Institutional Linkages for National and Regional GIS – Management Issues, Opportunities and Challenges

Mark Sorensen, Principal
Geographic Planning Collaborative, Inc. (GPC)
Running Springs, California USA

Summary

Geographic information system (GIS) tools and data hold great promise for helping countries, regions and continents to better plan and manage their natural and cultural resources and infrastructure. The use of GIS technology by national mapping organisations and other governmental, institutional and private enterprises is increasing rapidly all over the world. Collectively, we as a world society are making huge investments in a growing infrastructure of comprehensive GIS databases covering a wide range of topics and geographic areas. The technical infrastructure and capacity for distributing and using these data has grown dramatically in ways never imagined even a decade ago, but there still remain significant institutional and management challenges that affect the sharing of critical geographic data across administrative and national boundaries.

Spatial data infrastructure (SDI) is a concept and a process. This paper traces the management issues, opportunities and constraints associated with the various phases in the SDI lifecycle, based on the author's direct experiences and research regarding geographic information infrastructure development around the world.

When discussing management issues associated with the development of national and regional spatial data infrastructure (SDI) at this early stage in our 'information evolution', one can imagine the insecurity that Charles Darwin must have felt when as a young and inexperienced naturalist wandering the world aboard the H.M.S. Beagle, excerpts of his diary were being read in front of professional societies in England, in absentia. This field is so young, our experience immature, and the technological world around us so dynamic, that much of what we might observe or predict now is likely to seem short-sighted, or just plain wrong, in short order.

Like Darwin, the best we can hope to do is hone our observation skills, learn what we can from others around the world who are pursuing similar investigations, and test our ideas through trial and error. Eventually there will accrete a solid and proven framework for SDI. Until then there will be many useful ideas, some of which might eventually produce breakthroughs of Darwinian significance.

The central theme of this paper is the range of 'management and institutional linkage' issues associated with SDI implementation. It is clearly important that leadership also be folded into the discussion. Without leadership for initiating and sustaining each SDI effort, there will be nothing to manage, and these two principles are, of course, very different things.

The implementation of national and regional spatial data infrastructure seems to go through predictable phases, which may take different forms. Each phase comprises its own unique set of management and institutional linkage issues and challenges. For discussion purposes, these phases might be characterised as follows:

- **Phase one – Awareness.** This first phase involves the recognition of a need, and awareness of the technological opportunities available to meet it. Because infrastructure must serve many needs, awareness must be present at the highest levels of the decision-making hierarchy, beyond the more narrow and focused self-interests of specific sectors and disciplines;
- **Phase two – Commitment building.** Commitments must be made to establish the mandate and resources for the implementation of infrastructure. Under autocratic circumstances this can be quite simple, once awareness in the right high offices has been achieved. Other circumstances may require longer term and more complicated consensus building;
- **Phase three – Planning and design.** Once awareness and commitment are accomplished, it is necessary to plan and design a concept for an SDI framework, and a programme for its implementation. Information Technology (IT) science and recent experiences provide useful methods that can be partially emulated and adapted to bring institutions together under a common planning framework;
- **Phase four – Foundation building**. Establishing the foundation level of an SDI presents formidable challenges in building effective institutional linkages where none may have existed in the past. This phase involves laying the groundwork upon which future efforts can build. Initial implementation may require considerable investment and resources with little short-term results and is therefore the most risky and unstable phase of development.
- **Phase five – Proliferation, maintenance and maturation**. In this phase, the focus moves from database building to applications. As the user community grows in breadth and depth, so does the range and sophistication of demands placed on the system, and the institutional frameworks that support it.
- **Phase six – Technology innovation and adaptive management**. Technology is highly dynamic and there are new and improved opportunities presenting themselves every year. Increasing technology awareness and availability within the user community grows with leaps and bounds, and their applications become increasingly sophisticated and specialised. Managing the technology innovation process, and planning for logical expansion and increased institutional synergy is a never-ending management challenge.

Case study examples are used throughout this discussion to punctuate and underscore management and institutional linkage issues associated with each phase of system development.

Phase one – Awareness

The concept of basic infrastructure supported by government is well established. In all nations, the major road and telecommunications networks, and basic health and education facilities, and other major facilities have been funded by governments. It is a legitimate role of government to provide a common and consistent infrastructure to support a wide variety of government, private sector and community activities. The concept of SDI views spatial data as an infrastructure, with the same rationale and administrative characteristics and responsibilities as any other infrastructure. This spatial data infrastructure is needed to support a nation or region's economic growth, and its social and environmental objectives, backed by the standards, guidelines, and policies needed to maintain the integrity of the infrastructure, and to guarantee access.

