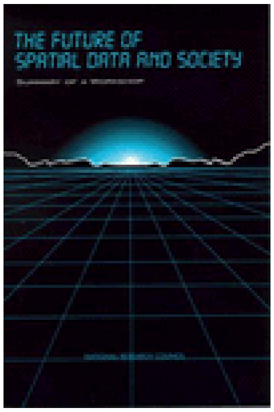

The Future of Spatial Data and Society: Summary of a Workshop

Mapping Science Committee, National Research Council

ISBN: 0-309-59028-0, 80 pages, 6 x 9, (1997)

THE FUTURE OF SPATIAL DATA AND SOCIETY: SUMMARYOF A WORKSHOP

Mapping Science Committee
Board on Earth Sciences and Resources
Commission on Geosciences, Environment, and Resources
National Research Council

National Academy Press
Washington, D.C. 1997

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

Support for this project and the Mapping Science Committee was provided by the Defense Mapping Agency, U.S. Geological Survey (USGS Agreement No. 14-08-0001), Federal Geographic Data Committee, Bureau of Transportation Statistics, National Oceanic and Atmospheric Administration, Bureau of Land Management, and Bureau of the Census. Partial support for workshop logistics was provided by the News Corporation/ETAK, Inc., Intergraph Corp., and Rand-McNally and Company. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the organizations or agencies that provided support for this project.

Copies of this report are available from
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Board on Earth Sciences and Resources
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2101 Constitution Avenue, NW
Washington, DC 20418

Cover: Sunrise over the future's horizon. (Design by Denise Smith, North Carolina Department of Environment, Health, and Natural Resources, Public Affairs.)

0-309-05753-3

Printed in the United States of America

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PREFACE

The Mapping Science Committee serves as a focus for external advice to the federal agencies on scientific and technical matters related to spatial data handling and analysis. The purpose of the committee is to provide advice on the development of a robust national spatial data infrastructure for making informed decisions at all levels of government and throughout society in general.

In the context of the above mission statement, the Mapping Science Committee (MSC) prepared a report in 1993, *Toward a Coordinated Spatial Data Infrastructure for the Nation*, that articulated its vision on how spatial information handling might best be approached from an organizational perspective. Of course, many specific issues are raised when examining what a national spatial data infrastructure (NSDI) encompasses. The committee followed its 1993 report with two other studies, each addressing individual components of the NSDI: (1) *Promoting the National Spatial Data Infrastructure Through Partnerships* (1994) and (2) *A Data Foundation for the National Spatial Data Infrastructure* (1995). In response to those reports and Executive Order No. 12906 (April 1994), the federal government, through the Federal Geographic Data Committee (FGDC; operating under the aegis of the Office of Management and Budget), has focused on improving many of the components of the NSDI.

Over the past few years, the MSC has identified and proposed many different ways of enhancing and strengthening the NSDI. While many of them have in nature been short term, others have addressed national needs over the next decade and beyond, as well as the long-term vision for the NSDI. In 1995, the committee proposed a workshop, in cooperation with the FGDC, as a way to develop a series of alternative long-term visions and identified many of the societal forces and changes that would make them more or less likely. If successful, the workshop would thus provide a framework for thinking about the future of the NSDI. To help workshop participants think beyond the constraints and noise of current programs and details, the committee selected a target year of 2010.

The specific purposes of the workshop were to:

- identify forces affecting the future of spatial data;
- discuss and anticipate possible future scenarios for the collection, dissemination, and use of spatial data;
- identify implications of the anticipated futures from local, regional, national, and other stakeholder perspectives; and
- identify cautions, suggestions, and directions to the spatial data community based on the identified futures.

Workshop participants were selected in such a way that all major sectors of spatial data activity were represented by their respective stakeholders, with an appropriate balance among them. Of the participants, 25 percent were from the federal government, 20 percent from academia, 17 percent from state and local governments, 32 percent from the private sector (split about equally between data system providers, data providers, and consultants), and 6 percent from other sectors (e.g., scientific societies, associations, retired). See Appendix A for a list of participants.

The committee coordinated the preparation of a series of white papers in advance of the workshop, which was held in April 1996, to stimulate discussion on certain key issues. These, along with copies of several published articles, were distributed to the participants several weeks prior to the workshop. The white papers produced specifically for the workshop are listed in Appendix B, together with references to background documents.

The workshop was professionally facilitated, which encouraged participation by all attendees and discussion of key issues. The agenda is given in Appendix C. Most of the activities were held in five breakout sessions (each with a facilitator) for which participants were assigned to specific groups (about 15 participants in each breakout group). Care was taken to ensure that all the sectors of the spatial data community (local, state, federal government; academia; and private sector) were represented in each group. Each small-group session was followed by a plenary session to examine the results.

During the workshop, participation was encouraged in an informal documenting of past events and forces that have affected spatial data activities. The information was collected on a large chronological chart. A discussion of some of the past forces is given in Chapter 2, and an unedited transcription of the chart appears in Appendix D.

John B. Evans (President, R.E.M. Productions, Inc.) led the first plenary session of the workshop with a personal view of the future, of how current societal pressures and issues might change, and of how the telecommunications and entertainment industries might be affected. This was followed by a presentation by Michael R. Curry (Department of Geography, University of California, Los Angeles) on the role of spatial data in society and of how current and future trends may force us to rethink concepts of space and place and the role of the individual with respect to such issues as privacy. A panel discussion covered aspects of data partnerships, sharing, and stewardship and summarized issues covered in several of the white papers prepared for the workshop.

Following these provocative presentations, workshop participants divided into five small working groups to consider what broad future forces in society might affect present spatial data activities. Discussions from these groups were then presented in a plenary session. The results are incorporated in Chapter 2 along with results of the post workshop categorization by the committee.

The participants again divided into five working groups to consider what changes these external forces might be expected to cause in the spatial data community in the next 15 years. These were presented and discussed in a plenary session. Compilation of these possible changes along with some post workshop categorization by the committee are contained in Chapter 3.

On the second day of the workshop, participants met to develop alternative future scenarios from the previous day's efforts. After several attempts to construct scenarios as a group, the participants again divided into five working groups. One group attempted to take the forces and possible changes developed by the workshop to develop a "forecast" for the future (see Chapter 4). Each of the other four working groups adopted one of the scenarios for future spatial data activities outlined by Wegener and Masser.* Each working group amplified or modified a specific scenario based on the forces and changes identified in the previous day's sessions (see Chapter 5).

Workshop participants discussed some of the actions they thought are needed for evolution of spatial data activities in a closing plenary session. Chapter 6 presents the results of that discussion. The report ends with a series of questions the committee suggests should be addressed when making decisions in the context of the NSDI that are likely to have long-term impact. Although it would be foolish to try to forecast or anticipate the future in a field that is likely to be driven by so many external forces outside its control, and to see so many changes, both trivial and profound, between now and 2010, the committee believes that by asking the right questions we can at least frame the discussion of decisions that have long-term impact in a useful and informative way.

* Michael Wegener and Ian Masser, "Brave New GIS Worlds," in Ian Masser, Heather Campbell, and Max Craglia, eds., *GIS Diffusion: The Adoption and Use of Geographical Information Systems in Local Government in Europe*, Taylor & Francis, London, 1996.

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EXECUTIVE SUMMARY

Public and private institutions are committing resources and making important long-term decisions concerning the collection, management, and use of spatial data. Although these actions are influenced by current pressures, priorities, and opportunities, their ultimate success depends on how these spatial data activities will be relevant to future needs and demands.

The Mapping Science Committee, in cooperation with the Federal Geographic Data Committee, convened a workshop in April 1996 to examine societal and technological changes that might occur within the next 15 years. The purpose was to consider within the context of spatial data activities a series of long-term visions and to identify societal forces and changes that would make those visions more or less likely. The workshop provided a framework for thinking about the future of U.S. spatial data activities.

Thinking creatively about the future is difficult, particularly in a workshop style. Our imaginations are dominated by experiences. Although the powers of reasoning through analogy and pattern recognition are normally very effective, these characteristics may work against us when attempting to speculate about the future. Presented with a new technology, our natural inclination is to put it to the same tasks as the old and to evaluate it on that basis.

While the national spatial data infrastructure is by now a recognized concept, discussions at the workshop reminded us of the role of spatial data through the broader changes occurring as society moves toward the information age. In many areas the problems of spatial data are merely echoes of much broader concerns; in others, they are comparatively unique. Although both types were discussed at the workshop, the emphasis there and in this report has been on the latter.

The workshop examined a wide variety of "forces" that are likely to shape the future of spatial data activities by the year 2010. Considering the large range of suggestions, the Mapping Science Committee grouped them into five generalized forces for change. These are discussed in Chapter 2 and are as follows:

- Synergy of information, technology, and access
- Expanding global interdependence
- Increasing emphasis on sustainability
- Emergence of community-based governance
- The individual

The workshop participants individually described anticipated changes in the collection, dissemination, and use of spatial data by the year 2010. Over 139 isolated forecasts of future changes were suggested (see Appendix E). The anticipated changes include technical ones as well as those that are more societal in nature. After the workshop, the committee placed these changes into the following 18 categories that are discussed in Chapter 3. These categories are not unique. After each entry is an abbreviated sense of direction of the change (in italics) suggested by the Mapping Science Committee based on comments at the workshop.

