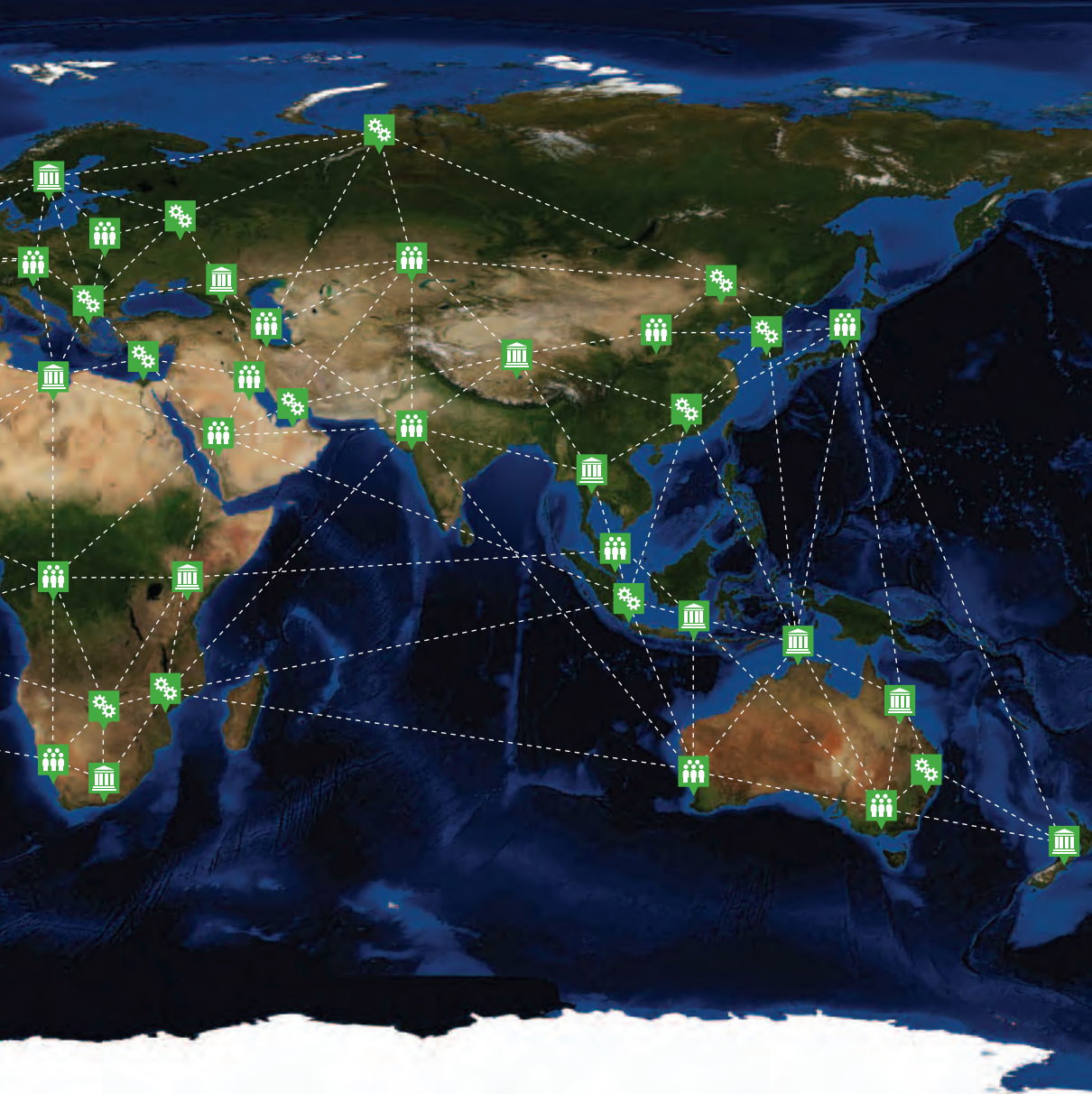# SPATIALLY ENABLING

GOVERNMENT, INDUSTRY AND CITIZENS

RESEARCH AND DEVELOPMENT PERSPECTIVES

EDITORS ABBAS RAJABIFARD & DAVID COLEMAN

GSDI ASSOCIATION PRESS

SPATIALLY ENABLING

GOVERNMENT, INDUSTRY AND CITIZENS

RESEARCH AND DEVELOPMENT PERSPECTIVES

SPATIALLY ENABLING GOVERNMENT, INDUSTRY AND CITIZENS

RESEARCH AND DEVELOPMENT PERSPECTIVES

EDITED BY
ABBAS RAJABIFARD and DAVID COLEMAN

GSDI ASSOCIATION PRESS

Spatially Enabling Government, Industry and Citizens
Abbas Rajabifard and David Coleman (Editors)

Cover design by Steven Bunton Design
Printed in Canada

Table of Content

Foreword

This book is the result of a collaborative initiative of the Global Spatial Data Infrastructure Association (GSDI), the Centre for SDIs and Land Administration (CSDILA) in the Department of Infrastructure Engineering at the University of Melbourne, and the Geographical Engineering Group in the Department of Geodesy and Geomatics Engineering at the University of New Brunswick. In addition to the traditional Call for Papers for the GSDI 13 Global Geospatial Conference: "Spatially Enabling Government, Industry and Citizens", contributions of full articles were solicited for publication in this peer reviewed book.

The authors and reviewers were advised of the conference theme in advance and, in most cases, the addressed this theme in their papers. Even in cases where the theme was not directly referenced, the article reflected the impact and application of the spatial data infrastructures that are now being developed world-wide. The peer-review process resulted in 14 chapters that together reflect how SDIs are enabling us all today. We thank the authors of the chapters and the members of the Peer Review Board.

We are grateful to the GSDI Association Press for its willingness to publish this work under a Creative Common Attribution 3.0 License. It allows all to use the experiences and research presented in this book to their own best advantage.

We especially thank the sponsors of this book. We would also like to thank Dr Sheelan Vaez and Dr Malcolm Park for their editorial assistance in preparation of this publication.

Abbas Rajabifard, *President*
David Coleman, *President-elect*
GSDI Association

Peer Review Board

About Editors

Abbas Rajabifard is a Professor and Head of Department of Infrastructure Engineering and Director of the Centre for SDIs and Land Administration at the University of Melbourne. He is President of the Global Spatial Data Infrastructure (GSDI) Association and a member of Victorian Spatial Council (VSC). He was Vice Chair, Spatially Enabled Government Working Group of the UN supported Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP). Abbas has authored/co-authored over 230 publications including 5 books. He has been also consulted widely on spatial data management, SDI, land administration and spatial enablement, to many national government agencies and ministries.

David Coleman is a Dean of Engineering and a Professor of Geomatics Engineering at the University of New Brunswick. Prior to obtaining his PhD, he spent 15 years in the Canadian geomatics industry - first as a project surveyor and engineer, then a general manager and vice-president with one of Canada's largest digital mapping firms, and later as an owner and partner in a GIS and land information management consulting firm. David has authored over 150 publications and reports dealing with land information policy development, geomatics operations management, geographic information standards and spatial data infrastructure. He is a Fellow of the Canadian Academy of Engineering, a member of two Boards of Directors, three federal government advisory boards, and has acted as a consultant on projects in Canada, Australia, the United Kingdom and South America.

PART ONE

CONCEPTS AND FOUNDATIONS

Towards Spatial Enablement and Beyond

Abbas Rajabifard[1] and David Coleman[2]

[1]Department of Infrastructure Engineering, The University of Melbourne, Australia
[2] Department of Geodesy and Geomatics Engineering, The University of New Brunswick, Canada

abbas.r@unimelb.edu.au; dcoleman@unb.ca

Abstract

With the many challenges facing society today at multiple scales, location has emerged as a key facilitator in decision-making. Location data is now commonly regarded as the fourth driver in the decision-making process, complementing the more traditional triple bottom line approach (social, economic and environmental drivers). The location provides more intelligent data analysis due to improved analytical and visualisation capabilities. Additionally, initiatives like Gov 2.0 have provided a driver to increase responsiveness and service delivery capacity. As well as, recent technological developments, such as Web 2.0 and ubiquitous location based services, have made it easier for ordinary citizens and businesses to become spatially enabled, but just as importantly, these developments have provided them with tools to contribute to the flow of spatial information through all levels of society.

In this context, the concept of Spatially Enabled Society (SES), is offering new opportunities for government and wider society in the use and development of spatial information, but it needs to move beyond the current tendency for the responsibility to achieve SES to lie solely with governments. SES will be more readily achieved by increasing involvement from the private sector, and in the same vein, if the spatial industries start to look toward other industries for best practices in service delivery.

With this in mind, the theme of the GSDI 13 World Conference, Québec 2012 is "Spatially Enabling Government, Industry and Citizens". Focusing on the journey we are on as professionals and researchers rather than just on objectives, it gives us a rich opportunity to examine how far we have come over the past twenty-plus years in

terms of the infrastructure put in place, the applications built on top of that foundation, and our vision and expectations of what needs to be done next.

1. Introduction

As recounted by Coleman and McLaughlin (1998), early visions of a global information infrastructure (GII) were very much wrapped up with issues surrounding the development of telecommunications infrastructure. These visions were driven by the belief that communications and information infrastructures were "transforming technologies" that served important social goals and were fundamental to economic growth. They were guided rhetorically by Marshall McLuhan's concept of a "global village", reflected trends towards privatization of services and increased competition in the telecommunications sector, and were already influenced by lessons learned from programs and reviews undertaken since the 1970's in (e.g.) France (Simon and Minc, 1978), Canada (Godfrey and Parkhill, 1979), Japan (Tsuruki, 1986), and the Commission of the European Communities (1987).

While Branscombe (1982), Kahin (1993) and others posed the concept of information infrastructure in broader terms, the telecommunications sector was largely responsible through the early 1990s for framing the initial definition and discussion of global information infrastructure in terms of conduit rather than content. U.S. Vice President Al Gore promoted the concept of an "information superhighway" and proposed that an advanced communications and information infrastructure should be a national priority. At the first World Telecommunication Development Conference in Buenos Aires, Argentina in March 1994, he presented a similar list of principals as the foundation for a "Global Information Infrastructure'" (Gore, 1994). In May of the same year, the European Commission published Europe and the Global Information Society. Commonly referred to as the Bangemann Report (1994), it formed the basis for much of the subsequent work of the European Commission on strategic planning for the Information society.

In our own geospatial community, proponents of integrated mapping practices through the 1960s advocated the registration, overlay, interpretation and analysis of different map "layers" or themes to the practical solution of important problems in land use planning and resource inventory [e.g., (Tomlinson, 1967); (McHarg, 1969)]. Through the 1970's, the multipurpose cadastre concept launched major topographic and cadastral "base-mapping" mega-programs to support land administration at the local, state and federal levels across North America, Australasia and in emerging nations (McLaughlin, 1975).

Institutionally, early architectural models to realize these data sharing precepts in practice evolved from: (1) centralized "land information databanks" [e.g., (Hearle, 1962); (Cook *et al.,* 1967); and (Roberts, 1968)); into (2) the vision of more complex distributed land information networks [e.g., (Palmer, 1984); (Sedunary, 1984); (Rhind, 1992); (Onsrud and Rushton, 1995)]. Branscomb (1982) introduced the term "information infrastructure" to refer collectively to the various media, carriers and

even physical infrastructure used for information delivery. By the early 1990's, spatial data infrastructure (SDI) programs were being proposed in support of accelerating geographic information exchange standards efforts, selected national mapping programs and the establishment of nation-wide spatial information networks in the United States (Mapping Sciences Committee, 1993), the United Kingdom (Rhind, 1992), Canada (McLaughlin, 1991), the European Community (EUROGI, 1996), and Australia (Kelley, 1993).

By 1996, people were only beginning to view the World Wide Web as a serious contender for information retrieval, and its potential for wider services was only beginning to take shape (Manjoo, 2009). While excitement over the World Wide Web had begun, the Internet was still a medium used primarily for email, news groups and file transfer by only 45 million people worldwide. Over 40% of American households owned computers, but just over 30% of those computers were connected to the Web -- typically through dial-up modem using their phone line, and for which they paid by the hour. Those households with Internet access spent fewer than 30 minutes a month surfing the Web. Netscape had only gone public a year earlier. Content services like YouTube, Google, Twitter, Facebook, or Wikipedia did not yet exist, Amazon was just getting started, and there was no instant messaging or online music.

It was against this backdrop that the first Conference on Global Spatial Data Infrastructure took place in Bonn, Germany in 1991. This conference, and the one that followed in Chapel Hill, North Carolina in 1997, focused primarily on issues at the interfaces between technology, policy, operational and economic concerns (Table 1) and, most of all, in defining what was meant by a global spatial data infrastructure. Perhaps due to the predominance of representatives from public sector mapping organizations rather than commercial location-based services firms, the focus was on user requirements for easy, standards-based discovery, access, downloading and use of map and image files rather than on real-time positioning and navigation services. Following these early conferences, participants began focusing attention on issues and problems faced by managers and practitioners in emerging nations.

	People	Policies & Agreements	Standards	Technologies
People				
Policies & Agreements	• Access to Information • Pricing Policies • Promoting Cooperation			
Standards	Dealing with: • unreasonable expectations • Facilitation vs. enforcement	• Alternative strategies re: Standards Implementation		
Technologies	• Technical literacy • Spatial literacy • Levels of Expectation	• Hardware & software procurement within organizations	•Interoperability specifications • Integration of positioning, mapping and analysis systems	

Table 1. Interfaces between GSDI Components

2. Spatially Enabling Government, Industry and Citizens

Compare the above to today's context. By December 2011, there were over 2.2 billion Internet users on all continents, with over 65% of the users coming from outside North American and Europe (Internet World Stats, 2012). Over 105 trillion email messages were sent in 2010, and over 700 billion YouTube videos viewed the same year. Goldman Sachs predicted global eCommerce sales of products and services to reach almost $700 billion in 2011. In our own geospatial community, the location-based services market alone (including GPS-enabled smartphones) was estimated to be worth $2.8 billion in 2010, with the promise of dramatic growth over the next five years (Pyramid Research, 2011).

Spatial Data Infrastructures are now in place that enables individuals to position themselves and navigate to a chosen destination by multiple routes, identifying nearby places and services of interest. Lives are saved as a result of emergency response services reaching the right destination in a shorter time. These infrastructures also enable group activities in terms of identifying each other's location and guiding them to a common point of interest, share their opinions concerning nearby services, attractions and points of interest, and updating shared maps. They enable

governments and private companies alike to solicit public opinion and analyze the movements & activities of both individuals and groups of people.

Services built atop such infrastructures -- like the City of Boston's Citizens Connect service (City of Boston, 2012), for example -- provide citizens with the means to provide government officials with detailed locations and up-to-date information on problems with city streets (Figure 1). Taking this a step further, the infrastructure even enables new prototype applications like Streetbump to monitor sudden cellphone movements to predict where potholes may be in certain streets (Brandon, 2011). Such applications provide tremendous new opportunities, but also pose new technical and ethical challenges in terms of providing valuable service while still accommodating, in some cases, legitimate concerns over confidentiality and loss of privacy.
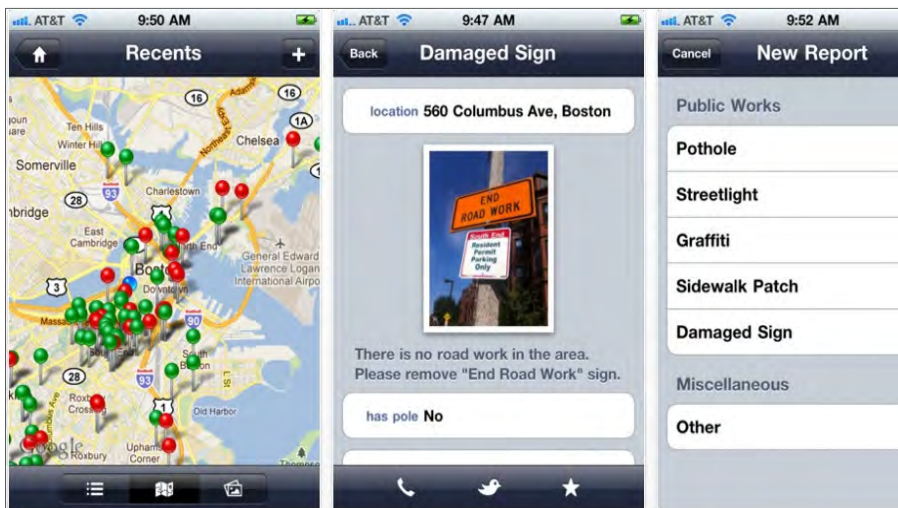
Figure 1. Screenshots from City of Boston's *Citizen Connect* iPhone Application (City of Boston, 2012)

The future of spatial enablement, and therefore the realization of a spatially enabled society incorporating government, industry and citizens, lie in it being a holistic endeavor where spatial (and land data) and non-spatial data are integrated according to evolving standards and with the SDI providing the enabling platform. Further, future activities need to take into account emerging trends in spatial information and the new opportunities they present for the application of spatial technologies and spatial information. These trends include (but are not limited to): location as the fourth element of decision making; differentiating between authoritative and volunteered (including crowd-sourced) information, yet recognising the importance and value of both types of information towards spatial enablement and the enrichment of societies; changing directions: simple to complex, autonomous to interdependent, spatial

ubiquity; growing awareness for openness of data e.g. licensing, and resultant improvements in data quality; move towards service provision; and recognising the difference between spatial enablement and spatial dependency.

In light of these trends, the activities in future will essentially need to be fit-for-purpose, ubiquitous, transparent and seamless to the user. Additionally, there is also a need to consider the developing challenges that are arising from having differing levels of maturity in use and management of spatial information, and perhaps a need to increase the focus on critical areas that are proving to be challenging.

3. Book Outline

This book is a compilation of articles as book chapters each focusing on different aspects of spatially enabled government, industry and citizens. All the chapters together give an overview of the current concepts, foundations, activities, connecting, participating and involving in spatial enabling societies in the world. The chapters presented in this book have gone through a full peer review process as part of the GSDI 13 World Conference in 2012. The book covers three specific areas of Spatial Enabling Government: (1) Concepts and Foundations, (2) Connecting Government, Industry and Citizens, and (3) Participating Spatial Enabling Government, Industry and Citizens.

Part 1: Concepts and Foundations

In the first part, the concepts and foundations towards spatial enablement are explained in more depth from different perspectives. With fundamentals, we mean the review and status assessment and the factors that influence the spatial enablement of government such as standards and metadata. This part with four chapters has a more theoretical focus on the concepts and fundamentals.

In Chapter 2, the concepts and foundations are first explained from the perspective of SDI review and assessment. In *SDI Past, Present and Future: A Review and Status Assessment* by Francis Harvey, Adam Iwaniak, Serena Coetzee and Antony Cooper, highlights that SDI is an evolutionary concept related to the facilitation and coordination of the exchange and sharing of spatial data and services. Today, SDIs are responding to the mushrooming of cloud-based and location-based services, neogeography, crowd sourcing and volunteered geographic information (VGI). What will the role of SDIs be in future? This chapter offers an initial examination of differences in SDI developments in three countries on three continents. The analogy of the human development stages to structure their description of the development of SDIs in Poland, South Africa and the United States of America (USA) has been used. First principles of SDIs are evident from this comparison. Their assessment clarified that SDIs remain important and significant for public administration and also for other actors, despite industry, technological advances, changing business models, VGI and neogeography activities. Web-based repositories provide geographic information for growing consumer-orientated applications, but the geographic information collected

and maintained by public administrations will remain a driving force for developers requiring or wanting the reliability of authoritative geographic information.

In Chapter 3, *Quest for a Global Standard for Geo-data Licenses* by Bastiaan van Loenen, Katleen Janssen and Frederika Welle Donker, emphasizes the ability to share geo-data is key to the success of spatial data infrastructures. It argues a major barrier in sharing geo-data is the use of non-standard licenses, which are difficult to understand both for human beings and computers. This chapter compares existing (national and international) licensing frameworks as to the key components they share. It draws out common elements that can serve as a basis for a global set of model licenses.

Finally, Chapter 4, *Bridging the Gap between Traditional Metadata and the Requirements of an Academic SDI for Interdisciplinary Research* by Claire Ellul, Daniel Winer, John Mooney and Jo Foord focuses on metadata as a fundamental component of any SDI, providing information relating to discovery, evaluation and use of datasets and describing their quality. It discusses that traditionally, spatial data was created by expert users (e.g. national mapping agencies), who created metadata for the data. Increasingly, however, data used in spatial analysis comes from multiple sources and could be captured or used by non-expert users. This chapter examines the applicability of metadata in the academic context, using a multi-national coastal/environmental project as a case study. The work to date highlights a number of suggestions for good practice, issues and research questions relevant to SDI, particularly given the increased levels of research data sharing and reuse required by UK and EU funders.

Part 2: Connecting Government, Industry and Citizens

With the previous part being more theoretically focused, this part is more practical in nature. In this part illustrative examples of activities from different regions in the world are presented that somehow contribute to the connecting of government, industry and citizens. These examples help to better understand the concepts and clarify the fundamentals of spatial enablement.

A spatially enabled society (SES) is an emerging concept to make spatial information accessible and available for the benefit of society. It is a concept where location, place and other spatial information are available to government, community and citizens. In this regard Chapter 5 on *Spatially Enablement of NRM Communities through Spatial Knowledge and Information Network Development* by Dev Raj Paudyal, Kevin McDougall and Armando Apan, investigates the social dimension of SDI and the theoretical foundation for spatially enablement of catchment communities. A network perspective of SDI was explored through a case study of the Queensland Knowledge and Information Network (KIN) project. Spatial information sharing processes among regional Natural Resource Management (NRM) bodies were analyzed using an object oriented modelling technique to assess the impact on catchment management outcomes. The relationships among the knowledge network stakeholders and the

influence of these relationships to spatial information and knowledge sharing was analyzed using social network analysis. The findings from this study suggest that a network perspective of SDI assists in understanding the spatial information management issues of catchment management and the broader goal of spatially enablement of society.

The Chapter 6, *3D Land and Property Information System: A Multi-level Infrastructure for Sustainable Urbanization and a Spatially Enabled Society* by Serene Ho and Abbas Rajabifard considers the specific challenges of urbanization on land and property and the development of a three-dimensional (3D) land and property information system as a new tool for managing rights, restrictions and responsibilities as part of a modern land administration system. By facilitating access, discovery, and sharing of land and property information, this system will provide a multi-level infrastructure to link government, industry and citizens to support the functions of a modern land administration system which provides the foundation for realising a spatially enabled society and achieving sustainable development.

Authoritative datasets, Volunteered Geographic Information (VGI) and other sources of spatial information collected by industry and citizens can be used to spatially enable government and society. Chapter 7 on *Legal liability concerns surrounding Volunteered Geographic Information applicable to Canada* by Andriy Rak, David Coleman, and Sue Nichols focuses on alternative and possibly more economical approach to reliably creating and updating authoritative datasets involves the integration of VGI. It argues that such potential integration of VGI with authoritative datasets raises important legal considerations. Issues of legal liability arising from creation, distribution and integration of VGI with authoritative datasets have received very limited attention by scholars and researchers at their work. This chapter will investigate the liability effects of using VGI under Canadian law. The questions of who is liable and when for VGI provided to authoritative public and private geographic datasets are among the most important questions which impact VGI, and are the ones which this chapter aims to address. Liability issues of using VGI are studied by examining the liability in contract, as well as tort. It concludes with liability risk management techniques, which, if incorporated properly, provide opportunities to minimize or eliminate the liability.

Chapter 8 on *Model for assessing GIS maturity of an organization* by Jaana Mäkelä illustrates an example of new GIS maturity model, which was developed in cooperation with the SDI utilization working group of the Finnish National Inspire Network to reinforce spatially enabled industry and government at different administrative levels. A GIS maturity model can be used as a tool to evaluate how mature an organization is in utilising spatial data in its businesses. Three cities, a state institute, and a private company assessed their GIS maturities with the new model and gave feedback about the usability of the model. The results of the assessments highlight both the strengths and the weaknesses of spatial data utilization in organizations and that the development of competence in all key areas is still needed.

Chapter 9 on *Irish Coastal Heritage Viewer Case Studies* by Roger Longhorn, Gearóid Ó Riain, Beatrice Kelly, William Hynes and Maria Rochford presents a case study describing a project to develop a GIS based approach to enable the comprehensive audit and assessment of the heritage in the coastal areas of eight Irish counties, led by the Irish national Heritage Council. The overall purpose for the Coastal Heritage Viewer is to provide clearer understanding of the heritage and its significance, and to provide a service for spatially enabling government to exercise better management in the future. The project demonstrates how multiple data sources covering disparate themes, from different data owners, and crossing local and regional (county) boundaries, can be integrated to aid conveying information to the public and decision makers at different levels of government. This chapter follows the development process for the viewer and presents three case studies highlighting how the viewer aids decision makers in preparing various types of assessment reports, examining wind and renewable energy strategy options, and enabling integrated coastal zone management, among other aspects.

Part 3: Participating Spatial Enabling Government, Industry and Citizens

In this final part, some participations leading to towards spatial enabling government, industry and citizens are presented. These practices show clearly the key drivers, the diversity of the scope, jurisdiction levels and sectors involved. This part consists five chapters demonstrating different area of participation of government, industry and citizens.

One of the practices towards spatially enabling government refers to risk management. All events that result from risks have a link to a specific location or a factor in space. In order to manage the risks however accurate and timely spatial information about land and property is first needed. Chapter 10 on *Spatially Enabled Risk Management: Models, Cases, Validation* by Katie Potts, Abbas Rajabifard, Rohan Bennett and Ian Williamson argues land administration systems have held this information historically, however, in recent years these systems have been superseded by other infrastructures that have the capability to capture and store information spatially. While these new systems offer the advantages of spatially enabled information, the authoritative information held within land administration systems is necessary for risk management. Land administration systems need to adapt to remain relevant in the 21st century, and coordination between these land administration systems and the new infrastructures is required to increase the ability of stakeholders to manage this information for risk management purposes. A framework targeted at this issue has been developed which proposes a spatially enabled approach for managing risks for governments, industry, citizens and wider society that takes into account the current information infrastructures (including land administration systems), the stakeholders, and the relevant risks that affect land and property. This framework results in the aggregation and dissemination of consistent information about risk to land and property to all stakeholders.

Chapter 11 on *An Assessment of the Contribution of Volunteered Geographic Information during Recent Natural Disasters* by Kevin McDougall further emphasizes in user generated or volunteered geographic information, is now becoming the first point of response in the immediate aftermath of a natural disaster in SES. Crowd source mapping platforms can be operation in a matter of hours of a natural disaster occurring and can utilize the information provided by citizens on the ground to collect timely and relevant information with respect to the disaster. This chapter examines the growth and development of volunteered geographic information over the recent years. The use of volunteered information and social networking in three natural disasters during 2011 are explored. The timeliness of the responses, the types of information volunteered and the impact of the information during and after the natural disasters are assessed. The relevance of these initiatives to the ongoing development of SDIs and their contribution to formal response efforts and authoritative mapping is discussed.

The next chapter (chapter 12) on *Are 'Smart Cities' Smart Enough?* by Stéphane Roche, Nashid Nabian, Kristian Kloeckl, and Carlo Ratti argues that in our contemporary societal context, reconfigured by wide spread impact of geolocalization and wikification on urban population's everyday work and life, two related concepts, "spatially enabled society" and "smart city", have emerged from two different but quite related fields: Global Spatial Data Infrastructure community drives the former while practitioners and researchers in urban planning, urban studies and urban design are more concerned with the latter. The authors believe that technologically enhanced, ICT-driven solutions that spatially enable the members of urban population, contribute to smart operation of the cities, and for that matter they suggest that a dialogue between the communities that foster these two notions needs to be established. The authors try to provide an ontology of categorically different, but still related, spatial enablement scenarios along with speculations on how each category can enhance the Smart City agenda by empowering the urban population, using recent projects by MIT SENSEable City Lab to illustrate their points.

The next participation towards spatial enablement refers to the domain of health care sector. Geographic Information Systems are one of the most widely used information technologies to assist governments in the management of spatial related problems such as those of healthcare practitioners in developing countries. As a follow-up of the challenges faced while customising OpenHealthMapper in Malawi and Guinea Bissau, Chapter 13 on *Factors affecting Geographic Information Systems implementation and use in Healthcare Sector: the Case of OpenHealthMapper in Developing Countries* by Zeferino Saugene, Márcia Juvane and Inalda Ernesto uses the case of Mozambique to highlight significant differences between the ways geospatial stakeholders approach the issue of geodata. Empirical data illustrates that boundary complexity and weak coordination are behind the problems encountered in the geodata. With an emphasis on geodata needed to perform healthcare analysis, it analyzes the role of boundary objects and how their quality is influenced by the tensions between the communities managing them. This chapter suggests a management mechanism focused on the notion of transfer, translation and transformation, which is used to conceptualize the

role of boundary objects as elements that helps to reduce the boundary complexity and strengthen community members' coordination.

Finally, the last practice is multi-view assessment of SDI status in the Republic of Kosovo performed in 2007 and in 2010. The main objective of Chapter 14 on *Multi-view SDI assessment of Kosovo (2007-2010) - Developing a solid base to support SDI strategy development* by Nushi, Van Loenen, Besemer and Crompvoets was to assess the SDI of Kosovo and to define the driving forces needed to support SDI strategy development. The chapter assesses the status of SDI implementation of Kosovo using SDI readiness Index (Delgado *et al.*, 2005), INSPIRE State of Play (Vandenbroucke *et al.*, 2008), and Maturity Matrix (Kok and Van Loenen, 2005) as assessment approaches. Each approach treats the assessment of SDIs from a different view and context and so with a different purpose in mind. An SDI readiness survey questionnaire was submitted to the SDI stakeholders in Kosovo in 2007 and 2010. The INSPIRE State of Play was assessed for the 5 countries of Estonia, Lithuania, Latvia, Slovenia and Luxembourg and an attempt to define the State of Play for SDI of Kosovo was also part of the assessment. This chapter has led to six driving forces selected to support the development strategy of SDI at the national level in Kosovo.

References

Bangemann, M., (1994), Europe and the Global Information Society. Report on Europe and the Global Information Society: Recommendations of the High-level Group on the Information Society to the Corfu European Council. Bulletin of the European Union, Supplement No. 2/94. [followup to the White Paper) (commonly called the Bangemann Report). [EU Commission - COM Document).

Brandon, J., (2011), Road Repair via Crowdsourcing, Technology Review. 13 May. Available at http://www.technologyreview.com/communications/37571/ [Accessed 12 February 2012].

Branscomb, A., (1982), Beyond Deregulation: Designing the Information Infrastructure, The Information Society Journal, Vol. 1, No. 3, pp. 167-190.

City of Boston (2012), Citizens Connect: Making Boston More Beautiful, Available at http://www.cityofboston.gov/doit/apps/citizensconnect.asp. [Accessed 12 February 2012].

Coleman, D.J. and McLaughlin, J.D., (1998), Defining Global Geospatial Data Infrastructure (GGDI): Components, Stakeholders And Interfaces, Geomatica, Vol. 52, No. 2, pp. 129-143.

