NSDI Building Blocks: Regional GIS in the United States

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Abstract: This paper presents an assessment of the regional capacity in implementing geographic information systems (GIS) and databases. We draw on a Web survey to determine the availability and assembly of spatial data at the metropolitan level in the United States. Information was sought from 388 planning organizations and regional agencies located in 349 metropolitan areas. Based on 116 responses (30 percent response rate), we generate descriptive statistics and run a regression model addressing the following aspects of the regional GIS capacity: data (contents, update, and assembly); technology (compatibility of software and data formats, data access, and the use of standards); people (staff, leadership commitment and support, regional communication and cooperation); policy (data sharing, funding, rules and responsibilities, and mandates/programs); and context (urban and regional issues and affluence). Although the survey reveals only a snapshot of a dynamic and evolving phenomenon, the results indicate that the status of metropolitan GIS in the United States may not be matching what is technically feasible. While the capacity is getting better over time, the process is relatively slow and the challenges of creating the base for building the National Spatial Data Infrastructure (NSDI) are persistent. Future research and practice should place more emphasis on the relationship between the NSDI and its installed base. Nurturing of networks and compatibilities among organizational entities at various levels, local and regional in particular, should be given priority in devising policies and programs for a useful and sustainable spatial data infrastructure.

INTRODUCTION

Since their beginnings in the 1960s, digital geographic information systems (GIS)—used for collection, storage, management, and analysis of spatial data—have penetrated many societal segments and have established GIS as a scientific discipline (Longley et al. 2005). A survey by Public, Technology, Inc., indicates that by the early 2000s, GIS have become integral resources in various local functions, including urban planning, public works, financial, public safety, and economic development (Public Technology, Inc. 2003). Both early (Budić 1993, Budić and Godschalk 1994, Croswell 1991, French and Wiggins 1989, 1990) and recent GIS studies (Caron and Bédard 2002, Haithcoat et al. 2001, ICMA 2002, Kreizman 2002, NACo 1999, Norris and Demeter 1999, Warnecke et al. 1998) provide useful information about the extent of GIS diffusion and use in the United States. These studies are complemented by significant research on data sharing and interorganizational GIS—as the apparent consequences of proliferation of spatial databases in digital form and the related pressure to exchange and access information resources (Greenwald 2000; Harvey and Tulloch 2006; McDougall 2006; Montalvo 2003; Nedović-Budić and Pinto 1999a, 1999b, 2000, 2001; Nedović-Budić et al. 2004a; Omran 2007; Onsrud and Rushton 1995). However, there is not much research on data assembly and availability at the regional metropolitan level.

Why is the regional metropolitan level important? First, more than three-fourths of the U.S. population (U.S. Census Web site) lives in metropolitan regions where most of urban growth and its implications occur and where large numbers of people are vulnerable in disaster situations. Second, many societal problems are tackled in a more holistic and coordinated manner at this level (Alliance for Regional Stewardship Web site, Feiock 2007, Wallis–MuniMall Web site), including the response to emergencies (Alliance for Regional Stewardship 2002). This is particularly true in the United States where the local level is the ultimate locus of decision making and action, but is extremely fragmented, often artificially bounded, and plagued by overlapping jurisdictions of more than 85,000 different local government entities (U.S. Census Bureau Web site). Third, regional GIS represent a base of the National Spatial Data Infrastructure (NSDI) (Georgiadou et al. 2006, Harvey and Tulloch 2006, Nedović-Budić and Budhathoki 2006, Rajabifard et al. 2006).

The U.S. NSDI is defined as "a physical, organizational, and virtual network designed to enable the development and sharing of this nation's digital geographic information resources" (Federal Geographic Data Committee (FGDC) Web site). It is realized through the development of spatial data and metadata standards, the establishment of spatial data clearinghouses (Geospatial One Stop), and the identification of national data sets (so-called "framework data," Tulloch and Fuld 2001), and more recently The National Map. Over the past decade, the NSDI concept has moved from a data-centered to a process-centered approach (Masser 2005), but the access to spatial data and information about available data has remained its primary tenet. In particular, the access to local and regional (i.e., subnational) data sets is recognized as the key element of the second generation of SDIs (Rajabifard et al. 2006). While the NSDI does not assume database assembly across the national territory, it does require data availability and compatibility to enable rapid and convenient data integration based on the user's needs.

The research presented in this paper is concerned with the provision and integration of spatial data at the metropolitan level. The objectives are to (a) assess GIS data availability at the metropolitan level and (b) identify the factors associated with assembling and sharing GIS data across multiple jurisdictions within a metropolitan region. The empirical evidence is acquired with a Web-based national survey of regional data collection and assembly efforts in 349 U.S. metropolitan areas. While the data does not reflect the most up to date status of regional GIS, it approximates a complex process somewhat stalled by institutional inertia, and is used to illustrate the challenge of building the NSDI base, particularly in a country as large as the U.S.

After the discussion of the research premises, frameworks, and methodology, we present the results based on descriptive statistics and a regression model. We conclude with a summary of the findings, implications for building a sustainable and viable NSDI, and suggestions for further research.

LINKING DATA SHARING, INTERORGANIZATIONAL GIS, AND SDI

Interorganizational GIS and Information Infrastructure

Fundamentally, regional GIS depend on developing seamless databases and techniques, securing incentives and resources for data integration, and establishing multijurisdictional intergovernmental cooperation. When geospatial technologies and information resources are distributed across organizational boundaries to include multiple local governments and nonprofit groups, or to involve private-sector partners, they form interorganizational GIS (O'Looney 1997). These systems draw on existing interdependences, but also are challenged by their complexities (Nedović-Budić and Pinto 1999b). To frame the complexities involved in building distributed systems, Fletcher (1999) proposes four levels of interoperability: global, regional, enterprise, and product; three types of interoperability: institutional, procedural, and technical; and three dimensions of interoperability: horizontal, vertical, and temporal.

The most important factors for achieving interoperability and multiparticipant geospatial technologies and systems are sharing and easy access to geospatial information. Sharing geospatial information is believed to promote more effective use of organizational resources and cooperation among involved organizational entities (Brown et al. 1998, Nedović-Budić and Pinto 1999a, 1999b, 2001). Obstacles to data sharing are numerous, including both technical and nontechnical issues. On the technical side, for example, it is very hard to resolve the varying needs for scales and accuracy of data that users located in the same region may have. On the nontechnical side, there may be inadequate communication about available information resources or a lack of willingness to share those resources. These are the same factors and issues the information infrastructures (IIs) and spatial data infrastructures (SDIs) in particular are established to facilitate and resolve by introducing a mechanism for a diverse set of data producers and users to interact in an open networked environment. "Data sharing among the participants on an unprecedented scale will be needed for SDIs to become fully operational and effective in practice" (Rajabifard et al. 2006, p. 738).

The connection between interorganizational systems and IIs also is acknowledged in research literature. For example, while proposing the characteristics of IIs, Star and Ruhleder (1996) argue that they cannot be independently built and maintained, but, rather, they emerge through practice and become connected to other activities and structures. Similarly, Borgman (2000) views IIs as much more than the physical substrate and thus considers broader social relations in constituting IIs. Hanseth and Monteiro (1998) suggest that some of the II characteristics may be present in certain information systems (IS), especially in interorganizational systems (IOS) or distributed information system (DIS) and, therefore, some commonalities and overlapping characteristics exist between IS and II (see Table 1, Budhathoki and Nedović-Budić 2007). The authors consider that IIs are initiated when: new and independent actors become involved in the development of an IOS or DIS, so that the development is not controlled by one actor anymore; one of the design objectives for IOS or DIS is to grow and become an II (or part of an II) in the future.