Before institutions and nations can undertake effective SDI development, there must be awareness of the principles involved and the real benefits that can be achieved. Awareness must ultimately be nurtured at many levels, but for SDI to move forward effectively, its value must be recognised at the top.

Global, national, state or city SDI needs to be conceived within the real business needs of the jurisdiction. The push for an SDI should not be based solely on the technical needs of the GIS users, or on the high level theory of the need for such a system (Barnes). Effective executive awareness must address the deeper implications of SDI, as a fundamental infrastructure to support the real mission of governance, commerce, science and informed citisenry.

SDI crosses all political and administrative boundaries, thus presenting institutional challenges to coordination and cooperation at a level not often required for other issues. Effective SDI implementation requires executive mandate and commitment to bring about an enabling administrative framework that might not have existed previously, and the resources to initiate and sustain the process.

How is SDI awareness achieved?

There are many different points of departure, but upon close investigation they all seem to share some common elements. Awareness seems to begin with individuals or groups who recognise a challenge or opportunity, have a vision for how to address it, and have the leadership, communication skills and political access to articulate this vision to key decision makers in high offices. Awareness may be initiated by a large problem needing solving, or a compelling opportunity to be pursued.

In the United States, a 'National Spatial Data Initiative' was called for by the Clinton administration under an Executive Order published in April, 1994. Initiative for this Order is largely attributed to the technologically savvy Vice-President, Al Gore. This initiative did not appear suddenly on the scene. It was preceded by many years of spatial database building by several large federal agencies such as the U.S. Geological Survey (USGS), the U.S. Environmental Protection Agency (USEPA), the National Oceanic and Atmospheric Administration (NOAA) and others. There was a growing recognition of a need for coordination and cooperation to leverage one another's information, and the standards that would be needed to make this possible. Ultimately, this common recognition of a large and compelling need was transmuted to an executive awareness that became a 'vision' for a national spatial data infrastructure.

In Jamaica, the vision for a national SDI has evolved out of a land titling reform process. The importance of land title reform as part of a national development strategy has been recognised since the early 1980s. A Land Administration Management Programme (LAMP) unit was established within the Office of the Prime Minister (OPM) to oversee and manage the land titling programme. The Land Information Council of Jamaica (LICJ) was established in 1991 to serve as the policy and technical focal point for GIS development in the public sector. A National GIS Coordinator position was created within LAMP to leverage the authority of the Prime Minister's office to help facilitate and integrate the efforts of the LICJ. In addition to the land titling issue, the LAMP unit is simultaneously grappling with other related development issues, and a national LIS framework concept is now recognised as an essential infrastructure to support land management reform across all sectors.

The State of Qatar national GIS was initiated under yet another scenario. The Undersecretary of the Ministry of Municipal Affairs and Agriculture, Sheik Ahmed Al Thani, had been trained as a civil engineer, and is a member of the Qatari royal family. With a technical background and interests, Sheik Ahmed had been exposed to GIS technology and its applications to land and utility management through conferences and visits to other countries. He was intrigued with the idea of establishing a national system for Qatar, and undertook an effort to build awareness of the technology and its implications among other high level offices in each of the national ministries. Through these efforts, all the key ministries were introduced to GIS technology, and this awareness was used to build the executive support needed to establish a national SDI initiative.

Establishment of a national GIS in the Sultanate of Oman was initiated in 1988. Rapid development and population growth in the late 1970s and 1980s resulted in the establishment of the Supreme Committee for Town Planning (SCTP). By Royal Decree, the SCTP was charged with overseeing and facilitating the orderly development of the country. This oversight authority extended across many sectors and ministries as a means of coordinating development activities across government. As part of their efforts, the SCTP envisioned a National Land Information System (LIS) that would establish a foundation of common GIS information and tools to better support and integrate the various ministries. A study was undertaken to conduct a requirements analysis for 23 ministries, and to plan a national LIS and a strategy for its implementation. Orientation seminars were held with each of the ministries involved to provide staff and management a conceptual grounding in GIS principles and practices. This and subsequent efforts helped to raise awareness of the technology within all the ministries.

The European Union (EU) is moving towards the development of a multinational SDI. Several countries have embarked on development of their own GII, and there is strong movement towards a EU-wide initiative. The former Commission President Delor called for the development of an 'information society' in his 1993 vision for Europe. In 1994, senior representatives of industry and government under chairmanship of Commissioner Bangemann made a number of recommendations leading to the adoption of the Commission's Action Plan 'Europe's Way to the Information Society' (Brand).