Commission of the European Communities (1987), Towards a Dynamic European Economy: Green paper on the Development of the Common Market for

Telecommunications Services and Equipment.

Cook, R. and Kennedy J., (1967), editors. Proceedings of a Tri-State Conference on a Comprehensive, Unified Land Data (CULDATA) System, December 9-10, 1966. University of Cincinnati, Cincinnati, Ohio, U.S.A.

EUROGI (1996), Towards a European Policy Framework for Geographic Information: A Working Document", Working Group report prepared on behalf of the European Organization for Geographic Information, Available at http://www2.echo.lu/gi/gi2000/en/egii/gi2000dd.html.

Godfrey, D. and Parkhill ,D., (1979), Gutenberg Two. Toronto: Press Porcepic Ltd.

Gore, A., (1994), Presentation to the first World Telecommunication Development Conference, Buenos Aires, Argentina, March. Available at http://www.interesting-people.org/archives/interesting-people/199403/msg00112.html [Accessed 21 February 2012].

Hearle, E.F.R., (1962), A Data Processing System for State and Local Governments, Public Administration Review, Vol. 22, No. 3, pp. 146-152.

Internet World Stats (2012), World Internet Users and Population Stats, Available at http://www.internetworldstats.com/stats.htm [Accessed 17 February 2012].

Kahin, B., (1993), Building Information Infrastructure,   McGraw-Hill, Inc.

Kelley, P.C., (1993), A National Spatial Information Infrastructure, Proceedings of the 1993 Conference of the Australasian Urban and Regional Information Systems Association (AURISA), Adelaide, South Australia, Australia.

Lenczowski, R. E., (1995), The Global Geospatial Information and Services Initiative, GIS in Government, The Federal Perspective, 1994. Fort Collins: GIS World Books, 1995.

Manjoo, F., (1996), Jurassic Web, Slate, Available online at http://www.slate.com/articles/technology/technology/2009/02/jurassic_web.html [Accessed 21 February 2012].

Mapping Science Committee (1993), Towards a Coordinated Spatial Data Infrastructure for the Nation, Report of the Mapping Sciences Committee, Board on Earth Sciences and Resources, Commission on Geosciences, Environment and Resources, National Research Council. National Academy Press, Washington, D.C., U.S.A.

McHarg, I.L., (1969), Design with Nature, Doubleday Books, New York, U.S.A.

McLaughlin, J.D., (1975), The Nature, Design and Development of Multipurpose Cadastres. Unpublished Ph.D. thesis, University of Wisconsin-Madison, Madison, WI., U.S.A.

McLaughlin, J.D., (1991), Towards National Spatial Data Infrastructure, Proceedings of the 1991 Canadian Conference on GIS, Ottawa, Canada, pp. 1-5. Canadian Institute of Geomatics, Ottawa, Canada. March.

Onsrud, H.J. and Rushton, G., (1995), Sharing Geographic Information, Center for Urban Policy Research, Rutgers University Press, New Brunswick, New Jersey, U.S.A.

Palmer, D.W., (1984), A Land Information Network for New Brunswick, MScE. thesis, Department of Surveying Engineering, University of New Brunswick, Fredericton, N.B., Canada.

Rhind, D., (1992), The Information Infrastructure of GIS, Proceedings of the 5th International Symposium on Spatial Data Handling, Vol. 1, pp. 1-19. Humanities and Social Sciences Computing Lab, University of South Carolina, Columbia, S.C., U.S.A.

Roberts, W.F., (1968), Some Basic Features of an Environmental Integrated Data Bank, Proceedings of the Symposium on Land Registration and Data Banks, Fredericton, New Brunswick, Canada, pp.30-33. (Reprinted in The Canadian Surveyor, Vol. XXIII, No. 1, March, 1969).

Sedunary, M.E., (1984), LOTS and the Nodal Approach to a Total Land Information System, Proceedings of the Decision Maker and Land Information Systems, FIG Commission III International Symposium, ed. A.C. Hamilton and J.D. McLaughlin. Edmonton, Alberta, Canada, October.

Simon, N. and Minc, A., (1978), L'information de la société, Rapport M. le President de la Republique, Paris: La Documentation Francaise.

Smith, M. and Thomas, E., (1996), Lessons Learned for the Leading Edge — Emerging Global Spatial Data Infrastructure, Proceedings of the 1996 Conference on Emerging Global Spatial Data Infrastructure, Königswinter, Bundesrepublik, Deutschland (Germany). European Umbrella Organization for Geographical Information (EUROGI), September.

Tomlinson, R.F., (1967), An introduction to the geo-information system of the Canada Land Inventory, Department of Forestry and Rural Development, Government of Canada. Ottawa, Canada.

Tsuruki, M., (1986), The telecommunications revolution and technological development : implications for Japan, Proceedings of the AMIC-CSD-WACC Seminar on the Communication Revolution in Asia : New Delhi, Aug 21-23. Asian Mass

Communication Research & Information Centre, Singapore. Available at https://dr.ntu.edu.sg/bitstream/handle/10220/459/AMIC_1986_08_08.pdf?sequence=1 [Accessed 21 February 2012].

SDI Past, Present and Future: A Review and Status Assessment

Francis Harvey[1], Adam Iwaniak[2], Serena Coetzee[3] and Antony K Cooper[3,4]

[1]University of Minnesota, United States of America
[2]Wrocław University of Environmental and Life Sciences, Wrocław, Poland
[3]Centre for Geoinformation Science, University of Pretoria, Pretoria, South Africa
[4]Built Environment Unit, CSIR, Pretoria, South Africa

fharvey@umn.edu; adam.iwaniak@gmail.com; serenacoetzee@gmail.com;
acooper@csir.co.za

Abstract

A spatial data infrastructure (SDI) is an evolutionary concept related to the facilitation and coordination of the exchange and sharing of spatial data and services. Since its initial use, the SDI concept has shifted its focus from data sharing and coordination to supporting policy, from a top-down approach to a bottom-up approach, and from centralized to distributed and service-orientated approaches. Today, SDIs are responding to the mushrooming of cloud-based and location-based services, neogeography, crowd sourcing and volunteered geographic information (VGI). What will the role of SDIs be in future? A reference point is the UN Economic and Social Council (ECOSOC) Programme on Global Geospatial Information Management (GGIM) to address key global challenges. The success of such programmes relies on understanding the development of an SDI. This paper offers an initial examination of differences in SDI developments in three countries on three continents. We use the analogy of the human development stages to structure our description of the development of SDIs in Poland, South Africa and the United States of America (USA). First principles of SDIs are evident from this comparison. Our assessment is that SDIs remain important and significant for public administration and also for other actors, despite industry, technological advances, changing business models, VGI and neogeography activities. Web-based repositories provide geographic information for growing consumer-orientated applications, but the geographic information collected and maintained by public administrations will remain a driving force for developers requiring or wanting the reliability of authoritative geographic information.

KEYWORDS: spatial data infrastructure, standards, development, GIS, Poland, South Africa, USA

1. First, there was GIS, then there was SDI and what comes next?

In 2010, the United Nations (UN) Economic and Social Council (ECOSOC) established a Programme on Global Geospatial Information Management (GGIM) to play a leading role in setting the agenda for the development of global geographic information and to promote the use of geographic information to address key global challenges, such as climate change, food and energy crises, peace operations and humanitarian assistance. GGIM plans to provide a forum for coordination and dialogue among member states and international organizations. Most countries are using geographic information as an important element in the formation of national policies, but effective coordination among countries in the use of geographic information is the exception rather than the rule (UN ECOSOC, 2010).

A spatial data infrastructure (SDI) is an evolving concept about facilitating and coordinating the exchange and sharing of spatial data and services between stakeholders from different levels in the spatial data community (Hjelmager *et al.,* 2008). GGIM and other SDI initiatives confirm that since the early- and mid-1990s the SDI concept has shifted emphasis, for example, from a focus on data sharing and coordination to one on supporting policy, from a top-down approach to a bottom-up approach, from centralized to distributed and service-orientated approaches (Williamson *et al.,* 2006; Van Loenen *et al.,* 2009). SDIs are responding to the mushrooming of cloud-based and location-based services, neogeography, crowd sourcing, volunteered geographic information (VGI) and standards for collecting and sharing geographic information (Goodchild, 2007; Rajabifard, 2006). Technological advances have left the theory far behind (Ormeling, 2011). The time is ripe to consider the underlying concepts of SDI and how these have evolved. It is important to understand that SDIs are different, therefore posing a challenge to global collaboration in GGIM.

Regional efforts, such as those of the European Union to create the Infrastructure for Spatial Information in Europe (INSPIRE) and those of the Permanent Committee on Spatial Data Infrastructure of the Americas and the Permanent Committee on GIS Infrastructure for Asia and the Pacific to create regional SDIs, are an indication of the value of such cooperation. Increased international cooperation in this field could help to develop the full potential of geographic information and the underlying technologies, and make them more useful and accessible to a wide range of users and policymakers (UN ECOSOC, 2010).

In this paper we offer our initial examination from an empirical study into differences in SDI developments in three countries on three continents. Our larger research aim is to develop a scientifically grounded perspective on how GIS became SDI and continues to change with a clear theoretical framework - this is our first paper and is more explorative in nature. We use the analogy of the human development stages to describe the development of SDIs in Poland, South Africa and the United States of

America (USA). Drawing on the comparison, we present first principles of SDIs and formulate a status assessment of SDIs with a perspective on the future.

2. The Development of SDIs in Poland, South Africa and the United States of America

Most humans anywhere on the planet understand the development phases of human life: conception, birth, infancy, childhood, puberty, adulthood, old age and death. To answer what comes next, we describe SDI developments in three different countries using these development stages:

1 conception: the need for an SDI is recognized and planning starts;
2 birth: the decision to build an SDI;
3 infancy: very early stages of the SDI when conceptual models are being developed;
4 childhood: early stage of the SDI with first implementations;
5 puberty: when the SDI can deliver on some of its objectives;
6 adulthood: maturely functioning reliable SDI;
7 old age: the SDI is showing signs of deterioration with clear needs for improvement or change; and
8 death: the SDI ceases to exist.

These stages reflect the very different environmental, social, cultural, and economic differences of the three SDIs.

Religions offer us metaphysical ways to find loved-ones, society and ourselves in relationship to these phases. They continue, in spite of fundamental differences, to be for many people reliable ways to frame our understanding of life. However, scientific experts often take up very different approaches and pursue research and hold rigorous debates about how humans develop. An analogy is how people represent SDI development and the scientific study of SDI. More popular descriptions of SDI turn to a metaphor of information technology development that harks back to popular understandings of human development. Their deeply routed metaphysical concepts of development frame their thinking. Georgiadou (2010) uses the term "myths" to signify the metaphysical roots of what becomes a popular way of sketching a bigger picture and how SDI developments fit in.

While a metaphysics of SDI is popularly used in presenting policy and to motivate politicians, social and information scientists have developed and drawn on rigorous theoretical and empirical work to study SDI (Onsrud and Rushton, 1995). Seminal work in the early 1990s drew on sociological work on information technology diffusion to develop important insights (Campbell, 1995; Campbell and Masser, 1995; Masser and Campbell, 1995; Masser, 1999). Later work (Rajabifard, 2002; van Loenen and Kok, 2004; Georgiadou *et al.,* 2005; Kok and van Loenen, 2005; Crompvoets, 2006;

Rajabifard, 2007; van Loenen *et al.,* 2009) has refined the insights from this work, offered critiques, and taken up a number of other theoretical approaches, constantly returning to empirical research to ground these contributions.

Both approaches coexist in different ways, depending on the interpretations of what is important for policy development and scientific research. Sometimes different objectives align, often gaps characterize one portion of the SDI-related activities and overlap another portion, and also depend on national and international developments. We recognize multiple paths of SDI development as a key feature that points to commonalities and differences in the evolution of SDI.

2.1 Poland

The conception of the Polish SDI happened as a result of a system implementation to collect, search and publish spatial data in Poland long before the rise of the Web. Under the communist system, all spatial data were acquired by state-owned companies and became property of the state. They had been collected in Geodetic and Cartographic Documentation Centres (ODGiK) which had full knowledge about such maps, like: registration maps, base maps, topographic maps, and aerial photographs. The ODGiK centres not only continue to sell this data but also supervise and control surveying and mapping activities at the regional level. After the collapse of the communist system in 1989 there was a reform of public administration (Regulski, 2003). Post-1989, government activities in the field of geodesy and mapping have been implemented by county administrations versus communal administrations. Now there are 379 local centres of documentation at the county level and 16 regional centres.

The first actions involving the construction of an SDI began in the late 1990s. Under the initiative of the Surveyor General an interdepartmental team was formed (Hopfer and Wilkowski, 2003), who began work on the construction of the NSDI – the birth of the Polish SDI. Its activities, however, had no legal basis, which meant that its actions did not produce any policy results.

A significant acceleration of Polish NSDI construction activities followed the accession of Poland to the European Union (EU) in 2004. By that time, the European Commission had been working on the INSPIRE directive for three years, which has turned out to be the prime factor motivating NSDI activities in Poland. During this period the concept of building a clearinghouse emerged and funds were acquired from the EU to build a national point of access to spatial information - the geoportal.gov.pl project (Iwaniak, 2005). The Polish SDI was in its infancy.

The first piece of legislation establishing the SDI is the Act of 2009 passed by the parliament two years after the adoption of the INSPIRE directive by the European Council and European Parliament (European Commission, 2011). According to the Act, 15 of the 34 topics specified by the Directive are to be implemented by the Head Office of Geodesy and Cartography. The next five topics are implemented by the

Ministry of the Environment, and the remaining fourteen topics by ten other central offices. Around ten executive acts are still needed to complete the creation of NSDI policy. The Polish government is now building the NSDI based on a top-down strategy. Considerable financial resources for this are mostly spent on the construction and development of a geoportal (geoportal.gov.pl), and the development of modern topographic maps and aerial images (K.U.Leuven Research, 2010).

Local governments use EU funds for the construction of the nodes following a bottom-up strategy, the puberty phase. Undoubtedly, the difficulty in this is the lack of legal regulations, which, in turn, not only causes delays, but also necessitates duplication, and reduces the interoperability of the created infrastructure.

One of the biggest benefits of the NSDI is the improvement in the functioning of the public administration by facilitating administrative access to spatial data. The departure from the existing business model based on the sales of maps and data and the lack of a complete policy framework are the reasons why these benefits will be difficult to achieve in the short term.

2.2 South Africa

Coordination from the 1990s onwards between stakeholder departments on the contracting of aerial photography to avoid duplication and to promote data sharing laid the groundwork for an SDI in South Africa. A report commissioned by the then Chief Surveyor General evaluated the feasibility of a centralized database for South Africa's national GIS. This was the conception of a South African SDI.

The first attempt to build the South African Spatial Data Infrastructure (SASDI) began in 1997 with the establishment of the Directorate: National Spatial Information Framework (NSIF), initially as a Sub-Directorate in the then Department of Land Affairs (now the Department of Rural Development and Land Reform). This was the birth of SASDI. The purpose of NSIF was to establish the technical and policy framework for enabling unimpeded access to, and utilization of, geographic data for effective and efficient governance, planning and decision making, through all spheres of government. As such, South Africa was then a pioneer in the development of SDIs and as with similar initiatives elsewhere, the focus was on standard development, framing policy and institutional arrangements, and developing a clearinghouse for geographic data (Cooper and Gavin, 2005). By 2002, there were about 3000 metadata records available. SASDI was in its infancy.

NSIF initiated the Spatial Data Infrastructure Act (SDI Act) (South Africa, 2003), which places requirements on data custodians. Unfortunately, by then NSIF was in decline, losing most of its staff over an 18-month period for various reasons. Other than the passing of the SDI Act into law in early 2004 and the preparations of draft regulations to support the Act, SDI activities effectively ceased in NSIF and their metadata catalogue was no longer operational (Smit *et al.,* 2009). Essentially, SASDI went into

hibernation, but even though officially little happened between 2003 and 2010, some SDI-like activities could be observed.

The Agricultural Geo-referenced Information System (AGIS) was developed by the National Department of Agriculture (DoA), all nine provincial departments dealing with Agriculture (PDA's) and the Agricultural Research Council (ARC). DoA takes responsibility for the hosting while ARC manages the content (AGIS, 2011).

The South African National Space Agency's (SANSA) Earth Observation unit at Hartebeeshoek has been receiving, processing and archiving satellite imagery for decades and the images and products are available through an online catalogue. In April 2007, the unit established the first multi-government license for SPOT 5 data anywhere in the world, making ortho-rectified and mosaicked images available to all in government, universities and schools in South Africa (CSIR, 2008). SANSA resembles a top-down approach reminiscent of early SDIs in the 1990s. In contrast, local governments in the Western Cape have adopted a user-driven bottom-up approach to data sharing (Smit *et al.,* 2009).

The South African address standard (South African National Standard 1883, 2009) was published in 2009 after wide participation from the private and public sectors (Coetzee and Cooper, 2007). The standard is now being implemented by various organizations, including the South African Post Office and some of the metropolitan municipalities. Private sector companies have various types of agreements with relevant authorities on bi-directional data sharing for compiling national datasets for streets, cadastre and addresses (Sebake and Coetzee, 2011). This and the private sector's involvement in the development of the standard illustrate the trend of private sector involvement in SDIs.

The SDI Act established the Committee for Spatial Information (CSI) to implement the Act, but members were appointed only in 2010 (Nkwinti, 2010) and the CSI met for the first time in June 2010. Hence, the CSI is still clarifying its roles. In general, CSI members lack expertise on SDIs, as there is a general lack of knowledge of SDIs in South Africa. In March 2011, the CSI adopted its reference document and established its sub-committees. NSIF is tasked with secretarial and administrative support. The metadata catalogue is being revived as the Spatial Metadata Discovery (SMD) (George, 2010), built with standards-compliant open source tools, such as Geonetwork (Geonetwork, 2011).

The South African SDI has arisen from hibernation and is ready to move from infancy into childhood. This provides the opportunity to leapfrog ahead of other countries by leveraging advances in science and technology without the burden of investment in old technology. Like an animal rising from hibernation, the SDI is disoriented and needs to find its feet, but has accumulated stored-up energy, reflected, amongst others, in the large number of voluntary CSI sub-committee members and the recent SDI workshop in Cape Town (CGIS, 2011).

2.3 United States

Developments in the United States (US) can readily fit into a developmental scheme, however, the decentralized nature of US governance means that thousands of governmental bodies are developing SDI capacities in a corresponding diversity. In that sense, any description of SDI developments in the US is partial. Nonetheless, we believe the following presentation touches on key elements that reflect states of the development. Before the abbreviation SDI was widely used in the US, during the conception phase, there were several distinct approaches to data sharing and coordinating technical and political issues (Harvey and Tulloch, 2006; Tulloch and Harvey, 2008) that informed national discussions. In the US, these approaches had and continue to have variable impact. Desires to reduce the negative consequences of disparate development of government capacity and to improve efficiency and efficacy of data sharing and coordination were key factors behind national-level support for development of the National Spatial Data Infrastructure (National Research Council, 1993; 1994), described in the Federal Geographic Data Committee's Framework Introduction and Guide from 1997. These and other documents we associate with the birth and infancy.

The concept of the framework reflects the devolved nature of US government organization (Judd, 1979; Somers, 1990; Krane, 2001; Putnam, 2000; Sperry, 2000) with invariable limits on the enforcement of federal government policy. The framework and highly relevant federal guidelines on coordinating geographic information activities (Circular A-16 and related documents) remain relevant, even if they are only 'mandatory' for federal, civilian agencies (Tosta, 1999). The Framework proposes the creation of vertical integration through the provision of seven core data sets around the county; core data can be extended with thematic data in regional or municipal, in the case of larger cities, for additional themes. This produces architecture with a flexible arrangement of centralized and decentralized approaches. Unfortunately, the architecture required local and regional activities and the different regional stakeholders for a multitude of reasons were not always easy to bring on board. We can think of this as childhood and puberty.

The Framework Survey conducted in 1998 (Federal Geographic Data Committee, 1998), revealed a multitude of issues. Studies revealed that local governments found that the NSDI was a wonderful idea, but not as relevant to local government legal and political mandates and funding to support activities, especially the creation and maintenance of metadata, was lacking (Harvey, 2001; Harvey and Tulloch, 2003; Butler et al., 2005; Harvey and Tulloch, 2006). In the adulthood phase, clearinghouses, gateways, and portals to local, regional, and state have become far more common, but accessing a number of data sets, especially parcels, generally require contracts and in most cases a licensing fee or access charge. Legal frameworks to control access under individual state open records laws have remained important hindrances in facilitating open data sharing (Masser, 1999; Sietzen Jr., 2003). Perhaps now in old age, but far from death, US SDI activities continue. National interest remains in improving federal

government coordination, including the possibility of creating and maintaining a national geographic information system or infrastructure (GIS) (Folger, 2011).

3. Concepts of SDI: First Principles

Following on the discussion of the three comparative SDI developments at the national level, we now turn to underlying principles held in common. In Tomlinson's conception (1998) for the first GIS, the Canadian Geographic Information System (CGIS), sharing and coordination are central to the rationale for CGIS. These two concepts remain the first principles for SDI developments. These principles reflect needs that existed before computerization was widespread, but only the wide-scale use of information technology for geographic information make it possible to fulfil these needs in such systematic and fundamental ways. These principles are confirmed by the work of others (Kok and Van Loenen, 2005; Rabjabifard *et al.,* 2002).

3.1 The Need to Support Decisions

A key common need behind the development of SDI is decision-support. It has long been recognized by policy makers that high-quality information and analyzes are prerequisites for good policy-making (Densham, 1991). If most government activities and decisions are spatial in nature, then the ability to locate activities and develop models of spatial consequences is key to reliable governance.

3.2 The Need to Share

The proliferation of GIS along with the ability to infinitely reproduce copies of data has opened possibilities for sharing geographic information that outstrip previous cartographer's capabilities many-fold. The need to share arises in this capacity. While information technology facilitates sharing, it is generally tempered by a desire to cover costs, create revenue, or grow programs. Spatial data re-use is a central incentive for public administration SDI investments.

3.3 The Need to Coordinate

While sharing is possible, for sustained sharing to become more meaningful, some measure of coordination is required. Fundamentally, coordination can also improve the effectiveness of SDI by improving the cost-effectiveness of data collection, maintenance, and updating by taking multiple needs and uses into account.

3.4 The Need for Policy

Of course, the facilitation of GI collection, maintenance, and updating soon required a framework beyond informal coordination. The need for policy arose out of success

with data sharing and coordination with the intent to assure that benefits are not outweighed by costs to keep sharing and coordination going.

3.5 The Need to Keep up with Technological Developments

With increased capacities, new potentials followed, and improvements, successes, and failures led to a need to keep up with new technologies and maintain existing technologies. The increased use of remote sensing land cover data is an excellent case in point. The rapid growth in LiDAR applications offers yet another example of how technological developments rapidly alter the potential of governments to improve services and improve the efficacy of their SDIs.

3.6 The Need for Standards and Specifications

Moving away from centralized bureaucratic approaches, standards and specifications arose from the need to coordinate multiple agencies arrayed in evolving fashions and improve the uptake of new technologies into functional information infrastructures. The primary sources for standards for geographic data and services are the relevant technical committee of the International Organization for Standardization, ISO/TC 211, Geographic information/Geomatics and the Open Geospatial Consortium (OGC).

4. Status and Futures

4.1 Status

Despite these principles being common, contextual differences, including institutionally anchored formal and informal arrangements, for example, the role of local councils in fiscal decision-making, lead to different approaches to SDI development. Established approaches to government decision support in Poland require an emphasis on fulfilling legal requirements. The South African SDI Act states that spatial information is important for effective governance, planning and decision making. The US SDI follows myriad legal requirements and policy guidelines. In Poland, data sharing increasingly follows the transposition of the INSPIRE Directive; in South Africa, the objectives of the SDI Act emphasize the facilitation of sharing and avoidance of duplication; principles common to relevant laws and policy in the US as well. Coordination in Poland follows existing governmental relations and procedures. In South Africa coordination should occur through the Committee for Spatial Information, established by the SDI Act. In the US, coordination occurs through a variety of formal and informal processes. In Poland, policy follows EU regulations and national laws. The South African SDI Act explicitly states this need and policy development is currently in progress. The devolved nature of the US leads to a plethora of policies impacting SDI development. Related, de jure standards are common in Poland (Iwaniak, 2005) whereas the South African SDI Act provides for the determination of

standards and prescriptions to facilitate sharing spatial information. In the US, de facto standards have been crucial to SDI developments with varying significance (Harvey, 2011).

In Poland discussions of new legislation reflect potential development of new business models to support financing SDI construction and increased use of the Geography Markup Language (GML). These activities can be connected to ongoing educational activities associated with INSPIRE. In South Africa SDI-related activities, such as AGIS and SANSA, are the building blocks for SASDI, despite the top-down coordinated approach of CSI still being in its infancy. In the US, work in the national geospatial program has produced specifications for a number of mapping activities, including the US Digital Topographic Product Standard that specifies the creation of GeoPDFs to replace traditional print creation of topographic maps.

In the evolving landscape of governmental and non-governmental data sharing and coordination activities, current trends point to the development of capabilities between extending flexibilities and calcification of existing status quo arrangements. There is a persistent perception that every organization or country needs a perfectly functioning SDI. In reality, an SDI has to fit competing requirements and limited budgets. In practice, it is acceptable to have an SDI where most sharing and coordination activities are operational, but not always running smoothly and with disputes and disagreements sometimes dominating. Current SDI models, such as those proposed by Rajabifard *et al.* (2002) and Kok and Van Loenen (2005), need enhancement to reflect recent developments such as volunteered geographic information, crowd sourcing, cloud platforms, mobile GIS and the geospatial semantic web.

4.2 Futures

The next stage in the development of SDIs around the world cannot be predicted, but nascent developments point to new types of hybridism with non-governmental data providers, re-users, and semi-public partnerships in complex networks blurring the distinction between users and producers (Budathoki *et al.,* 2008). The potentials of crowd sourcing remain unclear. The vitality and relevance of non-authoritative data sources, also known as volunteered geographic information (Goodchild, 2007), and services hold huge potential in new consumer-orientated markets. How they will fare in sectors requiring both de facto and de jure authoritative data remains unclear. Elwood *et al.* (2012) suggest that the abundance of data, geographical context and peer review by users and other contributors makes it difficult to produce fake VGI, either accidentally or deliberately. Of course, these authors live in a developed country rich in data and peer reviewers (Cooper *et al.,* 2012). In countries where geographic data is not as abundant, this assumption does not hold. Indeed, deeply rooted government activities and arrangements continue to hold vast influence on how future SDI development take place. Societal needs and priorities, laws and regulation, funding, and intra-governmental relations have a lasting impact on SDI developments.

5. Conclusions: No Future without the Past

While it often appeals to people to look to the next stage of the future as the birth of something new, given the history, traditions, and investments in government geographic information, the past will continue to affect the development of SDIs.

The diversity and complexity of SDI developments point to the need to develop an SDI Maturity Index (SDIMI), which objectively assesses the development stage of different aspects of an SDI. We plan to map human development stages against different aspects of an SDI, such as those mentioned by Rajabifard (2002), Kok and Van Loenen (2005) and Grus *et al.* (2007). This could draw on other models, such as the SDI model of the Commission on Geoinformation Infrastructures and Standards of the International Cartographic Association (Hjelmager *et al.,* 2008) and the Capability Maturity Model (CMM), which objectively assesses software development processes (Curtis, 1992). The index should reflect the development stage of the six needs described in section 3 above and the principles of data sharing and coordination (Tulloch and Harvey, 2008). The index should facilitate policy creation and guide incremental SDI development.

Current technologies, especially the growing use of mobile computing, point to a future with far more distribution and integration. Due to the Internet, wireless networking and mobile devices, it is possible to stay connected to the global network always and wherever you are - resulting in more distribution. As a result, there are ever increasing volumes of diverse data that need to be integrated. Standards provide one part of the solution, but there are definitive benefits in the creation of data-centric approaches (automatically discovering and interpreting spatial data). We don't know what comes next, perhaps, but it's clear that somehow SDIs will continue to play a part.

Acknowledgements

References

Agricultural Geo-referenced Information System (AGIS) (2011), Available at http://www.agis.agric.za, [Accessed 9 November 2011].

Budhathoki, N.R., Bruce, B.C., Nedovic-Budic, Z., (2008), Reconceptualizing the role of the user of spatial data infrastructure. Geojournal 72(3-4): 149-160.

Butler, A.l., Voss, A., Goreham, D. and Moeller, J., (2005), A Dramatic New Approach to Build the NSDI. GeoWorld, October 2005.

Campbell, H. and Masser, I., (1995), GIS and Organizations. How Effective Are GIS in Practice? London: Taylor & Francis.

Centre for Geoinformation Science (CGIS) (2011), SDI workshop held in Cape Town, CGIS news item Available at http://web.up.ac.za/default.asp?ipkCategoryID=16055&subid=16055&ipklookid=11&archive=1&ArticleID=7512, [Accessed 9 November 2011].

Coetzee, S. and Cooper, A.K., (2007), What is an address in South Africa? South African Journal of Science (SAJS), Nov/Dec 2007, 103(11/12): 449-458.

Cooper, A.K., Coetzee, S. and Kourie, D.G., (2012), Assessing the quality of repositories of volunteered geographical information. Submitted.

Cooper, A.K. and Gavin, E.J.O., (2005), Metadata in Africa and the Middle East, in Moellering H, Aalders HJGL and Crane A (Ed). World Spatial Metadata Standards: Scientific and Technical Characteristics, and Full Descriptions with Crosstable. Elsevier and the International Cartographic Association, ISBN 0080439497, pp 431–450.

Crompvoets, J., (2006), National Spatial Data Clearinghouses, Wageningen, The Netherlands: Wageningen University.

Grus, L., Crompvoets J., and Bregt A., (2007), A Multi-View Framework to Assess Spatial Data Infrastructures, International Journal of Spatial Data Infrastructures Research, 2, 33-53.

CSIR Earth observation for Africa—eyes in the sky (2008), CSIR pamphlet, Pretoria: CSIR.

Curtis, B., (1992), Maintaining the software process, Proceedings of the Conference on Software Maintenance 1992, pp2-8. DOI: 10.1109/ICSM.1992.242565.

Densham, P.J., (1991), Spatial Decision Support Systems, in Maguire D.J., Goodchild M.F. and Rhind D.W. (Ed). Geographical Information Systems, London: Longman, pp403-12.

Elwood, S., Goodchild, M.F. and Sui, D.Z., (2012), Researching volunteered geographic information: Spatial data, geographic research, and new social practice. Annals of the Association of American Geographers. In press.

European Commission (2011), INSPIRE website, Available at http://inspire.jrc.ec.europa.eu/index.cfm, [Accessed 9 November 2011].

Federal Geographic Data Committee (FGDC) (1998), NSGIC/FGDC Framework Survey. Folger P. (2011). Issues and Challenges for Federal Geospatial Information. Washington, D.C.: U.S. Congressional Research Service.

Geonetwork (2011), Available at http://geonetwork-opensource.org/, [Accessed 9 November 2011].

