## How to assess the success of National Spatial Data Infrastructures?

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**Abstract**

In the information age, information has become of vital importance to the economic and social development of a country. Especially geographic information is of increasing importance for the successful execution of (public) tasks. Spatial data infrastructures (SDIs) facilitate the collection, maintenance, dissemination, and use of spatial information. Due to the continuous change of the components of the SDI, the organisational component needs to change accordingly to enable the further development of an SDI. The authors used organisational theory to develop a means to assess the success of a National SDI's organisational context. This paper works out indicators and key conditions enabling the further development of an NSDI, accounting for its stepwise development. Crucial aspects from an organisational perspective in NSDI development are the existence of a vision, leadership, communication strategy, coherence and intention of the geographic community to initiate new innovations. The extent to which these aspects are present in an SDI initiative determines its stage of development, and as a result the success of that SDI.

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The NSDI characteristics of the Netherlands and the United States are used to test the proposed framework.

## 1. Introduction

In the information age, information has become of vital importance to the economic and social development of a country. Especially geographic information is of increasing importance for the successful execution of (public) tasks. Spatial data infrastructures (SDIs) facilitate the collection, maintenance, dissemination, and use of spatial information. By reducing duplication, facilitating integration and developing new and innovative applications, and respecting user needs, SDIs can produce significant human and resource savings and returns (see Chan et al., 2001).

The following components of SDIs are often identified (e.g., McLaughlin & Nichols, 1994, Rajabifard & Williamson, 2002): (Framework) data sets, Institutional framework, Policies, Technology, Standards, and Human resources. The discussions in the literature, however, primarily focus on the technical issues of SDIs. In these discussions the institutional framework, the policy, and human resources are often insufficiently addressed. If these organisational aspects of an SDI are addressed, they are often described as a stable, non-moving factor. There is, however, always interaction between the elements of the infrastructure. This interaction is a condition for the further development of the infrastructure. The organisational conditions are becoming increasingly important for the success and vitality of the advanced, or mature SDI communities.

This paper provides a framework for the assessment of success of an NSDI through its organisational characteristics. It identifies four stages of SDI development and

provides indicators to determine the stages of development of an SDI from an organisational perspective. The stages are obtained from organisational, business administration, and management theory. More specific, the theory addresses the ability of organisations, or communities to accomplish change or renewal. These changes or renewals result in stages of maturity of the development of SDIs. This paper develops, explains, and tests the model of development through the situation in the Netherlands and the United States of America.

## 2. The role of the organisational context of SDI in the development of an SDI

An SDI develops gradually. Step by step the needed components are improved and the most pressing issues addressed. In the very beginning, these issues focus on the collection of the data: what data should be collected, and who should collect it. In the other stages of maturity, the issues become more and more political: who is allowed to access the data, who is allowed to use the data and at what price? These different stages do have different characteristics.

Parallel to this development of an SDI as such, also the environment, in which an SDI develops, changes. Innovations result in the introduction of new technology, and new products, which may change the way an SDI performs, or the role it plays in society. New insights may result in new policies, and in new activities within an individual organisation or the NSDI. Further, changes in the SDI environment may lead to new needs and new believes, changing the ultimate ideal of an NSDI. Chan argues that it will never be possible to specify the ideal SDI because "SDI development takes place in a dispersed scenario in which the final purposes, functionalities and composition of the SDI change dynamically and can only be specified vaguely" (Chan et al., 2001). This argument implies that the needs of communities change over time and that therefore the ideal will change accordingly. This is fully in line with our experiences.

Organisational conditions are relevant in the process of the creation of a highly mature and sustainable NSDI. This is a continuing process that never ends. Every community may respond differently to the organisational change process.

*2.1 Organisational change theory*

In organisational change theory three approaches can be distinguished: Planned Change, Organisational Development, and Continuous Changing (Boonstra, 2004b). Boonstra (2004b, p.5) describes these theories as follows: "The purpose of Planned Change is to create economic value. Its focus is on formal structures and systems. It is driven top-down with extensive help from consultant and financial incentives. Change is planned and programmatic. The purpose of Organisational Development is the joint optimisation of social and technical systems, and the simultaneous development of organisational effectiveness and the quality of working life. Change is emergent, less planned and programmatic". He continues with "Planned Change focuses on rapid, dramatic, and painful changes that may be required to increase economic value, which cannot be achieved through a long-term Organisation Development strategy. Organisation Development strategy focuses on building new trust and commitment and the development of human competencies" (Boonstra, 2004b, p.5). Both theories regard organisations as "logical and objective entities whose outcomes are related to how it fits the environment and to organisational strategies, structures, cultures, and human resources. These two theories focus mainly on changing organisational structures, technologies, human relations and individual competencies to match environmental contingencies" (Boonstra, 2004b, p.7). The Continuous Changing theory, on the other hand, sees the relation between "person and organisation as one of mutual creation: through their interactions people construct an organisation as a

social reality, which in turn reflects and influences interactions. To understand processes of organising and changing, attention is given to multiple, local-historical and social realities that are constructed in relational processes and through interaction" (Boonstra, 2004b, p.7).