- Basic computing (and telecommunications) technology: *continued improvement*
- Analysis, visualization, and cognitive technologies: *development of search and integration tools; virtual reality*
- Pervasiveness of technology: *improved access to data and technology*
- Data integration: *spatial data becomes transparent to users*
- Timely data and use: *needs for currency will change data management*
- Intelligent instrumentation: *real-time locational information*
- Data transactions: *transactional updates become major data source*
- Personal systems: *spatial locators*
- Quality assurance/quality control: *greater role of metadata*

- Spatial literacy: *increased geo-understanding*
- Partnerships: *data utilities may emerge*
- Spatial data as a commodity: *consumers will drive data markets*
- Control of data: *conflicting public policies will continue*
- Data collection agents: *more local collection of spatial data*
- Data security and protection: *possible restrictions on public access*
- Decision-making process: *spatial analysis continues to grow in importance*
- Citizen involvement: *spatial capabilities will expand involvement*
- Privatization: *suggestive trend of increasing privatization.*

The workshop also considered the likelihood of these changes in the context of the framework of future forces identified in Chapter 2: technology, economics and markets, the environment and sustainability, and the individual and local governance. Chapter 4 presents a forecast of the future based on this analysis, identifying ways to enable a particular forecast to emerge and the impediments that may prevent it.

Chapter 5 presents an analysis of four scenarios of the future as presented by Wegener and Masser*: *trend scenario, market scenario, big brother scenario*, and *beyond-GIS scenario*. The workshop participants formed four working groups (one for each future scenario) to facilitate discussion. Each working group started with the premises laid out in "their" scenario and identified positive and negative implications of each, the stakeholders, and possible consequences to spatial data. This enabled the workshop participants to look beyond reality and examine what might happen as a result of societal shifts.

Not surprisingly, the workshop participants reached no conclusive consensus on the future of spatial data and society. However, the participants did think that it is valuable to consider the

* Michael Wegener and Ian Masser, "Brave New GIS Worlds," in Ian Masser, Heather Campbell, and Max Craglia, eds., *GIS Diffusion: The Adoption and Use of Geographical Information Systems in Local Government in Europe*, Taylor & Francis, London, 1996.

range of forces at work and the possible changes those forces may produce. An organization that has a stake in the future of spatial data will find that its strategic planning must be guided by changes that most certainly will occur and also by changes that may occur only if specific pathways are chosen or influenced. In preparing this summary report, the Mapping Science Committee extrapolated from issues and ideas raised during the workshop to construct a series of specific questions that would be useful in strategic planning. It is the committee's intent that this report represents the beginning of a dialogue in which organizations consider their future spatial data activities in a changing societal context.

1

INTRODUCTION

Government agencies and other organizations are now committing resources* and making important long-term decisions concerning the collection, management, and use of spatial data. Although these actions are influenced by current policies, priorities, and opportunities, their ultimate success depends on future developments and trends. An examination of possible futures and policies can be invaluable in creating strategies and procedures to support the evolution of the national spatial data infrastructure (NSDI)† Future decisions on the NSDI will depend on changing technologies, societal needs, and institutional structures.

The Mapping Science Committee, in coordination with the Federal Geographic Data Committee, convened a two-day workshop in April 1996 to examine the range of possible future scenarios and their effects on spatial data activities. The goal of the workshop was to initiate discussions of how spatial data activities

* The Office of Management and Budget (OMB) determined that federal spatial data activities amounted to about $4.4 billion in FY 1994; this number resulted from a data call described in OMB Bulletin 93-14. Most analysts agree that an equal or greater amount is spent on spatial data activities by state and local governments and the private sector.

† The national spatial data infrastructure was defined by the Mapping Science Committee in its 1993 report, *Toward a Coordinated Spatial Data Infrastructure for the Nation*, as "the means to assemble geographic information that describes the arrangement and attributes of features and phenomena on the Earth. The infrastructure includes the materials, technology, and people necessary to acquire, process, store, and distribute such information to meet a wide variety of needs." The NSDI was the subject of an Executive Order (No. 12906, signed by President Clinton in April 1994) that directs the Federal Geographic Data Committee to take the lead in further developing the NSDI, particularly from the federal perspective.

might evolve to meet future needs and opportunities. The framing question used at the workshop was:

> *In the year 2010, how will societal needs and public policies affect the requirements for spatial information and services and their integration at the individual, community, national, and global levels?*

Many thoughts are precipitated by discussions about the current and future evolution of the NSDI. Many fundamental issues appear consistently and prominently in such discussions and are presented as questions in the following sections to serve as a prelude to a discussion of the workshop and its results.

POLICY AND RESPONSIBILITY

The NSDI is the domain of many different institutions—public and private, local to national. As such, questions of policy and responsibility include the following:

- Who will be accountable for various components of the NSDI and who will pay for it?
- What roles will partnerships (e.g., federal-state, public-private) play in fulfilling spatial information needs?
- Who is responsible for maintaining the spatial data and supporting infrastructure?
- To what extent should spatial data activities be privatized?
- What are the potential risks and benefits from privatization?
- Can incentives be created to encourage widespread data access and data sharing?
- To what extent can data generated by defense/intelligence agencies support public civilian needs?
- How will public policies on the right to privacy and public access to information affect spatial data activities?
- What new liabilities and responsibilities will arise as a result of an NSDI that is more frequently updated and increasingly real time?

TECHNICAL REQUIREMENTS AND BARRIERS

Future technological advances will need to respond to several critical issues, such as the following:

- Is it possible to implement a data management strategy for the myriad spatial databases that are within the context of an NSDI?
- As data become easier to access, transport, and interpret, new procedures and techniques will be needed to ensure the security of spatial databases. What technological changes are needed to ensure both security and privacy?
- It is apparent that metadata (or data about data) will play an increasing role in the widespread sharing and integration of spatial data. Management of data quality and certification of data will increase in importance as the applications of spatial data expand. What needs to be done to ensure that metadata are created to meet future needs?
- Technological developments (digital libraries, the Internet, etc.) offer the potential to strengthen the NSDI. What are the barriers to the NSDI in embracing new technologies?
- Mechanisms to keep data current (often real-time) need to be incorporated into partnerships and technology implementation. As the NSDI evolves, our ability to deal with urgent problems such as flooding, storms, and accidents will improve. What elements of the NSDI will be affected by real-time processing?
- How will maintenance and data integration be supported and accomplished with continuously changing datasets?

ECONOMICS AND MARKETS

There is already a tremendous investment in the NSDI. Specific questions that arise concerning this investment include the following:

- What are we actually receiving by way of benefits from the NSDI?

- Are there performance measures that can be applied to the different components of the NSDI?
- Are there ways to measure the value of spatial data in comparison to the cost?
- How will the economics of the NSDI change in the future?
- How will national and international laws affecting intellectual property rights and patents impact the future course of the NSDI and the current market conditions?

RELEVANCE

There has been explosive growth in certain application areas that rely on spatial data. What about the future? Can a set of issues and problems be identified that will emerge or continue to concern us in the future? Issues that could influence future spatial data development include the following:

- What information requirements can be anticipated for the year 2010?
- Is there a core set of issues (such as clean water, air, food, health, education, transportation, urban development, and security) that will drive future spatial data concerns?
- Will sustainability and quality of life issues increase in importance to the extent that they become a principal force shaping the NSDI?

EDUCATION

Expanded use of spatial data in virtually all sectors of society raises questions concerning its infusion into the education system.

- What would be the impact of infusing "geospatial literacy" into school curricula?
- What additions or changes to curricula in the next 15 years would strengthen students' ability to participate in the NSDI?

GLOBAL SPATIAL DATA INFRASTRUCTURE

Many issues associated with the NSDI are also important at international and global levels. We foresee an increasing need in the coming decades for nations to cooperate in sharing spatial information, which raises the following questions:

- What form is such cooperation likely to take?
- What barriers must be overcome to make international cooperation work?
- What new initiatives should be undertaken to make a global spatial data infrastructure work effectively?

THE WORKSHOP

Clearly, a two-day workshop cannot fully address the numerous questions and issues that arise in thinking about the future of spatial data activities, let alone answer them all. At best, the workshop and this report provide a framework for discussion by identifying the forces likely to affect future policies and implementations; changes that are likely to occur in the environment of the NSDI, and issues that should be considered in planning for the future. These have been distilled from discussions at the workshop, committee discussions, and other sources. The report identifies a number of alternative scenarios for the future of spatial data and the NSDI in the year 2010, with the hope that readers may better understand the possible long-term consequences of choices made today and guard against futures that may be deemed undesirable. In summary, the Mapping Science Committee hopes that this report will provide a better framework and richer context for thinking about the future of the NSDI and stimulate a more extensive debate on these issues.

2

FORCES SHAPING THE FUTURE OF SPATIAL DATA

SPATIAL DATA IN A CHANGING WORLD

To its participants, stakeholders, and practitioners, the world of spatial data may appear well defined, cohesive, and of growing importance to itself and society at large. Viewed from a broader perspective, however, the spatial data community is but one of many sectors heavily dependent on developments in technology and driven by forces that are essentially beyond its control. If the spatial data community wishes to understand its alternative futures and to have any effective part in choosing between them, it must first address the external forces that are likely to be as important in driving the community's futures as they have been in the past.

The workshop participants were asked to help define two sets of external forces: hose that have affected the spatial data community in the past and those that will affect it in the future. This chapter presents the results of those efforts.

TO THE PRESENT

Throughout the workshop, participants were given the opportunity to help in an informal documentation of the major events and forces that have marked and shaped the evolution of current spatial data activities. Although this chronology or time line (see Appendix D) was used more as a device to stimulate thinking and workshop participation than as a definitive exercise, it was analyzed subsequently by the committee to determine whether the historical driving forces that have most affected spatial data activities could be identified. Although not mutually exclusive, the following four principal forces were identified as having been the drivers for most of the changes that occurred over the past three decades:

- **Technological developments.** Technology, and its rate of change, were predominant forces behind many of the changes that occurred in spatial data activities. Technological developments were driven by defense and other large government-funded efforts such as the space program.
- **Environmental awareness.** The environmental movement, which gathered momentum in the late 1960s, provided a major impetus to the collection and creation of spatial data. Location-specific data were needed to monitor impacts on the environment, to support programs for environmental restoration, and to manage and conserve natural resources more effectively. New technologies were developed, notably in the areas of computer mapping and Earth observation through satellite remote sensing.
- **Political unrest and war.** National security issues led to the collection and analysis of accurate spatial data throughout much of the globe. Spatial databases were constructed in support of intelligence activities and also as components of new "smart" weapons systems.
- **Peace time economy.** Spatial data have helped form a foundation for commercial enterprises, such as delivery services, and have also led to enhanced market analyses. At the same time, the use of spatial data has reduced costs and increased efficiencies in a wide variety of areas where it is necessary to manage large networks of geographically dispersed facilities, most notably in the utility industries, transportation, and local governments. Policies and practices of open and affordable access to spatial data have contributed to U.S. leadership in the world markets of spatial data technologies and applications. The peacetime economy has seen the diffusion of defense and intelligence technologies into the civilian sector, a particularly noteworthy example being the global positioning system, which was developed for military purposes but is now widely used as a cost-effective tool for determining geographic position.