George, J.A., (2010), Efforts and activities to make data accessible through development of national geospatial data clearinghouse, Proceedings of GSDI-12, 19-22 October 2010, Singapore.

Georgiadou, Y., Puri, S.K. and Sahay, S., (2005), Towards a Potential Research Agenda to Guide the Implementation of Spatial Data Infrastructures—A Case Study From India. International Journal of Geographical Information Science 19(10): 1113-30.

Georgiadou, Y., and Stoter, J., (2010), Studying the Use of Geo-Information in Government – a Conceptual Framework. Computers Environment and Urban Systems 34 70-78.

Goodchild, M.F., (2007), Citizens as voluntary sensors: Spatial data infrastructure in the world of Web 2.0. International Journal of Spatial Data Infrastructures Research, 2: 24–32.

Harvey, F., (2001), NSDI from the Trenches. Local Government Perspectives. Geospatial Solutions 11(5): 38-40.

Harvey, F., (2011), Spatial Data Infrastructures for Cadastres: Foundations and Challenges", in Nyerges T., Couclelis H. and McMaster R. (Ed). The Sage Handbook of GIS and Society, Los Angeles: Sage, pp287-303.

Harvey, F., and Tulloch, DL., (2006), Local Government Data Sharing: Evaluating the Foundations of Spatial Data Infrastructures. International Journal of Geographical Information Science 20 (7): 743-68.

Hjelmager, J., Moellering, H., Delgado, T., Cooper, A.K. , Rajabifard, A. , Rapant, P. , Danko, D., Huet, M., Laurent, D., Aalders, H.J.G.L., Iwaniak, A., Abad, P., Düren, U., and Martynenko, A., (2008), An initial formal model for spatial data infrastructures. International Journal of Geographical Information Science, 22(11): 1295-1309.

Hopfer, A., and Wilkowski, W., (2003), Polish System of Cadastre, Available at http://www.fig.net/commission7/krakow_2003/AM_FIG7_2003_Krakow/18-9-2003_SESSION_1_3_WILKOWSKI.ppt. [Accessed 19 October 2011].

Iwaniak, A. Metodyka opracowania i stosowania metadanych w Polsce (Methodology of Building Catalogue Services in Poland) (2005), Roczniki Geomatyki, Vol. III No. 3,

pp. 47-58, at http://ptip.org.pl/download/files/RG2005z3-Iwaniak.pdf, [accessed 19 October 2011].

Judd, D.R., (1979), The Politics of American Cities. Private Power and Public Policy. Boston, MA: Little, Brown and Company.

Kok, B. and Van Loenen, B., (2005), How to assess the success of National Spatial Data Infrastructures?, Computers, Environment and Urban Systems, Vol. 29, 699-717.

Krane, D., (2001), Local Government Autonomy and Discretion in the USA, at http://www.napawash.org/aa_federal_system/98_national_local.html, [Accessed 9 November 2011].

Kubik, T. and Iwaniak, A., (2007), Technologie interoperacyjne w projekcie GEOPORTAL na przykładzie użycia usługi WMS (Interoperable Technologies in the Geoportal Project Exemplified through the Use of WMS) (2007). Roczniki Geomatyki, Vol. V No. 6, pp. 71-83, at http://ptip.org.pl//download/files/RG2007z6-KubikIwaniak.pdf [Accessed 9 November 2011].

K.U.LEUVEN RESEARCH (2011), Spatial Data Infrastructures in Poland: State of play 2010 - INSPIRE, Available at http://inspire.jrc.ec.europa.eu/reports/stateofplay2009/rcr09PLv103.pdf, [Accessed 19 October 2011].

Masser, I. and Campbell, H., (1995), Information Sharing: The Effects of GIS on British Local Government", in Onsrud H.J. and G. Rushton (Ed). Sharing Geographic Information. New Brunswick, California, USA: Center for Urban Policy Research.

Masser, I., (1999), All Shapes and Sizes: The First Generation of National Spatial Data Infrastructures. International Journal of Geographical Information Science, 13(1): 67-84.

Nkwinti, G., (2010), Appointment of members of the Committee for Spatial Information, by the Minister of Rural Development and Land Reform. Notice 411 of 2010, Government Gazette, 33205, pp 3–4.

Onsrud, H.J. and Rushton, G., (1995), Sharing Geographic Information. New Brunswick, California, USA: Center for Urban Policy Research.

Ormeling, F., (2011), Cartography and Geoinformation in the 20th and 21st Centuries in conversation with Alexander Wolodtschenko and Florian Hruby". meta - carto - semiotics: Journal for Theoretical Cartography, 4:1-5.

Paluszyński, W., Iwaniak, A., Śliwiński, A. and Kubik, T., (2007), Building spatial data infrastructure at county level using open software", Proceedings of the XXIII

International Cartographic Conference, 4-10 August 2007, Moscow, Russia, Available at http://www.icaci.org/documents/ICC_proceedings/ICC2007/html/Proceedings.htm, [Accessed 9 November 2011].

Putnam, R., (2000), Bowling Alone. The Collapse and Revival of American Community. New York: Simon and Schuster.

Rajabifard, A., Feeney, M.-E. F. and Williamson I.P., (2002), Future directions for SDI development. International of Applied Earth Observation and Geoinformation, Vol. 4, 11-22.

Rajabifard, A., Binns, A., Masser, I. and Williamson I., (2006), The role of sub-national government and the private sector in future spatial data infrastructures, International Journal of Geographical Information Science, 20(7) 727-741.

Rajabifard, A., (2007), Towards a Spatially Enabled Society. ISBN 978-0-7325-1620-8, The University of Melbourne, 400 pp.

Rautenbach, V., Coetzee S. and Iwaniak A., (2012), Orchestrating OGC web services to produce thematic maps in a spatial information infrastructure. Submitted.

Regulski, J., (2003), Local Government Reform in Poland: An Insider's Story. Budapest: Open Society Institute.

Sebake, M.D. and Coetzee, S., (2011), On motivators and barriers of interorganizational GIS data sharing for address organizations in a South African SDI, Proceedings of AfricaGEO 2011, 31 May-2 June, Cape Town, South Africa.

Sietzen, Jr. F., (2003), Federal GIS, A Weapon of Mass Dysfunction? Geospatial Solutions 13(10): 16-20.

Smit, J., Makanga, P., Lance, K. and de Vries, W., (2009), Exploring relationships between municipal and provincial government SDI implementers in South Africa, Proceedings of GSDI-11, 15-19 June 2009, Rotterdam, the Netherlands.

Somers, R., (1990), GIS in Local Government: Characteristic Approaches. GIS World 3(6): 89-91.

South Africa (2003), Spatial Data Infrastructure Act (Act No 54 of 2003). G25973, 4 February 2004, Government Printer.

South African National Standard (SANS) 1883, Geographic information – Addresses (2009), Pretoria, South Africa: South African Bureau of Standards (SABS).

Sperry, R.L., (2000), What's the Federal Role in NSDI? GeoWorld 13(4): 48-50.

Tomlinson, R.F., (1988), The impact of the transition from analogue to digital cartographic representation. The American Cartographer, 5(3): 249–261.

Tosta, N., (1999), NSDI Was Supposed to be a Verb, in Innovations in GIS 6, Gittings B. (Ed). London: Taylor and Francis, pp3-24.

Tulloch, D. and Harvey F., (2008), When Data Sharing Becomes Institutionalized: Best Practices in Local Government Geographic Information Relationships. URISA Journal, 19(2): 51-59.

United Nations Economic and Social Council (UN ECOSOC) (2010), Report on global geospatial information management. Report of the Secretary-General prepared for the forty-second session of the United Nations Statistical Commission, 22-25 February 2011, New York, USA.

van Loenen, B. and Kok, B.C., (2004), Spatial Data Infrastructure and Policy Development in Europe and the United States. Delft: Delft University Press.

van Loenen, B., Besemer, J., and Zevenbergen, J., (2009), Spatial Data Infrastructure Convergence, in SDI Convergence. Research, Emerging Trends, and Critical Assessment, van Loenen B., Besemer J. and Zevenbergen J. (Ed). Delft, the Netherlands: Nederlandse Commissie voor Geodesie.

Williamson, I., Rajabifard, A. and Binns, A., (2007), Challenges and Issues for SDI Development. International Journal of Spatial Data Infrastructures Research, 1: 24-35.

Quest for a Global Standard for Geo-data Licenses*

Bastiaan van Loenen[1], Katleen Janssen[2] and Frederika Welle Donker[1]

[1]Delft University of Technology, the Netherlands
[2]Katholieke Universiteit Leuven, Belgium

b.vanloenen@tudelft.nl; katleen.janssen@law.kuleuven.be; f.m.welledonker@tudelft.nl

Abstract

The ability to share geo-data is key to the success of spatial data infrastructures. A major barrier in sharing geo-data is the use of non-standard Licenses which are difficult to understand both for human beings and computers. This article compares existing (national and international) licensing frameworks as to the key components they share. It draws out common elements that can serve as a basis for a global set of model Licenses.

KEYWORDS: Licensing, geo-data, standard, development

1. Introduction

In the SDI (spatial data infrastructure) community, technical interoperability and standardization are considered a *condition sine qua non* for facilitating data sharing and re-use. For example, INSPIRE requires technical interoperability of geographic data allowing different data sets across Europe to be smoothly combined in new data sets and/or services (see European Parliament and Council, 2007). However, not only technical standards are necessary to achieve this, but also agreements establishing interoperability on an organizational or legal level. Such interoperability involves ensuring the compatibility of licensing conditions for the use of spatial data, so that

---

* This chapter is based on and contains parts of Van Loenen, B., K. Janssen and F. Welle Donker, Towards true interoperable geographic data: developing a global standard for geo-data licenses, in: K. Janssen and J. Crompvoets, *Geographic data and the law. Defining new challenges*, Leuven: Leuven University Press, forthcoming.

data from different sources can be seamlessly combined. Non-transparent and inconsistent Licenses have often been identified as a major barrier to the sharing of data across the geospatial community and a clear need for harmonized geo-Licenses is increasingly being recognized (MICUS, 2008; Groot *et al.,* 2007; van Loenen *et al.,* 2007; National Research Council, 2004; Spatial Technologies Industry Association, 2001; RAVI Bedrijvenplatform, 2000; Meixner *et al.,* 1997). Currently, it is very difficult to readily assess and directly access geographic data and geographic information services, within one jurisdiction and particularly for cross-border and international use. Attention for legal interoperability and a standard for geo-information are starting to emerge, also influenced by the growing interest of the policy makers and public bodies in open data. For instance, in its proposal for amending the European Directive on the re-use of public sector information (PSI directive) (European Commission, 2011), the European Commission emphasizes the importance of licensing conditions and states its intention to create recommendations on licensing terms for the public sector bodies in the EU Member States. With regard to spatial data, there are already some promising initiatives the European Commission can draw inspiration from in the United States (National Research Council, 2004), Europe (INSPIRE DT Data and Service Sharing, 2010a), Italy (Garretti *et al.,* 2009), the Netherlands (Welle Donker, *et al.,* 2010), Australia (Fitzgerald, 2010) and at a global level (Onsrud *et al.,* 2010). While these initiatives address data sharing on a local level, calls are growing for licensing models that have a broader reach than just on a national or sector level, possibly based on existing models such as creative commons (see e.g. Group on Earth Observations, 2010; European Commission, 2011).

During its meeting at the GSDI 12 conference in Singapore in October 2010, the Legal and Socio-Economic Working Group of the Global Spatial Data Infrastructure Association decided to examine the possibility for a global licensing model for sharing geographic data. The Working Group felt that the differences between the national licensing traditions and practices might actually be smaller than generally assumed, making efforts to harmonize these traditions and practices worthwhile. A work plan was drawn up, consisting of different phases.

First, the Group collected existing material on (national and international) licensing frameworks, compared the key components thereof and categorized them in a number of 'common denominator' groups. In the second phase, a framework will be developed, based on these categories, of several types of Licenses that could be used on a global level, and that will increase transparency of the conditions for obtaining and using geographic data. Such transparency is an important first step towards reaching legal interoperability. The licensing framework should avoid creating new licensing conditions if this is not necessary, but also accommodate possible differences between organizations, cultures, and financing models. This paper presents the first stage of the work, by showcasing some existing licensing models that can be considered good practices, and by discussing the comparison that was made between the licensing models that were examined.

2. Existing Licensing Models and Frameworks

In this paragraph, we discuss some existing initiatives with regard to reaching transparency in licensing conditions and legal interoperability. While there are several models in the geo-domain that can serve as an example, first some attention should be paid to Creative Commons, which is the first licensing framework that attempted to standardize licensing. While this framework was not developed for geographic data, it has had a great influence on any licensing models for geographic data and is often used as a basis for harmonising initiatives. Therefore, its main characteristics will be discussed below.

2.1 The Creative Commons Framework

It can be argued that the standardization of Licenses at a global scale started with the foundation of the Creative Commons organization in 2001 (Dulong de Rosnay, 2010). Many initiatives in the geo-sector build on the licensing framework that is created by Creative Commons. In this section, we describe the Creative Commons framework, and discuss some of its advantages and drawbacks with regard to the harmonization of geo-Licenses.

Creative Commons (CC) was founded as a non-profit organization to offer flexible copyright Licenses for creative works such as text articles, music and graphics (see http://creativecommons.org). It advocates a system whereby rightholders can make works available through the Internet without forfeiting their intellectual property rights (IPR). To facilitate this, CC has developed a system of so-called Creative Commons Licenses, that try to balance between the "all rights reserved" concept of traditional IPR and the "no rights reserved" concept of the Public Domain, by employing a "some rights reserved" approach (see also Dusollier, 2006; Dulong de Rosnay, 2010).

Creative Commons Licenses are based upon a number of pivotal aspects: attribution, copying and redistribution, commercial and non-commercial use, creating derivative products, and extending the same License conditions to derivative products. Six different Licenses were created, holding standard terms except for three aspects where the licensor can choose to impose restrictions: commercial use, derivate products, and the licensing terms for those derivative products. The possible restrictions on the use that can be made of the work are summarized in the Table below.

Creative commons License attribute	Layman text
Attribution by	You let others copy, distribute, display, and perform your copyrighted work — and derivative works based upon it — but only if they give credit the way you request.
Share Alike sa	You let others distribute derivative works only under a license identical to the license that governs your work.
Non-Commercial nc	You let others copy, distribute, display, and perform your work — and derivative works based upon it — but for non-commercial purposes only.
No Derivative Works nd	You let others copy, distribute, display, and perform only verbatim copies of your work, not derivative works based upon it.

Table 1. Creative Commons Attributes

The six licensing models are made up of the following combinations:
1. Attribution Non-Commercial No Derivatives (by-nc-nd)
2. Attribution Non Commercial Share Alike (by-nc-sa)
3. Attribution Non Commercial (by-nc)
4. Attribution No Derivatives (by-nd)
5. Attribution Share Alike (by-sa)
6. Attribution (by)

In addition, the Creative Commons Zero License (CC0) allows one to waive all copyrights and related or neighbouring rights in one's work, such as moral rights (to the extent that these can be waived), publicity or privacy rights, rights protecting against unfair competition, and database rights and rights protecting the extraction, dissemination and reuse of data. Next, the Public Domain Mark (PDM) enables works that are no longer restricted by copyright to be marked as such in a standard and simple way, making them easily discoverable and available to others.

Creative Commons (CC) licenses have as an advantage that they are the result of a meticulous drafting process by leading legal scholars, they are well known and widely used across the globe, and they have been translated into numerous languages and adapted to numerous jurisdictions. Web search engines can automatically pick up embedded html code indicating that the returned sites contain CC licensed material (Onsrud *et al.,* 2010). The validity of the License has been upheld in various lawsuits

around the world (see for example Curry v Audax Publishing, the Netherlands; Spain: Sociedad General de Autores e Editores; Tribunal of Nivelles, Lichôdmapwa, Belgium).

However, CC Licenses also have a number of drawbacks. They may not be altered in any way (see J. Farchy, 2009), although others consider this a benefit: (Onsrud *et al.,* 2010; Dulong de Rosnay, 2010; Dusollier, 2006). Next, CC Licenses may not apply to some datasets in some jurisdictions. CC licenses are intended for "creative works" or those that meet the legal standard for "originality," regardless of the jurisdiction. As this standard for originality differs between jurisdictions (Janssen *et al.,* 2007), using CC licenses in a cross-border context may sometimes be problematic. The different national versions that have been created of the CC Licenses, all applying terminology adapted to their national legal frameworks, may complicate this even further (Dulong de Rosnay, 2010).

In addition, all the available Licenses may give rise to problems of interpretation. This is for instance the case with the CC License that only allows non-commercial use. What exactly constitutes 'commercial use'? What about a company representative visiting a client using a car navigation system, does this constitute commercial or internal use? The vagueness of the term 'non-commercial' has been criticized by several authors (Dulong de Rosnay, 2010; Welle Donker *et al.,* 2010; S. Dusollier, 2006; Rutledge, 2008), and while on a national level some consensus may be reached on the exact scope of the term 'commercial', on a cross-border or international level this will be much more difficult. Moreover, the use of only a non-commercial CC License may be a problem for geographic data stemming from the public sector in particular jurisdictions, e.g. in the European Union, where both non-commercial and commercial use of such geographic data should be allowed under the directive on the re-use of public sector information (van Eechoud *et al.,* 2007; Janssen, 2010). A separate License would still be possible for commercial use, but this would limit the harmonising potential of the use of the CC License in the first place.

Next, the CC License concept of 'no derivatives' may also pose a problem if the aim is to make datasets available for value-added products. If information (including geographic data) cannot be used to create derivative products, then it will only be suitable for internal business processes or for end users, and the addition of value by other users is not possible. A comparable problem rises with the share alike option. In a creative environment the concept of sharing works, adapting them, and making the derivatives available under similar conditions might be important to control potential free-riders who want to redistribute the work and their derivative works under a more strict License (see Lerner *et al.,* 2005). However, when geographic data is made available for the purpose of value adding, the requirement of making the value-added services and products available under the same open conditions would be counterproductive to the business model of many value-adders (see also Stewart *et al.,* 2006).

2.2 Licensing Frameworks in the Geo-domain

Even though the calls for standardization of licensing conditions are increasing, many public bodies providing geographic data are still hesitant to replace their own proprietary licensing system by a harmonized licensing policy (Janssen *et al.,* 2011). However, several recent initiatives aim at harmonising Licenses for public sector (geographic) data. In this section, we discuss three of these initiatives: Geo Shared in the Netherlands, Government Information Licensing Framework (GILF) in Queensland (Australia), and the INSPIRE basic and specific License. For an overview of some other initiatives, we refer to the INSPIRE Good Practice Guide (INSPIRE Drafting Team on Data and Service Sharing, 2010).

2.2.1 Geo Shared (Netherlands)

The Dutch Geo Shared licensing framework is embedded in the more general policy of the government to make available public sector information free of charge and without any (re-)use conditions (see Table 3): Van Boxtel, 2000; Donner, 2011. This policy applies to all information held by national government organizations and is endorsed by the Dutch provinces and water authorities. Most public sector information is envisioned to be available under a Creative Commons Public Domain Mark (see http://creativecommons.org/licenses/publicdomain/deed.en_US). If a PDM is not possible, a Creative Commons Zero declaration is advised.

However, for the instances when PDM or CC0 is not possible, because the public bodies concerned are still required to apply use conditions and/or charges, for example due to legal obligations, or because of costs that need to be recovered by the public organization, the Geo Shared (Dutch: geogedeeld) licensing framework was developed. This framework, created as part of the Dutch INSPIRE program builds on the Creative Commons concept, including symbols representing the various use conditions, a layman's text and a legal text. The data providers can choose the use conditions they want to apply to the dissemination of their geographic data from a limited list, shown in Table 2 below. The symbols representing the conditions of use are published in the Dutch national geo-register (see http://www.nationaalgeoregister.nl/). On 21 September 2010, the framework was accepted by the GI Council, the Dutch advisory council on geographic data.

	Attribution: Work can be used and reused if name of copyright holder and/or the date of the creation of the Work are mentioned on the Work.
	Derivative works only if: the Work can only be part of a Derivative works if the Work is not selectable from the Derivative Work.
	No redistribution: No redistribution of the Work is allowed.
	Time limitation: The license is valid for a limited period.
	Fee required: Use of the dataset requires a monetary payment.
	Purpose limitation: The Work can only be used for the purpose(s) specified in the license.
	Additional conditions: Other restrictions than the above apply.

Table 2. The Geo Shared Licensing Framework (see Van Loenen *et al.,* 2010)

2.2.2   Government Information Licensing Framework (Queensland, Australia)

The Queensland Government Information Licensing Framework (GILF), initiated by the Queensland Spatial Information Council (Australia) aims to make it easy for PSI users to understand the rights of use associated with the material they want to use. The GILF licensing framework consists of the six Creative Commons Licenses and a GILF Restrictive License (Fitzgerald, 2010). Originally only used in Queensland, it has now been taken up by the other Australian states and territories under the name of AUSGOAL, Australian Governments Open Access and Licensing Framework (see http://www.ausgoal.gov.au/).

Under GILF/AUSGOAL, the six Creative Commons Licenses are the preferred method for licensing government intellectual property. However, the restrictive License template can be used if the public bodies want to impose additional conditions. It has been developed specifically for material that contains personal or other confidential data, but it may also be used for other reasons, including for material that is licensed with limiting or restrictive conditions. In principle, the data obtained under this License can be used in Australia for the own internal purposes of the user. Possible restrictions the licensor can choose from include prohibitions to copy the data, to make it available, to transmit it electronically or to perform any act that is not explicitly allowed under the License. The License provides an appendix in which these standard restrictions can be overturned, and the making of copies, the online distribution, the electronic transmission, the distribution of hard copies or anything else can be allowed. Further, the GILF has an article and appendix on payment and in an appendix the License fee itself, and payment information is provided.

2.2.3   INSPIRE Drafting Team basic and specific Licenses

In 2005, the INSPIRE Drafting Team on Data and Service Sharing was set up to prepare the Commission Regulation executing article 17.8 of the INSPIRE directive on access by the bodies and institutions of the European Community (now European Union) to spatial data sets and services from the Member States falling under the scope of the directive under harmonized conditions.

The drafting team provided a guidance document for the Member States and public authorities on how to share spatial data sets and services with the institutions and bodies of the European Union (INSPIRE DT Data and Service Sharing, 2010a). In this guidance, the Member States are encouraged to make upstream framework INSPIRE agreements for data sharing between multiple organizations and for multiple datasets, in this way preventing the need for a separate License for each request for data. However, if such agreements are not available, the Member States are encouraged to use a Basic or Specific INSPIRE License, (INSPIRE DT Data and Service Sharing, 2010a). While these Licenses were created specifically for the dissemination of spatial data and services towards the EU institutions and bodies, they can also be used *mutatis mutandis* for data sharing between other stakeholders.

The Basic INSPIRE License applies when spatial data sets or services can be used under INSPIRE conditions without significant further restrictions or conditions and the use is free of charge. These INSPIRE conditions hold that the data or service can be used for the performance of public tasks that may have an impact on the environment by the institutions and bodies of the Community, and by contractors on their behalf. The institutions and bodies can allow public access to the data or service, but they should avoid unnecessary duplication of the original data set or service from the data provider, or any data or service derived from it (INSPIRE DT Data and Service Sharing, 2010a). The License also contains standard provisions on warranties and security

measures, liability, the access and delivery methods, personal data, assignment and sub-licensing, conflict resolution and termination.

3. Towards the Development of Cross-Border and Global Standards for Licensing Geographic Data

3.1 Objective and Methodology

As shown from the initiatives in the previous section, there are signs that ad hoc licensing policies from individual organizations will gradually be replaced by nationally or sectorally coordinated harmonized Licenses (see Figure 1). However, this does not solve the problems users are facing when they want to combine data from different sectors and across borders. The GSDI Legal and Socio-Economic working group wants to propose a global licensing model for geographic data that enables the users to License and use data from any source: see figure 1.
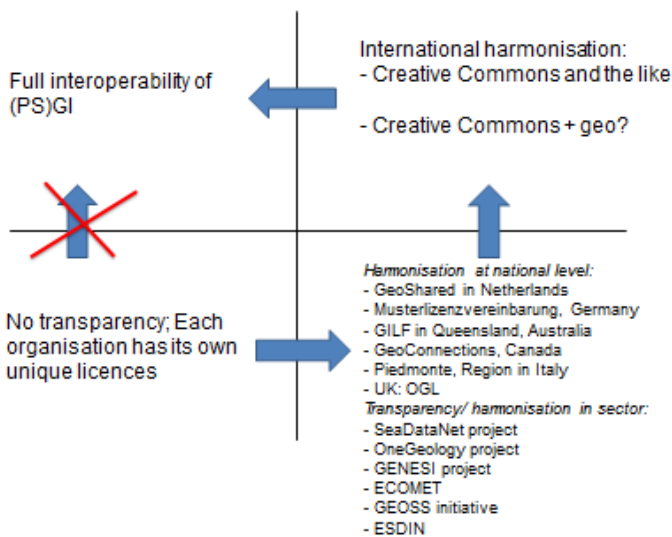
Figure 1. Suggested Stages of Development of a Standard for Geo-Licenses

The Group compared existing licensing frameworks and models, and categorized they key components in a number of groups. Based on the common denominators of these categories, in the future a licensing framework will be created that can be used globally and will increase transparency and support interoperability of the conditions for obtaining and using geographic data. The following licensing frameworks and models were examined (see Table 3).

Topic	Location/Region	URL
APIE	France	https://www.apiefrance.fr/sections/actualites/des-conditions-generales-pour-la-reutilization-des-informations-publiques/view
Creative Commons	Global	http://creativecommons.org
ECOMET	Europe	http://www.ecomet.eu/index.php?option=com_content&view=article&id=2&Itemid=3
ESDIN	European Union	
GeoConnections	Canada	http://www.geoconnections.org/publications/Best_practices_guide/Guide_to_Best_Practices_Summer_2008_Final_EN.pdf
Geo Shared	Netherlands	http://www.geonovum.nl/diensten/gebruiksvoorwaarden
Government Information Licensing Framework	Queensland, Australia	http://www.gilf.gov.au/
INSPIRE basic & specific License	European Union	http://inspire.jrc.ec.europa.eu/documents/Data_and_Service_Sharing/DSSDraftGuidancedocument_v4.1.pdf
Ministry of Justice	France	http://www.rip.justice.fr/1932-simplified-License-%C2%AB-conditions-of-the-reuse-of-public-information-that-is-freely-reusable
OneGeology-Europe	European Union	http://www.law.kuleuven.be/icri/deliverables/2071G-E_WP7_D7.pdf?where=
Open database License	Global	http://www.opendatacommons.org/licenses/odbl/
Open license	Montevideo (Uruguay)	http://monolitos.montevideo.gub.uy/resoluci.nsf/de053405568724cf832575ae004f0467/7adaf8ec8d70033b832576d60041760f
Ordnance Survey (Open Government License)	United Kingdom	http://www.ordnancesurvey.co.uk/oswebsite/business/licenses/agreements.html
SeaDataNet	Europe	http://www.seadatanet.org/content/download/3899/29604/version/2/file/SeaDataNet+Data+Policy+.pdf

Table 3. Overview of Existing National or Sectoral Geo-license Harmonization Efforts analyzed the GSDI Legal and Socio-Economic Committee

As almost all of the licenses contained provisions on the same topics and the users are confronted with the same elements, it seemed relatively easy at first sight to ensure interoperability and possibly even harmonization. However, the content of the provisions might still be significantly different. Hence, harmonization would need three steps. The first one would involve including the same topics in each license, so that a user knows what types of terms and conditions to expect. However, this would only provide a small benefit to the user. In the second step, standard formulations should be developed for each provision, ensuring that, even though the conditions that are applied to different data sets may still vary, at least for each requirement and

condition a standard clause with harmonized wording would be available. Third, not only the formulation of the conditions and requirements should be harmonized, but the types of conditions that can be imposed would be limited. The Working Group realized that this final step would be difficult to achieve due to the many different legal and institutional factors that need to be taken into account, and therefore aimed to develop a licensing framework that provides a number of model licenses built from standard clauses, but that still allows for the data providers to choose the conditions they want to apply.

3.2 Overview of the Categories of License Terms

The following categories of clauses were found in almost all of the licensing frameworks: definitions, grant of license, obligations, allowed use, use restrictions, term and termination, disclaimers (limitation on liability/warranties/indemnification), dispute resolution, governing law, jurisdiction, and form and effect of the agreement. For some of these categories, different options or subcategories could be found for particular conditions or requirements. As mentioned earlier, ideally the number of these options should be as limited as possible, but a first step in reaching interoperability or harmonization would already be that the different options and possibilities are formulated in a more uniform way, in this way creating more transparency and facilitating the combination of different types of geographic data by the user. In the next subsections, we discuss four examples of categories for which different clauses or clauses containing different options were found in the model licenses.

3.2.1 Grant of License

While all licenses contained a non-exclusive grant of use rights, some only allowed use within a certain territory (e.g. some of Queensland's GILF licenses), or required payment for using the data (e.g. the French APIE's licenses). Yet, many of the licensing frameworks that include multiple licenses include both royalty-free and charging license templates.

3.2.2 Allowed Use

The core element of a license is the kind of use the licensee can make of the data that he or she has obtained under the license. Understandably, the provisions on allowed use in the licensing frameworks held considerable variation in their level of restrictiveness, adapted to the specific needs of each framework and/or data provider. Generally, the types of allowed or restricted use included the following types (albeit formulated in many different wordings):

- Accessing
- Viewing
- Downloading
- Copying

- Distributing
- Making derivative works

3.2.3 Use Restrictions

Another part of the licensing frameworks that is essential are the acts that the licensee is *not* allowed to perform with the geographic data he or she obtained access to. The different licenses contained a wide variety of use restrictions, with each license within a particular framework holding a different combination of these restrictions. Possible restrictions can be divided into a number of main types:

- No sublicensing;
- No direct marketing;
- Viral clause: share-alike obligation
- No distribution or disclosure to third parties;
- Only internal use for legal persons or private use for natural persons;
- No derivative works, only non-copy derivative works, no changes or adaptations to the original information;
- Limitation on number of copies, number of views, number of users/computers;
- Only use for a particular activity, or for a particular purpose;
- Only use by a particular group of users.

The different types of user restrictions can have a greater or lesser impact on the possibilities of the licensees to use the geographic data for the purposes they need it. For instance, while a prohibition to sublicense the data only limits the user from acting as a licensor of the data he or she has obtained, the data can still be made public. Next, not being allowed to redistribute the data does not hinder the user from creating added-value products and disseminating those, while a restriction to internal use would also prevent the latter. Another example where the extent of the user restriction can make a great difference is the purpose: a license forbidding a particular type of use (e.g. no direct marketing) has much less impact than a license only allowing one type of use (e.g. only education).