The organisational theoretical framework of Boonstra (2000, see also Bennebroek Gravenhorst et al 2003, and Boonstra, 2004a) identifies the characteristics of the stakeholders in an organisation or community in a certain stage of development of the change process. They combined concepts from Organisation Development with concepts of Planned Change and concepts of Organisational Learning (Boonstra, 2004a). Boonstra's theory aims to fit a single organisational context. Our experiences indicate that although the multi-organisational setting of an SDI may be more complicated than a single organisational environment, at the conceptual level the issues are similar.

We used Boonstra's theory as a starting point for a new model assessing the success of an NSDI. This resulted in four stages of development of an NSDI: stand alone, exchange, intermediary, and the network stage (see Figure 1). Each of them relate to a specific organisational environment. Here, an insight is provided in the method of assessment of the level of maturity of an NSDI, and a way of NSDI comparison proposed.

*2.2 Stage I: Stand-alone*

The Stand-alone stage has the characteristics of Boonstra's "cynical context". In a cynical organisational context the individual organisations potentially participating in the SDI experience no bottlenecks. Change is considered unnecessary and almost no

support will exist for change. Phrases like "What's new?", "This will not work, do not get involved" are commonly heard in the organisations. The culture within organisations is conservative, pursuing their own interests, and the willingness to change is lacking. The development of the SDI is not considered a priority of the individual organisations. In this stage communication between organisations is hindered by hidden agenda's and, as a result, the commitment to change the organisation from internally centred towards a more externally focused one is lacking. The technical description of the data that ideally should exist, is emphasized. The vision often includes an infrastructure centralised within one major data producer. In an NSDI context, this implies that there is no (common) vision, leadership for NSDI is lacking, the communication is primarily within the organisation itself, and the self-organising ability of the sector is limited to pre-defined tasks resulting in a passive attitude towards new questions arising from society.

*2.3 Stage II: Exchange and Standardisation on Technical Level*

Boonstra describes this stage as the "sceptical stage". Organisations or communities think along common lines. In this stage a sense of communality is developed which may result in common short-term goals and recognition of common bottlenecks. The primary focus of the discussions is on standardisation and framework datasets. The recognised bottlenecks are accompanied with the acknowledgement of the difficulty to solve all barriers at once: problems are prioritised. In this stage the professional stakeholders are involved in the creation of the vision of the NSDI, leadership is being discussed, communication is used for data exchange, and the self- organising ability is active for some issues, but passive for others. Our model names this stage the exchange stage.

*2.4 Stage III: Intermediary*

The intermediary context has the characteristics of Boonstra's "desiring context". In the desiring context many bottlenecks exist in the organisation: the organisation desires a new and better situation. The need for change is evident, but has to be communicated effectively, for example through best practice examples. When people find the change necessary and they agree with the goals, their support for change and commitment are likely to increase. In such a context the support for change will be high within the organisations. In an SDI context, this implies that there is increasing awareness for the need to cooperate among stakeholders: organisations change from internally centred towards organisations open to external developments. There is consensus on the role of stakeholders in the development. Cooperation among stakeholders results in actively solving societal problems and opportunities. Standards are further developed and policy issues discussed within the geo-information community. The change in this stage is not promoted from the top, but is initiated at the bottom.

*2.5 Stage IV: Network*

In the network stage or Boonstra's "innovative context" few organisational bottlenecks exist and the change process is driven by innovative motives. "The goals of the change process are clear and there is broad support for them. Technological change is easily realised and the process does not cause tensions within and between organisations. Top managers are actively involved in the process and are stimulating full support from all organisation members. Members of the organisations have positive expectations regarding the development and outcome of the change process,

believe that change is necessary and want to contribute to the change process" (Bennebroek Gravenhorst et. al., 2003). Broad support exists for the NSDI vision, which is continuously reviewed by a variety of stakeholders through open communication channels. In this stage a pro-active community is working together on innovative solutions for societal problems.