Local and Regional GIS as the NSDI Building Blocks

We propose that the interorganizational GIS at the metropolitan regional level constitute an installed base and building blocks of the U.S. NSDI. NSDI is defined as "the technology, policies, criteria, standards and people necessary to promote geospatial data sharing throughout all levels of government, the private and non-profit sectors, and academia" (FGDC Web site). Rajabifard et al. (2006) consider spatial data infrastructure (SDI) "an enabling platform for data sharing" (p. 727). The authors differentiate between the first generation SDIs that are mainly led by national mapping agencies and focused on provision of national data sets, and the second generation SDIs that are process-based interactions between multiplicity of players in the joint effort toward managing and exchanging information assets in a networked environment. The switch from the first to the second generation happened around the year 2000 when a centralized (or top-down) product-oriented model was replaced by a bottom-up distributed model. Accordingly, the product-based model involves definition of data, collection of data, integration of data, database creation, and implementation; the process-based model involves knowledge infrastructure, capacity building, communication, and coordination. In relating the SDI hierarchy and the models, Rajabifard et al. (2003) associate SDIs from local to state level to the product model and operational tier; national SDIs with the management tier and both product and process models; and multinational[1] and global SDIs with strategic tier and process model only. Obviously, availability of and accessibility to spatial data remain the core of a functional SDI, although the services are increasingly being added to SDI clearinghouses and portals (Crompvoets and Bregt 2007).

1 We substitute the term *multinational* for the term *regional* used by the authors to avoid confusion with the regional metropolitan level that this research is concerned with.

Table 1. Characteristics of information infrastructures

Star and Ruhleder (1996), p. 113	
Embeddedness	"Infrastructure is "sunk" into (inside of) other structures, social arrangements and technologies."
Transparency	"Infrastructure is transparent in use, in the sense that it does not have to be reinvented each time or assembled for each task, but invisibly support those tasks."
Reach or scope	"This may be either spatial or temporal—infrastructure has reach beyond a single event or one-site practice."
Learned as part of membership	"The taken-for-grantedness of artifacts and organizational arrangements is a *sine qua non* of membership in a community of practice. Strangers and outsiders encounter infrastructure as a target object to be learned about. As they become members, new participants acquire a naturalized familiarity with its objects."
Links with conventions of practice	"Infrastructure both shapes and is shaped by the conventions of a community of practice."
Embodiment of standards	"Modified by scope and often by conflicting conventions, infrastructure takes on transparency by plugging into other infrastructures and tools in a standardized fashion."
Installed base	"Infrastructure does not grow *de novo*; it wrestles with the 'inertia of the installed base' and inherits strengths and limitations from that base."
Becomes visible upon breakdown	"The normally invisible quality of working infrastructure becomes visible when it breaks."
Hanseth and Monteiro (1998), pp. 41-49	
Enabling	"Infrastructures have a supporting or enabling function."
Shared	"An infrastructure is shared by a large community (collection of users and user groups)."
Open	"Infrastructures are open and support heterogeneous environments."
Sociotechnical network	"IIs are more than 'pure' technology; rather, they are socio-technical networks."
Ecology of networks	"Infrastructures are connected and interrelated, constituting ecologies of networks."
Installed base	"Infrastructures develop through extending and improving the installed base."

Local and regional (metropolitan) levels are the most relevant instances of spatial data production and data use and they could represent the building blocks of the NSDI (Nedović-Budić and Budhathoki 2006, Rajabifard et al. 2006). However, the connectivity between these levels is not easy to operationalize. For example, Harvey and Tulloch (2006) consider the available databases and the uptake of SDI concepts at these levels as essential for the success of the U.S. NSDI, but their 2002 case study shows that majority of U.S. local governments are either unaware of or do not take the SDI concept relevant to them. This is reinforced in a study by Nedović-Budić et al. (2004b) who report that the state SDI in Illinois does not meet the needs of local government planners. Similarly, in the emergency context, despite the important supporting role GIS has played in responding to both 9-11 (New York 2001) and Katrina (New Orleans 2006) crises, the challenge of quick data integration that could be provided only by a viable SDI is recognized (Adam et al. 2006, Butler 2005). Agreeing with these findings, Dresler and Woods (2000), in a summary of six community demonstration projects supported by the FGDC, point out the advantages and shortcomings of the federal SDI-related activities. Beside numerous positive developments, they report that "[i]nformation required to address very localized issues such as growth, flooding, and crime analysis is often require higher resolution data than is presently collected by the Federal community" (p. 6). Finally, despite major efforts and achievements in building NSDIs, based on their global assessment, Crompvoets et al. (2004) observe a declining trend of clearinghouse use and suggest that user-unfriendly interface and discipline-specific nature of metadata and clearinghouses are among the primary reasons for the decline. Clearly, the previous statements reaffirm the calls for the development of bottom-up NSDIs rooted in subnational governments and based on the needs of spatial data users (Budhathoki et al. 2008, Rajabifard et al. 2006).

U.S. National Spatial Data Infrastructure

The United States is among the first countries to embrace the idea of building the National Spatial Data Infrastructure (NSDI) since the early 1990s. The main impetus is given by President Clinton's Executive Order 12906 of April 1994 (FGDC Web site) and the Office of Management and Budget's (OMB) Circular A-16 and E-government Act of 2002 (FGDC Web site, U.S. OMB Web site). Development of national spatial data infrastructures has been undertaken in many countries worldwide. In their longitudinal survey, Crompvoets and Bregt (2007) report that by 2005 83 countries have adopted national-level SDI programs. SDIs also are developed at other levels, such as regional, state, and local (Rajabifard et al. 2002, Masser 2005), and billions of dollars are spent each year on SDI-related activities worldwide (Onsrud et al. 2004).

Substantial progress has been made since the inception of the NSDI in the United States. Following the efforts in conceptualizing the NSDI, there have been numerous activities in development of data and metadata standards, awareness-raising activities at all levels, establishment of clearinghouses, definition of framework data, and creation of partnerships to facilitate spatial data availability and access (FGDC Web site). The importance of building a sustainable and useful NSDI became particularly apparent after the events of 9-11 (CAD Digest Web site, GIS Monitor Web site) and Hurricane Katrina (UCGIS Web site). In addition to the Federal Geographic Data Committee, the U.S. NSDI is building on two other initiatives—the National Map (USGS Web site) and Geospatial One Stop (Geodata.gov Web site), which are all brought together by the National Geospatial Program Office. Also the Department of Homeland Security has restructured to better handle geospatial information of national interest (National Geospatial-Intelligence Agency Web site, ESRI Web site).

Despite these efforts and strategic documents issued in 1994, 1997, and 2004 (FGDC Web site), the U.S. NSDI still is not supported by a comprehensive and operational implementation plan. The latest NSDI Future Directions Initiative (2004) is a vague guiding document that lacks the programming component. Past efforts have been focused primarily on the federal level where the standardization activity is mandatory, but where full coordination still is missing. The main NSDI building tools are data partnerships. Thus, the local and state levels have been tackled through partnerships with national associations (e.g., the National State Geographic Information Council (NSGIC), the National Association of Counties (NACo), and the International City/County Management Association (ICMA)), as well as through direct contacts with government organizations at all levels. The FGDC Cooperative Agreement Program (CAP) that has been operating since the mid-1990s generates many seed projects and test beds of NSDI implementation. However, these CAP-supported projects could not amount to a nationally significant outcome (Mapping Science Committee 2001) or reach the organizations most in need for funding (MacPherson et al. 2003). The Mapping Science Committee (2001) finds that "funding incentives established by the FGDC through the NSDI partnership programs do not appear to have significantly" reduced data redundancy, decreased cost, improved access, and increased accuracy.