3.2.4   Obligations of the User

The fourth category of license terms for which a number of different provisions and options were found in the model licenses and licensing frameworks that were studied is the obligations of the user. In the reviewed licensing frameworks the following obligations for the user were found:

- No misuse of the data or misrepresentation of the data provider;
- No use of any identifiers/ trademarks of the supplier;
- Attribution;
- Notification of any misuse of the data or any infringements of the license that were noticed by the user;

- Notifications of errors in the data found by the user;

4. Discussion and Conclusions

Obtaining interoperability or harmonization can be relatively easy for many of the license provisions. However, particularly with regard to the restrictions that can be imposed on the use of the data, considerable flexibility will need to be maintained, allowing data providers to determine their own requirements outside of any standard provisions that are provided. For instance, for two use restrictions, 'Only use for a particular activity, or for a particular purpose' and 'Only use by a particular group of users' a standard option may be problematic, as it is difficult to distinguish between e.g. commercial use and non-commercial use, or to define personal use or end use. Starting with the purpose of use is even more troublesome with an infinite number of possible purposes. How can a computer decide which purpose does not conflict with another when trying to integrate to different data sets or services? A pragmatic approach has been implemented by the Seadatanet project (see www.seadatanet.org). Seadatanet attributes four different roles to its users. Based on these roles a user profile dictates the conditions of access to the datasets. For some it is free without any restrictions, for other datasets it is not. This approach needs further investigation as far as meeting the full interoperability requirements.

Whatever problems may arise in harmonising some elements of licenses for geographic data, we do believe that a global framework of standard geo-licenses is a prerequisite to stimulate cross-jurisdictional use of geographic data and to successfully move towards a service oriented SDI in which multiple services can be integrated into new services without delay. The review of existing licensing frameworks shows that they have many elements in common, at least at the generic level of categories included in a license. Even the more detailed subcategories show possibilities for harmonization in most instances. The most troublesome from a harmonization perspective, are those licenses with conditions per user type, per activity and/ or specifying the purposes for which a data set can be used. For these licenses, transparency of terms and full and automatic interoperability will be a real challenge. In the next phase, based on the categories that were defined in the first stage of the work, a framework will be developed of several types of licenses that could be used globally and increase transparency of the conditions for obtaining and using geographic data.

References

Brunsson, N., Jacobsson, B., and associates (2000), *A* World of Standards, Oxford: Oxford University Press.

David, P. A. ,(1985), Clio and the economics of QWERTY, American Economic Review, 75(2): 332-336.

DTI (2005), The empirical economics of standards, at www.bis.gov.uk/files/file9655.pdf [Accessed on 26/08/2011].

Donner (2011), Letter of the Minister of the Interior to the Dutch Parliament concernng reuse and open data (Brief Hergebruik en Open Data: naar betere vindbaarheid en herbruikbaarheid van overheidsinformatie), 30 mei 2011.

Dulong de Rosnay, M., (2010), Creative Commons Licenses Legal Pitfalls: Incompatibilities and Solutions, Availabe at http://www.creativecommons.nl/downloads/101220cc_incompatibilityfinal.pdf [Accessed on 26/08/2011].

Dusollier, S., (2006), The Master's Tools v. The Master's House: Creative Commons v. Copyright, Colum. J.L. & Arts, 29: 271-293.

European Commission (2011), Overview of the responses to the consultation on Directive 2003/98/EC on the re-use of public sector information, Available at http://ec.europa.eu/information_society/policy/psi/docs/consultations/cons2010/responses.xls (Accessed on 18/02/2011).

European Parliament and Council (2007), Directive 2007/2/EC of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), Official Journal of the European Union L 108, 1-14.

Farchy, J., (2009), Are Free Licenses Suitable For Cultural Works? European Intellectual Property Review, 31(5): 255–263.

Fitzgerald, A., (2010), Legal Issues and Experiences from an Australia Perspective, GSDI-12 Conference 'Realising Spatially Enabled Societies, Singapore, 19-22 October.

Garretti, L., Griffa, S., Luca R., and Lopreiato, M.T., (2009), Standard Licenses for Geographic Information: the Development and Implementation in Local Government in Italy, in: van Loenen, B., Zevenbergen, J.A. and Besemer, J.W.J. (ed.) SDI Convergence - Research, Emerging Trends, and Critical Assessment, Delft: NCG, 53-62.

Groot, N., Bregt A., Crompvoets J., Pluijmers Y., (2007), Toegankelijkheid publieke geodata vooral gehindered door juridische barriers, VIMatrix 15(8): 6-8 [in Dutch].

Group on Earth Observations (2010), GEOSS Data Sharing Action Plan, Available at http://www.earthobservations.org/documents/geo_vii/07_GEOSS%20Data%20Sharing.

Hughes, T.P., (1987), The evolution of large technological systems, In Bijker, W. et al. (ed.), The Social Construction of Technological Systems, Cambridge: MIT Press, 51-82.

INSPIRE Drafting Team on Data and Service Sharing (2010), Good practice in data and service sharing, Availabe at http://inspire.jrc.ec.europa.eu/documents/Data_and_Service_Sharing/GoodP ractice_%20DataService%20Sharing_v1.1.pdf (accessed on 26/08/2011).

INSPIRE DT Data and Service Sharing (2010a), Guidance on the 'Regulation on access to spatial data sets and services of the Member States by Community institutions and bodies under harmonized conditions, Available at http://inspire.jrc.ec.europa.eu/documents/Data_and_Service_Sharing/DSSDr aftGuidancedocument_v4.1.pdf [Accessed on 26/08/2011].

Janssen, K., (2010), The Availability of Spatial and Environmental Data in the European Union. At the Crossroads between Public and Economic Interests, Alphen a/d Rijn: Kluwer Law International.

Janssen, K. and Dumortier, J., (2007), The protection of maps and spatial databases in Europe and the United States by Copyright and the Sui Generis Right, John Marshall Journal of Computer and Information Law, 24: 195-225.

Janssen, K., B. van Loenen and Remetey-Fulopp, G., (2011),Harmonising Licenses on a Global Level: Mission Impossible or Piece of Cake?, Proceedings of the INSPIRE conference 2011, Edinburgh, Available at http://inspire.jrc.ec.europa.eu/events/conferences/inspire_2011/abstracts/2 40.doc [Accessed on 26/08/2011].

Krechmer, K., (2009), Open standards: A Call for Change, IEEE Communications Magazine, (May): 88-94.

Lerner, J. and Tirole, J., (2005), The scope of open source licensing, J. Law, Econom, Orgn, 21(1): 20-56.

Meixner, H. and Frank, A.U., (1997), Study on Policy Issues Relating to Geographic Information in Europe, Available at ftp://ftp.geoinfo.tuwien.ac.at/frank/2184 GIPolicy.pdf [Accessed on 26/08/2011].

MICUS (2008), Assessment of the re-use of public sector information (PSI) in the geographic information, meteorological information and legal information sectors, final report, Avaialble at http://ec.europa.eu/informationsociety/policy/psi/docs/pdfs/micus report december2008.pdf [Accessed on 26/08/2011].

National Research Council (2004), Licensing Geographic Data and Services, Washington D.C: National Academies Press.

Onsrud, H., Campbell, J., and van Loenen, B., (2010), Interoperable Open Access Licenses for the Global Earth Observation System of Systems (GEOSS), International Journal of Spatial Data Infrastructures Research, 5: 194-215.

RAVI Bedrijvenplatform (2000), Economische effecten van laagdrempelige beschikkingstelling van overheidsinformatie. Amersfoort: RAVI Bedrijvenplatform [in Dutch].

Raymond, E. S., (1999), The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary, Cambridge: O'Reilly.

Rutledge, V., (2008), Fair Comment: Towards a Better Understanding of NC Licenses, Available at http://www.col.org/news/Connections/2008feb/Pages/fairComment.aspx [Accessed on 26/08/2011].

Spatial Technologies Industry Association (2001), Phase 1 report: increase private sector awareness of, and enthusiastic participation in the National Spatial Data Infrastructure (NSDI), Avaialble at http://www.fgdc.gov/library/whitepapers-reports/sponsored-reports/stia/ [Accessed on 26/08/2011].

Stewart, K.J., Ammeter, A.P., Maruping, L.M., (2006), Impacts of License Choice and Organizational Sponsorship on User Interest and Development Activity in Open Source Software Projects, Information Systems Research, 17(2): 126-144.

Van Boxtel, R., (2000), Naar optimale beschikbaarheid van overheidsinformatie. Minister voor Grote Steden- en Integratiebeleid. Tweede Kamer, vergaderjaar 1999–2000, 26 387, nr. 7 [in Dutch].

van Eechoud, M., and van der Wal, B., (2007), Creative commons licensing for public sector information. Opportunities and pitfalls,Availabe at http://www.ivir.nl/creativecommons/en_government_information.html [Accessed 17/04/2011].

van Loenen, B., Zevenbergen, J., Giff, G.and Crompvoets, J., (2007), Open toegankelijkheidsbeleid voor geo-informatie vergeleken: het gras leek groener dan het was, Delft: Delft University of Technology [in Dutch].

Van Loenen, B., and van Barneveld, D.W., (2010), Implementing INSPIRE: the process towards the harmonization of licenses for public sector geographic information in the Netherlands, Proceedings of the INSPIRE conference 2010, Krakow, Avaialbe at http://inspire.jrc.ec.europa.eu/events/conferences/inspire_2010/abstracts/118.doc [Accessed on 26/08/2011].

van Loenen, B., and Welle Donker, F., (2010), Towards a framework of standard licenses for geo-information?! GSDI-12 Conference. Realising Spatially Enabled Societies, Singapore, 19-22 October.

Welle Donker, F. , B. van Loenen and Zevenbergen, J., (2010), Geo Shared licenses: a base for better access to public sector geoinformation for value-added resellers in Europe, Environment and Planning B: Planning and Design, 37: 326-343.

Werle, R., (1998), An Institutional Approach to Technology. *Science Studies,* 11(1): 3-18.

Court cases

Netherlands: District Court Amsterdam, Curry v Audax Publishing, 9 March 2006.

Spain: Court of First Instance of Badajoz, Sociedad General de Autores e Editores, 17 February 2006 (Spain).

Belgium: Tribunal of Nivelles, Lichôdmapwa, 26 October 2010.

See also http://www.edri.org/edrigram/number4.6/jurisprudence-creative-commons-europe [Accessed on 26/08/2011].

Bridging the Gap between Traditional Metadata and the Requirements of an Academic SDI for Interdisciplinary Research

Claire Ellul[1], Daniel Winer[1], John Mooney[2] and Jo Foord[2]

[1]University College London
[2]London Metropolitan University

c.ellul@ucl.ac.uk; daniel.winer.10@ucl.ac.uk; j.mooney@londonmet.ac.uk; j.foord@londonmet.ac.uk

Abstract

Metadata has long been understood as a fundamental component of any Spatial Data Infrastructure, providing information relating to discovery, evaluation and use of datasets and describing their quality. Having good metadata about a dataset is fundamental to using it correctly and to understanding the implications of issues such as missing data or incorrect attribution on the results obtained for any analysis carried out.

Traditionally, spatial data was created by expert users (e.g. national mapping agencies), who created metadata for the data. Increasingly, however, data used in spatial analysis comes from multiple sources and could be captured or used by non-expert users – for example academic researchers - many of whom are from non-GIS disciplinary backgrounds, not familiar with metadata and perhaps working in geographically dispersed teams. This paper examines the applicability of metadata in this academic context, using a multi-national coastal/environmental project as a case study. The work to date highlights a number of suggestions for good practice, issues and research questions relevant to Academic SDI, particularly given the increased levels of research data sharing and reuse required by UK and EU funders.

K<small>EYWORDS</small>: metadata, Spatial Data Infrastructures, GIS, inter-disciplinary, cross-disciplinary, Academic SDI

1. Introduction

Until the emergence of the geographical information technologies that are part of Web Mapping 2.0 (Goodchild, 2007, Haklay *et al.,* 2008, Elwood, 2009) geographical information was provided top-down by bodies such as National Mapping Agencies (NMA) (Goodchild in Schuurman, 2009). Advances in positioning, web mapping, cell/mobile communications, Web 2.0 and Volunteered Geographic Information (VGI) (Goodchild, 2007b) have led to increasing availability of data from multiple sources (Budhathoki *et al.,* 2008), with much of this spatial data available free of charge (Coleman *et al.,* 2009).

In the context of academic research in the United Kingdom (UK), a number of measures have responded to, and reflect, this greater availability of data. At European level, Seventh Framework Programme (FP7) funding requires funded projects to provide a data management plan (FP7, 2011) and the European Union's INSPIRE (Infrastructure for Spatial Information in Europe) (INSPIRE, 2011a) directive may impact academia. Initiatives to encourage greater sharing of research data are being established – e.g. the Engineering and Physical Sciences Research Council's *Policy Framework on Research Data* (EPSRC, 2011) and the Economic and Social Research Council's *Research Data Policy* (ESRC, 2010). The setting up of an Academic Spatial Data Infrastructure (SDI) is one of the aims of the Joint Information Systems Committee's Geospatial Working Group (JISC, which was set up to facilitate information and infrastructure sharing across the UK's universities) (JISC, 2011). Initiatives such as GoGeo[1] and ShareGeo[2] allow academic users to share geospatial data online.

This increase in available spatial data is coupled with a reduction in Geographic Information System (GIS) expertise of the end user of such data. Previously, users were GIS experts with advanced training in spatial data understanding and management and quality issues.   However, the British Library recently predicted an increasing emphasis on cross-disciplinary research (British Library, 2010). Initiatives such as research projects funded by the JISC Geospatial Programme (JISC, 2011b) recognize the importance of spatial data analysis and GIS to other disciplines. The availability of free GIS software (e.g. Google Maps[3], Google Earth Builder[4], ArcGIS Explorer[5], ESRI's Community Analyst Tools[6], Quantum GIS[7]) encourages non-specialist

---

[1] http://www.gogeo.ac.uk/gogeo/
[2] http://www.sharegeo.ac.uk/
[3] http://maps.google.com
[4] http://earth.google.com/builder
[5] http://www.esri.com/software/arcgis/explorer/index.html
[6] http://www.esri.com/software/arcgis/community-analyst/index.html

users to make use of GIS tools and data. This is particularly the case given the power of GIS as a tool for the integration of data from diverse sources and disciplines.

Given both the increase in data and the reduction in expertise of the users, having information to allow end-users to understand and integrate the heterogeneous data they are using, and identify any potential issues, omissions, data capture methods and previous analysis carried out, becomes more important (Deng and Di, 2009, Haklay and Weber, 2008). Traditionally, metadata ('data describing the data') has been used (Sboui *et al.,* 2009) and amongst the GIS profession the quality description provided by metadata is acknowledged as important to understand potential errors and issues. Good metadata increases trust (Craglia *et al.,* 2008) and could be important to help increase the credibility of a dataset, mentioned by Coleman *et al.* (2009) as important particularly for VGI. However, metadata is complex to create (Poore and Woolf 2010, Manso-Callejo *et al.,* 2010) and "many view its generation as monotonous and time-consuming" (Batcheller, 2008), standards are producer-centric (Goodchild, 2007, Devillers *et al.,* 2005) and where metadata exists its quality may be variable (Rajabifard *et al.,* 2009). Indeed, many systems currently rely on "caveat emptor" (Goodchild, 2007).

This paper describes a review of metadata creation and use in a multi-national, interdisciplinary research project where the data quality description it provides is fundamental to the success of the project. The review examines whether traditional metadata, as a descriptor of data quality, is relevant to and usable in an Academic SDI and if there are any considerations that could overcome some of the issues commonly associated with its use.

The remainder of the paper is structured as follows – first a review of data quality issues and metadata is given. This is followed by an overview of the case study (the SECOA project). The results of an evaluation of SECOA's use of metadata are then presented, along with consideration as to whether metadata is relevant and usable for academic research. The paper concludes by presenting some ideas and concepts for further work to more tightly integrate metadata into the academic data management workflow.

2. Data Quality and Metadata

Concerns about accuracy and uncertainty of geographical datasets have been articulated for some time (Goodchild, 2002*)*. The level of vagueness (zone boundaries are possibly guesses), uncertainty (both positional and attribute) and ambiguity (e.g. where objects are assigned different labels by different groups or disciplines) (Longley *et al.,* 2011) all contribute to the quality of a dataset. Borrough (1994) lists potential sources of error in data including the age of the data, areal coverage, map scale, density of observations, relevance, format and accessibility. Van Oort (2006) identifies

---

[7] http://www.qgis.org/

a number of groupings of geospatial data quality information: lineage (the history of the dataset, how it was collected, and how it evolved); positional accuracy (how well the coordinate value of an object in the database relates to reality on the ground); attribute accuracy (how correct attribute values are); logical consistency (does the dataset conform to rules such as 'no houses in the middle of a lake' and general topological correctness and other relationships that are encoded in the database); completeness (is there any missing data or any data included that should not be there); semantic accuracy (how should objects in the dataset be interpreted); usage (how the data should be used appropriately); temporal quality (if the real world changes, does the dataset change too?).

Within GIS, and in particular within an SDI it is the metadata that provides a formal description of the data quality (Kim, 1999), allows for data reuse (Craglia *et al.,* 2008) and avoids data duplication. To enable interchange and understanding by computer-based systems, metadata is often stored in a very structured, standardized format (e.g. the United States Federal Geographic Data Committee[8] or the International Standards Organization's 19115:2003 Geographic Information Metadata Standard[9]). A study by Moellering (2005) identified 22 standards still in wide use. Table 1 below lists core elements of metadata for the European Union's INSPIRE Spatial Data Infrastructure (INSPIRE, 2011b). As can be seen the information stored in standards-based metadata directly corresponds to the list of quality elements identified above, with additional information to facilitate searching for the dataset and sourcing it once its quality has been evaluated.

Metadata Element	Metadata Element	Metadata Element
Title	Data format	Extent
Alternative title	Responsible organization	Vertical extent
Dataset language	Frequency of update	Spatial reference system
Abstract	Limitations on public access	Spatial resolution
Topic category	Use constraints	Resource locator
Keyword	Additional information Source	West bounding longitude
Temporal extent	Metadata date	East bounding longitude
Dataset reference date	Metadata language	North bounding latitude
Lineage	Metadata point of contact	South bounding latitude
Originating controlled vocabulary	Unique resource identifier	Coupled resource

Table 1. INSPIRE Metadata Elements (adapted from Walker, 2009)

Traditionally, metadata is created by a dedicated team of professionals (Mathes, 2004 in Kalantari *et al.,* 2010, Budhathoki *et al.,* 2008) and metadata standards are producer centric (Goodchild, 2007, Devillers *et al.,* 2005, Craglia *et al.,* 2008). They focus on

---

[8] http://www.fgdc.gov/metadata
[9] http://portal.opengeospatial.org/files/?artifact_id=6495

information that data producers assume will be relevant to users and it is difficult for end-users to be involved at any point (Budhathoki *et al.,* 2008). These geospatial specialists understand the importance of producing and maintaining metadata and the underlying requirement to provide quality information with a dataset to ensure that it is used correctly for any subsequent analysis (Sboui *et al.* 2009). However, even for specialists the complexity of creating and maintaining such metadata is considered significant (Poore and Woolf, 2010, Manso-Callejo *et al.,* 2010, Batcheller, 2008, Craglia *et al.,* 2008). Metadata production is seen as tedious and left to the end of a project, which results in metadata that is barely useful and often contains errors (West and Hess, 2002).

Two approaches can be identified to automatic metadata production. First, it may be possible to automate data quality assessment and hence generate metadata from the results. This has been attempted by comparing the data with 'better/higher' quality datasets (Koukoletsos *et al.,* 2011) and through modeling (deBruin, 2008, Agumya and Hunter, 2002) and through examining the different values of nominal, ordinal, ratio and interval data (Van Oort, 2006, Servigne *et al.,* 2006). Secondly, direct automated metadata creation has also been attempted. Potential approaches here include harvesting existing metadata (Batcheller, 2008), automated tagging (Kalantari *et al.,* 2010), title and location information extraction (Olfat *et al.,* 2010), format, number and types of geometry, resolution, bounding box, use constraints (Manso-Callejo *et al.,* 2009). However, elements of metadata – in particular descriptions such as abstracts - creation cannot ever be eliminated from the process (Batcheller, 2008).

In addition, end-users may require further non-standard information. For example, they may wish to express their own measures of fitness-for-purpose (Craglia *et al.,* 2008), to add information providing a simple description of data quality or details of the impact that the dataset could have on the outcome of any analysis they wish to perform (Goodchild, 2007) or to describe data in terms aimed at non-expert users (Timkpf *et al.,* 1996, Frank, 1998 and Harvey, 1998 in Devillers *et al.,*2005). Poore and Wolfe (2010) note that issues relating to semantics and ontologies are not handled by current standards. Devillers *et al.* (2005) mention that the reputation of the data producer is important. Legal requirements are suggested as being relevant by Gervais (2004 in Devillers *et al.,* 2005) and Aalders and Morrison (1998 in Devillers *et al.,* 2005) propose including information about where a dataset has been used.

3. The SECOA Project

SECOA (Solutions for Environmental Contrasts in Coastal Areas) is a research project involving eight different universities and institutions around the world (in the United Kingdom, Italy, Portugal, Israel, India, Vietnam, Sweden and Belgium). It has been set up to examine the effects of human mobility on urban settlement growth and in fragile environments – in particular the potential impact of sea level rise (SECOA, 2011a; 2011b). SECOA is investigating and comparing eight metropolitan areas of international/global importance and an additional eight metropolitan areas of

regional/national importance in these European and Asian countries. Given the wide range of issues to be addressed by the project, the SECOA team recognized the importance of data and data management from the outset. Metadata forms a core component of the data management task and specific time for metadata capture was allocated in the project schedule.

SECOA's metadata end-users can broadly be divided into three groups: producers (creating metadata and datasets for others), users (making use of metadata and datasets for cross-location comparison and model building) and "produsers" (given the small teams, a number of people fell into both roles).   The teams are very interdisciplinary and include researchers having expertise in the Creative Industries, Fluvial and Flood Geomorphology, Tourism Studies, Urban Planning, European Integration and Globalization among others.

Although standards-based metadata (in particular INSPIRE) was considered at the outset of the project, its complexity resulted in the creation of a shorter version of metadata ("stripped down", Longley *et al.,* 2011) to describe the datasets and be manageable in terms of creation time and understanding by the end users. The required metadata fields were identified through a questionnaire issued to the end users themselves (see Figure 1 below). Importantly, flexibility was included – users could upload documents to provide more detailed data quality information, and additional elements of metadata can be added as the project progresses, building towards the INSPIRE standard (see Ellul *et al.,* 2009 for details of how this is achieved). To assist the metadata creation task detailed guidance was produced in the form of user guides, decision flow diagrams and example metadata records. To address the issue of the diverse backgrounds of the team, regular presentations to familiarize users with metadata and data management are given at the six-monthly project meetings. At all times, the emphasis is on the use of metadata as a means to allow users to correctly and scientifically use, integrate and compare datasets from multiple sources and for multiple locations.

Throughout the first eighteen months of project activity, usage of the system has been tracked – users' requests for metadata have been logged, along with the number of metadata records and associated data files uploaded – to provide a quantitative insight into the system. Additionally, a qualitative review of metadata captured has been carried out to assess the usage and perceptions of the metadata system from the perspective of content.

4. The SECOA Metadata System – Results

Figure 1 shows the resulting web-based metadata system, with the elements highlighted by producers, produsers and users as important.

Figure 1. SECOA Metadata Capture Form

In the above Figure, the following elements of metadata have been included: a short *Title* (around 5 words) that describes the dataset; an *Abstract* to give a short description of the dataset; the *Type of Data* – such as spreadsheet, spatial data, PDF; the *Time Period(s) covered by the data* – of particular importance given the time-based change analysis in SECOA; *How the dataset was created* – details to allow the user of the dataset to understand how particular numbers or results were derived' the relevant SECOA *Work Packages*; whether *Data can be shared with SECOA.* Items such as *Contact E-mail*, relevant *Case Study* and *Contact University* are captured automatically from the user's login. Additionally, the system provides the ability for

users to link to *'ancestral datasets'* if a dataset is derived from another, to upload additional files describing the data and to upload the data file itself where it can be freely shared.

4.1 Quantitative Evaluation of the SECOA System

Figure 2 below shows the number of metadata records created by each of the partners (anonymized except for London Metropolitan University, LMU, the creators of the metadata system).
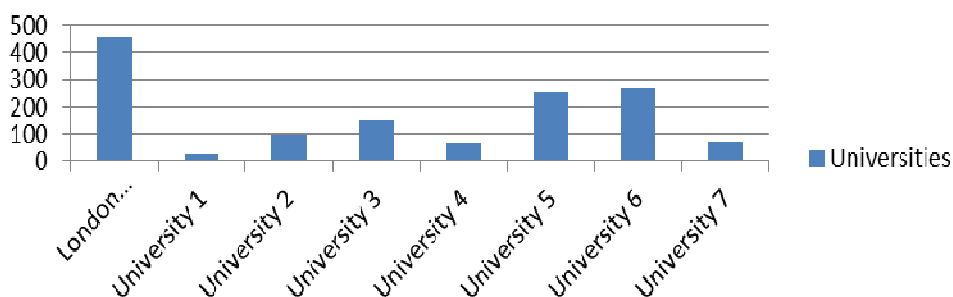
Figure 2. Number of Metadata Records Uploaded by Each Partner University

A total of approximately 1800 records have been created to date (October 2011). However, as can be seen, there has been a mixed response to the system with University 1 having submitted little metadata despite repeated encouragement, but others (5, 6 and LMU) performing well. Additionally, a total of 545 files (containing data or additional metadata information) have been uploaded.

Figure 3 below examines usage of the system for metadata viewing, again by anonymized university, with LMU excluded from the list. There have been approximately 2800 individual views of metadata records by non-LMU staff since system launch, but again there is great disparity between the teams with the universities showing a good record for metadata population also showing a good record for general use of the system. Detailed tracking results also show that there are relatively few users accessing the system in a significant way in each location - 13 core users (outside LMU) exist, who have viewed over 100 metadata records each since the system was launched.
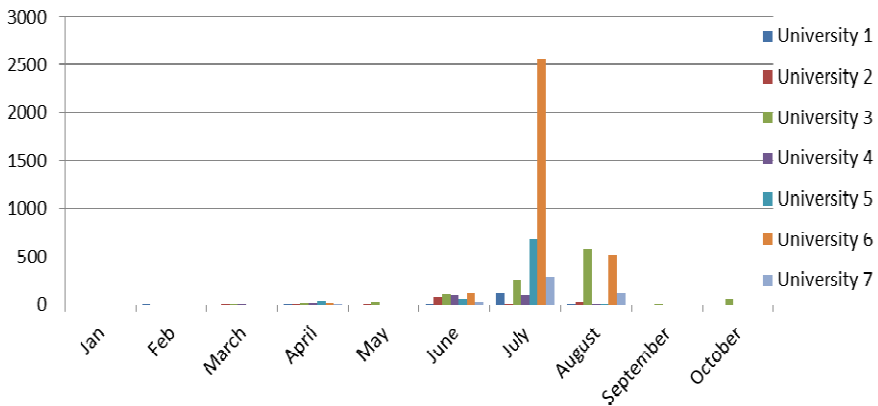
Figure 3. Number of Metadata Records Viewed by Partner Universities, by Month

The importance of a deadline in encouraging metadata submission cannot be underestimated - an additional 715 records were created in July 2011 in anticipation of the first metadata deadline. This is reflected in the heavier system usage in July in Figure 3 above.

4.2 Reviewing the Quality of SECOA Metadata

The disparity in the number of metadata records captured by the teams highlighted an issue with inconsistent metadata with some teams missing records although in theory all teams were required to contribute the same analysis results and associated metadata records to the project to allow comparability across the countries. A review of metadata content also highlighted the great variety of detail present in the metadata.   For example time-periods covered by various datasets included "1915 to present - variable depending on the location", "Collation of data as in Jan 2009" and "Details attached - depends on data type". Different descriptions and levels of detail were provided for data for a requested Driving forces, Pressures, States, Impacts, Responses (DPSIR) report (records below are anonymized):

• *University 1 created one metadata record with the abstract details: "DPSIR framework analysis for ecosystem of City A and City B"*
• *University 2 created one metadata record with abstract details: "Assessment of natural resources use for sustainable development (DPSIR analysis). The coastal wetlands in the municipalities of City A (peri-urban area) and City B (peri-urban area)"*
• *University 3 created eight metadata, with abstract details: "Report on the assessment of sustainable use of natural resources in the City A study sites: District and District B. The DPSIR framework is used to assess the sustainability of intertidal habitats in six statutory conservation areas. An index of sustainability is developed based on eight selected indicators. Results are very dependent on the*

*indicators used and their relative weight. Therefore the index is used here only to
rank the six areas based on the relative level of pressure they currently "*

Provision of more detailed guidance for metadata capture is on-going. First, a decision
tree is sketched out to allow users to determine whether a metadata record is
required to be captured or not (Figure 4).
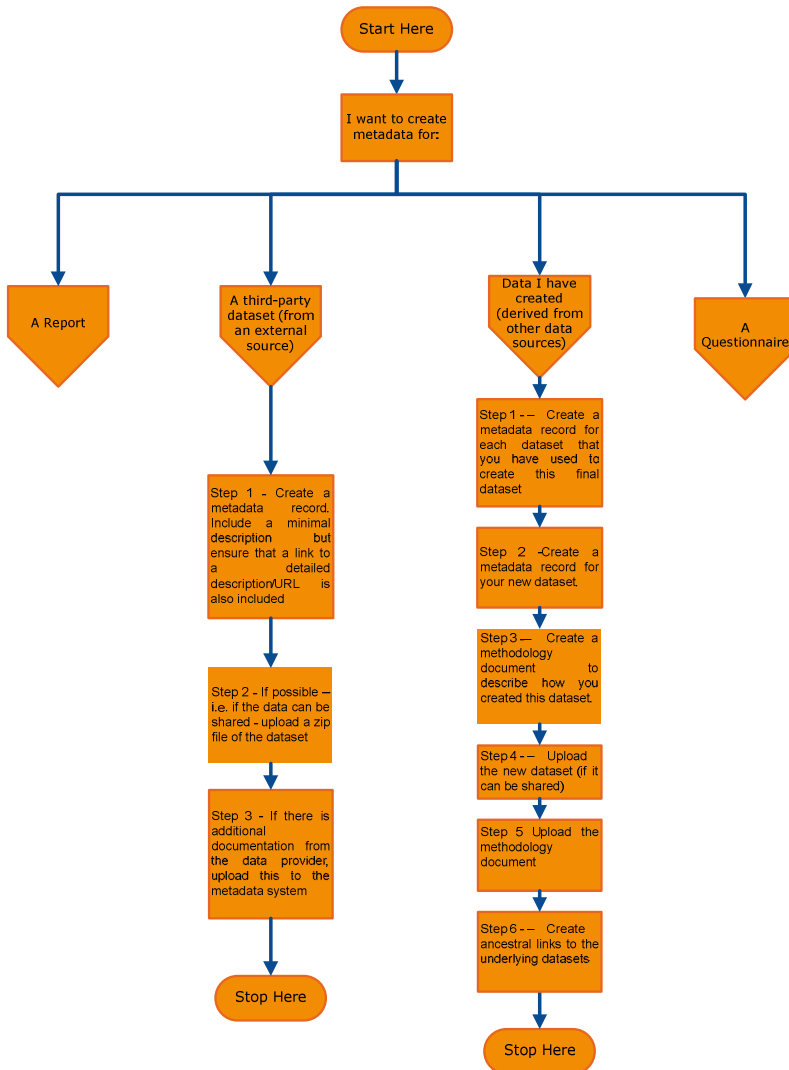
Figure 4. Decision Tree Diagram Guidance for Metadata Capture

Secondly, a series of best-practice examples have created in the metadata system by
the LMU team.