At present there are a number of European-wide and national initiatives for the development of GII. For the most part, these have been independently conceived and developed. In recognition of the need for more trans-national coordination, a European Spatial Metadata Infrastructure (ESMI) was conceived. ESMI is an initiative by several European public and private organisations to establish a framework for the distribution of geographic information by creating a universal metadata service. ESMI is partially funded as an implementation phase project INFMM 3041 of the INFO2000 Programme of the European Commission DG XIII-E. Partners in this initiative include CNIG (Centro Nacional de Informação Geográfica, Portugal), EUROGI (European Umbrella Organisation for Geographical Information, Netherlands), Geodan (Netherlands), LISITT (University of Valencia, Spain), and MEGRIN (France). These initiatives are going a long ways towards building awareness of SDI significance in Europe.

Phase one – Awareness – Manager's notes:

- A person or group must take the initiative to drive the awareness building process. It does not happen on its own.
- Global, national, state or city spatial information infrastructures need to be conceived within the real business needs and central mission of the jurisdiction.
- Executive awareness must be built from within. Technical awareness, and how technology can support 'mission critical' government, private sector and institutional business must be established first, providing a sound basis for building deeper executive-level awareness and support.
- The need for SDI must be communicated to agency management in a way that they can clearly recognise the potential benefits to their organisations.
- The need for SDI must be communicated to executive management in a way that they can clearly recognise the potential benefits to the nation or region.
- SDI must be promoted as an integrating concept for networked cooperation, not an effort to build another bureaucracy, or take away the responsibilities and information management authorities of participating agencies.

Phase two – Establishing commitment

Once awareness of GIS technology and the benefits of an SDI have been accomplished, it is necessary to secure firm commitment to move forward. Under an autocracy, awareness may be translated to commitment and action immediately, without too much further deliberation. In most circumstances, however, commitment must be carefully built and nurtured at several levels, over some period of time.

Commitment requires clear agreement in principle, a specific mandate and authority to move forward, and the resources to so do. Missing any one of these elements will doom a commitment to inaction or ineffectiveness. Commitment also requires a decision to address barriers to SDI development that may be deeply engrained in government policy and culture. Effective SDI involves sharing information in unprecedented ways. Common barriers that may need to be overcome to achieve commitment include:

- **No existing data sharing culture.** Getting people and organisations to share data where that attitude and function is not already ingrained, or somehow encouraged within the existing organisational culture is difficult, and sometimes may seem impossible.

- **No clear mandate for coordination**. While some countries assign the coordination of information technology (IT) to a single authority, this function is not often extended to include spatial data. This is because spatial information has traditionally not been recognised as an essential, common infrastructure that is needed to support the interests of many organisations.
- **Data are sensitive.** In many countries, topographic basemapping is administered under military mapping agencies, and is considered to be sensitive information. This may persist even though more detailed and accurate data is becoming increasingly available to anyone in the marketplace, through any one of several commercial providers of high resolution remotely sensed data. Some countries have recognised the benefits of the civilian application of their data and are amending national policies and practices accordingly.
- **Data are proprietary.** Some organisations feel that the databases they create are for their use only, and are only provided to others under special conditions, or as a favour or bargaining chip.
- **Pressure for cost recovery.** Organisations that have made a significant investment in developing GIS databases sometimes feel they must recover these costs by charging users exorbitant fees. This policy nearly always creates an environment of reciprocal charge-backs that ultimately defeats the original purpose, while seriously constraining the use of the technology and limiting the benefits that would otherwise accrue to the entire community of users.
- **No resources for the development of common-interest databases.** Under traditional paper mapping methods, the recording and compiling of data themes such as cadastral boundaries or topographic basemapping was carried out under the sole authority and budgets of specific agencies. Unless consciously changed, these conventions can persist as organisations move into the creation of digital databases. Modernising the organisation's accounting systems can be accomplished to treat the development of these fundamental digital data layers as a common infrastructure to be funded and administered as a joint resource.

In the U.S., a National Performance Review was conducted by the federal government to investigate, among other things, the need for a more integrated strategy for dealing with spatial information. The Review ultimately recommended that the executive branch develop, in cooperation with State, local, and tribal governments, and the private sector, a coordinated National Spatial Data Infrastructure (NSDI) to support public and private sector applications of geospatial data in such areas as transportation, community development, agriculture, emergency response, environmental management, and information technology. The resulting Executive Order further called for establishing a National Geospatial Data Clearinghouse for the development of a 'distributed network of geospatial data producers, managers, and users linked electronically'. A Federal Geographic Data Committee (FGDC) was created to coordinate the federal government's development of the NGII, and funding was established to support the initial development of the FGDC and Data Clearinghouse functions.