The states have been approached through the NSGIC with the 50 States Initiative (FGDC 50 States Initiative Web site), primarily for drafting the strategic and business plans. These plans are to "facilitate the coordination of programs, policies, technologies, and resources that enable the coordination, collection, documentation, discovery, distribution, exchange and maintenance of geospatial information in support of the NSDI" (50 States Initiative Web site). By October of 2007, strategic plans are completed in nine states, pending in four, in progress in ten, in final draft in one, starting in eight, N/A in one, and unknown in four; business plans are completed in seven states, pending in four, in progress in ten, starting in eight, N/A in three, and unknown in five states. CAP funding is used to support the development of strategic and business plans, but there are no other NSDI implementation resources committed. Otherwise, regardless of NSDI-related initiatives, GIS coordination at the state level is present in many of the 50 states (Warnecke et al. 2003).

Finally, the regions, as probably the most viable link between the local, state, and federal levels in the U.S. NSDI, are somewhat neglected. Suitability of the regional level as data assembly and distribution point, in particular, has been acknowledged early in the conceptualization of the U.S. NSDI through the idea of "area integrators" (FGDC 1995). Unfortunately, this idea never was implemented and the opportunity to build an NSDI with a strong regional and local base was missed. There is currently a revival of this idea through the National Geospatial Advisory Committee (NGAC) established in January of 2008. The NGAC reports to the FGDC chair and "provide[s] a forum to convey views representative of non-federal stakeholders in the geospatial community" (NGAC Charter, NGAC Web site). Local and regional governments and organizations are among the most important nonfederal stakeholders.

Comprehensive studies of the U.S. NSDI are scarce. Following the 1998–1999 Framework Survey, an inventory of organizations that produce or use framework data, availability of metadata, data sharing practices, and key contacts (Harvey 2001, Tulloch and Robinson 2000, Tulloch and Fuld 2001), there has been no systematic nationwide attempt to find out about the status of the U.S. NSDI. The Framework Survey suggests that the use of framework data in an SDI environment is challenging technically and institutionally: technically because data are in various formats and of different accuracies; institutionally because data producers are not fully prepared to share data. Other research efforts, including the one presented here, address the phenomena relevant to building the NSDI—policy and organizations; interoperability and sharing; and discovery, access, and use of spatial data (Budhathoki and Nedović-Budić 2007). The following sections discuss the research framework and the empirical evidence on the regional GIS capacity as the installed base and building block of the U.S. NSDI.

RESEARCH FRAMEWORK AND METHODOLOGY

Conceptual Framework

This assessment of regional GIS capacity is conceptually related to the literature and research frameworks on GIS, interorganizational GIS, and SDI (see Table 2). The presentation of findings is organized around five broad concepts that are commonly featured across the three frameworks: data, technology, people, policy, and context. This study builds directly on the research conducted by Nedović-Budić and Pinto (Nedović-Budić and Pinto 1999a, 199b, 2000, 2001; Nedović-Budić et al. 2004a) and includes variables that they discover as important in the process of data sharing and building interorganizational and multijurisdictional GIS. Indirectly, the research also captures Fletcher's (1999) regional and product levels of interoperability, procedural and technical type of interoperability, and horizontal and temporal dimensions of interoperability.

The primary focus of this study is the spatial (GIS) data held by governments in metropolitan areas. Inquiry into data available in individual jurisdictions (contents), data currency (update), and data assembly across jurisdictional boundaries are of main concern. In addition to finding out if specific data layers are available in some or all units (counties, parishes, or boroughs) that make up each metropolitan area, we are interested in identifying layers with regional coverage. We consider a comprehensive set of data themes, primarily because this work is driven by urban and regional planning concerns, which require such diversity and integration of spatial data (Dandekar 1988, Klosterman 2000). This diversity generally is found at the local government level, as reported in a U.S.

Table 2. Conceptual frameworks used to inform the study

GIS Literature (Antenucci et al. 1991, Bernhardsen 1999, Budić 1993, Budić and Godschalk 1994, Huxhold and Levinsohn 1995, Nedović-Budić 1997)				
Hardware/Software (Technology)	Data	People	Organization	Context
Interorganizational GIS Literature (Nedović-Budić and Pinto1999b, 2000; Nedović-Budić et al. 2004a)				
	Outcomes (benefits)	Motivation	- Motivation - Coordination mechanisms (structure, process, policies) - Internal/external	Context (organizational and interorganizational)
SDI Literature (Rajabifard et al. 2003)				
Technology	Data	People	Policy	
Regional (Metropolitan) GIS Capacity—Web-based Survey (Part I—Respondent's Background)				
FACTORS - TECHNOLOGY: - compatibility of software - compatibility of data formats and map projections - methods of data access - use of standards Source: a) Survey, Integration (Part III)	**FACTORS - DATA:** - contents - update - assembly across the region Source: a) Survey, GIS data (Part II)	**FACTORS - PEOPLE:** - staff - leadership commitment, support, and cooperation - regional communication and cooperation Source: a) Survey, Infrastructure (Part IV)	**FACTORS - POLICY:** - data sharing/exchange activities - formalization - rules and responsibilities - funding - mandates/programs Source: a) Survey, Infrastructure (Part IV) Interorganizational relationships (Part V)	**FACTORS - CONTEXT:** - regional per capita income - number of counties in a region (size) - planning issues (urban sprawl, natural resources) Sources: a) Survey, Interorganizational relationships (Part V) Planning (Part VI) b) U.S. Census

national survey by Warnecke et al. (1998). The authors find that more than 40 percent of the local governments sampled have the following components in their geospatial database: roads, hydrology, political/administrative boundaries, cadastral/land records, land use/zoning, elevation, digital imagery, and geodetic control. Those layers indicate the common data needs at the local level. With the addition of fire, police, and medical facility information, these local databases can easily meet the requirements of emergency applications as well.

Regional GIS capacity is affected by the *technological* factors such as compatibility of software used by various jurisdictions in the region, related data formats and map projections, data access methods used by organizations in the region, as well as the application of common data standards. It also is influenced by the nontechnological factors, including *human* (staffing, leadership commitment and support, regional communication and cooperation), *policy* (data sharing, formalization of data-related activities, funding of regional GIS, definition of roles and responsibilities, mandates/programs), and *contextual* (size of the region measured in the number of units it consists of, the region's affluence measured in per-capita income, and the presence of urban and regional issues such as sprawl and natural resources that could stimulate regional actions). Relevance of these factors is confirmed in GIS (Croswell 1991, Budić 1993) and interorganizational GIS sources (Nedović-Budić and Pinto 1999a, 1999b, 2000, 2001; Onsrud and Rushton 1995), but also has transferred into the SDI field (Askew et al. 2005, Craig 2000, Georgiadou et al. 2005, Tait 2005).

Sampling and Data Collection

Metropolitan planning organizations (MPOs) are basically the only public sector regional organizations within the U.S. institutional structure that deal with and integrate spatial data. Local governments have statuary authority to perform administrative functions and enact and implement programs and policies. They are the loci of urban decisions and activities. Regions in the United States, however, do not have such powers, despite the fact that they represent a more appropriate unit of policy and action in many domains, urban and regional planning and emergency response, in particular.[2] MPOs are established in each metropolitan area (MA) as a condition for receiving federal highway or transit funds in urbanized areas (Association of MPO Web site). The MPOs have responsibility for planning, programming, and coordinating federal highway and transit investments.

2 Portland Metro is the only constituted regional government in the United States (http://www.metro-region.org/).

Most MPOs have a larger scope of activities, including land-use analysis and planning as one of their standard tasks closely tied to transportation planning and modeling. Many MPOs tackle a variety of other urban and regional issues and rely on sophisticated methods and GIS databases (Greenwald 2000). Regional councils, commissions, and association of governments are region-specific and also address a wide range of planning concerns. They are not required by law, but are frequently established in urban areas to assist community leaders and citizens in developing strategies for attending to transportation, economic development, air and water quality, social equity, growth, housing, and other urban and regional challenges. Increasingly, those challenges include management of emergency situations. In many cases, regional councils or commissions also are the official MPOs.