A second issue to be addressed is how best to assess the quality of the metadata produced in an automated fashion. Although the manual review described above yields relevant results, this is not scalable to hundreds or even thousands of user-generated metadata records. A quality assessment measure was therefore applied to the metadata, using the following criteria:

- The total amount of text provided in the abstract
- The total amount of text provided for the description of the dataset creation process
- The links between each metadata record and parent records.

Figure 5 below shows early stage results of this type of analysis, with 15 being a maximum quality score for a metadata record. The analysis highlighted in particular the lack of 'links' to parent datasets and the lack of text in some metadata entries. Individual reports will be circulated to all participants to encourage them to improve their scores.
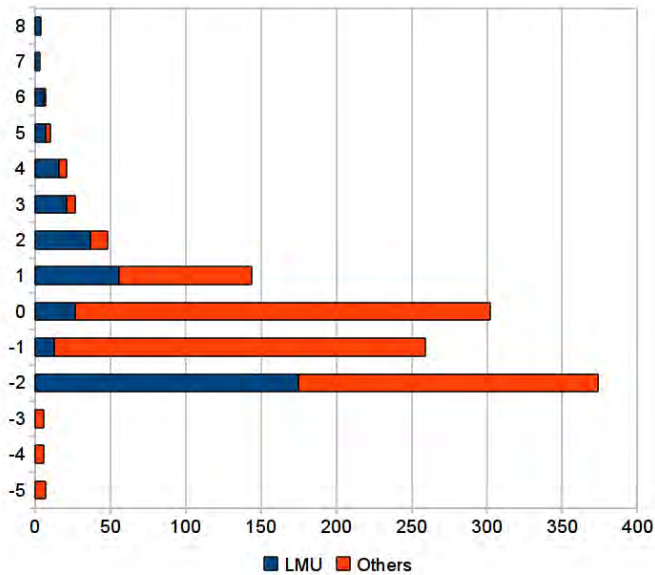
Figure 5. Automated Metadata Quality Analysis

4.3 Qualitative Evaluation of the Usage of the SECOA System

A second short questionnaire relating to usage of the metadata system yielded a total of 10 responses from users (5 out of 8 countries responded). Users were asked what they were using the system for, and whether they managed to locate the data they needed for their analysis work. Responses are given in Table 2 and Table 3.

Why do you use the Metadata System and Forum?	# Responses
To Upload metadata and datasets	8
To discuss issues on the forum	6
To search the metadata	6

Table 2. Metadata and Forum Usage

Do you find all the metadata/data that you need in the system?	# Responses
Yes - I find all the metadata/data I needed	3
Sometimes some metadata/data is missing	4
No - I cannot find what I need	0
I am not using the SEARCH option in the metadata tool	3

Table 3. Metadata Completeness

Two of the respondents, both members of the team currently conducting comparative studies, identified specific areas of missing metadata (and hence data that they required for analysis). Other issues included occasions where data did not meet the requested format (e.g. a PDF was supplied instead of a spreadsheet).

5. Is Metadata Usable and Useful within an Academic Research SDI?

Overall, the total of 1800 metadata records and 545 datasets uploaded and shared by the SECOA team point to a general level of success of the metadata tools. Having real, project-related, deadlines and having the data repository (and hence metadata) as an external deliverable with specific person-months allocated to it in the project schedule was fundamental to reaching this level of metadata as this gave the task higher impact. The majority of the work was carried out by a core team of 10 users, who have created on average 150 records each and quantitative assessment, by means of usage logging highlighted that within each team there are usually one or two 'metadata champions' who perform the majority of the entries and searches on behalf of the team.

The introduction of the "stripped down" metadata capture requirements and the automation of metadata capture for a number of elements was particularly successful, as was making the users aware that they would not be required to populate complex, complete standards-based metadata. Given the low level of individual queries to the development team (perhaps 5-10 across the first year) it would appear that the web-based system provided (along with the associated instructions) was deemed usable.

Members of the project team have become more familiar with metadata as the project has progressed. Feedback from the end users of the metadata – those team

members using the captured metadata – is also positive overall. Users were generally able to locate the datasets they required using the system's search tool, and the geographically dispersed project teams means that metadata was a first port of call for the teams searches for data, rather than an e-mail or phone call to the relevant team member. This use of metadata was also relevant within teams - anecdotally people were able to use metadata to answer questions about the datasets where details may have been forgotten due to elapsed time. Where clarification has been necessary, it has been possible to ask people to go back and add to or improve their metadata.

Comparing SECOA to traditional SDI, it can be realized that SECOA uses not only metadata on 'official' data but also requires metadata for the aggregated/analyzed data produced for comparative analysis. The metadata reflects the different methods used to produce the aggregated data, allowing comparison between the results from different teams. It is noteworthy that the results were often not spatial in nature, but consisted of summary reports or spreadsheets of aggregated numbers. Thus the SECOA SDI, and perhaps research SDI in general, needs to be able to handle both spatial and non-spatial data.

Despite the successes a number of issues have emerged which can be said to reflect those identified above (*Data Quality and Metadata*). Users have noted that some datasets and metadata are missing (i.e. have not been created/uploaded as required by various country teams) and our review highlighted inconsistent metadata creation and great inconsistencies in the resulting quality of the metadata. The SECOA team also exhibited the behaviour often described in association with metadata, where metadata was ignored in favour of more pressing data capture and analysis deadlines, unless specific metadata deadlines were set, and it remains to be seen whether participants will be willing to go through additional iterations to improve the quality of the metadata created.

Importantly, SECOA illustrates that metadata is relevant to facilitate data sharing and data quality description and ultimately ensure better science. Ideally, metadata and the data repository would be an external deliverable, and it is suggested that metadata deadlines are set on a frequent basis and accompanied by metadata review exercises. The issues with the quality of the metadata highlight the need for multiple iterations of metadata creation and maintenance to be scheduled and costed, and the need for detailed guidance and examples to be pre-created.

The time required to create detailed, more consistent, high quality metadata, perhaps including additional non-standard elements (see *Data Quality and Metadata* above), should not be underestimated. Even if, as was the case with SECOA users contribute fairly extensive metadata they are predominantly not GIS experts. Do they have the expertise in spatial data sufficient to do so with sufficient understanding of the limitations of their datasets? Therefore, perhaps the most fundamental question to address is 'how can we automate metadata capture and data quality assessment and documentation?'   If data has been manipulated or analyzed in a GIS, the metadata could list the software package and version, and also the exact operations that were

performed, in order, information which would not only be useful for the project but would contribute to the repeatability of the research downstream. However, even given this level of automatic data quality/metadata creation, fully automated metadata is as yet unreachable.

An interim alternative could be proposed that incorpoates metadata directly into a user's workflow – in other words, datasets cannot be accessed (e.g. in the GIS) without the user being made aware of corresponding metadata and hence any data quality issues, and cannot be shared without appropriate metadata being created (this contrasts with current systems, where metadata is held separately). Storing metadata with the data in an integrated single environment such as a spatial database would greatly assist in enforcing such rules. It would also allow the system to automatically update the metadata when the underlying datasets change (by means of a 'trigger' event in the database) and could generate regular prompts to the user to ensure that the metadata was up to date. Logging of GIS operations could be done directly into the database, and metadata records would be automatically created for new datasets, reducing the need for guidance and the existence of a separate 'metadata creation' task. Text mining tools could be used to automatically detect abbreviations and flag them to the user if they are not already logged in the system. Voice recording and transcription services could be included to faciliate the population of mandatory elements that cannot be automated, such as *title* and *abstract*.

The above measures may go some way to overcoming the wider issue of the complexity (and relevance) of standards-based metadata and the general perception that it is 'boring', 'irrelevant' and 'difficult to create and use' (Pasca *et al.,* 2009). To further this process, consideration should be given once again to one of the main purposes of metadata – it is a representation of the quality of the data, and should flag up any issues relating to the dataset to potential end users, empowering them to source data, make a descision as to whether to use a dataset and if used how to interpret the results obtained. Familiarizing researchers with the importance of such data quality descriptions to their project could assist in this task. Understanding motivation (from altruism to social reward, as suggested by Coleman *et al*. 2009) is relevant, as are participative methods of user feedback (Craglia *et al.,* 2008).

From the metadata creation perspective, techniques could involve adding quality ratings and descriptions to be applied both to the datasets and to the metadata - "*I used this dataset for task XYZ*", "*I rank this dataset as 4/5*", "*I found these issues in this data*", "*The metadata failed to mention that there is an entire county missing in the data.*" Further research into the applicability of the initial quality measures used above (Section 4.2) is also required – how can the quality of large numbers of metadata records be assessed on an ongoing basis? Online games could be created, with users competing in teams to describe spatial datasets and identify the most appropriate tags. More generally, the following questions 'how can we highlight the importance of understanding data quality?' and 'what would motivate people to voluntarily contribute metadata/quality information?' are relevant.

From the metadata user's perspective it is equally important to ensure that the resulting quality descriptions are relevant, and used in the correct context. Do users of metadata, increasingly not GIS experts, have the skills to interpret its meaning in terms of the underlying data quality and its impact on their analysis? 'How can people be encouraged to make use of metadata to obtain data quality information and correctly interpret the impact of data quality on their analysis and results?'

Automation has been discussed in the context of metadata creation, and it is possible that it may play a part here too, realizing one of the advantages of the structured approach to metadata storage. Given that it is created in a format to be machine-readable could such metadata be used to automatically assess the suitability of a dataset for a specific task, or perhaps issue warning flags or descriptions of 'suitable' datasets? For example, what is an appropriate point density for an inverse distance weighting interpolation with particular parameters? Does the proposed dataset have this appropriate point density? This concept extends the concept of metadata to processes and algorithms - a metadata record of an 'ideal' dataset could be created for each task, and then compared to that of the proposed dataset. Given the wider audience now using GIS (see *Introduction*) this would help to ensure that appropriate scientific output was produced and add an increased level of usability for novice users.

5. Conclusions and Further Work

The SECOA project could be said to reflect data creation and management requirements occurring across interdisciplinary, multi-national research and Table 4 highlights a number of similarities and differences between a 'traditional' SDI as exemplified by INSPIRE and an 'academic' SDI.

Bridging the Gap between Traditional Metadata and the Requirements of an Academic SDI for Interdisciplinary Research

'Traditional SDI'	'Academic SDI'
Complex metadata standards	Stripped-down metadata standards, but may have additional non-standard extras such as 'ancestor links', 'work package' or ratings.
Designed to handle spatial data only	Needs to handle mixed data including spatial, reports, questionnaires
Producer centric, data provided to anyone who requests/licenses it.	Both producer and user centric, as well as produsers. Data shared within a project, although greater emphasis now emerging on longer data life-cycle.
Expert producers, expert users who understand the importance of metadata and the detailed level of metadata required	Non-expert producers and users, who are not familiar with metadata and may not have expertise in interpreting it and then applying this interpretation to their research
Deadlines for metadata production	Deadlines for metadata production only exist if set within the initial project scope
Multi-Lingual metadata	Generally a single language agreed for each project, although multi-lingual also possible.
Ongoing data updates and metadata maintenance	Data updates and metadata maintenance end with the individual project.
Domain expertise high – e.g. many data producers participate in the working groups that define the standards for the data and metadata in their area of expertise	Metadata and data domain expertise can be very low – academics are generally specialists in their own field, rather than in data management. Important to familiarize team members with metadata concepts early on. Metadata champions important.
Time is allocated to metadata production	Time is only allocated to metadata production if defined as part of the original project scope.
Quality of metadata generally good – producers of the metadata know their data well	Quality of metadata can be poor, and metadata can be missing. Difficult for non-metadata experts to understand how much detail to provide. Further methods required to automatically understand the quality of metadata.
Metadata held separately from data	Metadata held separately from data. Ideally creation of quality information and application of this information to subsequent analysis should be integrated into the workflow and potentially 'hidden' from the end users.
Metadata time consuming to produce.	Metadata time-consuming to produce, automation fundamental to resolving this issue.

Table 4. Traditional Versus Academic SDI

The SECOA project is currently two-years into a four-year timescale. As well as ongoing quantitative measurements such as those described above (Quantitative Evaluation of the SECOA System), producers, produsers and users of the metadata system will be

surveyed again to identify issues, successes and their overall level of understanding of metadata. Lessons learned from SECOA, such as the importance of familiarizing end users with metadata early on and the importance of including metadata as a deliverable, can be directly applied to further interdisciplinary research and a more integrated spatial database and metadata system is currently being developed for another project.

Metadata is an established means to convey the quality of a spatial dataset and allow the user to locate data, understand its suitability for a task, undertake the required analysis and release and share the results. On the one hand, traditional standards-based metadata provides a potential opportunity to semi-automatically assess the suitability of a dataset for a specific task. Conversely, the complexity of such metadata (and the omission of more end-user-focused concepts such as a quality rating from the standards) discourages its creation and maintenance. Many challenges remain, both for SECOA and the wider world of Academic SDI in an increasingly inter-disciplinary and geographically dispersed research context, not the least of which is identifying a suitable descriptor or set of descriptors for data quality that are both easy to create (at least semi-automatically) and relevant to end-users. If the process can be simplified for both metadata generation and search, inexperienced users will be more likely to use such systems and in doing so there should be an increase in the cooperation between research and a reduction in the cost of unnecessary and repeated research (EPSRC, 2011).

The current trends in GIS – increasing amounts of freely available data and web-based and desktop processes and software, along with an increasing user base of non-specialists, have major implications for geospatial scientists. Ensuring that non-experts make informed, correct and scientific choices of data and relevant operations has implications for the quality of the resulting output and the reputation of the discipline as a whole. Education forms a key part of this, and the developers of training material for non-specialists should ensure that issues relating to data quality are included. In an ideal world, such metadata would be seamless and hidden. However, the data quality and the implications of quality on analysis would be displayed more prominently than in current tools.

Acknowledgements

References

Agumya, A. and Hunter, G., (2002), Responding to the consequences of uncertainty in geographical data, International Journal of Geographic Information Science 16(5): 405-417.

Batcheller, J., (2008), Automating geospatial metadata generation – An integrated data management and documentation approach, Computers & Geosciences, 34: 287-398.

Borrough, P., (1994), Principles of Geographical Information Systems for Land Resources Assessment, Oxford Science Publications, Clarendon Press, Oxford.

British Library (2010), 2020 Vision Project -Trends in Universities, Research and Higher Education - Internal discussion paper [online]. Available from: http://www.bl.uk/aboutus/stratpolprog/2020vision/trendsinuniresearch3.pdf 2010 [Accessed 21st November 2011].

Budhathoki, N.R., Bruce, B., (Chip), and Nedovic-Budic, Z., (2008), Reconceptualizing the role of the user of spatial data infrastructures, GeoJournal: An International Journal on Geography, 72(3-4): 149-160.

Coleman, D.J., Georgiadou, Y., and Labonte, J., (2009), Volunteered Geographic Information: The Nature and Motivation of Produsers ,International Journal of Spatial Data Infrastructures Research 4: 332-358.

Craglia, M., Goodchild, M. F., Annoni, A., Camara, G., Gould, M., Kuhn, W., Mark, Masser I., Maguire, D., Liang, S., and Parsons, E., (2008), Next Generation Digital Earth. A position paper from the Vespucci Initiative for the Advancement of Geographic Information Science, International Journal of Spatial Data Infrastructures Research 3:146-167.

De Bruin, S., (2008), Modelling Positional Uncertainty of Line Features for Stochastic Deviations from Straight Line Segments, Transactions in GIS, 12(2): 165-177.

Deng, M., and Di, L., (2009), Building an Online Learning and Research Environment to Enhance Use of Geospatial Data, International Journal of Spatial Data Infrastructures Research.

Devillers, R., Bedard, Y., and Jeansoulin, R., (2005), Multidimensional Management of Geospatial Data Quality Information for its Dynamic Use Within GIS, Photogrammetric Engineering & Remote Sensing, 71(2): 205-215.

Ellul, C., Haklay, M., Francis, L., and Rahemtulla, H., (2009), A Mechanism to Create Community Maps for Non-Technical Users", IEEE Computer Society, GEOWS, International Conference on Advanced Geographic Information Systems & Web Services, pp 129-134.

Elwood, S., (2009), Geographic Information Science: New geovisualization technologies – emerging questions and linkages with GIScience Research, Progress in Human Geography 33(2): 256-263.

EPSRC (2011), EPSRC Policy Framework on Research Data. [online] Available from: http://www.epsrc.ac.uk/about/standards/researchdata/Pages/default.aspx [Accessed 21st November 2011].

ESRC (2010), Research Data Policy. [online] Available from: http://www.esrc.ac.uk/_images/Research_Data_Policy_2010_tcm8-4595.pdf [Accessed 21st November 2011].

FGDC (2010), Geospatial Metadata Tools – Federal Geographic Data Committee. [online] Available from: http://www.fgdc.gov/metadata/geospatial-metadata-tools [Accessed 24th March 2010].

FP7 (2011), Research Data Management – European Commission – FP7 [online] Available from: http://www.admin.ox.ac.uk/rdm/managedata/funderpolicy/ec/ [Accessed 21st November 2011].

Goodchild, M. F., (2002), "Introduction to Part I: Theoretical models for uncertain GIS", in W. Shi, P.F. Fisher, and M.F. Goodchild, editors, *Spatial Data Quality*. New York: Taylor and Francis, pp. 1–4. [367].

Goodchild, M. F. (2007), "Beyond Metadata: Towards User-Centric Description of Data Quality", Paper read at Proceedings, Spatial Data Quality 2007 International Symposium on Spatial Data Quality, June 13-15, at Enschede, Netherlands.

Goodchild, M. F., (2007b). Citizens as sensors: the world of volunteered geography. *GeoJournal* 69: 211–21.

Haklay, M., Singleton, A.D., and Parker, C., (2008), "Web mapping 2.0: the Neogeography of the Geospatial Internet", *Geography Compass*, (3).

Haklay, M., and Weber, P., (2008), "OpenStreetMap – User Generated Street Map", *IEEE Pervasive Computing.* October-December 2008, pp. 12-18.

INSPIRE (2011a), About Inspire [online] Available from: http://inspire.jrc.ec.europa.eu/index.cfm/pageid/48 [Accessed 23rd March 2011].

INSPIRE (2011b). INSPIRE Metadata Implementing Rules: Technical Guidelines based on EN ISO 19115 and EN ISO 19119 [online] Available from: http://inspire.jrc.ec.europa.eu/documents/Metadata/INSPIRE_MD_IR_and_ISO_v1_2_20100616.pdf, [Accessed 23rd March 2011].

JISC (2011), JISC Geospatial Working Group – Terms of Reference [online] Available from: http://www.jisc.ac.uk/aboutus/howjiscworks/committees/workinggroups/geospatial.aspx [Accessed 21st November 2011].

JISC (2011b), JISC Digital Infrastructure Team - Grant Funding Call [online] Available from: http://infteam.jiscinvolve.org/wp/2010/09/10/jisc-grant-funding-call/ [Accessed 21st November 2011].

Kalantari, M., Olfat, H., Rajabifard, A., (2010), Automatic spatial metadata enrichment: reducing metadata creation burden through spatial folksonomies, in GSDI 12 World Conference: Realising Spatially Enabled Societies, Singapore.

Kim, T., (1999), Metadata for geo-spatial data sharing: a comparative analysis, The Annals of Regional Science 33: 171-181.

Koukoletsos, T., Haklay, M., and Ellul, C., (2011), An automated method to assess Data Completeness and Positional Accuracy of OpenStreetMap in Proceedings of the GIS Research UK 19th Annual Conference GISRUK 2011, University of Portsmouth, Portsmouth.

Longley, P.A., Goodchild, M.F., Maguire, D.J., and Rhind, D.W., (2011), Geographical Information Systems and Science, Third Edition, Hoboken, NJ, Wiley.

Manso-Callejo, M.A., Wachowicz, M., and Bernabé-Poveda, A., (2009), Automatic Metadata Creation for Supporting Interoperability Levels of Spatial Data Infrastructures, in GSDI 11 World Conference: Spatial Data Infrastructure Convergence: Building SDI Bridges to Address Global Challenges, Rotterdam, The Netherlands, June 15-19, 2009.

Moellering, H., (2005), *World Spatial Metadata Standards*, Elsevier, Oxford.

Olfat, H., Rajabifard, A., and Kalantari, M., (2010), Automatic Spatial Metadata Update: A new approach in Proceedings of the FIG Congress, Sydney.

Pasca, M., Petriglia, L., Mattioni, F., Torchio,M., and Mariotti, C., (2009), Experiences in the Creation and Updating of INSPIRE Compliant Metadata Catalogue, GSDI11 World Conference: Spatial Data Infrastructure Convergence: Building SDI bridges to address global challenges, Rotterdam, The Netherlands, June 15-19, 2009.

Poore, B., and Wolf, E., (2010), The Metadata Crisis – Can geographic information be made more usable? U.S. Geological Survey Proceedings of the Second Workshop on Usability of Geographic Information, London, March 23, 2010. Available from: http://www.virart.nottingham.ac.uk/GI%20Usability/Workshop%20papers% 20pdfs/ [Accessed March 1, 2011].

Rajabifard, A., Kalantari,M., and Binns,A., (2009), SDI and Metadata Entry and Updating Tools" in B. van Loenen, J.W.J. Besemer and J.A. Zevenbergen (Eds.) SDI convergence: Research, Emerging Trends and Critical Assessment, Netherlands Geodetic Commission, Delft.

Sboui, T., Salehi, M., and Bédard,Y., (2009), Towards a Quantitative Evaluation of Geospatial Metadata Quality in the Context of Semantic Interoperability, 6th International Symposium on Spatial Data Quality, St. John's, Newfoundland, Canada, July 6-8, 2009.

Schuurman, N., (2009), The new Brave New World: geography, GIS, and the emergence of ubiquitous mapping and data, *Environment* and Planning D: Society and Space, 27: 571-580.

Servigne, S., Lesage, N., and Libourel, T., (2006), Quality Components, Standards and Metadata, in Devillers R. and Jeansoulin R., editors, Fundamentals of Spatial Data Quality, pp179-208. Fundamentals of Spatial Data Quality, 179-208.

Sboui, T., Salehi, M., and Bedard, Y., (2009), Towards a Quantitative Evaluation of Geospatial Metadata Quality in the Context of Semantic Interoperability, Proceedings of the 6th International Symposium on Spatial Data Quality.

SECOA (2011a), SECOA Project Description [online] Available from: http://projectsecoa.eu/ [Accessed 23 March 2011].

SECOA (2011b), SECOA Case Studies [online] Available from: http://projectsecoa.eu/index.php?option=com_content&view=article&id=5 0&Itemid=73 [Accessed 23 March 2011].

van Oort, P., (2005), Spatial Data Quality: From Description to Application, PhD thesis, Wageningen University, The Netherlands.

Walker, R., (2009), UK GEMINI Standard - A UK Metadata Standard for discovery of geographic data resources, Association for Geographic Information.

West, L. and Hess,T., (2002), Metadata as a knowledge management tool: supporting intelligent agent and end user access to spatial data, Decision Support Systems, 32: 247-264.

PART TWO

CONNECTING GOVERNMENT, INDUSTRY AND CITIZENS

Spatially Enablement of NRM Communities through Spatial Knowledge and Information Network Development

Dev Raj Paudyal, Kevin McDougall and Armando Apan

Faculty of Engineering and Surveying
Australian Centre for Sustainable Catchments
University of Southern Queensland, Australia

paudyal@usq.edu.au; mcdougak@usq.edu.au; apana@usq.edu.au

Abstract

A spatially enabled society (SES) is an emerging concept to make spatial information accessible and available for the benefit of society. It is a concept where location, place and other spatial information are available to government, community and citizens. This is an important extension to the generational development and progression of Spatial Data Infrastructure (SDI) as it seeks to contribute to wider societal benefits and sustainable development objectives. This research paper investigates the social dimension of SDI and the theoretical foundation for spatially enablement of catchment communities. Two social science theories, namely, actor network theory (ANT) and social network theory are utilized to better understand the relationships in spatial information sharing and knowledge sharing across catchments. A network perspective of SDI was explored through a case study of the Queensland Knowledge and Information Network (KIN) project. Spatial information sharing processes among regional Natural Resource Management (NRM) bodies were analyzed using an object oriented modelling technique to assess the impact on catchment management outcomes. The relationships among the knowledge network stakeholders and the influence of these relationships to spatial information and knowledge sharing was analyzed using social network analysis. The findings from this study suggest that a network perspective of SDI assists in understanding the spatial information management issues of catchment management and the broader goal of spatially enablement of society.

KEYWORDS: Spatial data infrastructure, spatial information sharing, catchment management, spatially enabled society, social network analysis

1. Introduct

Spatial data infrastructure (SDI) and spatial technologies are now used routinely in decision making to address some of the world's most pressing societal problems. SDI is now recognized by many countries as an essential modern infrastructure such as information communication technology (ICT), electricity or transportation (Ryttersgaard, 2001; Williamson *et al.,* 2003). SDI application areas and custodianship of spatial information are changing with the emerging technologies and the societal needs. However, the overall objective of SDIs is it's economic, social, and environmental benefits to society with the emerging application areas now also becoming part of the solution (Masser, 2011). The creation of economic wealth, social stability and environmental protection can be facilitated through the development of products and services based on spatial information collected by all levels of society including governments, private sector and citizens (Rajabifard *et al.,* 2010). These objectives can be realized through the development of a spatially enabled community, government and society.

Spatial enablement requires data and services to be accessible and accurate, well-maintained and sufficiently reliable for use by the majority of society which may not be spatially aware (Williamson *et al.,* 2010). Traditionally, the mapping and spatial data infrastructure development was accomplished by government agencies, particularly national/state mapping agencies. However, this is now not the case, with all sectors of society increasingly becoming spatially enabled and contributing to the development of SDI. The readily accessible and available spatial products such as Google Earth, hand-held navigation systems (Including smart phones, GPS, etc.), web 2.0 technology, and social media has opened the way for spatial data collection and management and is contributing towards the next generation of SDI development and a spatially enabled society.

Within the SDI community there are differences in the understanding of SDI and its potential benefits (Grus *et al.,* 2007). Current progress of SDI initiatives shows that SDI is viewed, defined and interpreted differently by different practitioners. However, SDI has a common intent; to create an environment in which all stakeholders can cooperate with each other and interact with technology to better achieve their objectives at different political/administrative levels (Rajabifard *et al.,* 2003). SDI is about the facilitation and coordination of the exchange and sharing of spatial data between stakeholders in the spatial data community. Traditionally, SDIs were considered in a hierarchical context in which high levels of SDI (global, regional, national) built upon lower levels (regional, local) (Rajabifard *et al.,* 2003). The concept came with the top-down government approach where the custodians of spatial data were the mapping agencies which led the building of SDI. Now, the concept of more open and inclusive SDIs is emerging, where users play a vital role in spatial information

management and SDI development (Budhathoki *et al.,* 2008; Paudyal *et al.,* 2009). The custodianship of spatial data is also no longer totally controlled by mapping agencies.

The hierarchical concept of SDI is now also being challenged and may not be an appropriate model where all sectors of society are contributing for SDI design and development. The social network analysis by Omran and Van Etten (2007) revealed that a hierarchical structure could put serious constraints on spatial data sharing where providers and users are contributing for SDI development. Another approach is to view and examine SDIs from a network perspective. SDI practitioners (Crompvoets *et al.,* 2010; Omran, 2007; van Oort *et al.,* 2010; Vancauwenberghe *et al.,* 2009; Vancauwenberghe *et al.,* 2011) have examined SDI from network perspectives. Table 1 summarizes the main contributors of network perspective of SDI and their findings.

Contributors	Study focus	Strength	Limitations
Omran and van Etten (2007)	Examined motivations for spatial data sharing from network topology perspectives	The collective properties of spatial data sharing in organizations was investigated using social network analysis	Complex interactions that exist between information type, network structure, and individual behaviour, were not explored
van Oort *et al*. (2010)	Examined how the network can be used for sharing of metadata, requests for help, feedback on product quality, innovative ideas, and so on	The findings contributed to methodological research on monitoring SDI programmes	Only three categories of linkages between users were studied
Vancauwen-berghe *et al.* (2011)	Investigated SDI as the collection of arrangements that give shape to a network of spatial data exchanges	Social network analysis was used to explore hierarchical characteristics of the Flemish SDI	Study was only focused on four types of spatial data exchanges in formal arrangements

Table 1. Main contributors of network perspective of SDI

Onsrud (2011) defined SDI as a network-based solution to provide easy, consistent, and effective access to geographic information and services to improve decision making in the real world in which we live and interact. However, the principal objective of SDI has not changed. It is to facilitate access to the geographic information assets that are held by a wide range of stakeholders with a view to maximising their overall usage (Masser, 2011). Existing studies on network perspective of SDI have focussed on the spatially enablement of government agencies have only partially explored the user's perspective. However, this research examines the spatially

enablement of catchment communities with a particular emphasis on the user's perespectives.

The aim of this chapter is to explore the social dimension of spatial data infrastructure and its theoretical foundation from a network perspective in a catchment management context. This concept is examined through a case study of the Queensland Knowledge and Information Network (KIN) project. Two research approaches, namely, business process analysis and social network analysis are utilized to explore the spatially enablement of catchment communities and examine catchment SDI through these network perspectives.

2. Theoretical Framework: Social Science Theories

There are many social theories which can contribute to spatial data infrastructure design and development including actor-network theory (Harvey, 2001); the theory of planned behaviour (Wehn de Montalvo, 2003); social learning process (Rodriguez-Pabon, 2005) as cited in (Masser, 2011) and social network theory (Vancauwenberghe *et al.,* 2011). In the following sections, two social theories relevant to the network perspective of SDI development and useful to contributing to spatially enabled society are explored.

2.1 ANT and SDI Networking

Actor-network theory (ANT) is a social theory, also known as the sociology of translation, which emerged during the mid-1980s, primarily with the work of Bruno Latour (1987), Michel Callon (1986), and John Law (1992). ANT is a conceptual framework for investigating society-technology interactions and its primary building blocks which are interactions between actors. It considers the whole world as patterned networks of heterogeneous entities containing both human and non-human elements. Harvey (2001) defined actor networks as "the traces of relationships between people, institutions, and artefacts connected by agreements and exchanges". Shi (2008) has used ANT for analysing and understanding the social and technical nature of the watershed management process and decision tools.

The relevance of ANT theory for SDI development and GIS projects has been explored by a number of authors (Crompvoets *et al.,* 2010; De Man, 2006; Harvey, 2000; Harvey, 2001; Reeve and Petch, 1999). Reeve and Petch (1999) argue that the success of GIS projects depends upon the consideration of socio-organizational contexts i.e. actor-network theory. Harvey (2001) puts the actor-network of the professional GIS-user at the centre of the technology proliferation process. His approach incorporates all network activities, including the technological ones. Based on research in Switzerland, he asserts that actor networks and technology (GIS technology in this case) affect one another. Data exchange stimulates the emergence of effective inter-organizational de facto standards and assists in maintaining actor networks, while prescribed standards do not work and will consequently not have an impact.