The Permanent Committee on GIS Infrastructure for Asia and the Pacific was established to maximise the economic, social and environmental benefits of geographic information by providing a forum for 55 member nations in the Asia-Pacific region to: cooperate in the development of a regional geographic information infrastructure; contribute to the development of the global geographic information infrastructure; share experiences and consult on matters of common interest; and participate in any other form of activity such as education, training, and technology transfer. The Committee has established several Working Groups that are now focused on developing policies and action plans relative to various aspects of GII for the region.

In Qatar, the commitment phase took the form of an agreement to establish a National GIS Centre. Under this concept, each Ministry would contribute funding and staff to the Centre. The Centre was tasked with developing the national database, and was funded to carry out specific 'foundation' database development projects. The Centre was also responsible for training the participating staff so that they could eventually return to their own ministries to effectively support internal projects and operations.

The SCTP in Oman established technical and policy committee forums and continues to play a facilitation role in coordinating GIS development throughout the country. However, funding for database development has been left up to the individual ministries. Since there is no formal, effective mechanism for the joint funding of common-purpose databases, development has been slow. Awareness, interest and skills in GIS are high in Oman, and the mandate for a national LIS is intact, but development seems to have been slowed by the lack of a cohesive financial strategy for the development of common-purpose databases.

The Government of Jamaica (GOJ) has committed operating funding to the LAMP and the LICJ, and several organisations are carrying out their own GIS development work within the general guidelines of the national initiative. The government wishes to leverage external sources to finance the development of national basemap and cadastral databases. While the Jamaica SDI is therefore dependent on the motivations and priorities of external funding sources, this has been seen as the only practical approach since the country does not have the internal resources to implement this initiative in any timely fashion.

Phase two – Establishing commitment – Manager's notes:

- SDI commitment must come from the highest level office possible, to avoid reversals by higher authorities later in the process.
- The initial commitment must include:

  agreement in principle to the purpose and process for establishing an SDI;

  clear mandate, and authority upon which to proceed; and

  resources to support initial efforts.
- SDI commitment must be long term, and must be positioned as much as possible to outlive political cycles and shifts.

Phase three – Planning

For most countries, the development of a national SDI is a step-by-step, incremental process that must acknowledge and be responsive to the special circumstances of each nation. The special political, administrative, economic and legal contexts of each country or region can require unique, creative and unconventional solutions towards achieving the same basic end result. Developing a well-considered strategy and workplan towards an appropriate solution requires careful study, evaluation and planning.

While there is no single best approach for the initial planning stage of an SDI, a series of generic steps can be acknowledged, and each has organisational and institutional management implications that need to be addressed.

Identify the appropriate organisation to sponsor an initial feasibility study

In most countries, there is no clear administrative mandate or assignment for a central agency to coordinate the development of a SDI. Securing such a mandate in the near term may be politically impractical, and existing organisations may be ill-equipped to immediately assume such responsibility. A feasibility study may need to be carried out to assess the existing situation, provide a rational evaluation of the capacity of existing organisations to assume the coordination role, and formulate one or more alternative paths for assigning responsibility, building the necessary capacity, and laying out a phased implementation programme.

The sponsorship of a single agency that has a related administrative mandate and/or an existing technical capacity for sponsoring a feasibility study can be solicited. While this agency may not ultimately take responsibility for administering a national clearinghouse, it is important that there is one organisation that assumes primary responsibility and accountability for carrying out the feasibility study. Assignment of this sponsorship should be made at the highest level possible in the government bureaucracy, and supported by the broadest possible consensus of the agencies that will participate in carrying it out. High level mandate and popular support can overcome many obstacles. Once an organisation has been selected to sponsor the study, an appropriate implementation plan must be developed. Funding for the study will need to be secured from internal or external sources. Staff assignments for carrying out or participating in the study will need to be made, and a detailed plan for carrying out the study developed.

Establish funding for the feasibility study

If the sponsoring agency does not immediately possess the funds and/or staff resources to carry out the feasibility study, it may be necessary to solicit this funding from other sources. This may require allocation of internal government funds, cost sharing with other participating agencies or organisations, soliciting funding from external lending or granting agencies, and other means. Most sources will require the development of a funding proposal, including a description of the project, its intended benefits, a detailed work programme for its execution, assignment of roles and responsibility among the participants, staffing and staff qualifications, timeframe for execution, and a breakdown of project costs.