## 3. Organisational aspects determining the organisational context

In order to move from one stage to another one has to identify organisational characteristics to come to a more advanced SDI. A decade of experience of first generation SDIs (see Masser, 1999) enables us to evaluate the success factors, and to come to an organisational ideal in a certain stage of development. The likeliness that an ideal situation will be reached depends on four critical organisational components of the SDI:

- Leadership

- A vision

- Communication channels

- Ability of the spatial information community for self-organisation

### 3.1 Leadership

Leadership is one of the issues that is considered as critical (see When de Montalvo, 2001). The SDI needs a problem owner, someone who promotes, and coordinates the development of an SDI. Outreach and capacity building activities may lead to political support for SDI.

A leader can be appointed by a formal mandate, often supported with the highest level of political support. This is recommended in When de Montalvo (2001). A leader can

also emerge from existing national coordination activities (Masser, 1999). Both approaches have their pros and cons. Political support for the SDI is important (Craglia et al., 2002, p. 59) but also the 'work floor' (top/ high profile management) has to be positive about it. Continuous support for an SDI both in politics and management would be the thing to strive for (see also Craglia et al., 2002).

In the stand-alone stage of organisational development, the individual organisations do not consider the SDI as such, and as a result SDI leadership is lacking. In the exchange stage the awareness of the importance of coordination is increasing and potential leaders are discussed. This process would result in the accepted leadership of one or a limited number of entities. If the accepted leader manages to satisfy the geographic community on continuous bases the leadership will be respected.

*3.2 A vision*

A vision in this context may be described as a needed or beneficial future situation. A vision shared by stakeholders is likely to direct the activities of the stakeholders in the same direction. This agreement among stakeholders over the goals is important for transforming the abstract goals into concrete actions to be taken. Without a common goal, or objective, initiatives are likely to diffuse in any direction without taking advantage of each other. The vision provides the direction for SDI development.

In the stand-alone stage of development, every individual SDI stakeholder may have a unique vision, primarily promoting the organisation's objective. Later this becomes part of a negotiated vision shared by all (exchange stage). Ultimately an independent vision should be created and supported by all, and frequently reviewed (network stage).

*3.3 Communication channels*

Communication is very important for the acceptance, perception, and support of a leader. Communication channels may be the means that enable "the exchange of thoughts, messages, or information, as by speech, signals, writing, or behaviour" (Webster online, 2002). Communication in the first stages of an SDI is limited and directed to every individual organisation itself. Later it may focus on the exchange of information with other organisations, leading to partnerships in projects responding to public or private needs. This increasing focus on external communication leads to the need for standardisation, data exchange, and one time data collection. Further, political initiatives striving for an efficient government lead to the awareness that data created by one government entity are used by another agency. In such a context it is likely that an SDI initiative starts within government. In a next stage (intermediary) other stakeholders, for example the private sector, are invited to participate. Ultimately, open communication channels should be strived for, enabling everyone to express their thoughts, opinions, and to actively participate in the decision making process.

*3.4 Ability to self-organisation*

The ability of the self-organisation of the community can be explained by the problem solving ability. In the first stages the community will identify problems and leave it to others (the political "leaders") to solve them. If help of the community is necessary they will help, but their priorities will be in the execution of their (public/ legislated) tasks. This is a rather passive role. Later the community identifies problems and offers solutions to the decision makers. This is a more active role. In a later stage the sectoral problems are identified, and the community already starts working on

solutions. This is followed by actively answering questions from society with geographic information solutions. Finally, the community will provide innovative solutions without thinking in terms of problems and solutions, but offering actively better and new user-friendly services. It is in this stage that all stakeholders recognise their responsibility for their (part of the) NSDI.

*3.5 Organisational Maturity Matrix*

The way a vision, leadership, communication channels, and the ability of the spatial information community for self-organisation are present or perform in an SDI depends on the stage of development. The four organisational "context shaping" components from section 2 and the specific organisational aspects within the context of an SDI of section 3 result in the "Organisational Maturity Matrix" (see table 1). The Organisational Maturity Matrix may be described as an assessment of the level of coherence of the geo-information community. The more coherent the community is, the more likely it will be that the SDI development is successful. This may explain why well-intended SDI initiatives around the globe are meeting resistance from some organisations within, or outside the geo-information community. For example, from a political-economic perspective, the resistance may be the result of a conflict between the SDI vision and an organisation's business model. In such a context the development of an SDI may be seen as a threat to individual organisations instead of an opportunity for society.

## 4. The success of two NSDIs

The SDI of the Netherlands and the United States are among the most advanced NSDIs in the world. Advanced may be explained as the use of state of the art technology, adherence of datasets and technology to standard formats, and the

availability of ubiquitous datasets. Knowledge about the organisational maturity of the SDI, however, is not always considered. This section uses the organisational maturity matrix to provide an insight in the status of the Dutch and U.S. NSDI from an organisational perspective.