De Man (2006) argues that the process of developing networked assemblies is viewed by ANT as interplay between heterogeneous actors-technological and social elements tied together in actor-networks. The actor-network perspective views SDIs as resulting from continuous 'translations' between heterogeneous actors and, hence, as potentially unstable. Alliances may be locked into collaboration but generally only temporarily. He concludes that the actor-network perspective identifies the dilemma of how to navigate between the need for authority and some form of central control, and active involvement (participation) in developing SDI initiatives. Crompvoets (2010) argued that spatial data infrastructure is a complex actor-network and the value of spatial data can be added through complex value added network processes. Their value is added through the translations between the different actors. Therefore, the value of spatial data can be assessed realistically only when the interests, beliefs and values of the individual actors are taken into account. This theory can be useful for spatially enablement of community, government and society.

2.2 Social Network Theory and VGI

The social network theory is a social science concept that discusses the connection and relationship in a social structure (Kadushin, 2004). According to Brass (1992), a social network is a set of nodes or actors that are connected by a set of social relationships. It views social relationships in terms of nodes and ties. Nodes are the individual actors within the networks, and ties are the relationships between the actors. The actors can be all types of social entities, for example, individuals, groups, organizations, or nation-states (Wasserman and Faust, 2008). The outputs from social network analysis can be presented in a graphical or mathematical way (Keast and Brown, 2005). Graphical analyzes concern the map of all of the relevant ties between the nodes and are often displayed in a social network diagram, where nodes are the points and ties are the lines. Mathematical analyzes involve advanced calculations (measure of centrality and density of network or actors) and statistical analysis of the data.

Social network theory is being increasingly utilized for spatial data sharing and SDI related research. Omran (2007) used social network theory and social network analysis to explain spatial data sharing (SDS) behaviour. He used social network analysis to map organizational networks and to determine the actual SDS behaviour. His study was directed at understanding motivations for data sharing and how this was related to network topology. Van Oort *et al.* (2010) utilized social network analysis to study spatial data sharing across organizational boundaries. This study was focused on how the network can be used for the purpose of sharing of metadata, requests for help, feedback on product quality, innovative ideas, and so on. Vancauwenberghe *et al.* (2011) argued that SDI can be viewed from network perspective and social network analysis can be used as a method for SDI research. The case consisted of a sub-national SDI in Flanders and used social network analysis to analyze Flemish spatial data exchange network.

A number of authors (Coleman, 2010; Elwood, 2008b; Goodchild, 2007, 2008; Kuhn 2007; McDougall, 2010) have begun to explore the application of social networking theory to volunteered geographical information (VGI) and spatial information sharing. The term VGI was first used by Michael Goodchild to describe the diverse practices of observing, collecting and producing geographic information by citizens with no formal expertise in the area (Goodchild, 2007). The first research specialist meeting on VGI was organized under the auspices of NCGIA, Los Alamos National Laboratory, the Army Research Office and The Vespucci Initiative and brought researchers around the globe to discuss potential of VGI for spatial information management. Coleman (2010) explored how the concept of VGI fitted within SDI. The utilization of VGI for spatial information collection and updating is now widely used by OpenStreetMap, TeleAtlas, NAVTEQ and Google Maps. Government organizations have now also realized the power of VGI and crowd sourcing and are interested in utilising these technologies for SDI development. The U.S. Geological Survey was an early examiner of this technology. State governments in Victoria (Australia) and North-Rhine Westphalia (Germany) are two exemples of employing volunteered input to their mapping programs in the government sector (Coleman, 2010).

Table 2 summarizes the characteristics, strengths, and limitations of these two social theories and their possible contribution to spatially enabled society.

Social Theory	Characteristics	Strengths	Limitations	Value for spatial enabled society
Actor network theory (ANT)	Investigates society-technology interactions	Understanding of the social and technical nature of SDI	Views SDIs as resulting from continuous translations between actors	Useful for spatial enablement development
Social Network Theory	Discusses the connection and relationship in a social structure	Views the network perspectives of SDI	More social bias and sometimes delayed the implementation	Useful for VGI and spatial information sharing

Table 2. Social science theories and their contribution to spatial enabled society

2.3 Social Network Analysis

Social Network Analysis (SNA) is a research methodology that focuses on identification of relationships between and among social entities, and on the patterns and implications of these relationships (Scott, 2000). It is often applied to understand network structures and identify operational efficiencies. There is a body of literature on quantitative methods in social network analysis (Hanneman and Riddle, 2005; Wasserman and Faust, 2008).

Social networks relations can be analyzed for structural patterns that emerge among actors. Thus, an analyst of social networks looks beyond attributes of individuals to also examine the relations among actors, how actors are positioned within a network, and how relations are structured into overall network patterns (Scott, 2000; Wasserman and Faust, 1994). The ties are based on conversation, affection, friendship, kinship, authority, economic exchange, information exchange, or anything else that forms the basis of a relationship. In a network, flows between objects and actors and exchanges, which might contain an advice, information, friendship, career or emotional support, motivation, and cooperation, can lead to very important ties (Kadushin, 2004).

There are various types of relationships which exist as suggested by Knoke and Kuklinski (1982) including communication relations, boundary penetration relations, instrumental relations, sentiment relations, authority/power relations, kinship and descent relations. In social network analysis, a number of measures have been defined to quantify and classify these relationships. Terms such as centrality, closeness, betweenness and degreeness have been developed to better describe these relationships (Freeman, 1979). These measures can assist in defining where an actor sits within a network, where weak links exist or understanding the level of trust that may be associated with a particular actor. These measures may be used to determine if a user will share or diffuse their information or be willing to grant access to their information (McDougall, 2010). The concept of centrality is widely used in the resource management (Bodin *et al.,* 2006) and network analysis (Vandenbroucke *et al.,* 2009).

3. Methods

In this paper, two analysis techniques have been utilized. First, business process analysis using object-oriented modelling techniques was undertaken on the information sharing process within the knowledge network study. Secondly, social network analysis was used to analyze the network perspectives of various actors within the management of catchment spatial data infrastructure.

3.1 Study Area Description and Institutional Arrangement

The case study location of the Knowledge and Information Network (KIN) project is the State of Queensland, Australia (Figure 1). Queensland has 14 regional natural resource management (NRM) bodies spread from the far-northern region of Torres Strait to the New South Wales (NSW) border at southern end. These groups develop regional NRM plans and deliver sustainable catchment outcomes at grass-roots level.
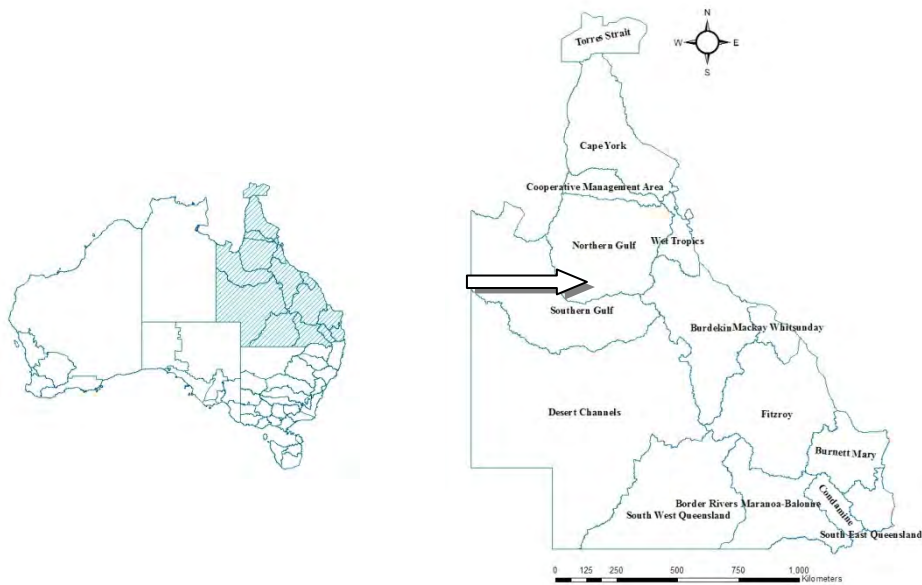
Figure 1. Location Map of KIN Project Areas

The Queensland Regional Groups Collective (RGC) is the lead body for regional NRM bodies in Queensland and represents the interests with the 14 regional natural resource management (NRM) bodies in the state. It is quite a young organization formed in 2002 and is dedicated to improving statewide NRM outcomes. The overall aim of the KIN project was to understand how regional NRM knowledge and spatial information can be better shared across Queensland. The funding for this project was supported by both commonwealth and state governments. The main stakeholders of KIN project were RGC, regional NRM bodies and Department of Environment and Resource Management (DERM) as shown in Figure 2. The project was managed by RGC and four knowledge coordinators. DERM was the state agency responsible for funding support and overall coordination. Apart from these organizations/professionals, there were about 300 landcare groups which were not directly involved in KIN project, however regional NRM bodies also shared spatial information with these groups. The landcare groups often create spatial data for their own use by utilising both government data (authoritative data) and freely accessible spatial products (e.g. Google Map) for grass-root level catchment management activities.
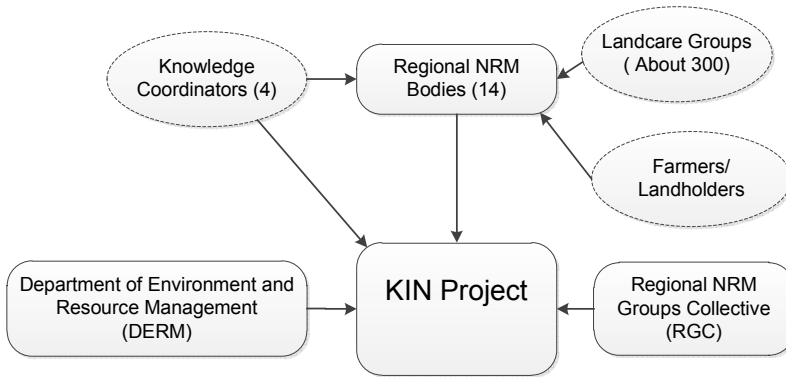
Figure 2. Institutional Settings

3.2 Business Process Analysis of the Spatial Information Sharing in the KIN Project

Both primary as well as secondary data were collected in order to investigate spatial information sharing between regional NRM bodies and state government organization (DERM). Existing project documents/reports, data share agreements and published papers were collected and studied to understand the current spatial information sharing processes. Semi-structured interviews were conducted with all 14 regional NRM bodies, state government representatives and RGC staff. Both telephone and face-to-face interviews were conducted. The staff involved in KIN project who were experienced in spatial and knowledge management activities were interviewed.

The unified modelling language (UML) which is based on the object oriented (OO) concept and standardized by the object management group (OMG) was used to understand the spatial information sharing process. The unified modelling language (UML) is a modelling tool for specifying, visualizing, constructing, and documenting the artefacts of a system-intensive process (Radwan *et al.* 2001). An UML use-case diagram was used to explore and demonstrate the spatial information sharing process. Basically, the use-case identifies the actors and activities which consist of three elements: the actors, use-cases and the system boundaries. In UML, the relationships between actors and use-cases can be shown using the concepts such as generalization, 'uses' and 'extents'. Six main actors and nine use-cases were identified for spatial information sharing process and the use-case analysis of spatial information sharing.

The characteristics and business process analysis of the spatial information sharing in the KIN project is presented in section 4.1.

3.3 Social Network Analysis of KIN Project

The primary reason for undertaking the social network analysis was to measure the variety of relationships between KIN project stakeholders. The targeted population for

this network analysis was 18 stakeholders consisting of six categories of organizations/professionals including DERM, RGC, regional NRM bodies, landcare groups, landholders/farmers, and knowledge coordinators. An online questionnaire was constructed and questions were framed in order to specifically target and measure responses regarding other stakeholders. The questionnaires were distributed to a non-random and purposive sample of representatives from regional NRM bodies, DERM and RGC. Three questions were asked to quantify the frequency of interaction, exchange of spatial information, and role of organization to achieve KIN goal.

Data were analyzed using UCINET 6 and NetDraw 2.11 programmes. Initially the data was analyzed using the UCINET programme and visualized through NetDraw programme. The value of InDegree centrality was used to measure the relationships between project participants. Three variables which were used for this analysis were frequency of interaction, rate of flow of spatial information and role of organization (see Table 3).

Level of Analysis	Measure	Relationship	Variable used
Network Analysis	InDegree Centrality	Communication relationship	Frequency of Interaction
	InDegree Centrality	Transactional relationship	Rate of flow of spatial information
	InDegree Centrality	Authority-power relationships	Role of organization

Table 3. Measures, relationship and variables used for social network analysis

The organizations were differentiated by different node shapes and node position, node size and line width was used to show the interaction between organizations in the network analysis. The results from social network analysis of KIN project is described in section 4.2

4. Results

4.1 Characteristics and Business Process Analysis of the Spatial Information Sharing in the KIN Project

Prior to the KIN project, the NRM data hub scoping project was conducted for Queensland's NRM science panel to identify the characteristics of data sharing between regional NRM bodies and state government organizations (Jones and Norman, 2008). These characteristics were also confirmed during the interview process. It was confirmed that the key characteristics of spatial information sharing with respect to NRM community were:

- **Current data sharing is not an organizational priority**: In the current NRM business environment, it was not in the interest of individual organizations to share data and information, even though it was in the collective interest.

- **Sharing led by dedicated sections**: Data sharing was mostly led by organizations with dedicated sections funded and resourced to share information.

- **Lack of metadata**: People do not know what information and data exists including within their own organization. Significant amounts of unpublished or uncatalogued spatial data exist with regional NRM bodies.

- **Willing to share but lack of trust**: People were willing to share data/information when asked, but didn't promote the fact that they have information available. They fear that if they put landholder's information in the public domain that it might be misused.

- **Data sharing through personal contact**: Where sharing occurred it was done on a person-to-person and immediate need basis. Much sharing was conducted via personal contacts rather than organizational processes.

- **Institutional issues are more complex than technical ones**: Many IT solutions have been developed to solve data sharing problems; however, most have not demonstrated long-term success or realized their potential. These normally require or assume that people will willingly format and package data sets for sharing with others, and then maintain those data or information sets in a suitable format.

- **No incentive for sharing**: The cost of data sharing is being rationally avoided by publishers of information.

- **Data sharing benefits are known:** The benefits of data sharing and its reduction of costs are desired by all NRM organizations.

The spatial information sharing characteristics demonstrated that the main concerns were related to the institutional and cultural areas of data sharing and not the technical areas such as the actual data hub portal. The study identified the importance of improving the institutional and cultural part of the data sharing mechanism. The KIN project was initiated to improve access and sharing of NRM information between regional NRM bodies and DERM. A single licensing agreement was made between RGC and DERM which covered the interest of all 14 regional NRM bodies. A framework was endorsed by RGC and the project is in the implementation phase. Six main actors and nine use-cases were identified for spatial information sharing process and spatially enablement of catchment communities via the modelling using object oriented use-

case process. As shown in Figure 3, six actors are interacting with nine use-cases in a system whose system boundary is defined by the 'Spatial Information Sharing Process'.
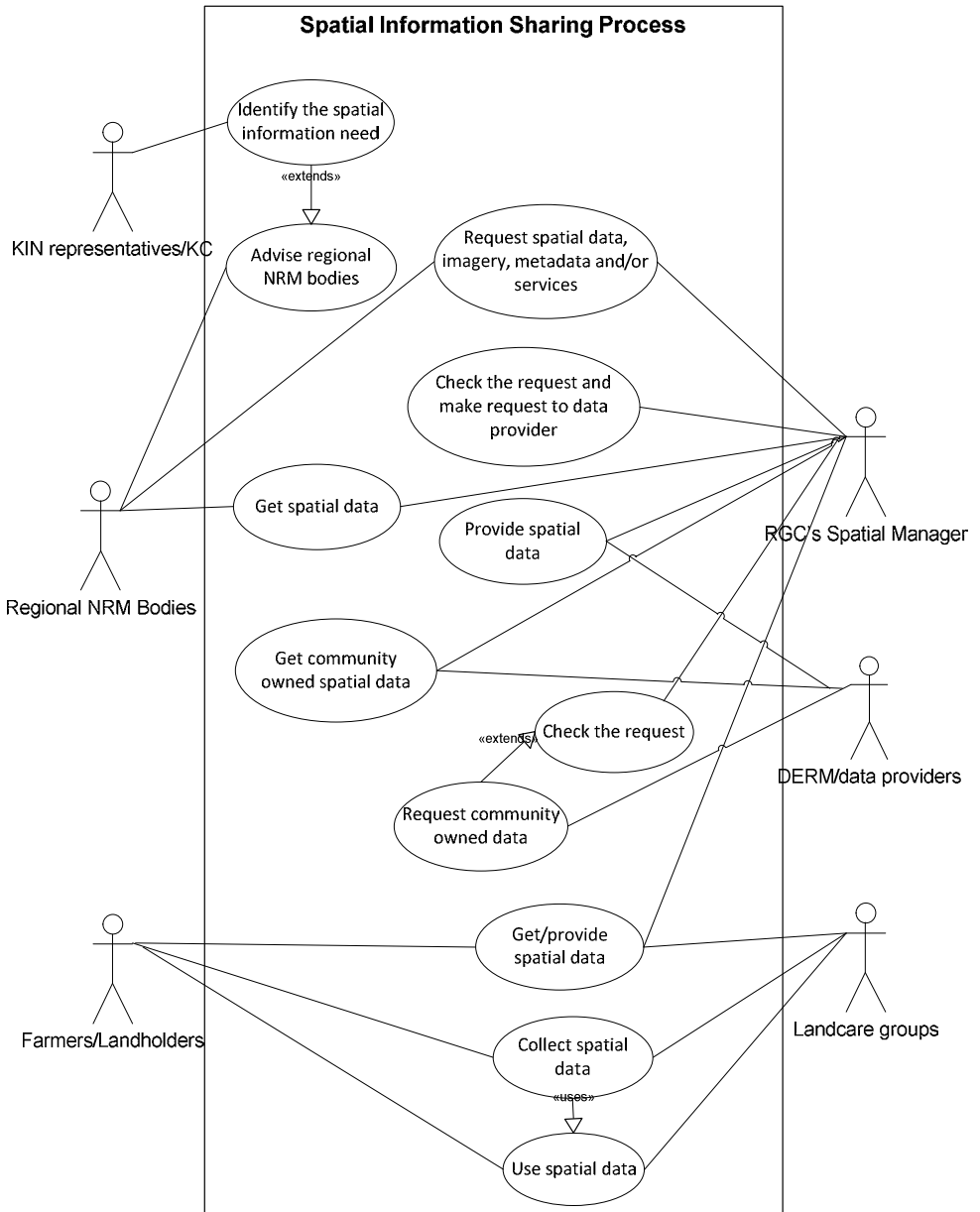
Figure 3. Use-case diagram of spatial information sharing process

The six main actors and spatial information sharing process include:

- **KIN representative/knowledge coordinators**: The KIN representative or knowledge coordinators (KC) identify the spatial information needs for catchment management and advise regional NRM bodies to make requests for the particular spatial information.

- **Regional NRM Bodies:** Regional NRM Bodies request spatial information, imagery, metadata and/or any spatial information services to RGC's spatial manager.

- **Spatial Manager (RGC):** RGC's spatial manager checks the request from regional NRM bodies and makes requests to a spatial information provider. They know how and who to approach to access and obtain spatial information.

- **DERM/Spatial Information Provider:** DERM provides spatial information to the RGC's spatial manager. If DERM or other government agencies need community owned spatial data, they request the data through RGC's spatial manager.

- **Farmers/Landholders:** Farmers/landholders receive spatial information through RGC's spatial manager. They also collect large scale spatial information and provide this to regional NRM bodies through RGC's spatial manager. RGC's spatial manager checks the request and facilitates the access of community owned spatial information to government agencies and other external bodies.

- **Landcare groups:** Landcare groups also receive spatial information through RGC's spatial manager from spatial information providers. They also collect large scale spatial information and make this data available to regional NRM bodies through the RGC's spatial manager. The RGC spatial manager makes this community owned spatial information available to government agencies and other external bodies.

4.2 Results from Social Network Analysis of KIN Project

4.2.1 Frequency of interaction

The frequency of interaction was used to measure communication relationship between catchment communities and state government organization. The value of InDegree Centrality was used as a measure.
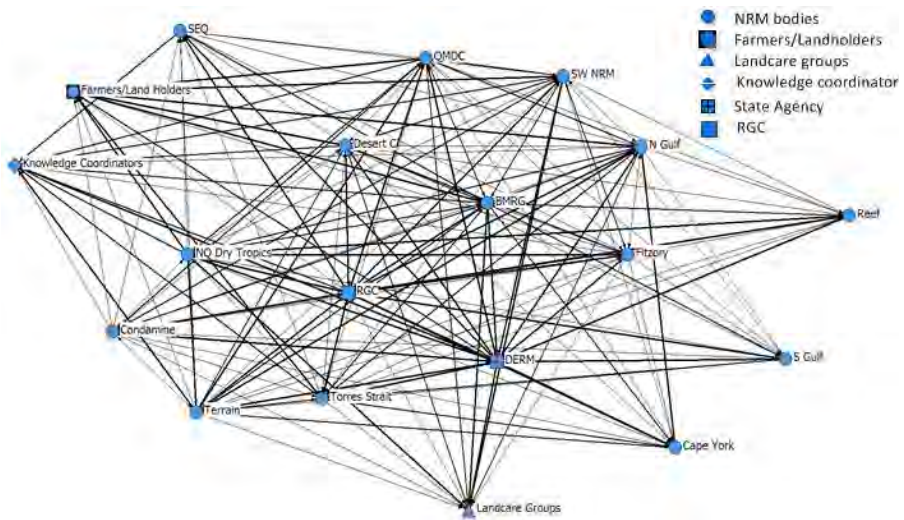
Figure 4. Frequency of interaction

Figure 4 shows the frequency of interaction between regional NRM bodies and
other organizations. Six types of organizations were directly or indirectly
contributing to the KIN project. The different shape node represents the
organization type. The thickness of lines and node size depict the frequency of
communication. The network position shows the importance of each organization
with respect to the communication.

It was observed that regional NRM bodies had the most frequent interactions with
farmers/land holders and landcare groups though these groups were not directly
involved in the KIN project. Regional NRM bodies also had frequent
communication with knowledge co-ordinators, RGC, and DERM. RGC appeared at
the centre of the network with a high InDegree centrality value in communication
and could be viewed as a good mediator in the process of spatial information
sharing. There was little communication between DERM and landcare
groups/farmers. The communication between regional NRM bodies also varied.
There were greater levels of communication among adjacent regional NRM bodies
compared to geographically distant bodies. However, it was found that if groups
had common environmental concerns (common interest) and good professional
relationships they had more communication. Further, the regional NRM groups
had more communication with external organizations (DERM, landcare groups,
etc.) in comparison to internal regional NRM bodies). RGC and DERM both appear
at the centre of the network which shows their importance to maintaining
communication relationships.

4.2.2 Flow of spatial information

The value of InDegree centrality was used to measure the flow of spatial information between organizations. The amount of flow of spatial information was used as a unit to measure transactional relationships between organizations.
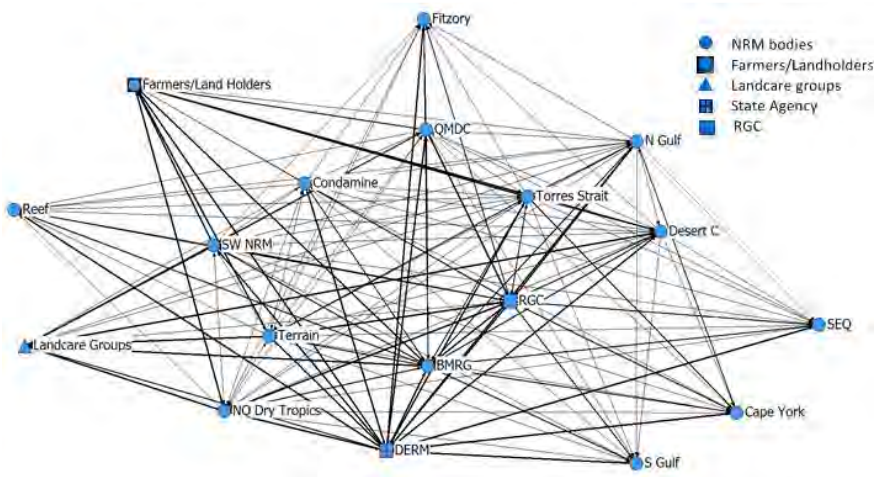
Figure 5. Flow of spatial information

Figure 5 shows the amount of flow of spatial information and spatial information exchange between regional NRM bodies and other organizations. There are five different categories of organizations involved in spatial information sharing and the organizations are differentiated by different node shapes. As discussed earlier, there were both spatial information providers and users in the network and they had varying capacities for spatial information collection and management. NRM bodies provide spatial information to community groups such as Landcare groups and farmers/land holders. The community owned spatial information is also provided to government (namely DERM). RGC is at the centre of the network so again it could be perceived that RGC is a key mediator and facilitator of the spatial information sharing process. Further, it was found the amount of flow of spatial information with adjacent regional NRM bodies is higher than those that are more distant.

4.2.3 Role of organizations in achieving the KIN goal

The value of InDegree centrality was used to measure the role of organization in achieving the KIN goal. Participants were asked to rate the importance of the role of organizations/professionals in achieving the KIN goal.
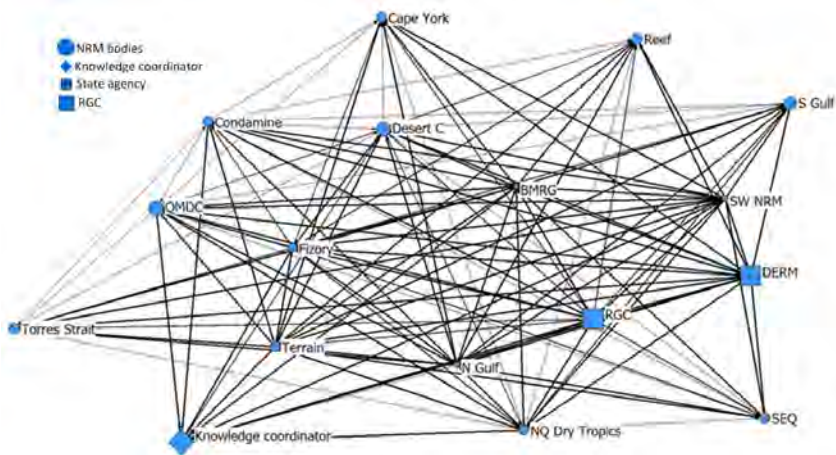
Figure 6. Role of organization in achieving the KIN goal

Figure 6 shows the role of organizations in achieving the KIN goal. The importance of the role is demonstrated by the size of the node. Three organizations are identified as having important roles in achieving the KIN goal. As RGC is at the centre of the network, it has the greatest role. Knowledge coordinators also have a very important role. The role of regional NRM bodies vary, however, RGC could be seen as having a coordination role in bringing all the regional NRM bodies together. This is a statewide project and DERM has provided the funding, so it has also an important role in the network. This network analysis demonstrated that intermediary organizations and professionals have very important roles in achieving the KIN's goal.

5. Discussion

Although technical solutions (spatial information portals) for spatial information access and sharing between regional NRM bodies and government agencies exist, the government led knowledge information network requires further development in order to be effective for catchment communities. The traditional concept of SDI has been conceived with government organizations as the primary custodians of spatial information. In this model, the catchment decisions rely on public sector data and regional NRM bodies are just the users of spatial information. Now, this concept has changed and the regional NRM bodies are also becoming spatially enabled and collecting a significant amount of large-scale spatial information which has social and environmental value. A recent national survey with 56 regional NRM bodies demonstrated that about 80% of regional NRM bodies were both spatial data providers and users. In Queensland, 13 out of 14 organizations identified themselves as both spatial information providers and users. This work also identified the main users of spatial information generated or value-added by regional NRM bodies were

the community organizations such as Landcare groups and landholders/farmers. Spatial technology and products like Google Earth, hand-held navigation systems, web 2.0 technologies, and social media are not only spatially enabling regional NRM bodies, but also empowering grass-root level communities and citizens.

Budhathoki *et al.* (2008) argue that it is increasingly difficult to differentiate data 'producers' and 'users' in an environment where many participants function in both capacities. The so-called users are now becoming more important and powerful for spatial data infrastructure design and development. The spatial information sharing between government agencies and natural resource management bodies is now also reflecting this trend. The significant amounts of unpublished or uncatalogued spatial data that exist with regional NRM bodies could be more effectively utilized as a resource for the sector. Additionally, the study found that regional NRM bodies are not willing to publicize their spatial information because they do not believe that it is a current organizational priority and will attract additional time and effort. However, most of the interviewees indicated that they were willing to share spatial information if they were asked. However, they were suspicious of government agencies and thought that their data may be misused.

Mostly, the sharing of spatial information occurs through a data sharing agreement or ad hoc process (informally) rather than organizational process. Some form of collaboration with respect to spatial information and knowledge sharing was desired by regional NRM bodies as a form of knowledge and information transfer. As with many similar organizational arrangements, the data sharing culture is not well practised among regional NRM bodies. The single licensed agreement between RGC and DERM was a useful process to facilitate the spatial information sharing. Although the RGC is a quite young organization, it has gained the trust of government organizations and community groups. It has also achieved a good level of co-ordination and promoted spatial knowledge and information sharing across the various catchments.

The social network analysis proved to be a useful tool to measure transactional relationships, communication relationships and authority-power relationships between project partners. Regional NRM bodies had their most frequent communication with farmers/land holders and land care groups, although these groups were not a formal part of KIN project. Regional NRM bodies also had frequent communication through knowledge coordinators, RGC, and DERM. With respect to spatial information exchange, the analysis indicated that RGC played an important role. There was also a positive two-way flow of spatial information between regional NRM bodies and the state government organizations. The analysis also highlighted the fact that NRM bodies generally work within their defined catchment boundaries so there was little need for sharing spatial information with other NRM bodies.

SDI practitioners (Budhathoki *et al.,* 2008; Elwood, 2008b; Goodchild, 2007) have recognized the power of user and grass-root citizens for the next generation of spatial data infrastructures and the spatial enablement of society. Elwood (2008a) illustrates

how these citizens and grass-root groups may also be generating spatial data that is useful to government officials. This research identified the role of regional NRM bodies and grass-root level community groups for spatially enablement through spatial knowledge and information sharing. Social network analysis and business process analysis demonstrated and qualified the spatial information sharing processes and relationship between stakeholders. It was also evident that there was an increasing utilization of web 2.0 technology and open source models for catchment SDI development activities. Volunteered contributions of spatial information prompted by environmental concerns will continue to grow.