Conduct SDI requirements analysis

A variety of organisations involved in the development or use of geographic data in the country must be approached to determine requirements for a national SDI. These include representatives of local, regional and national government organisations, NGO's involved in the planning and management of cultural and environmental resources, the international multi-lateral and bilateral agencies who provide funding for planning, development and resource management projects, and the business community that may use GIS data for commercial purposes. A series of issues should be explored with each organisation, including:

- type of projects conducted and most common data topics needed;
- geographic data generated or used;
- for data used, where acquired, and in what form, scale, data resolution, and so on;
- needs for a spatial data clearinghouse;
- perceived issues or concerns;
- needs for information exchange regarding GIS and related technologies;
- needs for specialised, GIS-related technical support that could be provided by a SDI clearinghouse or other form of service bureau;
- internal technical capacity maintained now, including staff skill levels, existing computerisation, and data communications infrastructure; and
- existing framework of policies or regulations that would affect data sharing and related issues.

Requirements identified during the interview stage should be carefully documented for use during the conceptual system design in a later task.

Conduct data inventory and evaluation

Information from the previous step can be used to compile a representative inventory and brief evaluation of key geographic data in the country, inclusive of data in both digital and hard copy forms. Special focus should be placed on the most commonly needed, fundamental data layers as discovered in the previous task. Characteristics of the data sources such as map accuracy and resolution, map scale and geographic extent, currency and quality, subject matter presented, and possible automation problems should be considered. Redundancy of data collection by different agencies, as well as inconsistencies between data sources of the same data theme, should be evaluated. A data evaluation report should be produced to provide a summary of each data source referenced during the interview stage. Metadata describing each existing source of hardcopy and digital information can be captured in this step, thus creating the first SDI component that will be useful even if nothing else is accomplished.

Prepare conceptual system design and implementation plan

In this task, a conceptual system framework design for the national clearinghouse and other components of the SDI framework can be prepared. The conceptual design should address all the key components of the proposed GII, including:

Spatial Data Clearinghouse. A conceptual design for a national spatial data clearinghouse should be developed, including a general definition of its recommended form, function and responsibilities. If not already selected, candidate agencies may be nominated to host the initial data clearinghouse, or to coordinate a network of sources, as appropriate. Candidates should be selected based upon a rational evaluation of the situation, based on existing capabilities, mandates, and other prerequisites for ensuring success:

- specific existing mandate for carrying out multiple-agency IT or data coordination;
- knowledge and experience in the management, use and distribution of data;
- specific experience in managing GIS data;
- executive interest and support for the initiative at the highest levels of the candidate organisation;
- technical expertise at staff level in the use and management of GIS data;
- strong base of existing computing infrastructure, including hardware, software, and data communication networks;
- willingness of management to commit sufficient staff to carry out the coordination and facilitation role;
- clear existing or potential funding sources;
- clear high-level support from the highest levels of government for the assignment of the mandate; and
- strong consensus of support for this assignment from the key agencies and organisations that will participate in building the SDI.

If an organisation meets a majority of the above conditions, chances are that any capacity deficiencies can be overcome through training of existing staff, adding staff or computing infrastructure, or other institution building measures.

Metadata. Metadata standards are becoming well established in many countries, and these can be used as a starting point for developing a standard that is appropriate for a given country or region. Full metadata standards are extensive and complicated. Some agencies may not be prepared to document their data at this level, so it is important to clearly identify which components of the metadata are absolutely required, and those that may be documented over time, or on an as-needed basis.

Data Standards. There will be a need to identify the fundamental data layers that are commonly needed by the majority of potential users. A conceptual design for these layers should be prepared, considering the application requirements of the users, and the form of the existing data. Spatial and tabular relationships among the fundamental data layers should be considered in the development of an integrated data framework. The conceptual design should also identify specific issues and conditions that will need to be addressed in the physical design of these data layers during the development of the pilot programme, as discussed later.

Considerable work has already been done in the development of standards in many countries, and it may not be necessary or appropriate to develop completely new standards. Time and effort may be saved by adapting existing standards to national needs. Also, the International Organisation for Standardisation (ISO) has established a committee structure (ISO TC/211) for geographic information standardisation as a field of technical activity. This ISO work will provide a framework for global, regional and national spatial data standardisation that may provide useful guidance for regional and national efforts. (Teknologistandardisering)

Process. Processes and functions of the primary participants in the initial building of the GII should be clearly spelled out. Processes to be addressed in the feasibility study will be focused on data conversion, integration, management and dissemination. The feasibility study should also describe other process-related standards that will need to be addressed in the future.

Organisation. The feasibility study should define the conceptual structure for the national data clearinghouse unit, including general roles and responsibilities, staffing, and cooperative linkages with other organisations. It should also define organisational and staffing issues of the other key agencies that will be involved in the initial stages of SDI development.

Technology. A technology framework for the SDI should be described in the conceptual system design, including software, hardware, data communications and system protocol issues. The conceptual design should focus on the required technical functions and capacity of the system, rather than any configuration specifics. This conceptual description can be used later as the basis for a physical system design that will provide detailed specifications for the actual system components at the time of implementation.