INTO THE FUTURE

For the first workshop exercise, participants were divided into five small groups to produce lists of *forces that might shape the future of spatial data activities by the year 2010*. The forces were categorized and ranked in the small groups.

In a plenary session that followed, the items generated by the small groups were categorized and discussed. The categories were arrayed on a large panel. Many were related to one another and in some cases overlapped. The participants discussed the focus of each category, and a facilitator captured relationships by placing them in close proximity to one another and sometimes by drawing links between them. Figure 1 is a rendering of the results of this exercise. For example, on the right-hand side, environmental surveillance, security, and technology were generally related in the discussions and are grouped accordingly. After the workshop, the committee examined these forces, further categorized them, and identified five principal forces that should motivate spatial data collection and use in the future. In no priority order these are:

- **Synergy of information, technology, and access.** In the near term, technology development will continue to have profound effects on spatial data activities. In the longer term, information needs will drive further technological developments. Individuals and groups will find new, expanded, and in many cases unanticipated uses for new technologies. New business practices (and new businesses) will emerge out of this volatile and dynamic synergy between information, technology, and access.
- **Expanding global interdependence.** With the end of the cold-war era, commerce and other economic activities will be increasingly global in nature and will drive a globalization of spatial information. In parallel with the globalization of telecommunications and other technology-based industries, the spatial data industry will become increasingly globalized as it becomes easier to integrate and transfer data across national boundaries and as international standards emerge.
- **Increasing emphasis on sustainability.** Many of the roots of the concept of sustainability lie in the environmental awareness that emerged beginning in the 1960s, but the concept has been broadened significantly to "embrace the essential components of sustainable development: environmental health, economic prosperity, and social equity and well-being."*

* President's Council on Sustainable Development, 1996, Washington, D.C.

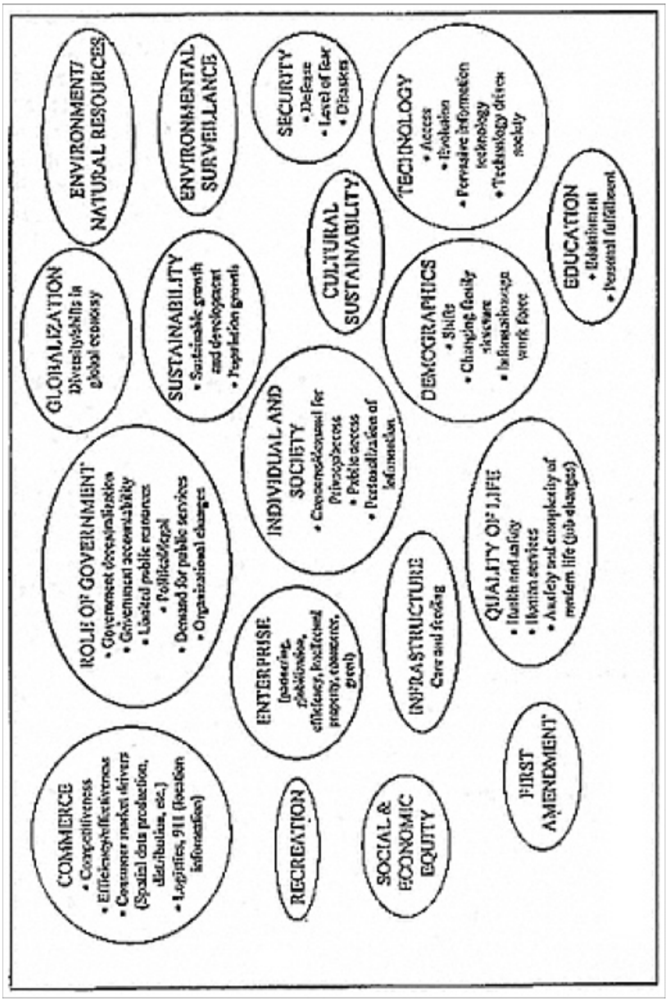

Figure 1.
Result of workshop identification of forces that might shape the future of spatial data activities by the year 2010.

- **Emergence of community-based governance.** Greater citizen involvement in governance (participatory democracy) will be enabled by readily accessible systems that integrate information from disparate sources.* To an increasing degree, spatial data systems will become commonly used tools for developing compromises and reaching decisions among groups with different positions.
- **The individual.** This force includes a wide range of concerns centering on the individual: health, personal rights, privacy, quality of life, and recreation. As spatial information becomes embedded in widely applied information technologies and is increasingly accessible to the general public, new uses and demands will change many of the current practices related to these concerns.

* A similar emphasis on the emergence of community based governance enabled by spatial data and tools is given in the report of the "Congress on Applications of Geographic Information Systems to the Sustainability of Renewable Natural Resources," *Renewable Resources Journal 14* (3), Renewable Natural Resources Foundation, Bethesda, Maryland, 30 pp., 1996.

3

CHANGES

Following the plenary session on forces, the workshop participants reconvened into five small groups. In each small group the participants individually described *anticipated changes that involve the collection, dissemination, and use of spatial data by the year 2010*. These were recorded by the small-group facilitators. The exercise continued until participant contributions were effectively exhausted. After clarification and discussion, the small-group participants ranked the five most important changes on the list. The lists were ranked according to the number of votes. The ranked lists (one per group) were presented in a plenary session, and the changes that received the most votes were discussed briefly. The rankings, although interesting as a way of focusing discussions, were not consistent—some groups emphasized the significance of a change, others emphasized the likelihood of a change.

The lists of anticipated changes are, in a sense, snapshots of 139 isolated forecasts of future events involving spatial data, with no organizing structure except the small-group rankings. In this form they do not provide a clear view of the trends and interactions the participants had in mind. Subsequent to the workshop the committee undertook an exercise to draw out this kind of information. It reviewed the collection of events in an attempt to give meaning and structure to the whole.

The committee found that the anticipated future changes could be classified into 18 general categories (a few of the changes were repeated in two separate categories). The categories are presented below, ordered generally from technical changes to changes that are more societal in nature. The italicized comments after the brief description indicate the anticipated direction of the change, based on the accumulated comments or "snapshot forecasts" from the workshop. The specific changes are tabulated for each category in Appendix E.

1. **Basic computing technologies** include computing and communications technologies that affect our ability to access, transmit, and work with spatial data. *There will be continued improvements in the areas of computing capacity, miniaturization, and wireless technologies.*
2. **Analysis and visualization technologies** include software tools and techniques that support spatial data analysis and visualization. *Advancements will be in key areas of multidimensional viewing, virtual reality, and spatial data search and integration tools.*
3. **Pervasiveness of technology** will be reflected in the availability and intrusion of spatially related technologies (e.g., geographic information systems, mapping) in our daily lives. *The use of spatial data will increase as user interface tools provide improved access to spatial data and spatial data technology becomes embedded in other standard software products.*
4. **Data integration** will be supported by standards and other mechanisms that help to integrate data horizontally, vertically, and synergistically. *With the availability of data integration tools and standards, spatial data will become common in the general digital environment.*
5. **Time lag between production and use** is a determining factor in the availability of current, timely spatial data. *Instrumentation of the environment will become a major source of real-time data. As the time lag between production and use approaches zero, the way data are managed, distributed, and used will be profoundly different.*
6. **Intelligent instrumentation** can support real-time monitoring of the environment, with associated feedback and response. *Instrumentation will provide location information and associated processing and analysis to aid vehicle navigation, traffic monitoring, weather and pollution monitoring, farming practices, and a host of other new applications.*
7. **Data transactions** are the individual changes a business makes in its databases. *Business transactions will become a major source of data fueling the need for the management of spatial data bases organized by features.*
8. **Personal systems** are technologies and systems that either control or are controlled by individuals. *There will be increasing*

availability of technology that either controls or is controlled by individuals. The ability for everyone (and everything) to have spatial locators will create opportunities for new applications. There will be positive and negative implications relating to privacy and personal safety.

9. **Quality assurance/quality control** issues will have greater emphasis, particularly in the area of standards. *Workshop attendees advocated the use of metadata standards—in other words, standards for the documentation of data that include information on the data's quality. While users will continue to demand more relevant information on data quality and greater system accountability, much greater research efforts will be needed to define effective metadata standards.*
10. **Spatial literacy** defines the ability to understand and make effective use of spatial data. *The ability of people in schools and in the labor force to understand and use spatial data will increase.*
11. **Partnerships** are collaborations between various stakeholders in the spatial data community, including the public, private, and academic sectors. *The current trend to promote partnerships will continue in the area of public-private partnerships, where a competitive advantage can be achieved. Data utilities will emerge from such partnerships as suppliers of data operating within the paradigms characteristic of utilities.*
12. **Spatial data as a commodity** treats spatial data as a good that can be bought and sold. *Per-unit costs will decline, and technology will make it possible to put large quantities of data in the hands of the public. Consumer application growth will fuel the market for spatial data.*
13. **The control of data** includes data responsibility, cost, stewardship, access, and privacy. *There will continue to be conflicting forces to challenge policy makers. Advocates of public data will be challenged by security concerns, rights to privacy, intellectual property rights, and profit (or cost recovery) objectives.*
14. **Data collection agents** include such institutions as local, state, and federal governments, nongovernmental organizations, and commercial companies. *The trend toward local government data collection will continue. This will be brought about by continuing declines in federal government budgets and lower-cost*

technology at the local government level. Government cutbacks will cause agencies to focus on mission-specific data.