## 4.1 The Netherlands

The Netherlands covers 41,000 square kilometres, with a population of about 16.1 million. The population density is about 420 pe ople per square kilometre. The Netherlands consists of 12 provinces, and almost 500 municipalities. The Dutch Gross Domestic Product (GDP) is roughly Euro 401 billion (2000 est.). The economic growth is almost 4% in 2000 and about 1.5% in 2001 (est.). According to the Information Society Index 2002 (Bruno & Minton, 2002), it is one of the most developed countries in the worldwide information society (sixth). There are about five million mobile telephones (2000, 30% of population), and about 50 percent of the population uses the Internet, a number that is growing rapidly.

## 4.1.1 Leadership

Partly the NSDI has developed through a planned government approach and partly as an organic process. This process is taking place gradually and in close relationship with people working in the field.

A coordinating minister for geographic information was appointed in 1990 (BiZa, 1990). This coordinating minister set about harmonisation and cooperation by the interested parties. This led to cooperation in Ravi, the consultative body for the geo-information sector, in 1993. Initially participation in Ravi was mandatory for certain

(public) agencies or groups. Presently, the members participate in Ravi on a voluntary basis.

The formal coordination has been divided between the coordinating minister and the Ravi, between which a formal agreement existed until 2002 (TK, 2002). Ravi is focussing on the field coordination. It initiates and stimulates the commitment within and outside the geo-information community, and promotes the concept and development of the national geographic information infrastructure (NGII).

Also part of the NSDI is left to self-regulation. Within government, services have been set up for the production, maintenance and distribution of geographic information. Examples are the Cadastre and Public Registers Agency (Kadaster), the National Mapping Agency (Topografische Dienst Nederland (TDN)), the Survey Department of the Directorate General of Public Works and Water Management (Rijkswaterstaat), Statistics Netherlands (Centraal Bureau voor de Statistiek), the Hydrographic Service, the National Geological Survey (NITG-TNO), and the National Institute of Public Health and Environment (Rijksinstituut voor Volksgezondheid en Milieu, RIVM). In addition to these 'information mills', there are many other institutions with primary tasks in such areas as spatial planning, transport, housing, environment, infrastructure (roads and waterways), agriculture and nature conservation, producing geographic information as a by-product.

*4.1.2 Development of a vision*

In the beginning of the nineties, Ravi brought together the major data producers and created a common goal for the geo-information community: establishing four uniquely defined, ubiquitous, and interlinked core datasets (registration of parcels, natural persons, enterprises, and buildings). Each of the individual organisations was

responsible for the establishment of a part of the 'structure plan for land information' (Ravi, 1992). The community worked 'together' on the implementation of this NSDI vision. After its visit to the United States, Ravi extended the vision, although the land information plan remained to be a guideline (see Ravi, 1995). The new strategy document provided a more comprehensive view on the NSDI. This document emphasised the role of the geo-information community in the implementation of the new task of national government: "to ensure the widest possible access for members of our society to communication media and the rich divers information sources". Further, the renewed vision stressed the need to (1) involve user needs in this process, (2) start a clearinghouse, (3) document metadata, (4) explore international developments, and (5) to represent the geo-information community actively in national policy discussions. The vision has been reviewed several times (Ravi, 1995; VROM, 1998; Ravi, 2003), but the core of the initial vision still holds.

### 4.1.3 Communication channels

The Ravi comprises all public services and local authorities with an important role in the provision of geographic information. These organisations aim to improve the NSDI by means of cooperation and agreement.

As a founding member of the European Umbrella Organisation for Geographic Information (EUROGI), Ravi also follows international developments, and initiates international partnerships. For example, the community initiated partnerships with North Rhine Westphalia, Germany, and Ravi has a memorandum of understanding with the Federal Geographic Data Committee (FGDC) in the United States. European SDI projects, like the European Union Land information service (EULIS), and the Infrastructure of Spatial Information for Europe (INSPIRE) also take advantage of the

experiences and the acquainted knowledge of the geo-information community (including both public, private, and academic sector) in the Netherlands.

As a result of the need to respond to private user needs, the Ravi Business Platform was founded. The Ravi Business Platform is the private sector equivalent of the Ravi, and performs as a geographic information platform of private entities. The business platform aims to improve cooperation between public bodies and private businesses on a national level, and to utilise opportunities, which arise in the field of geographic information supply. The business platform is now an independent body.