Communications. A framework of methods and procedures to establish and maintain active communications among the SDI user community should be identified in the conceptual design. This may include standard and as-needed information dissemination, executive and staff level committee meetings, a web site or other medium for communicating status and new developments, email list servers, annual conferences, and other means of maintaining clear communications and information flow among participants.

Cooperative Partnerships. A central mandate will establish responsibility for the national spatial data clearinghouse. This will need to be supported by formalised agreements among all the key participating member agencies and organisations. These agreements may take the form of Memoranda of Understanding (MOU), joint cooperative agreements, letters of intent, or other documented forms. Any such agreements should clearly spell out the roles and responsibilities of the participants, specific commitment of staff time, equipment, funding, or other resources, and timeframes for carrying out these commitments.

Implementation Strategy. A strategic plan for the initial implementation of the GII should be developed. While some fundamental components of the GII may take substantial resources and many years to complete, experience suggests that it is absolutely critical that visible and compelling benefits are made evident throughout the development process. The implementation plan should be carefully crafted to focus on the early execution of those components that are practical to implement, that can support the broadest needs, and that will yield near-term, visible benefits. These are all necessary to gaining and sustaining the executive and administrative support that will be necessary to build the system, and maintain support over time. Longer term issues should also be addressed in the plan, but these should be carefully balanced against the framework of more immediate and visible topics that will be needed to market the system during the early stages of development.

The implementation plan should clearly define specific tasks to be carried out, task responsibilities, timeframes, task interdependencies, milestones, task products and other issues. Depending on the situation, the implementation plan may be conservative, limited in scope and primarily focused on specific foundation issues. A more ambitious course may be prescribed where there is the interest, support, and resources to carry out a larger and more aggressive implementation programme. In either case, a pilot programme should be specified as an initial testing ground for the ideas and approach expressed in the conceptual design. The pilot will also be useful for demonstrating the utility and potential benefits of the system to others. The Pilot Programme should be structured to a limited implementation of key components of the design for one or more specific geographic areas.

Implementation Funding Strategy. There are a variety of internal and external funding sources that may be used for the initial and ongoing funding of the SDI implementation. Internal budgets may be established to fund the initiative as a multiple-agency infrastructure building effort. Multilateral and bilateral lending institutions and granting agencies may have an interest in providing all or part of the funding for implementation. The implementation funding strategy should identify and characterise funding scenario options, and articulate the opportunities and constraints of each. This may also involve opening discussions with potential external funding sources to determine their level of interest and conditions that may apply.

Phase three – Planning – Manager's notes

- A structured and well-considered SDI planning process can help to involve participants, build partnerships and communications channels, and establish consensus.
- The planning process can help to de-politicise the assignment of mandate for a coordinating role, or provide rationale for the establishment of a special unit of government to take on this responsibility.
- A step-by-step process allows consideration of the generalised organisational and technical context, within which priorities and focus for initial implementation can be developed.
- Present experience suggests that there is a recipe of ingredients needed to support SDI development. While the basic ingredients may be similar, every country and region will need to take care to conceive methods to meet their special situation and needs.

Phase four – Foundation building

A strong and effective structure requires first a strong foundation to support it. The initial implementation of an SDI requires such a foundation. This does not mean that an initial SDI implementation effort must be large in scope, costly, time-consuming and all-inclusive. In fact, most countries in the world will not have the resources to carry out such a massive programme. It does mean, however, that an incremental approach must seek to carry out the most important foundation elements first, followed in suit with additional elements as appropriate. What this really means, and the form and content of such an incremental programme, will vary from country to country. Current experience suggests some patterns that may be useful to consider.

The Jamaica LAMP and LICJ have prepared a national LIS implementation strategy to lay down a path for the incremental development of their SDI. Implementation will be fuelled by opportunities like the national land titling reform initiative, but each opportunity is to be implemented within the context of the larger strategy. Each opportunity is thus leveraged towards the broader vision, in a manner that is practical and incremental. Many opportunities are expected to occur at the ministry level. Ministerial representation and involvement in the LICJ, and the GIS implementation oversight responsibility of that Council, are therefore seen as critical to ensure that each opportunity can meet ministry-specific needs while also fulfilling national, multi-sectoral needs.