6. Conclusions

This chapter has contributed to the current body of knowledge by exploring the social science theoretical framework for the next generation of SDI development particularly the network perspective of SDI. The two theories, namely, the actor network theory and social network theory were found useful in understanding or describing the spatial enablement of community and society. The case study on the spatial knowledge and information network project provided some insights into the spatial information sharing arrangements between catchment communities and the state government organization. The business process analysis of spatial information sharing revealed the role of some intermediary organizations/professionals such as the RGC and knowledge coordinators can assist or facilitate community spatial enablement and spatial information sharing.

The social network analysis was found to provide some useful measures to understand and visualize the various relationships including the communication relationship (frequency of interaction), transactional relationship (spatial information exchange), and authority-power relationships (role of organization) in collaboration and networking. It was clear there is growing utilization of open models and social media for spatial information management and knowledge sharing at the community level. Spatial knowledge sharing is also emerging as an important process for achieving better catchment outcomes and SDI will be a critical underlying infrastructure. There is no doubt that spatial knowledge and information network development can contribute towards spatially enablement of catchment communities. The findings from this study suggest that the network perspective of SDI is useful to understanding the spatial information management issues for NRM bodies and to achieve the broader goal of spatially enabled society (SES).

References

Bodin, O., Crona, B., and Ernstson, H., (2006), WHAT you know is WHO you know? Communication patterns Ecology and Society Ecology and Society 11(2).

Brass, D.J. (1992), Power in Organization: A Social Network Perspective" in G Moore and JA Whitt (Eds) *Research in Politics and Society,* JAI Press, Greenwich, 295-323.

Budhathoki, N., Bruce B., and Nedovic-Budic, Z., (2008), Reconceptualizing the role of the user of spatial data infrastructure, GeoJournal 72(3): 149-60.

Callon, M., (1986), Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay, in J Law (Ed) *I*n Power, Action, and Belief: A New Sociology of Knowledge?, London, Routledge & Kegan Paul.

Coleman, D.,(2010), Volunteered geographic information in spatial data infrastructure: An early look at opportunities and constraints, in A Rajabifard, J Crompvoets, M Kanantari and B Kok (Eds) Spatially Enabling Society: Research, Emerging Trends and Critical Assessment, Leuven University Press, Leuven, Belgium, Leuven.

Crompvoets, J., De Man, W.H.E. and Macharis, C., (2010), Value of Spatial Data: Networked Performance beyond Economic Rhetoric. International Journal of Spatial Data Infrastructures Research 5(96-119).

De Man, W.H.E., (2006),Understanding SDI : complexity and institutionalization. International journal of geographical information science (IJGIS) 20 (3): 329-43.

Elwood, S., (2008a), Grassroots groups as stakeholders in spatial data infrastructures: challenges and opportunities for local data development and sharing. International Journal of Geographical Information Science 22(1): 71-90.

Elwood, S., (2008b), Volunteered geographic information: key questions, concepts and methods to guide emerging research and practice, GeoJournal 72(3): 133-5.

Freeman, L.C., (1979), Centrality in social networks. Conceptual clarifications, Social Networks 1(3): 215-39.

Goodchild, M.F. (2007), Citizens as voluntary sensors: Spatial data infrastructures in the world of Web 2.0, International Journal of Spatial Data Infrastructure Research 2(24–32).

Goodchild, M.F. (2008), Commentary: whither VGI? *GeoJournal* 72(239–44).
Grus, L., J. Crompvoets and A. Bregt. 2007. Multi-view SDI Assessment Framework. International Journal of SDI Research 2(33-53).

Hanneman, R.A. and Riddle, M. (2005), Introduction to social network methods. University of California, Riverside, Riverside, CA.

Harvey, F., (2000),The social construction of geographic information systems. International Journal of GIS 14(8): 711-3.

Harvey, F.,(2001), Constructing GIS: Actor Networks of Collaboration. 4 October 2011, <http://www.urisa.org/files/HarveyVol13no1-3.pdf>.

Jones, A. and Norman, P. (2008), NRM Data Hub Scoping Project, Queenslands NRM Science Panel, Queensland.

Kadushin, C. (2004), Chapter 2: Some basic network concepts and propositions, Introduction to social network theory.

Keast, R. and Brown, K. ,(2005),The network approach to evaluation: Uncovering patterns, possibilities and pitfalls South Bank, Brisbane, 10-12 October 2005.

Knoke, D. and Kuklinski, J.H., (1982), Network Analysis. Sage Publications, Inc.

Kuhn, W., (2007), Volunteered Geographic Information and GIScience, Proceedings of Position Paper for the NCGIA and Vespucci Workshop on Volunteered Geographic Information, Santa Barbara, CA, December 13-14, 2007.

Latour, B., (1987), Science in Action: How to Follow Scientists and Engineers through Society. Harvard University Press, Cambridge, MA.

Law, J., (1992), Notes on the Theory of Actor-Network: Ordering, Strategy and Heterogeneity. Systems Practice 5:379–93.

Masser, I.,(2011), Emerging Frameworks in the Information Age: The Spatial Data Infrastructure Phenomenon, in TL Nyerges, H Couclelis and R McMaster (Eds) The SAGE handbook of GIS and society, SAGE, London.

McDougall, K.,(2010), From Silos to Networks – Will Users Drive Spatial Data Infrastructures in the Future?, Proceedings of FIG Congress 2010: Facing the Challenges – Building the Capacity, Sydney, Australia, 11-16 April 2010

Omran, E.E., (2007), Spatial Data Sharing: From Theory to Practice. Wageningen University.

Omran, E.E. and van Etten J.,(2007), Spatial Data Sharing: Applying social network analysis to study individual and collective behaviour. International Journal of Geographical Information Science 21(6): 699-714.

Onsrud, H.,(2011), Afterword in N-B Zorica, J Crompvoets and Y Georgiadou (Eds) Spatial Data Infrastructure in Context: North and South, Taylor & Francis, CRC Press, London.

Paudyal, D.R., McDougall, K. and Apan, A. (2009), Building SDI Bridges for Catchment Management, in B van Loenen, JWJ Besemer and JA Zevenbergen (Eds) Spatial Data Infrastructure Convergence: Research, Emerging Trends, and Critical Assessment, Netherland Geodetic Commission (NGC), Delft, The Netherlands, 265-79.

Radwan, M.M., Onchaga, R. and Morales, J., (2001), A Structural Approach to the Management and Optimization of Geoinformation Processes, European Organization for Experimental Photogrammetric Research (OEEPE).

Rajabifard, A., Feeney M.-E.F. and Williamson, I., (2003), Spatial Data Infrastructures: Concept, Nature and SDI Hierarchy, in I Williamson, A Rajabifard and M-EF Feeney (Eds) Developing Spatial Data Infrastructures: From Concept to Reality, Taylor & Francis, London, UK. 17-40.

Rajabifard, A., Crompvoets, J., Kalantari, M. and Kok B., (2010), Spatially Enabled Societies in A Rajabifard, J Crompvoets, M Kalantari and B Kok (Eds) Spatially Enabling Society Research, Emerging Trends and Critical Assessment, GSDI Association and Leuven University Press, Belgium, Leuven.

Reeve, D.E. and Petch, J.R.,(1999), GIS organizations and people: a socio-technical approach. Taylor and Francis, London,

Rodriguez-Pabon, O., (2005), Cadre theoretique pourl'evaluation des infrastructures d'information geospatiale Canada. Laval University.

Ryttersgaard, J.,(2001), Spatial Data Infrastructure-Developing Trends and Challenges, Proceedings of CODI-2, Addis Ababa, 4–7 September

Scott, J., (2000), Social Network Analysis: A handbook. Sage, London.

Shi, Y., (2008), Virtual organization based distributed environmetal decision support systems: Applications in watershed management. Michigan State University.

van Oort, P., Hazeu, G., Kramer, H., Bregt A., and Rip, F., (2010), Social networks in spatial data infrastructures. GeoJournal 75(1): 105-18.

Vancauwenberghe, G., Crompvoets, J., Bouckaert, G. and Vandenbroucke , D.,(2009), A network perspective on Spatial Data Infrastructures: SDI as support to e-government", Proceedings of GSDI11, Rotterdam, The Netherlands

Vancauwenberghe, G., Crompvoets, J., Bouckaert G., and Vandenbroucke D., (2011), Social Network Analysis of the SDI in Flanders in Z Nedovic-Budic, J Crompvoets and Y Georgiadou (Eds) Spatial Data Infrastructures in Context: North and South CRC Press, Taylor and Francis Group, Boca Raton, London, New York.

Vandenbroucke, D., Crompvoets, J. , Vancauwenberghe, G., Dessers, E. and Van Orshoven, J., (2009), A Network Perspective on Spatial Data Infrastructures: Application to the Sub-national SDI of Flanders (Belgium). Transactions in GIS 13(105-22).

Wasserman, S. and Faust, K., (1994), Social Network Analysis: Methods and Applications Cambridge University Press, Cambridge, England.

Wasserman, S. and Faust, K., (2008), Social Network Analysis: Methods and Applications Cambridge University Press, Cambridge, England.

Wehn de Montalvo, U., (2003), Mapping the determinants of spatial data sharing. Ashgate Publishing Ltd, Aldershot, England.

Williamson, I., Holland, P. and Rajabifard, A., (2010), Spatially Enabled Society, *P*roceedings of FIG Congress 2010, Facing the Challenges - Building the Capacity, Sydney, Australia, 11-16 April 2010

Williamson, I.P., Rajabifard, A. and Feeney, M.-E.F., (2003), Developing spatial data infrastructures: from concept to reality. Taylor & Francis, New York.

3D Land and Property Information System: A Multi-level Infrastructure for Sustainable Urbanization and a Spatially Enabled Society

Serene Ho and Abbas Rajabifard

Centre for SDIs and Land Administration, the University of Melbourne, Australia

s.ho11@pgrad.unimelb.edu.au, abbas.r@unimelb.edu.au

Abstract

Urbanization is an inevitable part of the economic development process for any country and is considered a global phenomenon (World Bank, 2009). Currently, 50 percent of the world's population resides in urban areas; by 2050, this ratio will reach 70 percent. This concentration of growth will place increasing pressure on land resources that are already in high demand. The achievement of sustainable development goals is therefore predicated on achieving sustainable urbanization. This paper considers the specific challenges of urbanization on land and property and the development of a three-dimensional (3D) land and property information system as a new tool for managing rights, restrictions and responsibilities as part of a modern land administration system.

This system aims to provide an infrastructure that allows for the integration of information pertaining to the built and natural environments using land and property as a common framework. By facilitating access, discovery, and sharing of land and property information, this system will provide a multi-level infrastructure to link government, industry and citizens to support the functions of a modern land administration system which provides the foundation for realising a spatially enabled society and achieving sustainable development.

KEYWORDS: 3D, land, property, information system, infrastructure, sustainable urbanization, spatially enabled society, modern land administration

1. Introduction

Urbanization is an inevitable part of the economic development process for any
country and is considered a global phenomenon (World Bank, 2009). However, it is
only in recent years that the rate of urbanization has begun to accelerate. The year
2007 is widely regarded to be a significant milestone in the history of urbanization,
heralding the first time more than half of the world's population resided in urban
areas. More recently in 2011, the world's population surpassed the seven billion mark.
Demographic growth itself is not actually the primary issue; it is where this growth is
occurring that is creating challenges for governments around the world. Of these
seven billion people, one in two currently live in cities; by 2050, despite little actual
increase in the rate of urbanization, this ratio is expected to increase to seven out of
ten, reflecting concentrated (and potentially unsustainable) growth in urban areas
(UNFPA, 2011; UN-HABITAT, 2010). Considering that the total area of towns and cities
make up just three percent of the earth's surface area, sustainable management and
development of land and property represents some of the most complex challenges
today. These challenges are found at all scales – local, national and regional – and
require a concerted and holistic approach if any measure of success is to be achieved.
This paper will firstly reflect on the broad challenges arising from urbanization and
examine its consequences in sustainably managing and developing land and property.
As land administration systems evolve, the changing roles of government, industry and
citizens are examined especially in the context of land and property information
production and use. Finally, the concept of a three-dimensional Land and Property
Information System (3D-LPIS) for managing rights, restrictions and responsibilities
(RRRs) in complex urban areas is discussed as a new land administration tool to
achieve sustainable urbanization using Australia as a case study. Although this paper is
based on current research into a 3D-LPIS which is only at a preliminary stage, it is
envisioned that by providing accurate and timely information about land and property
that relates people to activities, this system will be a foundation for realising a spatially
enabled society and a tool for delivering sustainable development.

2. The Inherent Challenges of Urbanization

There are many different definitions for the term urbanization due to jurisdictional
differences but it is largely acknowledged that urban areas provide a different and
typically higher standard of living than rural areas; therefore in simplistic terms,
urbanization is the process of people moving from rural to urban areas lured by the
attraction of agglomerating economies (World Bank, 2009; UNSTATS, 2011). The
incipient problems of higher densities of both economic activity and people exert
enormous pressure on land resources, already scarce in urban areas.

Urbanization causes severe environmental, social and economic challenges for
managing land resources. Common problems arising from urbanization stem largely
from the increasing population density – housing scarcity which often leads to

unplanned development and informal land markets, traffic congestion, pollution, decreased public safety, higher natural resource demands; and increased risk from natural disasters. These challenges although local in scale, often have far-reaching consequences. For example, 20 of the largest cities in the world collectively consume 80 percent of the world's energy resources, and urban areas collectively account for 80 percent of the world's total greenhouse gas emissions (FIG, 2010). These climate change effects contribute to more severe weather events, which ironically have higher impact on urban areas due to its higher population and infrastructure investment; this higher risk will be most keenly felt in the urbanising regions of developing and less developed countries (IPCC, 2007).

Pertaining to land and property, urbanization has led to instances of informal development – most visibly as slums, but often as illegal construction, resulting in the development of an informal land market (FIG, 2010). The slum settlements in Africa and India are common examples. At a broad level, the challenges caused by urbanization are complex and difficult to resolve, least of all because of the rapidity at which they occur. More often than not, institutional arrangements, policies and basic infrastructure cannot keep pace with development (World Bank, 2009). Of the institutional aspects, there is increasing recognition that governance and institutional reform is of primary importance in trying to achieve any measure of resolution (FIG, 2010; GSDRC, 2011). Additionally, these challenges are typically multi-faceted, thereby requiring a concerted effort to coordinate multi-disciplinary approaches to solutions.

Despite all its challenges, urbanization is in fact, a measure of economic health with the productivity of cities indicative of a country's overall economic well-being (UN-HABITAT, 2010). However, this implies that sustainable development is not possible without sustainable urbanization (FIG, 2010).

If the inherent challenges of urbanization can be effectively managed and resolved, it will be possible to maximize the benefits of urbanization. As such, there are many initiatives targeting the management of cities and sustainable urban development. Increasingly, many of these initiatives show trends towards governance-based approaches, especially those that connect government, industry and citizens (GSDRC, 2011). An initiative with widespread resonance has been the United Nations' vision of the "Inclusive City" which promotes an ideal of equal and full participation by all citizens in the processes of decision-making within cities (see Figure 1). As a paradigm, it proposes that full equality in urban citizenship can only be achieved when the social, political, economic and cultural dimensions of a city are linked. The most recent 'State of the World's Cities' report found that if this paradigm is to translate to reality, these four aspects need to be implemented and managed through a "rights-based framework" that is predicated on inclusion of all stakeholders, flexibility and accountability, and institutional efficiency (UN-HABITAT, 2010: 56).
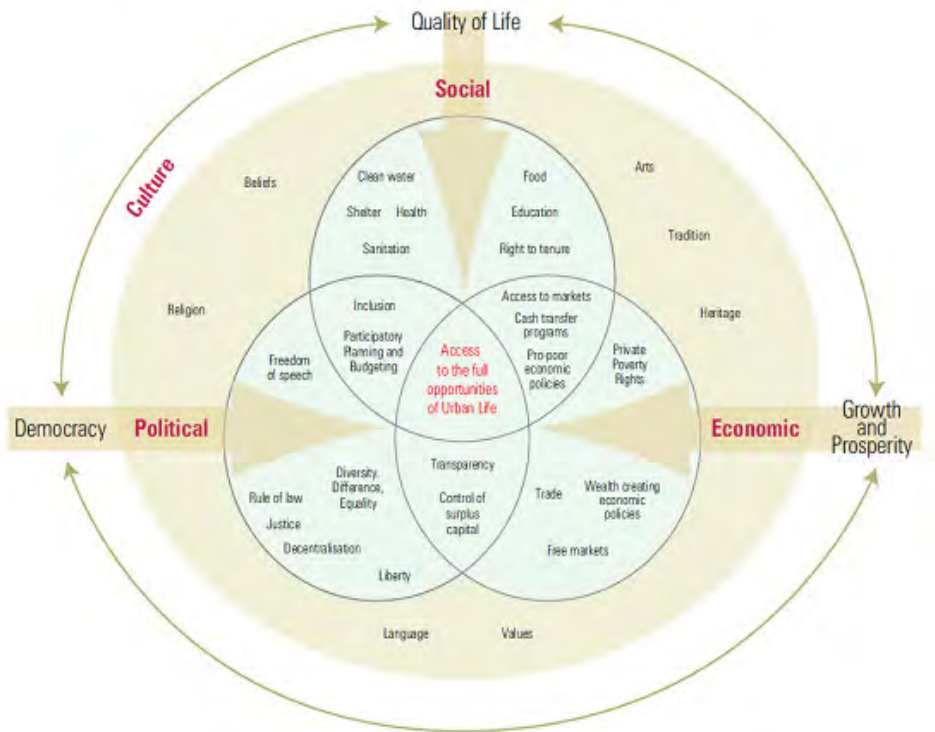
Figure 1. UN concept of an 'inclusive city' (UN-HABITAT, 2010).

This concept of a rights-based framework is aligned with land administration systems which are traditionally built using land parcels as the basis for recording interests in land. However, this traditional construct is being challenged with the emergence of new interests in land that transcend parcel boundaries. Land use in metropolitan areas provides a prime example of these new interests where a high demand for land creates complexities in building structure and use, which in turn results in various permutations of RRRs that are difficult to record, organize, access, maintain, analyze and comprehend if represented in their current format of two-dimensional (2D) (and often paper-based) parcel-based cadastral records. This issue needs to be addressed if the vision of a spatially enabled society is to be achieved, where the whole of society has free access to spatial information and development is encouraged through improved transparency and decision-making, and also the reduction of administrative costs (Williamson *et al.,* 2006; Rajabifard, 2007).

Sustainable development is therefore a key driver for more efficient land administration processes and achieving this necessarily requires an integrated approach to managing land resources (Williamson *et al.,* 2010). This can be facilitated through spatially enabling land and property information. The following section will examine the broad developments that have led to the current interest in 3D technologies as a common infrastructure to manage land and property and potentially,

how this can become a new tool in modern land administration systems. Such a tool would not only improve governance frameworks by facilitating transparency and decision-making, but by providing information in a format that is clearly understood by all stakeholders, will ensure inclusivity through all levels of government, industry and society.

3. 3D and the Geospatial Industry

The current interest in 3D spatial technology is a likely consequence of advancements in 3D technologies, which have brought this technology into the mainstream. A generic Google search under the term '3D' recovers just over 2.3 billion hits with the volume index graph for this search term (Table 1) showing a sharp increase in searches for the term from the start of 2010. Many of the peaks in the Table are associated with searches for 3D television technology. This is occurring against a backdrop of a proliferation of technology into many aspects of life.
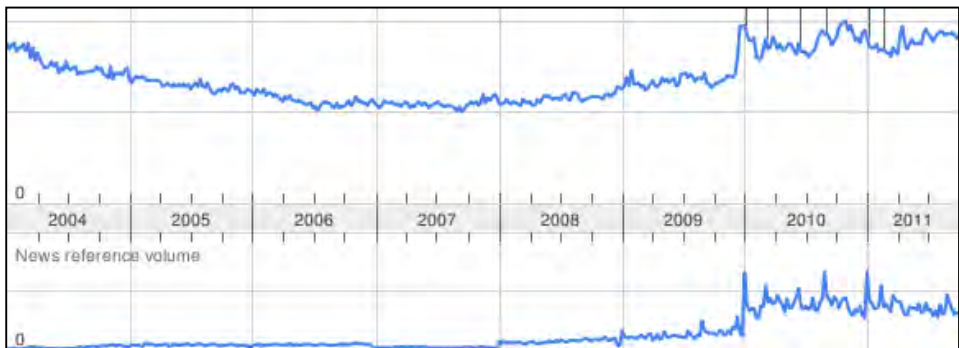
Table 1. Google's search volume index for the term '3D' (http://www.google.com/trends?q=3D).

Stakeholder Group	Planning, Engineering, and Design Phase	Construction Phase	Operations and Maintenance Phase	Total
Architects and Engineers	1,007.2	147.0	15.7	1,169.8
General Contractors	485.9	1,265.3	50.4	1,801.6
Specialty Fabricators and Suppliers	442.4	1,762.2	—	2,204.6
Owners and Operators	722.8	898.0	9,027.2	10,648.0
Total	2,658.3	4,072.4	9,093.3	15,824.0

Source: RTI estimates.

Table 2. Table of "Costs of Inadequate Interoperability by Stakeholder Group, Life-Cycle Phase (in $Millions)" (Gallaher *et al.,* 2004: p. 6-2)

This pervasiveness is also evidenced within the geospatial industry. In 2004, the United States (US) Department of Labor heralded geo-technology as one of the three 'mega-technologies' of the new millennium that will catalyse radical changes in society (Berry, 2009). However, while technology has arguably had a positive impact on productivity, its use without common standards is akin to conversing without a common language, resulting in impingement rather than enablement. In a report examining this specific issue for the capital facilities industry, the National Institute of Standards and Technology (part of the US Department of Commerce) reported that the impact of a lack of interoperability between stakeholders cost the industry approximately US$15.8 billion per year (based on 2002 statistics), with owners and operators bearing the brunt of this loss (Gallaher *et al.,* 2004). Table 2 above provides the breakdown of these costs.

This state of affairs is not idiosyncratic. In Europe, a recent study into building information models (the InPro project) similarly revealed that many different and incompatible IT systems exist within the construction industry to cater for its complexities and these systems are either costly or too specific in their application, leading to high investment costs (Gralla *et al.,* 2010). It is therefore feasible to assume that similar trends in costs exist in other countries within a comparable sector. Consequently, the impetus from the development of 3D technologies, geospatial databases and standards has led to the increased concentration on the use of building information models as a key and interoperable management framework for the lifecycle of the building (Bacharach, 2007). More importantly, our drive towards 3D information models for land and property management may come down to one simple, salient point: that it more accurately reflects the world we inhabit.

This push for an integrated platform for land information has as its main driver, the desire for sustainable development of land. This requires current and comprehensive information about the built, natural and physical environments to facilitate decision making that will have environmental, social and economic ramifications (Enemark, 2010). Traditional land administration systems are typically not equipped to cope with complex urban challenges as it is viewed to be too linear and often, too disjointed (Palmer *et al.,* 2009). It has also been increasingly acknowledged that governance lies at the heart of sustainable development and management of land and property, and that new land administration tools need to incorporate and facilitate governance processes (Palmer *et al.,* 2009; Enemark, 2010; FIG, 2010; GSDRC, 2011).

The following section will discuss how modern land administration systems can help deliver sustainable development objectives and the roles that different levels of society play in this new system.

4. Modern Land Administration Systems: The Role of Government, Industry and Citizens

Traditional land administration infrastructure has tended towards being a rights-based framework. In its current iteration as a parcel-based framework, such a system exerts limitations pertaining to the type of information that can be collected and managed, which is proving to be limited in its use, especially as a tool to deliver sustainable development. A modern land administration system needs to be able to provide not just a platform to integrate all types of information about the functions of land (tenure, value, use and development), but also the relevant processes and activities (Williamson *et al.,* 2010). More importantly, as Enemark et *al.* (2005: 53) noted, a modern land administration system (particularly those in more developed countries) should "facilitate sustainable development - the triple bottom line of economic, social and environmental sustainability - through public participation and informed and accountable government decision-making in relation to the built and natural environments".

The administration of land and property plays a vital role in any market economy. Therefore, governments will continue to play a central coordinating role in the modern land administration system, manifest as the cadastral component of the system, which accounts for the administrative, legal and fiscal processes of land and property. Rajabifard et al., (2006) observed that while such a coordinating role will likely be the domain of national governments, state and local governments will increasingly perform more operational functions. Additionally, developments in information and communication technologies (ICT) are rapidly changing the overall dynamics of land and property data demand and supply (echoing a general trend in spatial data use and consumption) such that industry and citizens are increasingly becoming both producers and consumers of this information, albeit to differing extents. This changing dynamic will foster greater linkages between the land administration systems and the people it directly affects thereby ensuring that sustainable development objectives are delivered at all levels.

This widespread use of ICT is an important factor in considering the specifications of modern land administration systems for urban areas. ICT is facilitating the development of new land administration processes between government, industry and citizens. For example, a 2010 study conducted by the Economist Intelligence Unit (EIU) on the use of ICT for city management (Siemens Press Release, 2010) found that ICT has become a basic infrastructure of cities and its use not only facilitated new ways of addressing urban challenges but also nurtured an environment for e-government initiatives to be implemented. This is an important aspect for supporting land administration governance processes as it will improve interactions between government, private industry and citizens.

Increased participation by citizens, fuelled by ICT developments, has also led to a change in their roles as purely data consumers to dual roles in production and

consumption. Consequently, both industry and government are looking to increased engagement as part of modern land administration systems (ANZLIC, 2010). Citizen-reliant initiatives abound, with OpenStreetMap a frequently cited example of how user-generated content can produce an authoritative or quasi-authoritative product. The EIU study also showed a strong trend in user-generated content that focused on urban applications. Citizens were increasingly consuming official datasets and mobile technologies to produce new applications that were relevant to their cities. In a similar vein, increased citizen participation is likely to improve the cycle of information between users, be it government, private industry or citizens. This is critical if land policies are to remain relevant (Bennett *et al.,* 2011).

The modern land administration system therefore needs to effectively engage and promote participation of government, industry and citizens, particularly in urban areas. It also needs to evolve with, and harness, developments in ICT to improve the efficiency of its processes. The concept of a 3D-LPIS is effectively that of a multi-level infrastructure that will enable all parties with an interest in land and property information to record, access, discover, share and manage information about RRRs that is not limited by parcel boundaries. By facilitating access, discovery, and sharing of land and property information, this system will support the processes and broad governance objectives of modern land administration systems and provide the foundation for realizing a spatially enabled society. This has been investigated in the context of Australia and the following section will demonstrate how government, industry and citizens have roles to play in a land administration system if urban development is to be sustainably managed. It will use specific challenges and issues to show how a 3D-LPIS can provide a platform to connect all levels of society to achieve sustainable urbanization.

5. 3D-LPIS: A New Tool for Sustainable Urbanization

A 3D-LPIS is a system that utilizes 3D geospatial technology to respond to the complexities of managing interests in land and property. This has particular application for urban areas where these interests, held as large-scale, people-relevant datasets, are becoming increasingly difficult to record, manage, analyze and comprehend. This is a critical issue as the value and stability of any land market is based on accurate and current information being available to support trading in land rights (Williamson *et al.,* 2010).

This system will enable the visualization of RRRs in a 3D digital format that will represent the data in a way that accurately reflects reality. This will also provide a common infrastructure for all stakeholders upon which collaboration or the management of other information can be based. It will improve access to information, participation in decision making, improve transparency in processes and facilitate multi-disciplinary approaches to urban issues. By providing accurate and timely information about land and property, this system will be a tool for realising a spatially enabled society.

Land administration systems and processes need to be contextualized to be effective hence Australia is used as a case study to show how a 3D-LPIS can support sustainable urbanization.

5.1 Urbanization and Land Administration in Australia

Australia is the sixth largest country in the world and one of the most urbanized albeit least densely populated (Department of Foreign Affairs and Travel, 2008). It is a federated country comprising six states and two territories and occupies an entire continent. More than 70 percent (approximately 15 million) of Australia's population (of 22 million) is concentrated within its five largest urban regions – as this proportion is expected to increase, the management of such large and dynamic urban areas is becoming more challenging (Department of Infrastructure and Transport, 2011). Table 3 below demonstrates the rate of growth of Australia's 18 major cities over the last decade.
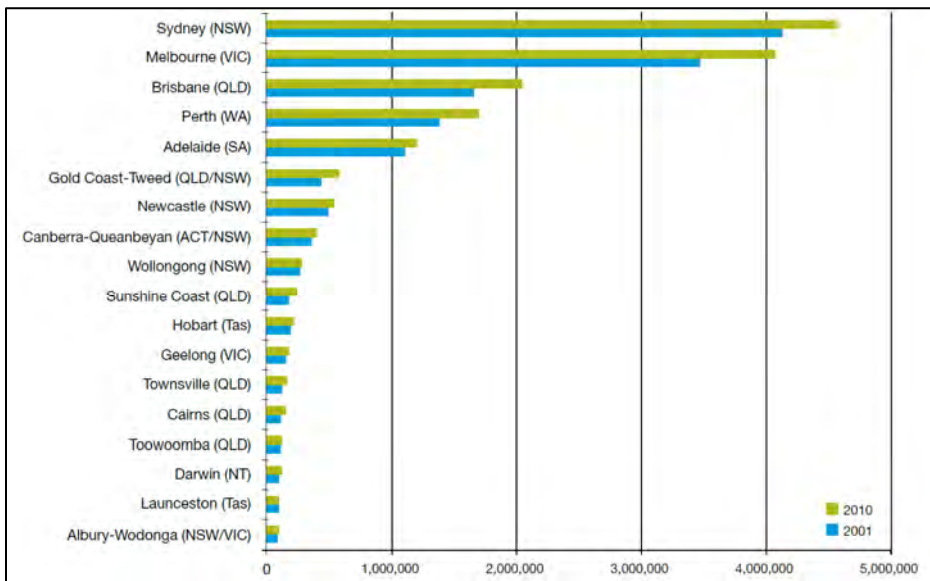
Table 3. Population change in Australia's 18 Major Cities (2001-2010) (Department of Infrastructure and Transport, 2011: 6)

Land administration has long been the purview of the state governments (to be henceforth considered synonymous with territory). This responsibility is formally recognized in the Australian constitution. The federal (national) government plays little or no direct role; however, relationships exist at this level due to non-statutory organizations such as the Australian New Zealand Land Information Council (ANZLIC),

the Intergovernmental Committee on Surveying and Mapping (ICSM) and PSMA Australia Limited (previously known as 'Public Sector Mapping Agencies' but now known as PSMA Australia and henceforth referred to as PSMA). Based primarily on the Torrens system, the land administration system of each state share similarities with each other but is sufficiently differentiated to provide for a complex national landscape.

Land and property information plays a vital role in Australia's economic, social and environmental well-being. A buoyant and secure land market is essential for economic prosperity; effective management of the built and natural environment is necessary for sustainable development; and land information is vital in administering to the needs of citizens by linking location to activity (Wallace *et al.,* 2010). Nonetheless, it is difficult to paint a clear picture of the value of the land and property industry in Australia. Using land tax as an oblique way of considering value, the amount collected by all levels of government in the last financial year (2009-10) amounted to AUD$31 billion, an increase of 14 percent over the previous year and accounting for ten percent of total revenue (Australian Bureau of Statistics, 2011). Reflecting the way land is administered in this country, property tax provided the greatest source of revenue – 37 percent of total revenue intake – for state governments (Australian Bureau of Statistics, 2011). The value of this industry also has a multiplier effect on affiliated sectors such as construction, and ancillary industries like property management and real estate transaction services. For example, within Victoria, every dollar spent on construction generates three dollars in other sectors (Master Builders Association of Victoria, 2009).