With their institutional nature and activities, MPOs and other regional organizations provide a conceptual and practical tie between the enabling function of information infrastructures and their link to communities of practice (Hanseth and Monteiro 1998, Star and Ruhleder 1996). The primary field of practice incorporated in this study is urban and regional planning, as probed by Nedović-Budić et al. (2004b) in their evaluation of utility of state-level SDI for local applications. Other authors also mention urban and regional planning as one of the main justifications of SDIs (Craglia and Johnston 2004, Masser 2005, NRC 1993).

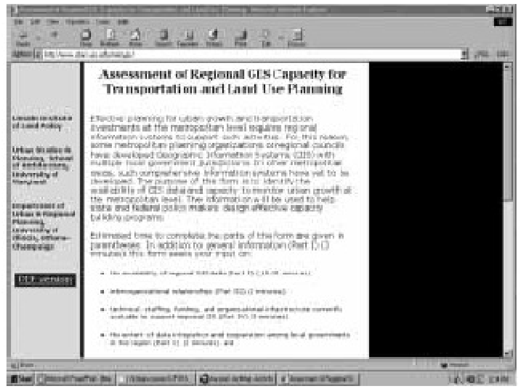
In 2001, the U.S. Census Bureau identified 349 metropolitan areas (MAs), including: 261 metropolitan statistical areas (MSAs); 76 primary metropolitan statistical areas (PMSAs —aggregated in 19 consolidated metropolitan statistical areas or CMSAs); and 12 New England consolidated metropolitan areas (NECMA). Six MAs and one CMSA are located in Puerto Rico (U.S. Census Bureau Web site).[3] Corresponding to the structure of their respective metropolitan areas MPOs' jurisdictions range from one to over 10 constituent units (counties, parishes or boroughs).

A Web survey was used to collect data from the contacted organizations (shown in Figure 1). The Web form was developed internally by the UIUC Department of Urban and Regional Planning using Macromedia DreamWeaver MX and custom coding (http://www.urban.illinois.edu/faculty/budic/W-metroGIS.htm). Once submitted, the responses were written to a Microsoft Access 2000 database. Data was collected from July of 2002 to March of 2003.[4] The sample for this study drew from the lists of metropolitan

3 The source of MPO addresses and contacts was the 2001 Profile of Metropolitan Planning Organizations (Association of Metropolitan Planning Organizations 2001 Web site). The National Association of Regional Councils (NARC Web site) provided addresses of other regional organizations (e.g., councils, commissions, and associations of government). To secure information for each metropolitan area, both the metropolitan planning organizations and the regional councils/commissions were contacted with a request to fill in and submit the Web form. A total of 388 organizations were contacted—374 MPOs and 14 other regional organizations.

4 Even with the time passed between data collection and this reporting, the situation it portrays has not changed substantially. The rapid technological advances are followed by much slower institutional change and their full incorporation and use usually lag behind the potentials (Budić and Godschalk 1994, Campbell and Masser 1995, Masser and Onsrud 1993).

Figure 1. The Web survey form



planning organizations and other regional agencies dealing with planning issues and located in one of the U.S. metropolitan areas. The surveys were filled out by staff members in managerial positions who were aware of (and in some cases involved in) regional GIS activities.

Responses were received from 116 agencies, or 30 percent of all metropolitan organizations contacted. The initial wave of responses was received during the summer and fall of 2002 and included 64 organizations. Most of them (61 or 95.3 percent) were the official metropolitan planning organizations located across 34 states. These 64 responses constituted a random cross section of metropolitan organizations that were used in further data analysis. This initial set of responses is referred to as "SAMPLE 64." Additional responses were obtained in the fall of 2002 and the spring of 2003 after a targeted solicitation of responses from large urban areas by telephone and e-mail. Because the second wave of solicitation did not include all nonrespondents and the element of randomness was lost, the responses from the large urban areas were analyzed separately from the initial sample. The second set was a targeted sample consisting of 49 responses received from organizations located in the top 50 most populated urban areas in the United States—14 were eligible from the set of initial 64 respondents (i.e., 14 responses were from top 50 urban areas) and 35 came from the second set of respondents. The majority of these 49 responses (42 or 85.7 percent) were the official MPOs located in 29 states. In the remainder of this report, this set is referenced as "TOP 50/49."

The 64 initial responses (SAMPLE 64) and the 49 responses from large urban areas (TOP 50/49) were nationally well dispersed (shown in Tables 3a and 3b and Figure 2). With regard to metropolitan area size, the 64 initial responses were a representative cross section of metropolitan areas, i.e., the percentage of respondents in each size category corresponded closely to the distribution of all metropolitan areas in those categories. Almost 90 percent of the 49 responses from the largest 50 urban areas were from metropolitan areas of more than one million inhabitants. The SAMPLE 64 offered insights into the national trends; the TOP 50/49 responses

Table 3a. Distribution of responses in SAMPLE 64 by census region and area population

	SAMPLE 64		MAs				SAMPLE 64		MAs	
Region	**Number**	**Percent**	**Number**	**Percent**		**Popula-tion**	**Number**	**Percent**	**Number**	**Percent**
Northeast	10	15.6%	72	20.6%		**Under 500,000**	37	57.8%	235	68.5%
Midwest	19	29.7%	82	23.4%		**500,000-1 million**	11	17.2%	44	12.8%
South	21	32.8%	131	37.4%		**1-5 mil-lion**	13	20.3%	59	17.2%
West	14	21.9%	65	18.6%		**Over 5 million**	3	4.7%	5	1.5%
Total	64	100.0%	350*	100.0%		**Total**	64	100.0%	343*	100.0%

*This count excludes 6 MAs located in Puerto Rico and double counts for 7 MAs located in two regions.

** This count excludes 6 MAs located in Puerto Rico.

Table 3b. Distribution of responses in TOP 50/49 by census region and area population

	TOP 50/49 Sample		TOP 50 Urban Areas				TOP 50/49 Sample		TOP 50 Urban Areas	
Region	**Number**	**Percent**	**Number**	**Percent**		**Popula-tion**	**Number**	**Percent**	**Number**	**Percent**
Northeast	5	10.2%	6	12.0%		**Under 500,000**	0	0.0%	1	2.0%
Midwest	11	22.4%	11	22.0%		**500,000-1 million**	5	10.2%	12	24.0%
South	21	42.9%	20	40.0%		**1-5 mil-lion**	38	77.6%	32	64.0%
West	12	24.5%	13	26.0%		**Over 5 million**	6	12.2%	5	10.0%
Total	49	100.0%	50	100.0%		**Total**	49	100.0%	50	100.0%

pointed to specific circumstances and issues in the most populous metropolitan areas.

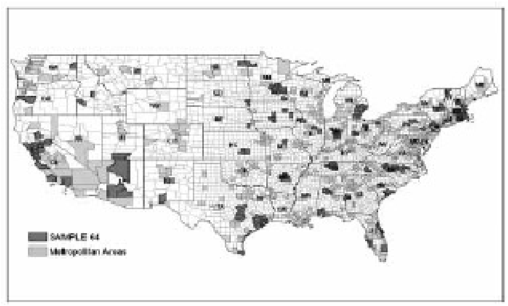
One concern with the sampling was the unavoidable bias introduced by the respondents' self-selection. The respondents in the random SAMPLE 64 could be described as more interested in and concerned with regional spatial data sharing and integration than the nonrespondents and, consequently, the assessment would be on the more optimistic side. In fact, many respondents were involved in regional GIS activities, primarily as coordinators or members—about one-third in each group from the random SAMPLE 64 and about one-half and one-fifth, respectively, from the TOP 50/49 largest urban areas. Very few respondent organizations acted as financial sponsors, subscribers, or observers of the regional GIS activities. On one hand, the active participation status was a factor that could potentially influence the responses. On the other hand, this same factor could ensure more informed and accurate answers.