In the U.S., the NSDI process has focused on the development of standards around which coordinated efforts can be structured. The FGDC was first assigned responsibilities for coordinating geospatial data themes to different Federal Departments, including the establishment and implementation of data standards for quality, content, and transfer. An Executive Order designates the FGDC as the lead entity to coordinate the National Spatial Data Infrastructure (NSDI), which is defined as the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilisation of geospatial data. The FGDC is charged to ‘develop standards for implementing the NSDI, in consultation and cooperation with State, local, and tribal governments, the private and academic sectors, and, to the extent feasible, the international community’. The FGDC is also charged to promote the use of these standards and whenever appropriate submit them to the Commerce Department for consideration as Federal Information Processing Standards.

The FGDC Standards Working Group (SWG) was established to help meet the organisation’s objectives and activities. The SWG provides guidance to the FGDC subcommittees and working groups on standards policies and procedures, reviews standards proposals and standards documents for compliance to these policies and procedures, and makes recommendation to the Coordination Group for final FGDC endorsement. The FGDC Standards Reference Model represents an effort by the SWG to document standards policies and procedures and to provide guidelines by which the FGDC will conduct standards development. This model describes the relationship of FGDC to other standards bodies, identifies the expectations of FGDC standards, defines the various types of geospatial data standards and outlines the FGDC standards development process.

The State of Qatar adopted an approach to foundation building that is probably unique in the world – they simply went out and built the entire system in a concentrated, multiple-year effort. The country is relatively small, and there was sufficient resources and executive commitment and support to implement the fundamental topographic, cadastral and facility databases in a relatively short period of time. The strong executive consensus underlying the decision to establish a National GIS Centre also helped to make this development possible.

In the Southern Hemisphere, the governments of Australia and New Zealand have taken an active role in developing SDI within their respective countries, as well as joint development and discussion towards an Australasian programme. The Australia-New Zealand Land Information Council (ANZLIC) has developed a regional SDI programme focused on surveying, mapping, and property related data. The organisation is also working with other agencies involved in other topical areas to encourage and improve coordination and standardisation between different types of data, towards the development of the Australian Spatial Data Infrastructure (AGII) (Baker).

ANZLIC have also thrown their weight behind the Global Spatial Data Initiative (GSDI) being promoted by Brand, of Northern Ireland. The secretarial support for these initiatives is being provided by AUSLIG (the national government's surveying and land information group). AUSLIG are also supporting the Open GIS Consortium as a full member, along with the FGDC, US Army Topographic Engineering Centre, and the US Department of Defense National Imagery and Mapping Agency (NIMA), among others (Barnes).

Phase four – Building the foundation – Manager's notes

- There must be an identifiable organisation responsible for initiating, coordinating and overseeing SDI foundation development (Barnes).
- Foundation building must be backed up by clear, long-term commitment by executive management. The structure must be seen as able to survive normal political change.
- Establishment of acceptable standards is a fundamental foundation component for SDI development.
- Opening and actively maintaining channels for multiple-organisation communications and dialog is critical.
- Framework database development must be undertaken with the involvement of all the major stakeholders, under a logical financing structure that recognises data as an infrastructure asset, the benefits of which will accrue to many others beyond the immediately responsible agency.

Phase five – Proliferation, maintenance and maturation

Experience suggests that as more data become available, and more people become aware of its existence and use, the corresponding demand increases exponentially. As the technology and stakeholders mature, the demands not only increase in number, but in levels of sophistication and specialisation as well. Standards that may have been commonly accepted in the beginning, when stakeholders were mostly concerned with building databases and providing access to previously inaccessible information, may come into question as users attempt to apply this information to increasingly sophisticated and specialised applications. At the same time, technology is advancing at breakneck speed, and offering all sorts of seductive opportunities that can strain institutional linkages and the balancing of specialised discipline-specific needs against those of a broader user community. Managing exponential demand while maintaining common infrastructure integrity and risks associated with ongoing technology innovation will become a large and significant management challenge in the years to come.

National SDI is a relatively recent development, thus we must include experiences at the local and regional levels to apply an informed guess about how this might be manifest at the broader scale.

For over a decade, the City of San Diego in California has aggressively and successfully pursued the implementation of a comprehensive geographic information system (GIS) capability. More than 200 layers of important geographic data are now available to City Departments. GIS technology has evolved to become a very significant component of the City's information infrastructure, supporting a broad range of management and operational activities. The City has also participated in formalised coordination with the County of San Diego and other regional stakeholders, first in the form of the Regional Urban Information System (RUIS), and now the SanGIS organisation established through a Joint Powers Agreement (JPA) between the City and the County.

In 1990, RUIS adopted a particular vendor's line of products as the City/County standard software, based on the recommendation of their Standards Committee. This decision was largely founded around a GIS Enterprise System concept that was envisioned as the most effective way to serve the broadest range of user applications within the City/County. While it was recognised that some Departments would eventually have very specialised needs, the Committee determined the vendor's family of products was best suited to support the broadest range of functional requirements across the City and County. Today, nearly every department within the City and County governments uses this vendor's products, or other products that interface well with them.