Also leading academics are involved by taking part in SDI discussions, workshops, projects, and share their knowledge with the other parties involved.


*4.1.4 Self-organising ability*

The self-organising ability of the geo-information community in the Netherlands has developed from single organisations performing their predefined tasks to consortia of organisations willing to address societal challenges with SDI solutions. The community is or has been actively participating in national discussions on access policies, standardisation, and initiated the clearinghouse in 1996. The community is further considered critical for the success of the execution of the e-government program (TK, 1998), and many geographic data sets (parcel data set, buildings, topographic data set 1:10,000, and addresses) are likely to obtain a special "authentic" status (TK, 2003a; TK, 2003b). At 1 January 2004, two data providers of framework data sets, the Kadaster and TDN, merged formally into one organisation with the promotion of an effective Geographic Information Infrastructure as one of the agency's objectives (Kadasterwet, 2003).

The user demands are increasingly important to the producers, but the needs of the users are not commonly understood or heard. One project that includes citizen participation is the creation of an Internet community for building and living information. However, a call for proposals of the Minster of Industry and Economic Development for innovative knowledge projects accomplished by consortia of public, private, and academic organisations stimulated the community to work on the tender proposal "Space for Geo- information" (Ravi, 2003). This proposal works out the original NSDI vision, accounting for the shift in the geo-information sphere over the last decade, partly as a result of technological, social and economic developments. It concerns a shift of the build-up of domain specific geo-information aimed at limited application for the development of the NSDI to support the enormity of complex social problems. Space for Geo-information aims to integrate the geo-information discipline with adjacent disciplines such as water, transport, nature and environment, and emergency. The proposal is demand-oriented, integrates technological know-how and alpha and gamma-related sciences, and promotes the exchange of knowledge between the geo-information community and adjacent communities (Ravi, 2003). Consortia of more than 120 public, private, academic, research and development, and international organisations, and knowledge centres support the proposal. Together, the consortia provided a financial commitment of €27 million for the execution of the proposal (Kok, 2003). The proposal attracted on 28 November 2003 €20 million public funding for projects promoting the innovation of the NGII.

*4.1.5 Maturity of Dutch NSDI*

In the Netherlands, most organisational components of an NSDI are in place in a rather advanced stage of development. The vision is widely shared among geo-

information stakeholders and users, and is in line with and influences general national policies (see for more detail Van Loenen & Kok, 2002). Ravi has taken a leading role in the development of the SDI. It has helped the community to organise itself. First by awareness building activities among data producers, later by inviting users, and other professionals (experts) to participate in SDI discussions. The geo-information community continuously monitors the political agenda and increasingly provides actively geo-information solutions to pressing societal needs with or without a formal request of parliament. Table 2 summarises our findings of the organisational state-of–the-art of the Dutch NSDI.

*4.2 The United States of America*

The Unites States covers 9,629,091 square kilometres, with a population of about 280 million. The population density is approximately 29 people per square kilometre. The U.S. GDP is roughly $10.082 trillion (2001 est.). The economic growth is 0,3% in 2001 (est.). According to the Information Society Index 2002 (Bruno & Minton, 2002), it is one of the most developed countries in the worldwide information society (fourth). About 25 % of the population uses cell telephones (1998), and about 60 percent of the population uses the Internet (2002).

*4.2.1 Leadership*

In 1990, the Office of Management and Budget (OMB) issued Circular A-16 that identified all federal mapping agency's responsibilities with respect to coordination of *federal* surveying, mapping, and related spatial data activities (OMB, 1990). The management of this activity was directed to the Federal Geographic Data Committee (FGDC). The OMB expanded the A-16 processes to include specific responsibility

and accountability for the mapping agencies engaged in surveying, mapping, and spatial data collection, archive and distribution.

In 1994, the Executive Order 12906 called for the establishment of a coordinated National Spatial Data Infrastructure (NSDI) as one of the President's principal programs that it was going to pursue through his administration (see Clinton, 1994). FGDC was charged with coordinating the federal government's development of the NSDI. In the Executive Order, FGDC was given a mandate to involve state, local and tribal governments, academia and the private sector in coordinating the development of the NSDI. The roles of various parties and their relationships in moving towards a common NSDI vision are being developed over time. Within the federal government itself, the Office of Management of Budget has assigned lead coordination responsibilities based on themes to specific Federal agencies. The Executive Order indirectly resulted in the revised Circular A-16 of 2002, which further affirms the role of the FGDC and the importance of the NSDI within the nation (OMB, 2002). The revised Circular establishes the FGDC as the interagency coordinating body for NSDI-related activities. The FGDC is chaired by the Secretary of the Department of the Interior, with the Deputy Director for Management, OMB, serving as Vice-Chair. All agencies responsible for spatial data themes are *required* to be members of the FGDC. Departments or agencies that are not members of the FGDC, and that have activities in geographic information or spatial data collection or use will become members by requesting membership in writing to the Chair of the FGDC.