15. **Data security and protection** includes security problems and mechanisms to avoid them. *Concerns over security and data protection will cause some organizations to restrict public access to data. Security breaches will occasionally interrupt the information infrastructure.*
16. **Decision-making processes** cover the use of spatial data to make decisions at all levels. *The potential for higher-quality analyses and decisions (affecting the management and conservation of the environment and its resources) will increase from improved analytical tools and spatial data availability.*
17. **Citizen involvement** includes spatial data use, management, and access at those levels of government where ordinary citizens can participate. *The trend toward data collection at the community level and the greatly increased availability of technology by individuals will provide an expanded forum for citizen involvement in the decision-making process.*
18. **Privatization** concerns a shift toward the commercial sector for collection, ownership, and stewardship of spatial data. *While the workshop attendees did not rate this as one of the most significant changes, their statements suggested a trend toward increased privatization of data.*

4

A FORECAST

The forces and agents of change identified in early sessions of the workshop can be used to generate a forecast for the future. Some aspects of this forecast appear more certain than others. For example, it appears likely that technology will continue to increase in sophistication, speed, and information-processing ability. It is less certain how legislative bodies will deal with such issues as open access, intellectual property rights, patents, tax research credits, and market forces related to the development of that technology.

This chapter presents some of those forecasted certainties and uncertainties within a framework provided by the future forces identified in Chapter 2. When possible, the discussion, which parallels the forces, identifies both the pathways that will enable a particular forecast to emerge and the impediments that may prevent it.

TECHNOLOGY

The sense of the workshop participants was that there is a high probability that technology changes will continue to accelerate and that the growth rates of information and telecommunications technologies will increase. Wireless technologies will be part of that growth, which will help reduce the requirement for traditional infrastructure. It is less certain how new technological advances will be brought into society, how technological changes will be affected by existing mechanisms, or how the mechanisms themselves will change. For example, patents have a life of 17 years, technology purchases depreciate on 5-year cycles, and research tax credits are taken over 3 years. These time frames are already much longer than the life cycles of many new technologies and will become more so if the pace of technological change continues to accelerate.

Regardless of how technology diffuses into society, the workshop discussion indicated that "technological seepage patterns" probably will continue to impact our institutions. Global positioning systems have seeped into law enforcement, biological monitoring, and recreational applications. Likewise, emerging technological innovations will continue to seep into and change social and political institutions. Standards will probably be one of the enabling mechanisms for the coordination, adoption, and development of technology seepage. However, it is less certain how this technology seepage will change the workplace or what impact processing spatial data in the workplace will have on the definition of work, the role of workers, and the structure of working organizations.

ECONOMICS AND MARKETS

The evolution of the peacetime economy was identified in Chapter 2 as a major force driving the spatial data community. New applications for spatial data will continue to emerge, stimulating the continued growth of a spatial data industry providing data, software, and associated services. In Chapter 3 a parallel trend was identified toward privatization of spatial data functions traditionally associated with government. Partnerships between public and private sectors were identified by workshop participants as a significant pathway that can facilitate economic growth.

Despite these forces and changes, there continue to be many sources of uncertainty regarding the future. The concept of information as a commodity is still relatively new, and there is little experience with the problems associated with operating an open market in data. The necessary mechanisms to protect ownership of data and intellectual property may not exist or may be impossible to enforce in an age of open telecommunications.

While the current trend toward public-private partnerships may be driven by short-term economic considerations, in the longer term it is likely that social forces related to equity, access, accountability, and governance will become more important. But the extent of these arrangements will depend on how far organizations and individuals are willing to go in promoting the "community good," since it can often take more effort to cooperate than to act independently.

In the presence of such uncertainty, one way to effect change would be through the development of a coherent national policy on spatial data and technology. For example, consider current U.S. public policy and land information. Property taxes are the largest source of funding for local governments, mortgage interest is the most common source of large deductions from family income tax, and local taxes are deductible from federal taxes. Public policy as expressed in the U.S. tax code thus creates a demand for information, which in turn leads to information use and increased business for various elements of the spatial data community.

Workshop participants discussed many areas where legislative actions might impact the future of spatial data and technology, including patents, intellectual property rights, database liability, and tax research credits. Many of these issues will be discussed and resolved in a context that is much broader than the spatial data community and over which the spatial data community has growing but nevertheless limited influence.

ENVIRONMENT AND SUSTAINABILITY

The workshop discussion indicated that there is a high probability that environmental issues will continue to be important in national policy, but how the nation will deal with these issues is less certain. The concepts of sustainability and environmentally sensitive development also will be important in the national and international arenas.

Environmental degradation and reduction in biological diversity will probably remain issues, with implications for the robustness of the environment and its ability to withstand change. To date, environmental concerns, monitoring, and mitigation efforts appear to be dominated by problems caused by point sources, such as smokestacks or effluent discharge pipes. The nonpoint-source problems of agricultural runoff, groundwater quality, and watershed management require very different approaches to monitoring and mitigation. Increased instrumentation and measurement of the environment will provide a more complete, higher-resolution picture of the world in which we live and one that is better suited to addressing nonpoint-source problems. While we can be reasonably confident that spatial data technologies will emerge to make it economically feasible to collect and maintain such data, it is much less certain how these data will be incorporated into policy making or how the data will affect use and management of the environment.

THE INDIVIDUAL AND LOCAL GOVERNANCE

Education and governance emerged from the workshop as two important societal issues and forces. The current trend is away from a strong central government toward local autonomy and initiative, and it seems likely this trend will continue. It is much less certain how local solutions will be harmonized and synthesized upward and how such efforts will be funded. Workshop participants were generally confident that federal agencies and the bases of federal governance will be modified as part of and in response to this trend toward local autonomy.

In the short term, public-sector costs will probably rise faster than public-sector revenues, leading to continued pressure for public-private partnerships and other mechanisms for cost sharing. What will emerge from this reshaping of public-sector roles is uncertain.

Despite these structural problems, governments at all levels are likely to make use of a variety of mechanisms to stimulate the information industry and direct its course. New federal mandates may focus on building a modern information-age industrial community. State and local governments may see benefits to their communities that can be stimulated by tax incentives.

Workshop participants felt confident that new technologies would ultimately lead to the empowerment of many individuals through better and more rapid access to public data, the ability to present data in more persuasive ways, improved communications and technologies to support collaboration, and the power of the Internet and the World Wide Web for rapid publication and dissemination of ideas and data. In the future, public data sources will reflect transactions immediately, reducing or avoiding the lengthy delays that have traditionally impeded effective decision-making.

In the education area, workshop participants agreed that decisions about how we cultivate our human resources in grades K-12, in college, and beyond need to be made soon. Possible actions in this area range from developing a means to accommodate the older student, to adding spatial thinking to kindergarten classroom instruction. There is certainty that the society of 2010 will require increased use of spatial data and spatial thinking in problem solving, at scales from the human genome to the human body to the environment to galaxies. There is a transition in systems planning that involves greater citizen participation, which could require different types of users and uses of spatial data. It remains uncertain whether the citizens of this nation will be adequately prepared in 2010 to reason spatially or to deal with spatial data.

5

SCENARIOS

The workshop broke into small groups, each elaborating on one of the four scenarios for the future discussed by Wegener and Masser (1996).* Their paper was intended to provoke response, and their scenarios adopt extreme positions based on emerging prominence of specific forces. The small groups worked from the premises laid out in the four scenario statements to identify positive and negative implications, stakeholders, and possible consequences for access to and use of spatial data. The Wegener-Masser scenarios were largely European based, and the small groups adopted a U.S. perspective in their discussions.

The purpose of this exercise was not to produce scenarios that are likely to occur, but for workshop participants to look beyond the status quo and examine what might happen without any system of checks and balances. The value of such an exercise in *scenario building* is twofold. First, it provides insight, through positive and negative outcomes, into what might occur if there are major societal shifts. Second, by systematically shifting assumptions about the future, we can assimilate different outcomes of current policies and approaches.

The names adopted for the four scenarios are those suggested by Wegener and Masser. The *trend scenario* is characterized by incremental diffusion of information systems along the lines experienced in the past. The *market scenario* extends current tendencies toward commodification of information, which restricts access to information to the more powerful. The *big brother sce*

* Michael Wegener and Ian Masser, "Brave New GIS Worlds," in Ian Masser, Heather Campbell, and Max Craglia, eds., *GIS Diffusion: The Adoption and Use of Geographical Information Systems in Local Government in Europe*, Taylor & Francis, London, 1996.

nario dramatizes the potential of geographic information systems (GIS) to be used for surveillance and control by fully integrated omniscient systems, which pervade all aspects of life. The *beyond-GIS scenario* speculates on how information in the public domain might contribute to greater democratization and grassroots empowerment. The beginning portion of each of the following discussions is a brief summary of the respective Wegener-Masser scenario.

THE VALUE OF SCENARIO BUILDING

Scenarios are alternative environments in which today's decisions may be played out. They are not predictions. Nor are they strategies. Instead, they are descriptions of different futures specifically designed to highlight the risks and opportunities inherent in specific strategic issues. Alternative scenarios provide a way of focusing on the future without locking in on one forecast to the exclusion of other possibilities.

At one level, scenarios can help overcome anxieties about the lack of evidence regarding the future, because scenarios do not claim to be predictions. Since we have no way of knowing which of the critical elements in our present environment will prevail in the future, we build existing uncertainties into different possible models of the future. The point of creating a set of scenarios is not to gather evidence to determine the most probable future, but rather . . . to make your stance to the future—which may change moment to moment, situation to situation—visible to you.

From the June 1995 issue of the Global Business Network's (GBN) publication, *The Deeper News*, which features a report that GBN completed for the National Education Association.