FINDINGS

Data

Availability of specific content data was determined for each metropolitan area according to the respondents' awareness about data themes developed for their organizations' basic constituent units (counties, parishes, or boroughs) and about assembling data themes across all constituent units. The survey provided for three possibilities:

Figure 2. Spatial distribution of SAMPLE 64 responses



NONE: meaning that the specific data theme did not exist in any of the counties, parishes, or boroughs in the organization's region;

ALL: meaning that the specific data theme existed for all counties, parishes, or boroughs in the organization's region; and

SOME: meaning that the specific data theme was developed for some (but not all) of the counties, parishes, or boroughs in the organization's region.

Data categories included land, regulation, boundaries, natural features, transportation, utilities, services, utilities, and other (satellite imagery, aerial photography, and real estate/market data). Data was considered assembled if the theme data for the entire region was integrated into a single data set. Therefore, it was most interesting to find out to what extent the data was available and assembled across ALL constituent units. In SAMPLE 64, the most developed data themes were municipal boundaries, street/road network, traffic analysis zones (TAZs), and hydrology (rivers/streams), reported as available for ALL constituent units by 86 percent, 83 percent, 78 percent, and 78 percent of respondents, respectively. However, the same data sets were assembled by less than one-half of the regions that had data themes available across ALL units, and only about one-third of all respondents (see Appendix A).

Other data themes were less developed. For example, land use and parcel boundaries were *available* across ALL constituent units in 55 percent of the responses, but much less in their *assembled* form—44 percent and 30 percent, respectively. Inventory of developed, vacant land and infill sites, growth boundaries and service, zoning, and comprehensive plans were reported by about one-third of the organizations as *available* and about one-fifth as *assembled*. Finally, the percentages for data themes on urban infrastructure (e.g., sewer and water utilities) were considerably lower.

The respondents also reported the frequency of updating and assembling specific data themes. The options were monthly, semiannually, annually, every five years, every ten years, every ten+ years, and irregularly. The respondents were to provide an estimate that would represent an average across various constituent units holding a particular data theme. This was a difficult task that resulted in many missing responses. However, with a few exceptions, the responses received showed that "irregularly" was an overwhelming response across the themes for both data availability and data set assembly. Land use, land cover, and aerial photography were in many cases updated and assembled at least once in five years; tax assessment records, parcel boundaries, and TAZs were addressed at least annually, and the former bimonthly as well; finally, some of the service boundaries (e.g., schools) also were relatively regularly updated or assembled. Figures in Appendix B illustrate the geographic distribution of responses on availability and update of land use, street/road data, aerial photography, and satellite imagery for the SAMPLE 64 and TOP 50/49.

On average, data themes were more *available* across the constituent units and more likely to be *assembled* in the largest 50 urban areas than in the case of the random 64 responses that came from metropolitan organizations located in urban areas of various sizes.

Technology

Compatibility of GIS software, formats, and map projections and access to spatial data used to be among the most challenging technical issues to resolve in multijurisdictional and multiorganizational settings. Over time, however, with the stabilization of the commercial software market, the development of conversion tools, and the availability of open codes, the software-related problems have decreased. The respondents to the Web survey indicated that, in general, most of the local governments in their regions used at least somewhat compatible software—56 (87.5 percent) responses from the random SAMPLE 64 and 41 (83.6 percent) responses from the TOP 50/49.

A range of methods of access to data developed and maintained by local governments in the region included Web mapping service (WMS), Internet-based access with automated file conversion system, centralized GIS storage/data warehouse, uploading/downloading via a computer network, and delivery via digital media (e.g., CDs, tapes, ZIP disks). Data access via portable digital media was the main method for a majority of the respondent organizations (see Figure 3). Other access methods also were present, with network-based access available to about half of the respondents and the Internet-based method only starting to emerge. Respondents from the TOP 50/49 urban areas reported a somewhat higher reliance on Internet or network-based approaches than the respondents from the random SAMPLE 64. However, the difference was not substantial.

The respondent organizations did not experience the access to data developed and/or maintained by other local organizations to be too difficult. More than two-thirds of the respondents (47 or 73.4 percent from SAMPLE 64 and 35 or 71.5 percent from the TOP 50/49) stated that the access was easy or somewhat easy, or were neutral about it. The respondent organizations from the TOP 50/49 largest urban areas found the access difficult or somewhat difficult slightly more often than the respondents across various sizes of metropolitan areas (15.7 percent versus 22.4 percent, respectively).

Using perceived difficulty in converting between map projections and formats as an indicator of facility of data integration, we found that data conversion did not represent an obstacle for the majority of respondent organizations. About two-thirds of them reported a low or very low level of difficulty with different GIS file formats, except for a somewhat higher percentage from the sample of 64 initial respondents reporting some difficulty with varying map projections used by local governments and other organizations in their region. No respondent qualified the conversion difficulty to be "very high."

Finally, with respect to the use of standards, the responses pointed to limited efforts: 40 respondents (62.5 percent) from the random SAMPLE 64 group and 32 respondents (65.3 percent) from the TOP 50/49 group had no mutually accepted standards across the region.

Policy

Existing activities and mechanisms for regional data development and sharing were considered fundamental for securing access to metropolitan data sets and a step toward building the NSDI. Based on previous studies of interorganizational GIS, the following joint activities were considered: shared applications, shared geographic data clearinghouse, fee-based data exchange, coordinated database maintenance, shared database, coordinated data development and/or acquisition, and data sharing (free of charge).

Free-of-charge data sharing as the most basic type of interaction was reported by the majority of respondents (shown in Figure 4). While this was encouraging and valuable, particularly for its open

Figure 3. Common methods used to access external GIS data

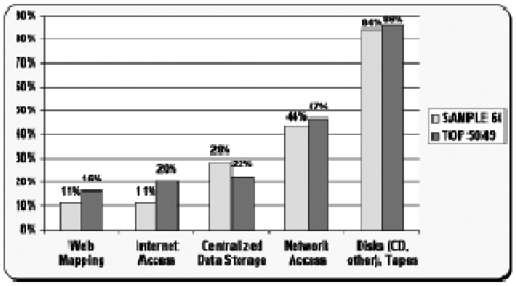
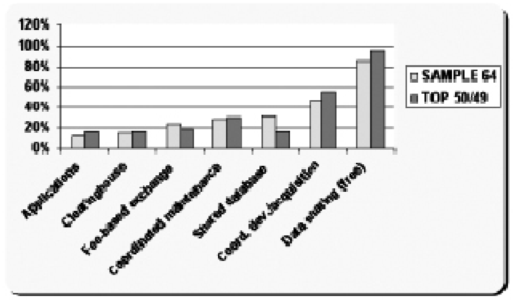


Figure 4. Extent of GIS data interorganizational activities



**The percentages do not add up to 100 percent because respondents were asked to report multiple methods.*

nature, more complex interactions, including the establishment of clearinghouses, were pursued on average by less than one-fifth of the respondents. Consistent with responses on data availability and assembly, the existence of shared databases was sporadic, particularly among respondents located in the TOP 50/49 largest urban areas. Interestingly, these same respondents reported more frequent free exchange of data and less concern for cost recovery than the respondents from the random SAMPLE 64. They also displayed a slightly higher propensity toward coordinating their database activities.

Interorganizational GIS activities were guided by a variety of mechanisms, with some organizations often reporting multiple mechanisms. Technical groups, memoranda of understanding (MOU) or intergovernmental agreements (IGA), and various coordinating entities were used by about one-half of all the respondents. But, generally, only for 24 respondents from the group of random SAMPLE 64 organizations and for 15 respondents from the TOP 50/49 largest urban areas (37.5 percent and 30.6 percent, respectively), the interactions were formalized with ordinances or resolutions of governing bodies, MOUs or IGAs, policies of elected officials or CEO/CAOs, and service or other contracts.