Although the Circular A-16 and the Executive Order were well conceived, criticism has been accumulated over time. NAPA (1998, p.110), for example, stressed that the Circular and Executive Order are relatively weak policy bases, compared with mandates having the force and effect of law, for fulfilling goals as ambitious as those

set for the NSDI. Further, the FGDC chairman "has no formal authority over his fellow committee members. He also has no means to compel attention by political leaders at the state and local levels. They have their own constitutional and statutory mandates to guide their actions" (NAPA, 1998, p. 63). These relatively weak policy bases make it difficult to fully implement the NSDI vision.

Although FGDC stimulated participation in FGDC's actions by state and local government organisations, state and local government organisations are not full partners with the federal government: "Neither academia nor the private sector are formally represented, except as members of stakeholders groups. Federal agencies active in FGDC also do not reflect the full range of federal agencies active in geographic information and some FGDC members are not fully active" (NAPA, 1998, p.65, see also Koontz, 2003, p.10).


*4.2.2 High level political support*

In 1992, the Clinton Administration assigned the task of streamlining and reducing the size of the federal government to the Vice-President Gore. The Vice-President recognised the potential increased efficiencies and effectiveness of the goals of the FGDC: *'collect it (spatial data) once, use it many times'.* Because the Vice-President took an active personnel interest, the then Secretary of the Interior, Mr. Bruce Babbitt, personally chaired the FGDC Steering Committee. This further forced the highest level of interest and involvement from all other cabinet level departments/agencies. As a result, the FGDC benefited for 8 years of the highest level support of two very different administrations. The relatively weak policy bases, however, makes the continuity of leadership depend on supportive high politicians longevity in office and

the willingness of their successors to assume a similar supportive role (see also NAPA, 1998, p.63).

Although the political support for the NSDI at the federal level seems to have diminished under the Bush (Jr.) administration, considerable funds have been available for projects from which the NSDI may benefit. As recently as 2002, the current administration under its efficiencies improvement programs lifted the E-Government, Geospatial one-stop initiative to the highest level of support for implementation.

*4.2.3 The U.S. Vision*

In 1997, FGDC agreed on a vision for the U.S. NSDI (FGDC, 1997):

*Current and accurate geospatial data will be readily available to contribute locally, nationally, and globally to economic growth, environmental quality and stability, and social progress.*

This vision is still valid today. The vision is not typically one of supplying coast to coast data sets for the nation but of encouraging those acquiring data sets for some explicit purpose to make those data sets available such that islands of spatial data meeting NSDI metadata and data standards will grow, expand, and be maintained over time by those with the greatest interests in the datasets. Thus, coordination is primarily provided through creation of a networked system or infrastructure that governments, businesses and individuals may tie into and through provision of standards (Onsrud, 1998).

The U.S. vision of the NSDI uses the concept of framework spatial data themes to which other data may be referenced. In the U.S. the core framework data themes being developed are geodetic control, elevation and bathymetry, digital imagery, government boundaries, land ownership, transportation and hydrography (rivers and lakes). The vision is that these widely available data sets will provide a current base on which to collect, register, or integrate other information. Thus, not only framework data sets but also a wide range of other thematic spatial data sets are being made available through the NSDI.

Ideally, framework data for a geographic area will be developed, maintained, and integrated by organisations that produce and make use of data for that area. Virtually all spatial data producers are invited to join the effort and provide a National Geospatial Data Clearinghouse node.

The NSDI vision may result in (extracted from NAPA, 1998):

- A common spatial data foundation organised according to widely accepted layers and scales (or resolutions) that is available for the entire area of geographic coverage (parcel, neighbourhood, city, county, state, nation, and so forth) to which other geospatial data can be easily referenced.

- The foundation (or core) data is readily accessible and available at no or little cost from user-friendly and seamless sources to meet public needs and encourage conformance with it by producers of other geospatial data.

- Both foundation and other geospatial data, as required and specified co-operatively by data producers and users, are updated according to commonly accepted standards and measures of quality.

- Thematic and tabular data are also available on terms not incompatible with the foundation data.

- Cost-effective, geospatial data produced by one organisation, political jurisdiction, or nation is compatible with similar data produced by other organisations, political jurisdictions or nations.

- Geospatial data can be integrated with many other kinds or sets of data to produce information useful for decision makers and the public, when appropriate.

