wider national information infrastructures now being conceived (in which GI is playing a key role).

Something as diffuse as NSDI will never be seen as a success by everyone, but it has been a catalyst for many positive developments and was a precursor of national information infrastructures.

Perhaps the greatest success of SDIs has been as a catalyst, acting as a policy focus, publicizing the importance of geographic information, and focusing attention on the benefits of collaboration through partnerships.

18.7 Coping with Spatial Stupidity

We live in a world where we expect technology to work, and it usually does: Making satellite calls from the summit of Mount Everest is now routine. However, in some trying circumstances, technology may fail or be disabled by enemy forces (Section 17.5), hackers, or failures of organizational processes. Disasters may also occur through misuse by individual users.

Beware the user's ability to create disasters using GI and GI technology.

Technology alone rarely causes disasters. The disastrous replacement by Apple of Google maps with their own service in September 2012, with some towns being erroneously positioned by as much as 50 km (31 miles), demonstrated that even the most technologically competent organizations make serious management mistakes. Beyond that, Figure 18.9 shows that users can also misuse GI and GI technology to cause disasters. There is much speculation and some research on what causes an individual to ignore or misinterpret what the technology says. Studies of cognitive processes in relation to driving have stressed the importance of attention control, but most of the conclusions are theoretical at present. What we do know is that humans are good at producing post hoc justifications, as the captions to Figures 18.9A and 18.9B testify. Where consistent bad judgments occur, however, it may well be that there is something wrong with the satellite navigation system, the GI therein, or the design of the human interface. But spatial stupidity exists everywhere and is manifested even without help from technology. In May 2010 a novice sailor intended to sail his new motor boat—bought online—from Gillingham to Southampton round the English coast. To guide him, he only had a road atlas, and he navigated by keeping the land on his right. Sadly, he went around an island, the Isle of Sheppey, several times and ran out of fuel before being rescued. We must strive to make our systems safe for use, but there are limits to our ability to anticipate such stupidity on the part of *homo geographicus*!

A

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Figure 18.9A Three Japanese tourists followed their GPS's instructions to drive directly at low tide through Moreton Bay to Stradbroke Island, Queensland, Australia. One student said, "The GPS told us we could drive there."

B

Dan DeLong/seattlepi.com

Figure 18.9B A bus driver responsible for a high school girls softball team drove into a bridge in the Washington Park Arboretum, Seattle—despite flashing lights and yellow warning sign. The president of the charter bus company blamed the GPS: "We just thought it would be a safe route, because why else would they have a [route] selection for a bus?"

C

© Peter Facey/geograph

Figure 18.9C After numerous vehicles got stuck in narrow lanes near Winchester, England, authorities erected a warning sign to disregard GPS instructions.

18.8 Conclusions

In this chapter we have highlighted the importance of operating as transparently as possible—about the tools used, the experience of staff, the appropriate business model and methods used, and the commitment to a professional code of ethics. Knowledge of all these needs to be in the public domain. Any organization also needs to have its own data and metadata in good shape, and its staff must understand the data's foibles, provenance, and those applications for which it is fit for purpose.

All the processes used must be documented and a good audit trail preserved of what was done and when. As hardly needs to be said, good working relationships with clients and good customer care are essential. Before anything goes wrong, however, the managers and leader need to know where to go for legal advice in any area of their activity touched by the law (i.e., all of it).

To win business the GI professional will need to be articulate, persuasive, and honest in his or her presentations as well as understanding the science, social science, and technology of GI. He or she will need to ensure that the organization's reputation is burnished by keeping it positively in the public eye through the media.

Enthusiasm and commitment are characteristics of the GI world. But to survive and prosper, a degree of skepticism is helpful, as is a knowledge of others in the business and the ability to make a judgment of what is good enough to meet or surpass the client's requirements without bankrupting the organization.

As pointed out earlier, it is sometimes wise to join with others to achieve desired ends. The lessons from GI partnering are clear: Small and focused partnerships are much more controllable and successful than large and diffuse ones. Nevertheless, there is no escape from some national-level thinking, planning, and action if resources are not to be wasted and benefit is to be maximized. Do not, however, expect to be popular or progress to be rapid in such schemes!

All this sounds formidable, but much of it is not. It becomes part of the normal world once anyone has been appropriately trained and has accrued management responsibilities. Good luck!

QUESTIONS FOR FURTHER STUDY

1. What business models have been used in commercial GI systems enterprises? What might be a good business model for a government GI systems unit?
2. Describe, using an example culled from the Web, one example where intellectual property rights have figured in disputes involving geographic information.
3. Is privacy a doomed concept? If not, how can it best be protected in the GI world?
4. What is meant by a spatial data infrastructure, and what have GI system practitioners learned from SDI experience over the period since President Clinton's edict for the United States to create one?
5. What forms of GI-related partnership can you identify in your local area? What have they achieved?

FURTHER READING

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