Establishment of rules and responsibilities was another indicator of the readiness to pursue joint data activities. The survey revealed only sporadic institution of joint rules and responsibilities for GIS database development, update, and use by local governments in the region. The results suggested that 45 respondents (70.3 percent) of the random SAMPLE 64 and 40 respondents (81.6 percent) from the organizations located in the TOP 50/49 sample of largest urban areas had no clearly assigned rules and responsibilities.

Next, funding was examined as the important operational aspect of implementing GIS technology and supporting data development, integration, and access. Three most frequently suggested sources of funding regional GIS included renewable grant funding, continuous financing (i.e., budget-line item), and contributions by local governments as part of regular programming/services, totalling about two-thirds of the funding sources. There was a noticeable difference between the funding sources for the random SAMPLE 64 respondents and the organizations from the TOP 50/49 largest urban areas. The latter had a substantial number of respondent organizations receiving continuous financing and renewable grants; the main source of funding for the former were the contributions by local governments.

Finally, the existence of state mandates for the development of land-information systems and the requirement for GIS use was explored. Seventeen or one-quarter of the random SAMPLE 64 respondents stated that there was a state land-information system program in place along with other related programs (14). Only a few respondents found the program funding to be adequate or somewhat adequate. GIS as a tool for developing land-information systems was required only in three cases. Fourteen programs in cadastral areas and 11 in other areas were reported by the organizations from the TOP 50/49 urban areas. The pattern was similar to the one that emerged in the SAMPLE 64—only a few considered the funding adequate and GIS was required only in one case.

People

The respondent organizations ranged in their professional staff size from a few to 140 for the random SAMPLE 64 and 450 for the TOP 50/49 group; the sample means were 18.7 and 52.5, respectively. The means dropped to the respective means of 3 and 4.6 professional full-time equivalent staff members working on GIS database development, maintenance, and integration.

Inquiry into the history of regional cooperation revealed that respondents from the TOP 50/49 largest urban areas on average had less positive experiences. A total of 17 (24.7 percent) of those organizations responded as having either an "excellent" or a "very good" history of cooperation; 22 (34.4 percent) of the respondents from the random SAMPLE 64 checked those two options. This result is not too surprising given that cooperation is more needed but also more difficult to realize in large metropolitan regions with more governmental entities and substantive and administrative complexities.

Communications were considered one aspect of regional cooperation. Many respondent organizations were part of a regional network that facilitated interaction between their members. In assessing their network's functionality, about two-thirds of the respondents perceived it as a viable means of communication (i.e., strongly agreed, agreed, or were neutral). Still, about one-quarter of the respondents either "disagreed" or "strongly disagreed" about

Figure 5. Leadership and commitment for cooperation and GIS data sharing

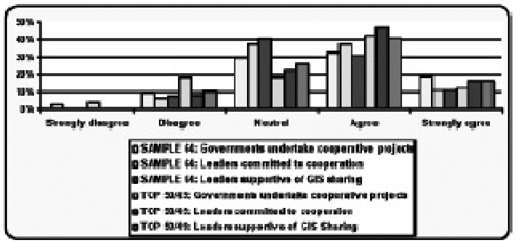


Table 4. Regression analysis of regional database integration (N = 64)

Dependent Variable: Number of GIS Layers Across the Jurisdiction					
	Coefficients				
	Unstandardized		Standard.	t	Signif.
Model	B	Std. Error	Beta		
(Constant)	-0.23691	6.0365102		-0.039246	0.9688604
Format conversion difficulty	4.5729306	2.2124197	0.2199442	2.066992	0.0442773
Staff	0.8157634	0.3457442	0.267693	2.3556214	0.0227213
Continuous financing	3.8493139	2.2049533	0.1978425	1.7457576	0.0873876
Rules and responsibilities	-4.694611	2.6320393	-0.206128	-1.783412	0.0806772
GIS required	9.4165081	4.6976749	0.2200601	2.004504	0.0507865
Urban sprawl issues	5.9716886	2.0448916	0.3126526	2.9206867	0.0053604
Natural resource issues	9.2094389	2.6196564	0.3666951	3.5156482	0.0009031
> 3 counties in jurisdiction	-7.207787	2.8008507	-0.296909	-2.573429	0.0132948
Per capita income	0.0003813	0.0002812	0.1459773	1.3561216	0.1816402
Adjusted R Square 0.44					

the network's functionality. Overall, the respondents from the TOP 50/49 group were slightly more positive about the value of the network than the respondents from the random SAMPLE 64.

Interestingly, in general, higher engagement in cooperative projects was reported by organizations from the TOP 50/49 urban areas. Similarly, leadership support and commitment for cooperation and GIS data sharing seemed to be associated with those same respondents. Figure 5 summarizes the responses on the following statements from both the random SAMPLE 64 respondents and from the TOP 50/49 group of largest urban areas:

In general, governments in your region often undertake joint cooperative projects;

The political and government leaders in the region are committed to cooperation; and

The government leaders in your region have been very supportive of geographic data sharing.

Exploring the Significance of Factors

Regression analysis was used to explore factors that affected the integration of data sets across metropolitan areas. All well-established and proven factors were included and significantly related to the number of layers available for the region as a whole (see Table 4).

Staffing support and provision of continuous funding were associated with a higher number of geographic information layers. The other stimulating factors, such as GIS mandates and pressing urban and regional issues, also played an important role in database integration at the regional level. As expected, the technological element in terms of ease of conversion between different data formats was not relevant. However, surprisingly, clearly defined rules and responsibilities were statistically significant but negatively related to the number of regionally assembled layers.

Finally, while the regional wealth did not seem to be associated with the establishment of an integrated database, the number of administrative entities (e.g., counties, parishes, boroughs) that a metropolitan area consisted of was crucial. The complexity of regional relationships increased with the number of entities involved and with it the challenges they faced.

SUMMARY AND CONCLUSIONS

Information on spatial data holdings and regional assembly was solicited via a Web-based survey of 388 metropolitan planning organizations (MPOs) and other regional entities to assess regional GIS capacity. In addition to understanding the availability of relevant data themes in the metropolitan constituent units (counties, parishes, or boroughs), the extent of data assembly at the regional level, technological, people, policy, and contextual conditions for development and integration of regional GIS data sets were assessed. Summary and analysis of responses were based on two samples: 64 randomly received responses representing a cross section of metropolitan areas of different sizes and 49 responses from organizations located in the largest 50 urban areas.

The study results suggest that despite the major advancements in GIS technology and the extensive efforts spent in spatial data development at the local, regional, state, and national levels in the past two decades, the status of the regional GIS capacity may not be taking full advantage of what is technologically feasible. To begin with, regional data sets were available, assembled, and regularly updated in only a small segment (one-third or less) of metropolitan areas. There was a high compatibility in software and data formats and general openness to geographic data sharing, but limited use of advanced methods for data exchange and integration. For example, Internet-based access to data and establishment of clearinghouses still were rare. Also underdeveloped were the formalized interorganizational mechanisms and agreements on standards, rules, and responsibilities, with one-third or more respondents reporting the absence of such agreements. This finding is consistent with Harvey and Tulloch's (2006) recent research on local data sharing, where they report a relatively low level of formalization of those relationships and activities.

The most interesting and unexpected result in the regression model was the negative significance of rules and responsibilities as a factor in favor of more extensive database assembly. Possibly, the fact that very few respondents had defined rules and responsibilities may have influenced this result. Also, this finding points to differences in sampling between this and the previous research by Nedović-Budić and Pinto. Namely, the sample in the previous research drew from the organizations that already were engaged in

GIS coordination and interorganizational GIS, while this research drew on the population of all regional agencies, regardless of their GIS coordination activity. Perhaps in the organizations already coordinating their GIS, rules and responsibilities were commonly established and reinforcing (but not determining) the success of interorganizational activities; in the random sample where very few organizational groups had established rules and responsibilities, they turned out to be irrelevant for the outcome of joint database activities.