The City's Information Technology and Communications (IT&C) department has been responsible for coordinating and overseeing geoprocessing standards. In 1996, the ITC agreed to a request by a large department to use a non-standard GIS software package strictly for the purpose of meeting specialised needs and to satisfy certain legal requirements dictated by a court decree. IT&C accepted this approach, under specific limiting conditions. That department now wishes to expand the use of the software to meet other inter and intra-department needs, and the IT&C has acknowledged that the current policy framework and review procedures within the City are not sufficient to effectively manage technology innovation and the evaluation of associated opportunities, impacts, and risks. The IT&C is now undertaking a comprehensive review and refinement of the City's policy in an effort to develop a more rigorous and flexible framework to better support effective technology innovation management.

In a regional case example, the Florida Marine Research Institute (FMRI) located in St. Petersburg, Florida, USA has compiled a large collection of coastal and marine resource information for the State. This collecting includes a full range of information extending from highly specialised basic scientific research results for limited geographic areas, through large databases of common basemap and reference information. Much of this data has been assembled from a variety of local, state and federal government sources. The Institute has been attempting to use these data together to support regional resource assessment and other advanced applications, but has been hampered by the lack of integration among these disparate sources. The Institute is now having to invest significant resources and time in attempting to integrate these data sources to a level that can be used for multi-factor resource assessment, ecosystem management and other uses. While many of these legacy databases were created prior to establishment of the FGDC, there still exists a significant gap between the standards under development, and their universal application in any comprehensive way at multiple levels of government.

Phase five – Proliferation, maintenance and maturation – Manager's notes

- With increased data availability and technology awareness comes an exponential growth in the number, sophistication and specialisation of system demands, with all the requisite management issues.
- Geoprocessing standards must acknowledge the needs of the broader information community while allowing flexibility for specialised, discipline-specific requirements.
- Technology is changing rapidly, and advancements in de facto and adopted information technology (IT) standards are opening new opportunities for advanced applications and more heterogeneous computing environments.
- Increasing the quantity, quality, currency and availability of information requires a rigorous and consistently maintained SDI structure.
- SDI is an informational asset. Management must define who will continue to invest in the development of this asset and who benefits, in a form that is equitable and sustainable.

Phase six – Monitoring and adaptive management

As noted previously, information technology at all levels is advancing at breakneck speed, and new opportunities and challenges are surfacing all the time. Establishing structured methods for monitoring technology horizons, supporting an ever-growing sophisticated information community, managed technology innovation adoption where warranted, and the incremental adaptation to this changing environment, will likely be the most significant challenges to SDI in the early years of the next millennium. We are too young in the SDI development cycle to have any real, proven case examples in this phase, so any summary is pure conjecture. This is new territory, and ideas and hypotheses are as numerous and diverse as the SDI community is broad.

At the risk of seeming presumptuous, or just plain wrong upon future historic retrospective, there are a few guiding principles that managers may wish to consider as we chart a future course for national, regional and global SDI.

Embrace change as an unavoidable opportunity. If there is one thing that can be predicted with some reliability, it is that technological change and the context of SDI will continue to change and evolve rapidly. We might as well embrace this change, and learn to recognise and harness change as a positive force, rather than become a victim to its vagaries.

Avoid the 'bleeding edge'. Many flashy technologies come and go at a whim. SDI is an infrastructure that must have a consistency and integrity that outlives yearly perturbations on the technology radar. Advanced research and development functions can be established to provide monitoring and evaluation support, but the core of the SDI should only be built around proven technology.

Move towards more open technology. De facto and industry standards such as those proposed by the ISO, Open GIS Consortium and others are moving us ever closer to the open technology and universal interoperability ideal. There is some question whether this can actually be accomplished, but the principle is good and these initiatives are having a positive impact on overall computing and geoprocessing flexibility and usability

Less GIS, more operations. Trends suggest that as GIS continues to evolve, it will become less and less a specialised technology, and more an integrated component of operations support and decision-support systems. The advancement of global communications, mixed media, 'knowledge networks', and other emerging technologies will reveal new horizons that we have not even yet imagined.

Massively connected public. The Internet is probably the tip of a technological iceberg that will ultimately impact all parts of our life, including how we live, work and play, purchase goods, interact with others in new social formats, the form and function of cities, and the form and function of governance.

Phase six – Monitoring and adaptive management – Manager's notes

- The only thing we can be sure about this phase is that change will continue to happen, and the most successful managers will likely be those who figure out how best to harness and direct that change through rational, well-considered leadership and management.

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