TREND SCENARIO

The trend scenario is characterized by incremental diffusion of information systems along the lines experienced in the past, effectively envisioning a future that might result if current trends continue. Wegener and Masser describe a 20-year period (through 2015) of incredible technological innovations with quick market penetration. Spatial data are widely available, and GIS technology is embedded almost transparently in day-to-day activities. In the United States, regional disparities in spatial data literacy are apparent among local administrative units (government and utility infrastructures). Disparities between professions are still evident. Elsewhere one still sees national discrepancies in citizen access to spatial data, although national level spatial data collection has been resolved in most countries. Occasional reports appear in the news media on gross inefficiencies in public-sector spatial data use. Despite this, legal decisions are more commonly based on GIS-processed data than in the past.

Under this scenario, in the United States data would be available to everyone, business would experience a growth boom, and citizens would find a tremendous amount of individual freedom. GIS technology would be universal and transparent. The average citizen would be unaware of the extent to which decision-making would be based on imperfect technology or data. Spatial data would be available, and the technology for data access would reside in most consumer households. Responsibility for locating data and assessing fitness for use would rest with the private citizen. A generation gap in literacy would be evident, since schools would be using GIS in the normal curriculum, but older adults would find it increasingly difficult to keep abreast of the newer aspects of the technology. Spatial literacy would be evident in school children at an earlier age. Over time this generational discrepancy would likely disappear.

Data would simply appear on the Internet. There would be no clear mandates for ownership or responsibilities for maintenance and collection. This could result in greater redundancy and its associated costs. Technological advances would continue. Software would be available commercially, more often in the form of individual applets than as integrated monolithic packages or software suites. Data delivery technology would become integrated, and conglomerates for data transmission would proliferate. At the private citizen level, data transmission service providers might continue in corner storefronts, expanding on the current services provided by Kinko's and similar vendors.

Many positive implications can be predicted for stakeholders, a class including state and local government agencies (i.e., nonfederal) as well as commercial-sector data producers, and citizens. All three types of stakeholders would experience tremendous operative freedom. Producers would benefit from increasing business opportunities. Decentralized data production and a lack of centrally adopted data standards would reduce some production costs and allow for redundant products to compete in the marketplace. Support for a national spatial database would likely wither in the face of private-sector market pressures. For the data consumers, levels of uncertainty about data availability and quality might increase. "Let the buyer beware" would be the unspoken credo. Risk and liability issues would be unresolved, and court cases would continue to proliferate. All three classes of stakeholders would experience this consequence.

Negative consequences of the trend scenario also surfaced during discussions at the workshop. One negative consequence would be that, although a huge volume of spatial data would be available, and much would be in the public domain, only the educated elite would likely be aware of their existence or be able to assess the quality of the data.

The task of data certification would become much more prominent than before because of the ease of data dissemination and lack of effective standards. Data certification would likely become privatized and decentralized, with analysts specialized for specific applications or geographic regions.

This scenario proposes that the current trend away from centralized production of spatial data by the public sector will continue, placing huge responsibilities on the shoulders of data consumers. It would be more risky to remain a passive user of information, yet more people would be unaware of the potential consequences in the face of omnipresent and transparent technology. Under the "buyer beware" principle, untrained consumers (individuals and agencies) might trust in data as long as errors or inconsistencies were not discovered. The best defense against these negative consequences would be to ensure that robust curricula for spatial literacy are installed in schools at all levels of education.

MARKET SCENARIO

Under the market scenario, current tendencies toward commodification of information accelerate rapidly. In this future the information industry becomes the largest and most powerful economic sector. Communications technology has completely integrated telephony, video, data, and text, and all transactions are logged in a network. Transactions are geocoded such that geographic location and electronic (topological) location on the network link electronic ordering and sales transactions with efficient delivery of physical items. Because of its potential value to marketers, control of network information has become a source of economic power.

The factors that lead to this scenario are varied, but all are present at some level in most systems. The indicators for this scenario follow progressive steps toward privatization from today's level of public control. Each item in the list below brings society closer to privatization.

- As data copyright protections increase, profit incentives (to produce data) increase.
- There is an increase in the number of businesses adding value to spatial data.
- Citizens increase their demands to reduce public spending overall.
- Concerns about surveillance and invasion of privacy fail to capture popular interest.
- Industries that monitor and control consumer credit continue to grow.

If these trends were to continue, information about more individuals would be recorded in central (proprietary) databases, and there would be an increase in logging of commercial transactions, allowing more effective monitoring of monetary flows. Opportunities to make a profit from monitoring and surveillance would arise; personal surveillance by corporate entities would be increasingly accepted; and corporate entities would merge to ensure a competitive edge. In these ways, privatization would begin to drive the generation of, use of, and access to spatial data and spatial data tools.

Wegener and Masser discuss privatization occurring at all levels of government and the increasing homogenization of jobs. In developing nations, jobs would be tied to the production of goods. In developed nations, jobs would primarily entail the handling of information. As privacy legislation becomes harmonized, it would remain legal to ". . .collect and trade data on individuals as long as the information appears to be correct" (Wegener and Masser, 1996). A market for value-added data services would develop, as well as consumer services for virtual tourism (imagine a virtual vacation to ancient Rome). Other rapidly growing markets, such as utility planning, facility management, and vehicle tracking and navigation systems for the rapidly growing Intelligent Vehicle-Highway Systems industry, would place opportunities for citizen surveillance squarely in the hands of large corporations. Marketing strategies could be developed and implemented with surgical precision. As Wegener and Masser comment: "As with today's video games, customers were lured into buying cheap hardware to make them captive to expensive software."

This scenario describes a period of creative turbulence and confusion. Spatial information of any commercial value would be repeatedly encoded because there would be little commercial incentive for sharing or interoperability. Proprietary databases would vary in reliability, and incompatibility would become a common protection against data theft. Customized designer information could be created for specific purposes of individual clients. The notion of what is correct information would undergo a subtle change, and litigation skills would remain in great demand. One might see citizen participation in local planning and governance wither in the absence of public-domain spatial data. The higher costs of access to information from rural areas or inner cities would be important in this balance. "There is a widening gap between the information-rich and the information-poor, between those who participate in the information society as providers and manipulators of information and those who participate in it only as consumers and have access only to manipulated information" (Wegener and Masser, 1996).

In summary, this scenario is marked by private-sector domination of the collection and dissemination of spatial data and associated services. Many corporate consolidations can be predicted, and the reduced number of players would be very competitive. The links between spatial literacy and economic power lead to greater and widening inequities. Personal monitoring and surveillance would be conducted by private entities for the purpose of making a profit. One consequence of privatization would be that most network information would be proprietary; a second would be that government would likely pay real market costs for data traditionally produced by itself.

BIG BROTHER SCENARIO

The big brother scenario dramatizes the potential of GIS to be used for surveillance and control by fully integrated, omniscient systems that pervade all aspects of life. This third scenario of Wegener and Masser is characterized by increasing centralization of authority over access to, and distribution of, spatial data and GIS tools. A driving force for this future is reduced budgets coupled with lack of government responsiveness to rising crime and environmental catastrophe. The situation has instilled personal fear, together with political and social unrest. Information systems lack the accuracy and precision to resolve litigation relating to commercial and land-record disagreements.

Indicators of this scenario would include rising fraud and corruption, rising white-collar and violent crime rates, increased dissatisfaction with governmental responses to natural disasters and social crises, increased visibility of real estate litigation, and terrorism against the information infrastructure at all levels (local to national). Authority over information systems and information technology would be centralized to regain control.

As a result, the government in this scenario would regulate database accuracy and access. Artificial intelligence tools would be used to assess data quality. Access to information by the average citizen would be limited as a protection against terrorism. Individual commercial transactions and movements would be tracked. Taxation would become increasingly linked to commercial transactions, possibly in the form of a value-added tax, to preclude opportunities for evasion and tax fraud. At the limit, this scenario would completely replace the present internal revenue system.

Vehicle tracking and personal positional tracking would be used to monitor daily movements (of all sorts, from consumerism through journey-to-work), justified by the need for societal protection and alerts in the event of environmental catastrophes, as well as to predict and respond to demands for improved transportation networks and infrastructure. Centralized GIS training programs would be implemented that sidestep the existing education infrastructure. These tools would be designed by the most prominent GIS experts and delivered at all levels (K-12 through lifelong learning) of curricula.

In the Wegener and Masser scenario, the average citizen feels secure. There is a loss of individual privacy, since personal surveillance is encouraged and even enforced. Spatial databases become fully integrated and allow easy linkages of all types of personal information. Those who do not participate are marginalized in society, effectively isolating those living in poverty or indicted for crimes. Interestingly, much of the big brother scenario is market driven. Wegener and Masser (1996) comment that global economic dominance drives the move toward data integration. They also state that ". . . spatial information which is freely available to everybody is intrinsically dangerous, whereas in the hands of the corporate state it can guide a society to achieving its highest economic potential."

As positive consequences, personal location devices would likely enhance public safety and deter incentives to violent crime. Emergency response and government agencies would be able to evacuate people from disaster areas more quickly. The Centers for Disease Control could better monitor the spread of infectious disease. A value-added tax on financial transactions could eliminate personal income tax. Improved traffic flow and efficiency could reduce the stress on renewable energy resources and on maintenance of the transportation infrastructure. Goods would move more efficiently, which would benefit commerce. The introduction of artificial intelligence technology could reduce fraud and abuse. Increases in database accuracy might reduce calls for litigation. On the negative side, GIS educational reform that brings spatial literacy to qualified students nationwide would not be offered to those outside the surveillance net, implying the exclusion of children of the poor, children of political dissenters, or social outcasts.

BEYOND-GIS SCENARIO

The beyond-GIS scenario speculates on how information in the public domain might contribute to greater democratization and grassroots empowerment. In Wegener and Masser's description, the

GIS boom ends in the late 1990s, coincident with a major change of values favoring a revival of grassroots democracy.