- Responsibility for generating, maintaining, and distributing the data is widely shared by different levels of government and the private sector. Governments take advantage of private-sector capabilities available at reasonable prices rather than maintaining dedicated capabilities.

- The costs of generating, maintaining, and distributing such data are justified in terms of public benefits and/or private gains; overlap and duplication among participating organisations is avoided wherever possible.

*4.2.4 Communication channels*

The development of the NSDI is being fostered through a diversity of communication channels. First, the required FGDC membership of all agencies responsible for spatial data themes allows for public sector involvement in the NSDI. Further, FGDC has through its outreach and capacity building activities close working relationships with several state and local governments, and the international community. Moreover, FGDC has a close working relationship with the Open GIS Consortium (OGC) in the definition of a matrix of national interoperability standards.

Finally, the many public outreach activities and capacity building endeavours both domestically and globally, for example:

- FGDC national Geo-Data Forums, conference presentations, workshops, training, training materials, newsletters, website, publications, and so forth;

- The "Cookbook" (Nebert, 2001) of the FGDC is recognised both domestically and globally as a good tool to assist fledgling organisations with geospatial definitions, metadata development, clearinghouse creation and operation, standards activities, and business case examples;

- The establishment and maintenance of a grant program that provides moderate level 'seed' funds to organisations to encourage their engagement in NSDI activities. This has helped many state governments, libraries, universities, regional bodies, and the private sector to become anchor tenants on the NSDI ultimately attracting others to use and become a part of the infrastructure;

- The role of the FGDC in the emergence and evolution of the Global Spatial Data Infrastructure (GSDI) as a concept and an organisation pursuing non-profit incorporation status promoting SDI on a global basis.

Although the FGDC has close relationships with other federal government agencies, at local level the concept of NSDI is often unknown (see Harvey, 2002), and the development and implementation of the NSDI vision seems to lack private sector involvement (see also NAPA, 1998, p.65; Koontz, 2003, p.10). Therefore, the NSDI seems primarily to be a federal initiative without much outreach to other public sector levels and the private sector. This may explain why the main results of the NSDI are at the federal le vel, for example, the adoption and implementation of the FGDC metadata and related geospatial standards throughout the federal government. However, even for the federal level significant criticism exists. Koontz' testimony (2003, p.5), for example, found: "In many cases, federal agencies independently

collect data that, while not identical, is similar and potentially duplicative in many respects. In other cases, data may be collected in different resolutions or with different degrees of accuracy but still essentially cover the same theme over the same geographic area".

*4.2.5 Self organising ability*

Federal agencies continue to collect spatial data in support of their missions as defined by legislative mandates and are making more of such data accessible through clearinghouse nodes. The FGDC in collaboration with federal agencies has coordinated the NSDI Competitive Cooperative Agreements Program to help start collaborative projects among local governments, state governments, academic institutions, non-profit groups and others willing to collect and make spatial data available through NSDI clearinghouse nodes. In addition, the federal government has begun to establish the NSDI through a number of other component programs like "a collection of voluntary 'I-Teams' to foster community-level data collection and sharing, and - most recently - the Geospatial One-Stop initiative, aimed at promoting coordination and alignment of geospatial data collection and maintenance across all levels of government" (Koontz, 2003, p.8).

However, the lack of local and state government and private sector involvement hampers the self-organising ability of the geo-information community as a whole. An example is found in the U.S. Border Patrol. Since security has become a high priority in the federal policies, one would expect that such a critical agency has ready access to most data needed for their tasks. However, the U.S. Border Patrol has to negotiate contracts with local governments for property ownership data, and other critical data

sets for the execution of their task, blocking them to respond to national needs immediately.

*4.2.6 Maturity of U.S. NSDI*

The U.S. NSDI has been the example for many other NSDI initiatives. The vision of 1997 is still valid today and many stakeholders are working on its implementation. The FGDC is the formal leader of this process, and builds on high-level political support. However, the high political support for FGDC is fragile to changes in the administration. Further, FGDC has only jurisdiction over the federal government level. Adherence to FGDC policies in lower levels of government would be feasible if this is well communicated with all participants in the NSDI and all participants are formally involved. The programs initiated to bring NSDI concepts into state and local government seem to work at a small scale. The lack of local and state government and private sector involvement in the development of the NSDI seems to hamper the self-organising ability of the geo-information community as a whole.

Although most successes of the FGDC coordination efforts have been limited to the federal level, FGDC is currently the primary problem owner of the NSDI, and initiates activities to communicate the NSDI with other government levels, and FGDC's vision seems to be accepted by most stakeholders, who together with FGDC continue to work on the implementation of the vision. Table 3 shows the Maturity Matrix for the current U.S. NSDI at the federal level.