In addition to the establishment of standards and rules and responsibilities as the most concrete manifestation of the readiness to pursue joint data activities, regional cooperation and communication were considered fundamental for building regional GIS capacity. However, they as well were not fully functional in the majority of metropolitan environments. Other factors appeared as expected, such as the presence of regional problems related to urban sprawl and natural resources that stimulated the development and integration of regional GIS databases. Similarly, mandated programmatic requirements for GIS also were encouraging, although not adequately funded. Finally, the lack of stable funding for regional GIS was a general problem. A majority of regional database endeavors drew on local contributions and grants; continuous funding based on budget line items was rare.

The organizations located in the TOP 50/49 largest urban areas functioned under slightly different circumstances than did organizations in medium and small urban areas. Their environments on average could be characterized as more affluent (and thus having more stable funding to support regional GIS efforts), more active in data development activity, more open to data sharing, and more likely to employ advanced methods (e.g., the Internet) for providing data access. However, the larger size of those regions and the higher number of participants involved posed substantial difficulties in cooperating, establishing functional communication networks, accessing other organizations' data, and agreeing on mutual standards and roles and responsibilities. This finding is consistent with previous research on multiparticipant GIS, which recognizes that the increased number of participants complicates the GIS interactions (Ventura 1995). It also relates to the already proven account that coordination incurs cost (Kumar and van Diesel 1996) that grows with the size of the organizations involved.

This study provides one of the rare comprehensive national assessments of regional GIS capacity. It challenges the perception that GIS and spatial data are everywhere and ubiquitously available and accessible even in a country well advanced in the application of geospatial technologies such as the United States. The progress is slower than expected or perceived. Even though the picture probably has changed somewhat since the time the evidence presented in this paper was collected, the situation would not be radically different. Previous studies on the diffusion of GIS show that institutional change lags behind the technology (Budić and Godschalk 1994, Campbell and Masser 1995, Masser and Onsrud 1993). In addition, the regional GIS explored in this study requires interorganizational coordination activities that themselves present many challenges, including, among others, the balancing of diverse interests and motivations; technological, human, and financial resources and capacities; rules and responsibilities; as well as the particulars of each context (Nedović-Budić and Pinto 2000, 2001; Nedović-Budić et al. 2004a). While we are optimistic that the picture has improved since the data for this study was collected in 2003 (particularly with respect to Internet-based access to regional datasets), we also believe that the difference would not be dramatic.

The study findings also raise the question whether these regional GIS could qualify for SDIs and whether they present a substantial installed base for building the higher levels of SDI, e.g., the U.S. NSDI. To a large extent, the answer to this question depends on the definition of SDI. If it is equated with the presence of a clearinghouse, than many of the regional GIS explored here still are unqualified for SDI status; if there is a more relaxed understanding of SDI as a network of data producers and users who exchange spatial data in many ways, than regional GIS may be considered as SDIs and as building blocks of the NSDI. This conjecture along with the other research findings applies primarily to building of the U.S. NSDI, because of its unique institutional setting and culture. The latter is increasingly recognized as an important factor in understanding the nature of SDI developments around the world (Atlantic Institute 2005) and one of the key variables in any international comparative study and project (Hofstede 1980).

As predicted, NSDIs are not easy to develop and we have a long way to go (Masser 2005, Nedović-Budić and Pinto 1999b). The question of NSDI and its installed base is particularly intriguing and is only related to regional GIS but not explicitly addressed in this study. However, we suggest that local and regional GIS have merits and require attention as the constituents of such an installed base. In the United States, a consistent inclusion of this level of spatial data production and use is missing. Despite the FGDC's attempts to reach beyond the state level, these efforts are not sufficiently systematic and binding as they are for the federal agencies. The partnership approach is valuable but limited in the environment that is competitive and fiscally tight. Progress toward the U.S. NSDI requires implementation of more creative and perhaps more aggressive programs geared toward the local and regional installed base. While funded mandates are proven mechanisms of motivating local and regional actions, there may be other innovative approaches to developing and sustaining a viable NSDI, such as restructuring or realignment of institutions dealing with spatial data, inventions in the legal realm, or pragmatic and productive financing schemes. Among other recent efforts is the formation of the National Geospatial Advisory Committee (NGAC) in 2008. The purpose of the group is to facilitate discussions about the framework for a national geospatial policy outcomes as well as organizational structure (http://www.fgdc.gov/ngac/).

Finally, unlike Rajabifard et al. (2003) who consider the local and regional levels as primarily product-driven, we find that it is also interorganizational processes and interactions that give shape to the regional GIS (and consequently the regional SDI). The relationship between different levels of the NSDI hierarchy and the need for a bottom-up building of the NSDI should be explored in more detail. The topics to tackle include, but are not limited to: definition and characteristics of local and regional SDI; connectivity and compatibility among SDIs at different levels; exploration and comparison of SDI hierarchical and network models; programmatic, legal, and financial support for enhancing local and regional capacity; relationship between interorgnizational GIS and SDI; a link between the NSDI and its installed base; and innovations in institutionalizing and sustaining (spatial) information infrastructures. Ultimately and most importantly, it is the translation of the existing and future SDI research results into effective practice that matters the most.

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Appendix A

SAMPLE 64

DATA THEME	DATA AVAILABILITY						IS THE DATA SET ASSEMBLED?	
LAND	All		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Land Use—Existing	35	55	4	6	23	36	28	44
Land Use—Future or Planned	29	45	11	17	23	36	30	47
Parks and Public Lands	37	58	4	6	20	31	27	42
Open Space and Protected Lands	27	42	7	11	25	39	24	38
Developed Land	26	41	13	20	22	34	21	33
Vacant Land	25	39	18	28	17	27	18	28
Infill Sites	4	6	39	61	14	22	8	13
Brownfields	3	5	38	59	17	27	6	9
Historic/Archaeological Sites	17	27	21	33	19	30	16	25
Tax Assessment Data	26	41	11	17	21	33	22	34
REGULATION	All		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Zoning	20	31	10	16	33	52	20	31
Local Comprehensive Plan Designations	26	41	11	17	22	34	18	28
Building Permits (Georeferenced)	11	17	28	44	19	30	10	16
Subdivision Approvals	10	16	30	47	19	30	10	16
Development Rights (Georeferenced	5	8	41	64	7	11	6	9
Growth Boundaries/Service Areas	24	38	21	33	14	22	17	27
BOUNDARIES	All		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Municipal	55	86	7	11	0	0	38	59
Annexation (Georeferenced)	27	42	15	23	13	20	20	31
School Districts	36	56	7	11	19	30	25	39
Special Districts	20	31	22	34	17	27	9	14
Parcel Boundaries	35	55	1	2	25	39	19	30
NATURAL FEATURES	All		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Rivers/Streams	50	78	0	0	10	16	30	47
Floodplains	36	56	6	9	17	27	21	33
Wetlands	32	50	10	16	16	25	20	31
Soils	31	48	14	22	13	20	18	28
Land Cover/Vegetation	28	44	22	34	6	9	15	23
Biodiversity/Habitats	13	20	34	53	8	13	9	14
Topography	35	55	10	16	12	19	22	34
TRANSPORTATION	All		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Street/Road Network	53	83	0	0	8	13	30	47
Transit Lines	42	66	6	9	11	17	24	38
Ports (Air, inland, sea)	38	59	11	17	6	9	20	31
Traffic Analysis Zones (TAZ)	50	78	5	8	7	11	33	52
UTILITIES	All		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Sewer Infrastructure	8	13	19	30	32	50	12	19
Storm Drainage Inf.	5	8	24	38	30	47	7	11