"The shift benefited local government GIS. As local self-governance and local planning reemerged as a central forum of political debate, local government GIS became even more important in the form of decision support systems for local land use, transport, and environmental planning. In particular, the need to redirect urban development towards sustainability gave an unexpected boost to local government GIS as it became apparent that environmental analysis in fields such as air pollution, noise propagation, vegetation, wildlife, or microclimate required a more disaggregate spatial scale than conventional aggregate methods" (Wegener and Masser, 1996).

In the big brother scenario, databases are large and centrally maintained and are applied by experts to the solution of society's problems. In this new scenario there is deep skepticism regarding such central solutions and a strongly held belief that society's problems can be solved only through participation of citizens at the local community level. The effect of new technology would be seen most clearly in the empowerment of individuals, and the ability to incorporate local knowledge into the databases used to find solutions to problems. The spatial data industry would become decentralized, adding value to local data and providing services to local communities. Users of a database would be able to spot errors and correct them based on their familiarity with the area, leading to substantially higher quality in both data and solutions to problems.

The beyond-GIS scenario represents a major departure from many aspects of current practice. In addition to a different approach to the collection and assembly of data, involving much greater levels of local participation and control, it would require the development of decision support tools that emphasize collaborative decision-making and provide support for alternative perspectives and thus go far beyond the designs of the current generation of GIS.

The small group examining this scenario undertook the exercise of itemizing the positive and negative effects on specific stakeholders. The beyond-GIS scenario would have positive effects in citizen satisfaction, overall spatial literacy, local sustainability, and protection for individual autonomy. The scenario would benefit the GIS market because it implies demand for a new generation of GIS tools. Value is placed on personal privacy. The shift toward public control of spatial information places librarians and educators in the center of mediating between data producers and consumers in this scenario. The scenario provides a potential role for integrators of data and commercial services that add value to data. The scenario would create a demand for academic research that is more applied and more locally driven. Local community colleges would benefit, with increasing demands by local citizenry for literacy training.

The negative consequences relate to the possibilities for local isolation and reluctance to preserve vertical and horizontal integration of data and decision-making tools. Wegener and Masser also indicate that participatory planning may become excessively time consuming because of increased awareness and active participation. Have-not communities could emerge. There could be problems maintaining local standards, and this could restrict movement of data. There could be impacts on the credibility of federal and state stakeholders and problems with the vertical integration of data from local to national holdings in the absence of standardization. Large utility companies could experience a negative impact, but local utilities would benefit. Individual citizens would benefit, particularly in well-off communities, but "outsiders" would not have opportunities to participate in decision-making.

6

WORKSHOP RESULTS

Not surprisingly, the workshop reached no conclusive consensus on the future of spatial data and society. Consequently, the results of the workshop as summarized in this report consist of ideas and issues drawn directly from the workshop in addition to issues arising from subsequent discussions of the Mapping Science Committee. This chapter contains lessons learned from the workshop including an evaluation of the workshop mechanisms and new insights about the national spatial data infrastructure (NSDI). Additionally, it contains sections on strategic planning as it relates to organizations that have a stake in the future of spatial data and a set of questions about major strategic decisions.

LESSONS LEARNED

Workshop Mechanism

Organizers of the workshop made use of several mechanisms for encouraging participants to think creatively about the future of the NSDI: circulation prior to the workshop of background documents and white papers and an agenda that broke the meeting into three stages of facilitated discussion, first identifying external driving forces, then enumerating anticipated changes, and finally considering four alternative scenarios.

It goes almost without saying that thinking creatively about the future is difficult. Our imaginations are dominated by present and past experiences and, while the human brain's powers of reasoning are normally very effectively based on learning by analogy and recognizing patterns, these characteristics naturally work against us when attempting to speculate about an uncertain future. Presented with a new technology, our natural inclination is to put it to the same context as the old and to evaluate it on that basis. Thus, the first automobiles were evaluated as carriages in which the horse had been replaced by the internal combustion engine and the first computers as calculating machines. These legacies of old technologies are important in the short term but must be put aside if we are to think clearly about the impacts of new technologies a decade and a half from now. Nicholas Negroponte, in his book *Being Digital*, notes that much of his creative input in speculating about digital futures comes from listening to teenagers, who approach new technologies relatively free of the constraints that legacy ideas impose on the rest of us.

Unfortunately, no teenagers were available to participate in the workshop. Moreover, assuming that creative ideas are comparatively rare outliers, the democratic processes of workshops, particularly when facilitated in the interests of consensus building, may work directly against creativity. In that sense the discussion that is provoked by the publication of this report may have greater value in the long run than the report itself.

The Importance of Spatial Data

While the NSDI is by now a well-entrenched and well-recognized concept, discussions at the workshop remind us of the role of spatial data in the much broader changes now occurring as society moves forward into the information age. In many areas the problems of spatial data are merely echoes of much broader concerns. In others, however, they are distinctive. While both types were discussed at the workshop, the emphasis there and in this report has been on the latter. For example, it would be difficult if not impossible to make sense of the four Wegener and Masser scenarios discussed in Chapter 5 if the word "spatial" were replaced with some other type of data, however well defined. The vast majority of the points made in this report apply more or less exclusively to spatial data; in that sense there is, indeed, something special about "spatial."

National Spatial Data Infrastructure

In earlier reports, the Mapping Science Committee took the view that the NSDI should not be limited to datasets or to the technology for assembling, disseminating, and processing them but should be defined as the entire means to assemble geographic information, including the materials, technology, and people necessary. The workshop provided strong endorsement for that view, amply justifying the decision to adopt a broad definition that could accommodate technological change, focusing instead on the purposes that technology serves. In the future it will be more important than ever that the NSDI continues to be responsive to societal needs, politically relevant, and economically viable.

STRATEGIC PLANNING

The last session of the workshop reviewed the forces, trends, and likely outcomes for spatial data in the next 15 years. The implications of these outcomes for local, regional, state, and federal agencies and the entire spatial data community were discussed in terms of future concerns, workshop observations, and cautions. As with the previous sections, the committee summarized these observations and findings.

It is the Mapping Science Committee's sense that most workshop attendees think it is more likely that the spatial data community will influence rather than change the course of society to any significant degree. However, workshop participants were given the opportunity to look at the specific implications of a wide range of future forces on the spatial data community, first by identifying external forces likely to drive changes, then by identifying specific changes, and finally by discussions framed by four alternative-future scenarios.

These three stages of the workshop provide a template for strategic planning with wide applicability to organizations, agencies, and groups in the spatial data community. To frame its strategic planning within the template outlined in this report, an organization might ask itself the following questions:

1. How important to the organization are the past and future driving forces identified in Chapter 2, and should other driving forces of particular significance be added to the list?

2. How significant to the organization are the changes identified in Chapter 3, and should other changes of particular significance be added to the list?
3. Could society or the community change so dramatically that it would alter the demands on the organization or job?
4. What will be the impacts of the decisions proposed in the organization's long-term strategic plan if parts of the scenarios discussed in Chapter 5 materialize?
5. Is the organization's long-term strategic plan sufficiently flexible to accommodate several alternative future scenarios?
6. What future scenarios would be incompatible with the organization's long-term strategic plan?

STRATEGIC QUESTIONS

Organizations and stakeholders within the spatial data community will be making many strategic decisions and choices in the coming years. In some cases a choice may directly influence the path of society toward one of the Wegener and Masser scenarios. This section presents a series of questions that could be asked about a major strategic decision and that might help elucidate a decision's implications. Each question addresses one or more issues of fundamental significance for the future of the NSDI.

Questions for Partnership Initiatives

1. Does the partnership arrangement achieve shared financial and management control and benefits among all participants?
2. Does the partnership arrangement account for proposed or anticipated demand for the information generated, used, or assembled by the partnership activities beyond the life of the activities?
3. Does the partnership arrangement address issues related to information liability, public records management, commercialization, copyright, and third-party distribution of databases in the present as well as into the future?

4. What level of government, partnership, or commercial authority is best to establish the institutional owner of the information to guarantee long-term viability, accountability, and cost effectiveness of the public funds?
5. Have differences of professional terminologies and standards among the partners been identified and understood?

Questions for Data Suppliers

1. How will your organization develop information policies to balance the rights of the individual against the community's right to know? What information should be secure and what should be public?
2. How will your organization assimilate real-time or near-real-time data into information policies? As the gap between collection and use shortens, how will updates, dissemination, security, access, quality assurance, and information integrity be managed?
3. How will your organization take advantage of data collected from nontraditional sources?
4. How will your organization manage personnel, technology, and information as it changes from production operations to partnerships?
5. How will your organization adapt its investment strategies to respond to rapid technological change and yet ensure cost-effective access to current technology?
6. Is your organization prepared to provide data in full immediate digital form, and are your customers ready to receive the information?
7. Is your organization prepared to certify the quality and timeliness of its data?

Questions for Education and Research Initiatives

1. What will be the impact of this initiative on equity of access to future technologies?
2. How will alternative future scenarios for intellectual property rights impact this initiative?

3. What degree of access will midcareer professionals and traditionally under-represented groups have to this initiative?
4. Does this initiative emphasize training in the current state of the technology or education in its underlying principles?
5. Is this proposal for applied research to address immediate problems or basic research on longer-term, fundamental issues?

Questions for Other Organizations

1. As a user of data produced by others, is your organization provided with appropriate quality and timeliness certification, and are you able to make use of it effectively?
2. Is your organization prepared to manage information in an environment where data are ubiquitously available on demand using wireless technology?

SUMMARY

As noted previously, the workshop and this report are intended to be one step in a continuing dialogue on the future of the NSDI, as a collective vision is developed of the role it will play in society in the coming decades. The NSDI is comprised of consortia in which all stakeholders in the spatial data community play important roles, whether as federal, state, or local governments; corporations; academic institutions; or individuals. The NSDI must function as a forum for continuous dialogue, as a mechanism to promote research and education, and as a source for numerous partnerships and collaborations.