## 5. Conclusions

This paper proposes a means to assess the success of an NSDI. Through organisational indicators of an NSDI the level of maturity of an NSDI can be assessed. The Organisational Maturity Matrix identifies four levels of SDI maturity:

stand alone, exchange, intermediary, and the network level. The organisational indicators are the extent to which the NSDI vision is supported, the extent to which leadership exists, the level of communication between NSDI stakeholders, and the ability of SDI stakeholders to respond to societal problems and its ability to innovate. The Netherlands and the United States score for these indicators differently. Therefore, it is likely that both countries need different strategies for the further development of their NSDI.

The economically advanced parts of our world are heading towards a dynamic environment in which the infrastructure is confronted with specific themes, frequently changing according the needs of society. From an organisational point of view it is then critical that the SDI vision is widely supported, that leadership in the geo-information community is present, and communication channels are open to all and frequently used, making the geo- information community in terms of organisational context a fairly mature sector that is ready to take the change.

The introduced model is a first attempt to assess the success of an SDI from an organisational point of view. Further research and discussion are necessary to test the applicability of the model to other SDIs, for example the emerging European SDI. One of the issues that may be subject to further study is theory development of the most appropriate strategy to move from one organisational stage to another. This may result in detailed recommendations for future strategies of these SDIs.

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**Vitae**

Bas Kok has been the Director of Ravi, Netherlands Council for Geo-Information, since 1993. From 1994-1998, he was Vice President of EUROGI (European Umbrella Organisation for Geographical Information). Since 2000, he is co-chair of the GSDI (Global Spatial Data Infrastructure) legal and economic working group. He holds a position as Associated Professor at Delft University of Technology. His research centralises around the legal, and organisational aspects of National (Geo-) Information Infrastructures.

Bastiaan van Loenen graduated from Delft University of Technology, the Netherlands in 1998 and from the University of Maine, USA in 2001. In 2000 he started his PhD study at Delft University of Technology, Department of Civil Engineering and Geo-

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access policies in the development of SDIs more specific.

**Captions of figure and tables:**

Figure 1: conceptual view on development of NSDI

Table 1: Maturity of SDI from an organisational perspective

Table 2: Maturity of Dutch NSDI from an organisational perspective

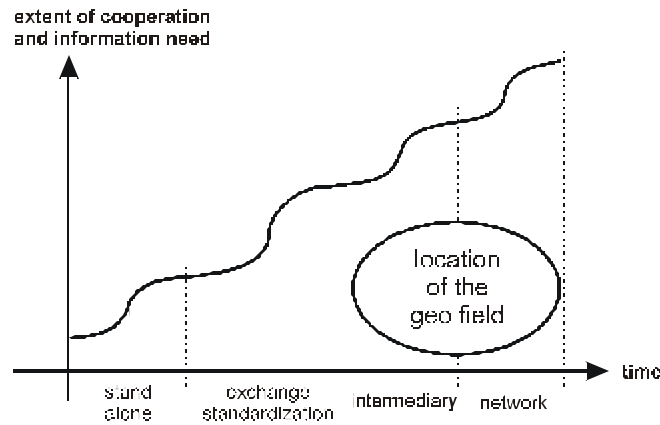Table 3: Maturity of the U.S. NSDI from an organisational perspective

**Figure 1: Conceptual view on development of NSDI**

| Stage<br><br>Aspect | Stand alone | Exchange/<br>standardisation | Intermediary | Network |
|---|---|---|---|---|
| **Vision** | Focus on individual organisation | Developed with all stakeholders | Implementation | Commonly shared, and frequently reviewed |
| **Leadership** | Focus on individual organisation | Questioned | Accepted | Respected by all stakeholders |
| **Communication** | Focus on individual organisation | Open between public parties | Open between all stakeholders | Open and interactive between all |
| **Self-organising ability** | Passive problem recognition | Neutral problem recognition | Actively helping to solve identified problems | Actively working on innovation |

**Table 1: Maturity of SDI from an organisational perspective**

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**Table 2: Maturity of Dutch NSDI from an organisational perspective**

| Stage / Aspect | Stand alone | Exchange | Intermediary | Network |
|---|---|---|---|---|
| **Vision** | Focus on individual organisation | **Developed with all stakeholders** | **Implementation** | Commonly shared, and frequently reviewed |
| **Leadership** | Focus on individual organisation | Ques tioned | **Accepted** | Respected by all stakeholders |
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