Potable Water Inf.	9	14	22	34	27	42	6	9
Other Utilities	6	9	28	44	24	38	6	9
SERVICES	**All**		**None**		**Some**		**Yes**	
	Number	**Percent**	**Number**	**Percent**	**Number**	Percent	Number	Percent
Schools	31	48	6	9	22	34	19	30
Schools Service Areas	15	23	21	33	22	34	15	23
Fire Stations	24	38	13	20	20	31	15	23
Fire Service Areas	15	23	24	38	19	30	10	16
Police Stations	23	36	13	20	21	33	14	22
Police Service Areas	9	14	28	44	20	31	9	14
OTHER	**All**		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Satellite Imagery	10	16	36	56	10	16	9	14
Aerial Photography	45	70	2	3	14	22	23	36
Real Estate Market Inf. (MLS)	4	6	47	73	5	8	4	6

TOP 50/49

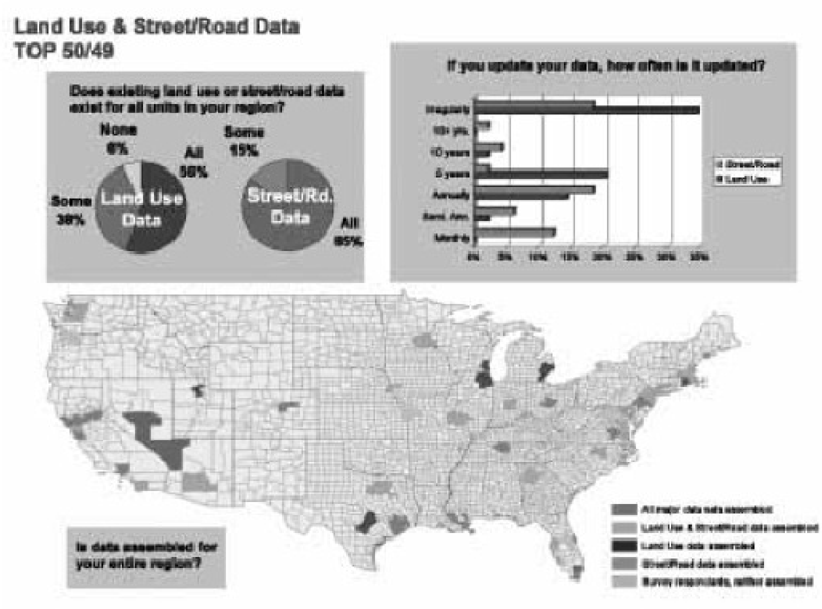
DATA THEME	**DATA AVAILABILITY**						**IS THE DATA SET ASSEMBLED?**	
LAND	**All**		**None**		**Some**		**Yes**	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Land Use—Existing	26	53	3	6	18	37	25	51
Land Use—Future or Planned	20	41	9	18	18	37	23	47
Parks and Public Lands	30	61	2	4	13	27	23	47
Open Space and Protected Lands	23	47	4	8	17	35	23	47
Developed Land	18	37	7	14	19	39	18	37
Vacant Land	16	33	8	16	19	39	16	33
Infill Sites	5	10	21	43	16	33	7	14
Brownfields	2	4	22	45	20	41	4	8
Historic/Archaeological Sites	13	27	11	22	20	41	12	25
Tax Assessment Data	13	27	15	31	15	31	11	22
REGULATION	**All**		**None**		**Some**		**Yes**	
	Number	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Zoning	9	18	9	18	28	57	9	18
Local Comprehensive Plan Designations	13	27	13	27	19	39	12	25
Building Permits (Georeferenced)	8	16	19	39	16	33	9	18
Subdivision Approvals	6	12	18	37	19	39	5	10
Development Rights (Georeferenced)	2	4	27	55	12	25	2	4
Growth Boundaries/Service Areas	14	29	19	39	11	22	14	29

BOUNDARIES	All		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Municipal	41	84	0	0	6	12	33	67
Annexation (Georeferenced)	16	33	12	25	12	25	14	29
School Districts	26	53	7	14	11	22	19	39
Special Districts	12	25	15	31	15	31	11	22
Parcel Boundaries	14	29	7	14	25	51	12	25
NATURAL FEATURES	All		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Rivers/Streams	42	86	0	0	4	8	29	59
Floodplains	30	61	3	6	12	25	20	41
Wetlands	26	53	5	10	13	27	21	43
Soils	27	55	8	16	9	18	18	37
Land Cover/Vegetation	24	49	10	20	8	16	17	35
Biodiversity/Habitats	14	29	18	37	9	18	13	27
Topography	23	47	7	14	13	27	14	29
TRANSPORTATION	All		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Street/Road Network	39	80	0	0	7	14	25	51
Transit Lines	39	80	2	4	5	10	22	45
Ports (Air, inland, sea)	28	57	9	18	5	10	16	33
Traffic Analysis Zones (TAZ)	44	90	1	2	2	4	33	67
UTILITIES	All		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Sewer Infrastructure	4	8	19	39	22	45	5	10
Storm Drainage Inf.	4	8	19	39	22	45	3	6
Potable Water Inf.	5	10	20	41	17	35	4	8
Other Utilities	4	8	21	43	17	35	2	4
SERVICES	All		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Schools	29	59	4	8	11	22	10	20
Schools Service Areas	12	25	18	37	11	22	6	12
Fire Stations	18	37	10	20	14	29	9	18
Fire Service Areas	9	18	19	39	13	27	4	8
Police Stations	17	35	10	20	15	31	8	16
Police Service Areas	9	18	19	39	12	25	5	10
OTHER	All		None		Some		Yes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Satellite Imagery	16	33	21	43	7	14	14	29
Aerial Photography	35	71	3	6	10	20	18	37
Real Estate Market Inf. (MLS)	4	8	33	67	6	12	3	6

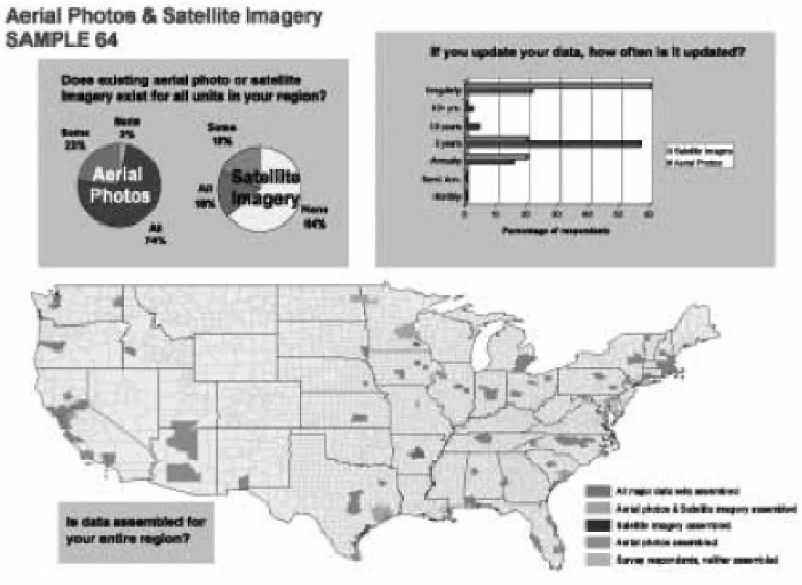
Appendix B

Availability and Update of Land-use and Street/Road Data (SAMPLE 64)

Availability and Update of Land-use and Street/Road Data (TOP 50/49)



Availability and Update of Aerial Photography and Satellite Imagery (SAMPLE 64)



Availability and Update of Aerial Photography and Satellite Imagery (TOP 50/49)