The committee hopes this report will serve to stimulate continuing dialogue in the coming months and years and help inform policy and advisory groups that make decisions and develop strategic plans for the long term. Although this report is not definitive, it may serve as a starting point, to be modified and enhanced through ongoing debate and discussion of the NSDI in the future.

APPENDIXES

APPENDIX A

WORKSHOP PARTICIPANTS

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* Breakout group facilitator.
† Workshop facilitator.

APPENDIX B

BACKGROUND PAPERS

PUBLISHED ARTICLES

Steven D. Dorfman, "Satellite Communications in the Global Information Infrastructure," *Revolution in the U.S. Information Infrastructure* , National Academy of Engineering, Washington, DC, 1995.*

Xavier R. Lopez, "Stimulating GIS Innovation Through the Dissemination of Geographic Information," *Journal of the Urban and Regional Information Systems Association* 8(2), (Fall 1996), University of Wisconsin Press: Madison.

John E. Major, "Current Trends and Likely Futures in Wireless Systems," *Revolution in the U.S. Information Infrastructure*, National Academy of Engineering, Washington, DC, 1995.*

John S. Mayo, "The Evolution of Information Infrastructures: The Competitive Search for Solutions," *Revolution in the U.S. Information Infrastructure*, National Academy of Engineering, Washington, DC, 1995.*

Harlan J. Onsurd, Jeffrey Johnson, and Judy Winnecki, "GIS Dissemination Policy: Two Surveys and a Suggested Approach," *Journal of the Urban and Regional Information Systems Association*, University of Wisconsin Press: Madison.

Michael Wegener and Ian Masser, "Brave New GIS Worlds," in Ian Masser, Heather Campbell, and Max Craglia, eds., *GIS Diffusion: The Adoption and Use of Geographical Information Systems in Local Government in Europe*, Taylor & Francis, London, 1996.

Lawrence Wilkinson, "How to Build Scenarios: Planning for 'Long-Fuse, Big Bang' Problems in an Era of Uncertainty," *Wired*, 1995.

* *Revolution in the U.S. Information Infrastructure* is available at the following URL: http://www.nap.edu/readingroom/books/newpath/.

PAPERS PREPARED FOR THE WORKSHOP

The following white papers were prepared and distributed to the workshop participants as provocative authored articles; they were designed to stimulate thought and were not peer reviewed. The full papers (generally 4 to 5 pages) are available on the Worldwide Web at http://**www2.nas.edu/besr/224a.html.** This web site will be maintained at least through the end of 1998.

1. Research Mechanisms, *Michael F. Goodchild and Michael J. Folk*
2. Local Thinking About the National Spatial Data Infrastrucure: How Will Rural Local Governments Access the Information Superhighway?, *University of Wisconsin-Madison NSDI Seminar Participants*
3. Comments on Law and Government Mechanisms, *Lee C. Gerhard*
4. Winds of Change, *Hugh N. Archer*
5. Spatial Data Partnerships in the Knowledge Age, *John D. Bossler and Michael O. Varner*
6. Spatial Data in the Classroom: A Vision for Education, *Barbara P. Buttenfield and Sara L. McLafferty*
7. Promoting the Educated Use of Spatial Data: The Internet, Worldwide Web, and NSDI, *Kenneth E. Foote*
8. The Final Stages of Land Records Modernization and Their Associated Benefits: The Pot at the End of the Rainbow?, *David L. Tulloch, Bernard J. Niemann, Jr., Stephen J. Ventura, and Earl F. Epstein*
9. One-Meter GSD Imagery from Space: Not Just Better Spatial Resolution, *Jon D. Dykstra*
10. A Look Back 10 Years, *Nancy von Meyer*

APPENDIX C

WORKSHOP AGENDA

THE FUTURE OF SPATIAL DATA AND SOCIETY
MAPPING SCIENCE COMMITTEE
FEDERAL GEOGRAPHIC DATA COMMITTEE
WORKSHOP
April 24-25, 1996
Agenda
Workshop Objectives

- Identify forces affecting the future of spatial data
- Discuss and anticipate possible futures for the collection, dissemination, and use of spatial data
- Identify implications of the anticipated futures from local, regional, national, and other stakeholder perspectives
- Identify cautions, suggestions, and directions to the spatial data community based on the identified futures

Wednesday, April 24, 1996	
7:45 a.m.	Continental breakfast
8:30	Welcome, introductions, and agenda review
8:45	Plenary presentations; questions and answers
	John B. Evans
	Michael R. Curry
10:30	BREAK
10:45	Panel Presentation; questions and answers
	Nancy von Meyer (Moderator)
	John D. Bossler, Xavier R. Lopez, Bernard J. Niemann

11:45	LUNCH
12:45 p.m.	*What societal forces will affect the need for collection and use of spatial data?* (Exercise in small groups)
1:45	Plenary review of small-group results
2:15	BREAK
2:30	*What does the future hold?* (Small-group discussions to identify anticipated changes)
4:10	Plenary review and discussion of small-group visioning results
4:35	Plenary discussion with Mark Schaeffer, *Deputy Assistant Secretary, U.S. Department of the Interior*
5:00	RECEPTION/DINNER
	Reception and dinner provided by Intergraph Corp., Rand-McNally & Co., and ETAK

Thursday, April 25, 1996

8:00 a.m.	Continental breakfast
8:30	Welcome and agenda review
8:45	*What are the key questions raised by the identified future(s)?* (Full-group identification and discussion)
9:45	*What are the implications of the identified future(s) for stakeholders in spatial data and for society as a whole?* (Small-group identification and discussion)
10:30	BREAK
10:45	Plenary review of small-group results

11:30	*What issues should we as a community be addressing?* (Small-group discussion and exercise)
12:30 p.m.	LUNCH
1:30	Full-group review of "questions to be answered"
2:00	Generation of cautions, suggestions, and statements to the field
2:30	BREAK
2:45	Continuation of cautions, suggestions, and statements
3:15	Next steps
	• Plenary discussion of what will or should happen with the product of the workshop • Reflections on the process
4:00	ADJOURN

APPENDIX D

TIME LINE OF SIGNIFICANT PAST EVENTS AND FORCES

As they registered, worksop participants were directed to a long sheet of newsprint on one wall of the plenary meeting room. Across the top of the paper was a time line beginning with 1950 and reaching to 1996. (The beginning of the time line was later moved back to 1900.) The paper was further divided horizontally by a line. The area above the line was labeled "events," the area below the line "forces." Participants were to write on the paper those events or societal forces they knew about that had propelled the collection, dissemination, and use of spatial data to the present day. The results are presented below. There is no correlation between an event and a force in any given year. *This is not meant to be an all inclusive time line and the committee recognizes that it reflects the biases of the participants. No attempt was made to remove any bias. The accuracies of specific dates were not verified.*

Time	Event	Force
1910	• International Society of Photogrammetry and Remote Sensing formed	
1940		• Post-WWII attitudes to science & technology
1950		• ILIAC
	• Atlas of British meteorological maps	
1955		

Time	Event	Force
1957	• Waldo Tobler at University of Wisconsin • First digitizer • COBOL invented • U2 high-altitude photography for mapping • Computerized atlas of British flora	• Sputnik
1960		• Growth of environmental awareness
1961	• Formated file system invented by IBM	
1962	• First satellite mapping camera (Unamace AS-11)	• Civil disobedience (beginning confidence in questioning authority and in significance of grassroots initiatives)
1963	• Sketchpad (MIT)	• Military-geo info computerized as GIS for battlefield • First radar map system
1964	• Ready-React produces digital map for the White House • GPS specifications developed by DOD • SYMAP • Bruce Cook, Australia on topology • Chicago transportation studies (Duane Marble)	
1965	• CGIS • LINMAP	• Drugs/Flower children
1966	• Electrostatic printer	• Vietnam War • WGS-66
1967	• Soil cell digitizing (MIADS) • New Haven study • ECU launched • Harvard lab	
1968	• MLMIS	• Relational database defined by E. F. Codd
1969	• First spatial data transfer standard published (by ECU) • LUNR	

Time	Event	Force
1970	• Tektronix 4010/4014 • M+S • Integrated circuit	
1971	• Blue-ribbon committee creates DMA • Local governments begin using networks to compute travel times for fire, police, siting, with assistance from NBS and HUD; First application of GIS • ERTS/Landsat-1 • GBF DIME • First computer-produced multicolor map in standard series (ECU/BGS)	
1972	• Nixon's order to consolidate all DOD mapping • Graphical user interface • HUD USAC project	• WGS-72
1973	• Ordnance Survey starts digitizing 230,000 maps	
1974	• ALTAIR (personal computer) • Endicott Holse topological data structures • Electric pencil • UNIX	
1975	• Federal Mapping Task Force • IBM's GFIS • PIOS/GRID	
1976	• Automated map scanner for soil maps (computer vision) • GIRAS	• Mandelbrot's first book on fractals • Larson report
1977	• COMARC • Digital line graph (DLG) • Raster-to-vector technology • Defined standards for DTED-DEAD pads	• Need to handle large volumes of spatial data • APBS field use of photogrammetry
1978	• IMA GIS for advanced weapons, cruise missile simulators	

Time	Event	Force
1979	• DIDS • RESPA • World CGA creation of hypermedia	
1980	• NRC multipurpose cadastre report • Arpanet creation • FEMA integration of USGS 1:2 million maps, first wall-to-wall digital map • NCDCDS initiated	
1981	• FICCDC formed (Federal Interagency Coordinating Committee on Digital Cartography) • Large-Format Camera Mission	• Bill Gates talks with IBM
1982	• Digital photogrammetry	• 8088 chip; IBM personal computer
1983	• ETAK formed	• USGS/Census MOU • NAD-83 (North American Datum)
1984	• University-use "internet" • SPOEM • Radio Shack M-100 • DMA DPS initiated • Dane County Land Records Project	• Client-server RISC chip • WGS-84 • 80286 computer
1985		• First GPS satellites launched
1986	• Burrough published	
1987	• Mapping Science Committee formed	• 80386 computer
1988	• First public TIGER files • NCGIA created	• Berlin Wall comes down
1989		
1990	• FGDC formed • DLPO	
1991	• National Digital Ortho Program • DMA DPS IOC • USGS topo series completed	• 80486 computer • Dissolution of the Soviet Union

Time	Event	Force
1992	• DMA GGIS initiative • DHI (MSDDD) • NSGIC formed	• OMB Circular A-130
1993	• NRC Report *Toward a Coordinated Spatial Data Infrastructure for the Nation*" • Spatial data on Internet • GIS on NT • Spatial data transfer standard	• National Performance Review (NSDI issue paper) • End of Cold War • Pentium computer (P5)
1994	• MSC *Partnerships* report • FGDC framework report • Open GIS Consortium established • WWW hypertext • ISO TC 211	• Executive Order 12906
1995	• FGDC clearinghouse • FGDC metadata standard • Windows 95 operating system • TVA geographic partnerships • GIS brought forward as force of change at U.N. HABITAT-2 conference • Ordnance Survey finishes digitizing 230,000 maps	• Defense Science Board report on *Defense Mapping for Future Operations* • Congress "allows" 1-m imaging from space • Oklahoma City bombing • Concept of an IPT formed • P6 computer
1996	• OGIS Spec. V1	• GPS—selective availability scheduled to be turned off

APPENDIX E

TABLES OF ANTICIPATED CHANGES

As discussed in Chapter 3, the Mapping Science Committee grouped the 139 statements of anticipated changes that emerged from the five working groups into the following tables. The groupings are not unique; individuals could take the anticipated change statements and develop their own groupings. Within each table the changes are approximately ordered by "voting" within the respective working groups that developed the statement. As discussed in Chapter 3, these rankings, although interesting as a way of focusing discussions, were not consistent—some groups emphasized the significance of a change, others emphasized the likelihood of a change.

Table 1. Basic Computing Technologies

Anticipated Change
Computer technology two orders of magnitude faster
Continued miniaturization of electronics
Miniaturization
Wireless will be major technology for distribution of spatial data
Publicly available navigable databases
Greater bandwidth for data transmission/wireless
Saturation of wireless communication
Urban density increased, and rural density decreased, in response to limited bandwidth

Table 2. Analysis, Visualization, and Cognition Technologies

Anticipated Change
Virtual reality will change way to conceptualize and use spatial data
Spatial data as the GUI to all information fundamental
Emergence of n-dimensional geotemporal systems (holodeck)
New technology will distill information products from data glut
Virtual reality interface with GIS
Software tools sort and search heterogeneous data for relevant data

Table 3. Pervasiveness of Technology

Anticipated Change
Greatly increased involvement of spatial data in litigation
Intuitive and helpful user interfaces (Turbo Tax Deluxe '96); boss becomes data voyeur
GIS will be enterprise-wide
GIS standard office software
Consumer application growth will drive down costs and increase and pay for infrastructure
MS Windows 2010 has GIS embedded
Personal fulfillment (recreational) data needs will dominate the growth of the GPS/GIS data industry
More flexible and usable "maps"

Table 4. Data Integration

Anticipated Change
Satellite communication-based systems that integrate data
Spatial data more embedded and transparent
Integrated networks of spatial database servers (free access/pay per view)
Integration of collection, use, and dissemination of spatial data
Spatial data undifferentiated and universally available
Major advances in generalization will allow "scaleless" spatial data
Adoption of family of standards by users and developers; data and metadata
Greater standardization in data categories for collection (standards based on needs of most users)
Technology replaces need for single standards
Global data infrastructure established with sparse data coverage
Information on every illness is geolocated and available to the health industry
Time, along with the three spatial dimensions, is routinely encoded
Period of revolt against standards before we get it right
GPS and georeference of all government and commercial activities
New scientific understanding of physical/chemical/biological processes will cause demand for new classes of information
All appropriate data will be spatially referenced
Internet enables the integration of all data

Table 5. Timely Data Collection and Use

Anticipated Change
Instrumentation of the environment will become the major source of real-time spatial information (e.g., traffic, weather, pollution)
Wide availability of cheap, accurate, high-resolution imagery —real-time delivery
Real-time Earth-observing satellite data available
Real-time data collection on everything
Time lag between data collection and use moves toward zero
Maps on demand
Much spatial information will be collected ad hoc
Just-in-time dynamic mapping
Real-time aircraft-based digital mapping
Data on demand—driven by changing needs
On-line data distribution will be prevalent
Real-time dissemination
Global, comprehensive, persistent imaging of the Earth

Table 6. Intelligent Instrumentation

Anticipated Change
Instrumentation of the environment will become the major source of real-time spatial information (e.g., traffic, weather, pollution)
Individuals as data input "nodes"
Automated vehicle navigation a reality—precision farming
Individual vehicles will be data probes
Use of biological identification techniques

Table 7. Data Transactions

Anticipated Change
Customer transactions drive spatial data creation and maintenance (records create maps rather than vice versa)
Much spatial data will be collected via transactions
Automated data collection in common use/transactions to DBMS
Spatial data collection as transaction to DBMS
Widespread, recurrent, transaction-based satellite data production-high resolution, multispectral
Transaction collection, dissemination, use
Digital property searches/transactions

Table 8. Personal Systems

Anticipated Change
Everyone will be able to have a spatially enabled communicator
Positional devices on everyone and everything
Personal recognizance systems
Personal (cell phone) appliances that determine location and integrate with network
Use of spatial data in seamless messaging and safety system (GPS, etc.)
Government will have to support all "have-nots" identified through spatial data
Three strikes and you're implanted with a geolocation device
All probationers and parolees will be tracked by integrated GPS/GIS and their movements related to crime data

Table 9. Quality Assurance/Quality Control

Anticipated Change
Data quality assurance institutions
Data developers will create metadata
Adoption of family of standards by users and developers; data and metadata
SDTS dies (assisted suicide)]; increased metadata availability

Table 10. Spatial Literacy

Anticipated Change
Emergence of a technologically aware labor force into the workplace
K-16 geography teaching norms/practices in place ("a more spatially aware and literate citizenry")
Spatial analysis will have caused dramatic change in all educational endeavors
Education is information poor

Table 11. Partnerships

Anticipated Change
More public-private partnerships based on competitive advantages
Data utilities come from public-private partnerships
Public policy will be rendered to legislation that allows public-private partnerships without unduly limiting fair usage
Increased partnerships (government/university/private) for data sharing
Partnerships and data sharing become accepted business practices

Table 12. Spatial Data as Commodity

Anticipated Change
Spatial data are a commodity
Spatial data undifferentiated and universally available
1M and better current imagery on the NET accessible to all
Telecommunication advances will put large-volume access application in hands of the public
Collection, dissemination, use cheaper per unit
NSDI succeeds—all data free
Commodity use of very-high-resolution-satellite imagery
Consumer application growth will drive down costs and increase and pay for infrastructure
Huge ramp-up in revenue in sales of data/services
Constraint on public access will be ability to pay

Table 13. Control of Data

Anticipated Change
Major databases classified and public access restricted in response to fear of terrorism, industrial espionage, and national security concerns
Local governments license their data (becomes proprietary)
Access to personal data will be significantly restricted and controlled by the individual
Supreme court decision on privacy/First Amendment that has unpredictable social consequences
1984 finally arrives
Collection, dissemination, use is power; closely held and costly
Increasing gap between haves and have-nots
Global convergence of principles regarding access to government and scientific data
Greatly decreased citizen privacy
Case law for privacy/access issues
Data cost recovery and network financing issues will be resolved
Debate on privacy vs. right to know will become more intense
Individuals will have open access to spatial information

Table 14. Data Collection Agents

Anticipated Change
Local collection, dissemination, use supplants federal
Government cutbacks will cause agencies to focus on only mission-specific data needs
Government data collection approaches zero—Census is a headcount only
More community involvement in collection/dissemination
Government agencies smaller, focus on database standards
Local government will be primary collector/disseminator of spatial data
Local government predominant source of data; federal and state roles to consolidate umbrella data; hierarchical responsibility
Commercial sector(s) will collect everything (detailed geospatial data) and keep it themselves
Greatly distributed data collection
Breakup of existing nation states—decentralization of data
Outsourcing and privatization of government data will have reached their limit

Table 15. Data Security and Protection

Anticipated Change
Major databases classified and public access restricted in response to fear of terrorism, industrial espionage, and national security concerns
Electronic and software attacks will occasionally interrupt the information infrastructure

Table 16. Decision-Making Processes

Anticipated Change
Use of spatial data information for decision-making/operations management
Environmental issues addressed on cost/benefit basis; dynamic modeling
Telecommunications advances will put large-volume access application in hands of the public
More digital government operations (major jump to intelligent robots and agents)

Table 17. Citizen Involvement

Anticipated Change
Indirect democracy will evolve to direct democracy
Spatial data use will aid understanding of urban issues across jurisdictional boundaries
Individual freedom, quality of life trade-offs will dictate data needs
No potential users without access (RFD for the net)
Collection, dissemination, use-based democracy
Spatial information use/management/integration/dissemination at community level
Parcel-based data available to all citizens (developed nations)
More diverse groups of people will need to address how we want technology to affect the world

Table 18. Privatization

Anticipated Change
Commercial sectors will collect everything (detailed geospatial data) and keep it themselves
Spatial economies of scale-commercial companies dominate market sectors
Communications companies plan a significant role in merchandising spatial data
Increased GIS/GPS use will increase dispersion of industry
Private industry will produce wide variety of business GIS products
Increased privatization of government services; virtual government remains
Tremendous expansion of value-added industries
More commercialization of "government" data

Table 19. Uncategorized

Anticipated Change
Selective termination of excess population
Big differences between countries
Global spatial data industry dominated by Asians
U.S. lead/dominance in spatial technology has disappeared
Boredom with on-line data glut—Internet ennui