Land ownership in Australia is recorded and reflected in its cadastre, or the land and property map base. This is predicated on a legislative framework dictating processes relating to land ownership (and associated RRRs) and boundary definition. This has been catalogued as 2D textual cadastral records in the past but these records are increasingly being stored in digital cadastral databases. A 2008 workshop organized by the ICSM found that cadastral systems amongst the states generally had a high level of integration between survey and title data with other forms of information which was accessible via online services, and that this data tended to be of high quality and integrity (ICSM, 2008). It therefore found that there was high confidence in the systems by its users and a low incidence of disputes in transactions.

However, in a recent in-depth study looking at four parcels (albeit only in the states of Victoria and New South Wales), Bennett (2009) found that whilst 'above the line' interests (i.e. interests on title) were relatively easily discovered, this comprised only a small percentage of all interests associated with a property and that the majority of interests were in fact, 'below the line' interests. These ranged from zoning to heritage information, and there was no singular or systematic way to discover and access such information. A logical corollary is the existence of complex, and perhaps disparate, administration systems and processes. The following section articulates in greater

detail some of the current issues of land administration within Australia and how this transposes as drivers for a 3D-LPIS.

5.2 Current Land Administration Issues and Drivers for a 3D-LPIS

The land administration system in Australia is widely regarded to be of high quality and integrity; however, there are some acknowledged issues. Due to the pluralism that exists, and the preliminary stage of current research into 3D-LPIS, this section will reflect broad issues, or at least common ones across the eight state-level jurisdictions.

At the most intrinsic level, the lack of a single federal authority with overarching responsibility for land administration places Australia's system in stark contrast with modern land administration theory (Bennett *et al.,* 2011). This absence makes it difficult to aggregate information collected at local and state levels up to a national level (although PSMA fulfils this task to some extent with the production of fundamental national datasets). In a country where 70 percent of the population (and increasing) resides in urbanized areas, this poses a real challenge to the federal government's ability to fully understand the complexities of urban challenges from a national perspective. As Kelly *et al.* (2011: 10) noted, "When no one level of government owns the challenge, it is easier to avoid difficult decisions about managing the effects of population growth". This issue could translate as a key strategic driver for the development of a 3D-LPIS.

At a state level, ongoing and recent changes and restructures within government agencies responsible for surveying, registration and land administration matters are compounding the already complex institutional processes that exist. Looking further afield to the 563 local governments that also have land planning and management responsibilities for their own jurisdictions, Australia is faced with a significant land and property information management challenge (in legal, institutional and technical administration aspects). As a country, this reflects a land administration system that, although sound, is fairly disparate and complexities in bureaucracy and institutional processes inevitably result in higher costs to all stakeholders; addressing this issue is identified as a driver for the development of a 3D-LPIS.

These issues are being addressed in some way for the first time by a federal government with the publication of the National Urban Policy (NUP) in 2011 that was produced in consultation with state governments. The NUP is framed around addressing the broader urban challenges of the nation but also has implications for land and property management – it specifically looks to establish a framework for inclusive participation by sub-national governments, industry and citizens in sustainable urbanization of the country's cities (Department of Infrastructure and Transport, 2011). The NUP is one of three key policies that have been produced that will be used to guide sustainable development in this country. Table 4 provides a summary of the goals, objectives and principles that are to be adopted by all levels of government. In summary, the policy has as its main goals:

- improving productivity;
- improving sustainability and resilience of built and natural environment;
- improving the liveability in terms of housing, transport and community services; and
- improving governance through integration of processes, engagement and evaluation.

The implementation of the NUP can be seen as a key driver for the development of a 3D-LPIS in Australia as such a system could help facilitate many of the policy objectives by providing a common framework for all stakeholders to collaborate within and for all relevant information pertaining to the tenure, value, use and development of land and property to be integrated. Such a platform is aligned with modern land administration theory where the interaction of these functions is necessary to deliver policies aimed at achieving sustainable development (Williamson *et al.,* 2010).

		OBJECTIVES		PRINCIPLES
GOALS	PRODUCTIVITY	1. Improve labour and capital productivity		Efficiency
		2. Integrate land use and infrastructure		Value for money
		3. Improve the efficiency of urban infrastructure		
	SUSTAINABILITY	4. Protect and sustain our natural and built environments		Innovation
		5. Reduce greenhouse gas emissions and improve air quality		Adaptability
		6. Manage our resources sustainably		
		7. Increase resilience to climate change, emergency events and natural hazards		Resilience
	LIVEABILITY	8. Facilitate the supply of appropriate mixed income housing		Equity
		9. Support affordable living choices		Affordability
		10. Improve accessibility and reduce dependence on private vehicles		Subsidiarity
		11. Support community wellbeing		Integration
	GOOD GOVERNANCE	12. Improve the planning and management of our cities		Engagement
		13. Streamline administrative processes		
		14. Evaluate progress		

Table 4. Overview of goals objectives and principles of Australia's National Urban Policy (Department of Infrastructure and Transport, 2011: 18).

The following section discusses how a 3D-LPIS could help achieve these goals, especially with relevance to land and property, and in doing so, how it could improve the current processes of the various land administration functions.

a. Improving productivity

The scope of productivity as defined in the NUP encompasses labour, industry, knowledge, land and infrastructure. Pertaining to land and infrastructure, efficiencies in productivity is to be gained from more holistic planning incorporating social and

economic aspects as well as improving transportation modes. This is relevant to improving the functions of land use and development.

A 3D-LPIS could provide a platform to catalogue and connect 'above the line' interests with a specific property's 'below the line' interests. When this is visualized in a holistic manner, it could potentially result in improved analytical capabilities and therefore a way to improve current regulatory processes. This could potentially yield economic benefit especially since recent modelling carried out by the Reserve Bank of Australia demonstrated that zoning regulations that impeded development in urban areas generally resulted in higher housing prices (Kulish *et al.,* 2011 in Kelly *et al.,* 2011). This would also address the current difficulty in discovering all interests pertaining to a property in a simple and systematic way, and result in greater transparency in associated processes that would directly benefit government agencies, industry and citizens. The integration of all interests in land and property would also assist in planning efforts to reduce urban sprawl. This is an important issue for urbanising regions as urban sprawl has implications for productivity as it typically results in congestion, longer commuting times and increased costs of travel. Increased distance from established regions also impacts upon liveability by limiting citizens' access to opportunities and can result in diminished labour resources for businesses located in urban areas.

The NUP also prioritizes maximising returns on infrastructure investments. In research carried out in Europe for the InPro project, Schade (2007) found that an office building will cost at least three times its capital cost over a 25 year period but if more investment and emphasis is given to the planning and development stage, it will result in less costs being incurred by the building over its lifetime. Similarly, this system is well suited to provide a collaborative environment for developers, architects, planners and surveyors (amongst the most common professions engaged in the development phase of a building) to achieve the most efficient and sustainable building design pre-construction.

b. Improving sustainability

This goal aims to improve sustainability of the built and natural environments through protection of the environment, improvements in air quality, sustainable management and increasing the ability of cities to adapt and respond to natural disasters. These various aspects are increasingly being regulated through the emergence and development of new RRRs over land as a way to achieve sustainable development (Bennett *et al.,* 2007; Enemark *et al.,* 2005).

Likewise in Australia, new legislation aimed at mitigating climate change has recently been passed such as the National Greenhouse and Energy Reporting Act 2007. Such legislation implies the possibility that carbon and energy information will become mandatory elements of a modern land administration system for Australia. A 3D representation of property could provide an appropriate infrastructure to enable such information to be collected and managed, because land and property information is

used as the common denominator. This information could then be accessed and used by relevant industries such as risk and disaster management.

c. Improving liveability

Liveability is a fairly broad goal and the objectives the NUP seeks to achieve targets of affordable housing, improvements in public transport and supporting communities. Where a 3D-LPIS could directly support this goal is in the processes associated with land use and development.

There is a well-acknowledged shortage in affordable and appropriate housing supply in Australia's major cities, with factors such as land use policies and construction costs resulting in development more likely to occur at the edge of cities than within, and a tendency for single-unit dwellings to be built rather than multi-unit ones (Kelly *et al.*, 2011). Table 5 below shows the comparison between construction costs of building in established areas (infill) versus on the edge of cities (greenfield) in five of Australia's major cities. A 3D-LPIS could help planners achieve better urban design by providing a visual representation of the types of land use currently in place, as well as the types of structures and how these may impact upon the well-being of residents in adjacent properties. It could provide analysis by spatial clustering of land use type to ensure an appropriate mixture of land use. It could also provide a spatial representation of land use policies to foster understanding of these policies and evaluate their relevance to the communities they serve.
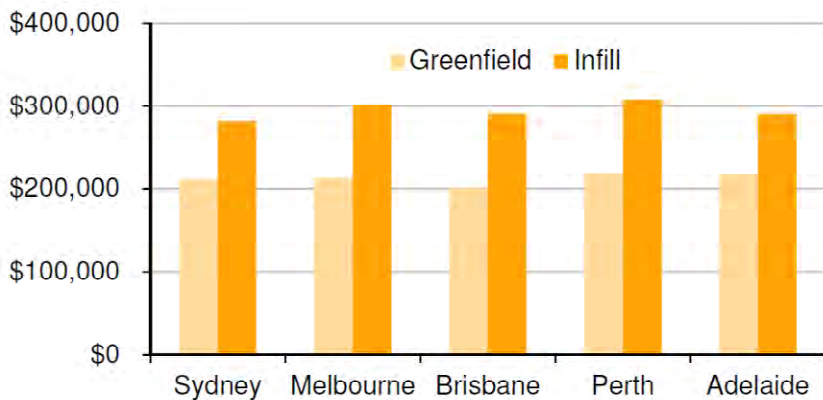
Table 5. Construction cost differences between infill and greenfield developments in five Australian cities (Kelly *et al.,* 2011: 28)

ICSM's review of cadastral systems in Australia (2008) noted that there has been an increase in boundary disputes, exacerbated by a general trend towards using litigation to resolve disputes. This can result in higher costs to all parties (and tax payers)

involved in land development, as well as generating ill will amongst communities. For example, the Gold Coast City Council, a local government, has found their legal costs for resolving land development disputes to be approximately AUD$6.8 million a year (Potts, 2011). A 3D-LPIS could provide an authoritative, but perhaps more importantly, easily visualized and comprehensible source of information that could assist in boundary disputes between neighbours (and reduce the costs of disputes) and support the aims of improving liveability in communities.

d. Improving governance

The goal of governance aims to improve upon current institutional processes to support the achievement of all other goals but particularly with regards to the planning and management of cities, the streamlining of administrative processes and evaluation mechanisms.

The three objectives are perhaps less distinct and more inter-connected: the improvement of one necessarily benefits the others. Complex processes impact upon the ability to sustainably plan and manage, in addition to impacting upon transparency and creating legal loopholes. A 3D-LPIS could facilitate open access of information and communication between stakeholders by providing land and property data in a (comparatively) more comprehensible format, that is, 3D visualization. This would be in line with existing federal initiatives within Australia supporting an open government based on principles of information, engagement and participation (Australian Government Information Management Office, 2011). This system would not only link citizens with governments and industry with each other, it could link the various levels and branches of governments dealing with land and property matters.

Productivity:
• Platform to connect and catalogue above- and below-the line interests;
• Collaborative environment for building design;
• Improved analytical

Government

Industry

3D-LPIS

Citizens

Sustainability:
• Managing new RRRs;
• Provide info to relevant industries e.g. risk and disaster management.

Liveability:
• Visualization of land use – better urban and structure design;
• Analyze impact of structure on community well-being;
• *Improved analysis of land use type;*
• Source of information for boundary disputes.

Good Governance

Figure 2. Facilitating Australia's National Urban Policy – 3D-LPIS to connect and deliver policy goals.

Figure 2 (above) conceptualizes the use of the 3D-LPIS by all levels of society to organize and manage the requisite information pertaining to achieving the goals outlined in the NUP by cataloguing and visualising land and property RRRs. The facilitation of the three goals of liveability, sustainability and productivity is inter-related and necessarily requires good governance. The integrated delivery and management of land and property information is necessary to deliver sustainable development objectives (Enemark *et al.,* 2005; Williamson *et al.,* 2010). As the cadastre in Australia provides a record of title and current ownership, it provides the appropriate basis of fundamental and authoritative data for a 3D-LPIS as the registration of property provides a mechanism for maintaining currency of ownership

data – from this base, it is then possible to relate to other types of data and/or information.

In summary, a 3D-LPIS could help facilitate policy goals by providing a way to integrate previously disparate sources of information, and consequently, provide improved analytical capabilities which would provide new insights for managing land use sustainably. The integration and streamlining of information would improve governance processes by facilitating engagement with stakeholders (be it government, industry or citizens) in the form of better access, transparency and feedback avenues.

6. Future Research

This paper has discussed a 3D-LPIS at a largely conceptual level due to the fact that ongoing research is still at a preliminary stage. Whilst significant research exists regarding the technical aspects of 3D systems (in general) for land and property data, it is acknowledged that a significant gap exists in the current body of work regarding furthering understanding of the institutional benefits of such technologies especially with relevance to cadastral data (Paulsson and Paasch, 2011). Therefore, the aim of this ongoing research into a 3D-LPIS is to utilize a multi-disciplinary approach to develop the institutional, legal and technical specifications for such a system to be implemented in Australia and determine if many of the conceptualizations mentioned in this paper will bear out in reality and can be evaluated against real life applications. It is envisioned that the outcome of this research this will likely provide a roadmap for other jurisdictions to demonstrate how a 3D-LPIS could be successfully introduced into current land administration systems.

7. Conclusions

This paper has shown that urbanization is an inevitable process and the challenges arising from urbanization have complex and multi-scale environmental, social and economic impacts that must be addressed. Sustainable urbanization is therefore necessary for sustainable development. The confluence of several drivers such as development of 3D technologies, the emergence of new interests in land because of urbanization, and the inability of traditional land administration systems to cope with complex urban challenges have all resulted in the increasing use of 3D spatial technology as a new tool in modern land administration systems.

The concept of a 3D-LPIS is proposed which uses 3D spatial technology to store, manage and visualize above and below the line interests (RRRs) in land and property. Such a system would enable integration of previously disparate sources of information pertaining to the built and natural environments, thereby resulting in improvements in access to information, participation in decision making, transparency in processes and

facilitate multi-disciplinary approaches to complex urban issues. Australia was used to provide context to demonstrate the potential of a 3D-LPIS to support the various functions of land to facilitate sustainable urbanization objectives as part of a modern land administration system. In a country where cadastral information (in many cases) is still held as 2D textual records, such a system would represent a significant evolution of its land administration system and provide a foundation not just for a spatially enabled government, but ultimately, a spatially enabled society.

8. Acknowledgement

References

ANZLIC (2010), Economic Assessment of Spatial Data Pricing and Access, Stage 1 Report: Principles, Issues and Alternative Models. Report prepared for ANZLIC by PricewaterhouseCoopers Availble at http://www.anzlic.org.au/Latest+News/Downloads+section+for+News+items /Downloads_GetFile.aspx?id=272 [Accessed at 29 October 2011].

Australian Bureau of Statistics (2011), Taxation Revenue, Australia, 2009-10, Australian Bureau of Statistics Resources Avaialble at http://www.abs.gov.au/ausstats/abs@.nsf/Latest products/5506.0Main percent20Features22009-10?opendocument&tabname =Summary&prodno =5506.0&issue=2009-10&num=&view= [Accessed 31 October 2011].

Australian Government Information Management Office (2011), Declaration of Open Government Available at http://www.finance.gov.au/e-government/strategy-and-governance/gov2/declaration-of-open-government.html [Accessed 29 October 2011].

Bacharach, S., (2007), Converging on the Market: CAD, Geospatial, 3D, Visualization and BIM, Cadalyst June 4 2007 Available at http://www.cadalyst.com/aec/converging-market-cad-geospatial-3d-visualization-and-bim-6125 [Accessed at 13 October 2011].

Berry, J., (2009), What's in a Name? Beyond Mapping, GeoPlace March 2009, Avaialbe at http://www.geoplace.com/ME2/dirmod.asp?sid=DA72DA013599412F85B2FD 29498DD7E3&nm=a+test&type=MultiPublishing&mod=PublishingTitles&mid=

2F0B36C074B04B3DAACB3F3733414366&tier=4&id=CA39BB70EA434EE9A94 DDF720A68E839 [Accessed at 13 October 2011].

Bennett, R., Wallace, J. and Williamson, I.P., (2007), Organising Land Information for Sustainable Land Administration, *Journal of Land Use Policy*, 25 (2008): 126-138.

Bennett, R., Rajabifard, A., Williamson, I. and Wallace, J., (2011), On the Need for National Land Administration Infrastructures, Journal of Land Use Policy, 29 (2012): 208-219.

Department of Foreign Affairs and Trade (2008), Australia's Environment At a Glance, About Australia, Avaialbe at http://www.dfat.gov.au/facts/env_glance.html [Accessed at 10 November 2011]

Department of Infrastructure and Transport (2011), Our Cities, Our Future – A National Urban Policy for a Productive, Sustainable and Liveable Future*, Department of Infrastructure and Transport, Australia, 2011.

Enemark, S., Williamson, I. and Wallace. J., (2005),Building Modern Land Administration Systems in Developed Economies, Spatial Science, 50 (2): 51-68.

Enemark, S., (2010), From Cadastre to Land Governance: The Role of Land Professionals and FIG, Proceedings of the Annual World Bank Conference on Land Policy and Administration, Washington D.C., 26-27 April 2010 Avaialbe at http://siteresources.worldbank.org/INTARD/Resources/335807-1229025334908/enemark.pdf [Accessed at 20 October 2011].

FIG (2010), Rapid Urbanization and Mega Cities: The Need for Spatial Information Management. International Federation of Surveyors (FIG), Publication No 48. Copenhagen, Denmark: FIG.

Gallaher, M. P., O'Connor, A. C., Dettbarn, J. L. and Gilday, L.T., (2004), Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry, Report prepared for the National Institute of Standards and Technology, U.S. Department of Commerce, Technology Administration, USA.

Gralla, M., Brandt, T., Rommen, L. and Meckmann, K., (2010), Business Concepts – State of the Art. InPro Project, Report D9 Avaialbe at http://www.inpro-project.eu/docs/InPro_BusinessConceptsSOTA.pdf [Accessed at 21 September 2011].

ICSM (2008), Report on the Cadastral Reform Workshop, Intergovernmental Committee on Surveying and Mapping, Permanent Committee on Cadastral Reform, Sydney, 18-19 March.

IPCC (2007), Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kelly, J-F., Breadon, P. and Reichl, J., (2011), Getting the Housing We Want, Grattan Institute, Melbourne.

Master Builders Association of Victoria (2009), Submission to the President's Review of the Victorian Civil and Administrative Tribunal, Master Builders Association of Victoria, August 2009 [Accessed at 21 September 2011].

Palmer, D., Fricska, S., Wehrmann, B., (2009), Towards Improved Land Governance. Land Tenure Working Paper 11, in collaboration with Augustinus, C., Munro-Faure, P., Torhonen, M. and A. Arial Availabe at http://www.unhabitat.org/pmss/getElectronicVersion.aspx?nr=3216&alt=1 [Accessed at 6 Nov 2011].

Paulsson, J. and Paasch, J., (2011), 3D Property Research - a Survey of the Occurrence of Legal Topics in Publications, Proceedings of the 2nd International Workshop on 3D Cadastres. 16-18 November 2011, Delft, The Netherlands.

Ploeger, H., (2011), Legal Framework 3D Cadastres, Position Paper 1, Proceedings of the 2nd International Workshop on 3D Cadastres. 16-18 November 2011, Delft, The Netherlands.

Potts, A., (2011), Council court costs top $6.8m a year, Gold Coast Sun, 21 April 2011, Avaialbe at http://www.goldcoast.com.au/article/2011/04/21/309835_gold-coast-news.html [Accessed at 21 September 2011].

Rajabifard, A., Binns, A., Masser, I., and Williamson, I.P., (2006), The Role of Sub-national Government and the Private Sector in Future SDIs, International Journal of Geographical Information Science, 20(7): 727-741.

Rajabifard, A., (2007), Towards a Spatially Enabled Society, Australia: University of Melbourne/ Centre for SDIs and Land Administration.

Schade, J., (2007), Lifecycle Cost Calculation Models for Buildings, InPro Project Avaialbe at http://www.inpro-project.eu/media/lcc_juttaschade.pdf [Accessed at 21 September 2011].

Siemens Press Release (2010), Siemens Releases Study on How Information Communications Technology Can Be Used to Enable, Engage and Empower City Stakeholders, Siemens IT Solutions and Services Availabe at http://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2010/siemens_it_solutions_and_services/sis20100628015.htm [Accessed at 10 October 2011].

Stoter, J., (2004), 3D Cadastre. PhD Thesis, TU Delft, Publications on Geodesy 57, Netherlands Geodetic Commission, 2004, Delft, The Netherlands.

UNFPA (2011), State of the World Population 2011: People and Possibilities in a World of 7 Billion, Report by the United Nations Population Fund Available at http://www.unfpa.org/public/op/preview/home/sitemap/swp2011 [Accessed at 3 November 2011].

UN-HABITAT (2010), State of The World's Cities 2010/2011: Bridging the Urban Divide, Report by the United Nations Human Settlements Programme. London, Sterling, VA, Earthscan.

UN-STATS (2011), Population density and urbanization. Demographic and Social Statistics, Online resource of the United Nations Statistics Division, last updated 2011 Avaialbe at http://unstats.un.org/unsd/demographic/sconcerns/densurb/densurbmetho ds.htm [Accessed 11 November 2011].

Wallace, J., Williamson, I., Rajabifard, A. and Bennett, R., (2006), Spatial Information Opportunities for Government, Spatial Science Journal, 51 (1): 79-99.

Wallace, J., Marwick, B., Bennett, R., Rajabifard, A., Williamson, I., Tambuwala, N., Potts, K. and Agunbiade, M., (2010), Spatially enabling land administration: drivers, initiatives and future directions for Australia, In A. Rajabifard, J. Crompvoets, M. Kalantari and B. Kok (eds.), Spatially Enabling Society, Belgium: Leuven University Press, pp. 175-190.

Williamson, I., Wallace, J. and Rajabifard, A., (2006), Spatially Enabling Governments: A New Vision for Spatial Information, Towards a 2015 Vision of Land, Taipei, Taiwan, 24-25 October 2006.

Williamson, I., Enemark, S., Wallace, J. and Rajabifard, A. ,(2010), Land Administration for Sustainable Development, California: ESRI Press.

World Bank (2009), World Development Report: Reshaping Economic Geography, Report by the World Bank, Washington D.C.

Legal Liability Concerns Surrounding Volunteered Geographic Information Applicable to Canada

Andriy Rak, David Coleman and Sue Nichols

Department of Geodesy and Geomatics Engineering, University of New Brunswick, Canada

andriy.rak@unb.ca; dcoleman@unb.ca; nichols@unb.ca

Abstract

Authoritative datasets, Volunteered Geographic Information (VGI) and other sources of spatial information collected by industry and citizens can be used to spatially enable government and society. Authoritative geographic datasets are the source of accurate and reliable data. The process of acquiring, updating and maintaining such datasets using traditional approaches requires both time and costly resources. An alternative and possibly more economical approach to reliably creating and updating authoritative datasets involves the integration of VGI. Such potential integration of VGI with authoritative datasets raises important legal considerations. Liability is a primary issue that can deter organizations from incorporating VGI into their datasets. Due to the lack of research on this topic, organizations consider it to be a better practice to exclude VGI as a viable option. In the view of benefits that VGI can bring it is important to continue and deepen the research on liability concerns surrounding VGI, so that organizations will not fear to face the legal liability risks that can arise and will be equipped with appropriate techniques to manage such risks.

This paper will investigate the liability effects of using VGI under Canadian law. The questions of who is liable and when for VGI provided to authoritative public and private geographic datasets are among the most important questions which impact VGI, and are the ones which this paper aims to address. Liability issues of using VGI are studied by examining the liability in contract, as well as tort. To minimize and/or eliminate liability, in most cases, requires organizations to develop a risk management plan (Martinez, 2003). This paper concludes with liability risk management techniques which, if incorporated properly, provide opportunities to minimize or eliminate the liability.

Issues of legal liability arising from creation, distribution and integration of VGI with authoritative datasets have received very limited attention by scholars and researchers

at their work. Further research is required in order to overcome shortcomings in the studies concerning legal liability arising from usage of VGI.

KEYWORDS: VGI, authoritative data, liability, tort liability, volunteer, volunteerism, volunteer activity.

1. Volunteered Geographic Information

In the literature, there are at least five terms aimed at defining the phenomena of geographic data collection and distribution by volunteers using the Internet. Terms such as "neogeography" (Sui, 2008; Turner, 2007), "ubiquitous cartography" (Gartner *et al.*, 2007), "user-generated content" (Sieber, 2007), and "collaboratively contributed geographic information" (Bishr and Mantelas, 2008) have been proposed. The most commonly used term, however is "VGI" (Goodchild, 2007), being extensively used in the literature and on the web. Volunteered geographic information has been studied and used by social scientists for decades, often referred to as Traditional Ecological Knowledge (TEK) or local knowledge (Huntington, 2000). It should be noted that TEK and local knowledge can be a rich source of geographic data at the local level, for example a Coastal Collaborative Geographic Information System (CCGIS) that has been developed in the University of New Brunswick by using local knowledge (TEK) as "input in threat mapping to develop adaptation strategies for the effects of sea level rise and storm surges" (Titus, 2011).

As noted by Goodchild (2007) "the proliferation of user-generated content is viewed as a harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals". VGI is also seen as "an extension of critical and participatory approaches to geographic information systems" (Elwood, 2008) and a "by-product of the so-called 'Web 2.0' environment" (Flanagin and Metzger, 2008). In this paper, the term VGI will be used to describe geospatial information which has been pulled together for the most part by non-professionals in the sphere of Geographic Information (GI) and submitted to a public or private GI database.

The interest in VGI has grown considerably over the past decade in geography and geomatics (Bishr and Mantelas, 2008; Elwood, 2008; Flanagin and Metzger, 2008; Goodchild, 2008). Much of this interest has been driven by the availability of new technologies to collect and manage geographic data. As noted by Budhatoki et al. (2008), geographic information collected voluntarily by individuals is now being considered by researchers as a possibility to be one of the primary sources in collection of GI to public and private datasets taking into account that: "the six billion humans constantly moving about the planet collectively possess an incredibly rich store of knowledge about the surface of the Earth and its properties" (Goodchild, 2007). VGI has the potential to be among primary sources of data to private and public GI datasets, as it combines both the state of art technology and the human desire to discover the world around them and to have better, up-to-date information. VGI

makes invaluable input for the GI. As volunteers are not limited in their actions by any provisions of the employment contract (as discussed below in this paper in the section "liability in contract") and they can develop their unique approach and be working in the atmosphere of so-called "outside the box thinking".

VGI importance is likely to grow in the future, taking into account its positive aspects of providing timely, low cost, up-to-date geographic information. As noted by Goodchild (2007) "by motivating individuals to act voluntarily, it is far cheaper than any alternative, and its products are almost invariably available to all". Coleman *et al.* (2009) noted that if: (1) volunteers are encouraged appropriately; (2) the processes are managed wisely; and (3) the potential and the limitations of their contributions are understood and used in the proper context, then "there is an opportunity to produce and enjoy richer and more up-to-date databases than we have ever seen in the past".

Authoritative geographic datasets are the source of accurate and reliable data. The process of acquiring, updating and maintaining such datasets using traditional approaches requires both time and costly resources. An alternative approach, which is more economical, to reliably create and update authoritative datasets is linked to its integration with VGI. The term "Authoritative Data" has been used to describe products produced by professional mapping organizations (Ball, 2010; Coleman *et al.,* 2010; Goodchild, 2009). Authoritative datasets, VGI and other sources of spatial information collected by industry and citizens can be used to spatially enable government and society. Spatial enablement requires "… data and in particular services to be accessible and accurate, well-maintained and sufficiently reliable for use by the majority of society which is not spatially aware…" (Rajabifard *et al.,* 2010). Such spatial enablement involves integration of VGI with authoritative datasets, and as a result raises important legal considerations. Legal liability is a primary issue that can deter organizations from incorporating VGI into their datasets.

2. Is VGI a Volunteer Activity?

According to Statistics Canada (2006), 12 (twelve) million citizens in Canada contribute almost 2 (two) billion hours of their time to volunteer work over the course of a year. A large number of people involved indicate that volunteerism is bound to reach many spheres and that these volunteer activities might include VGI.

Before looking in depth at VGI and some of the legal issues surrounding this phenomenon, it is necessary to have a good understanding of wider terms such as "volunteer" and "volunteerism", and identify whether VGI is an actual volunteer activity. Being able to classify VGI as actual volunteer work is an important step in conducting research on liability concerns of VGI. Having VGI classified as volunteer activity or not, will determine if court decisions, statutes and research materials on volunteerism can be applied and used in respect to VGI.

The Inter-Parliamentary Union et al. (2004) pointed out that there is no universal model for a legal definition of the terms "volunteer" and "volunteerism". Tilly and Tilly (1994) defined volunteer work as "unpaid work provided to parties to whom the worker owes no contractual, familial, or friendship obligations". Thus, volunteering is defined as a type of work – "human work that adds use value to goods and services" (Wilson and Musick, 1997). The Inter-Parliamentary Union *et al.* (2004) defines voluntarism as a "group of activities carried out by individuals, associations or legal entities, for the common good, by free choice and without the intention of financial gain, outside the framework of any employment, mercantile or civil service relationship." These two interpretations are very similar in that: (1) they define 'volunteerism' as unpaid or without intention of financial gain activities; and (2) they are performed by free will without any obligations. The second definition, on the other hand, includes the purpose of the activity – for the common good – which directly and/or indirectly raises a lot of questions in the VGI context, such as:

- Who owns contributed VGI to GI providers? (Martinez, 2003)
- Who has the liability for the use of such data?

At present there are no laws, statutes and/or legal cases that state or describe volunteer responsibilities while performing VGI related activities. In the absence of such legal norms it is proposed that contributors of VGI should follow all legal rules, both federal and provincial, just as if they were conducting any other activity (Volunteer Alberta, 2011). Government on the other hand, should take proactive steps and pay careful attention in defining and regulating voluntary activities (Inter-Parliamentary Union *et al.,* 2004), so as not to decrease the opportunities VGI could provide to public and private GI databases, by introducing too many regulations for the volunteers and hosts of their information. At the very least, Government should extend a formal thanks to those who volunteer their time.

Do VGI activities comply with the definition and therefore follow volunteered regulations or do they not really fit the volunteerism model at all? As discussed above the main characteristics of volunteer activity should comply with the following standards:

- activities carried out by individuals, associations or legal entities;
- for the common good;
- by free choice and without the intention of financial gain;
- outside the framework of any employment or civil service relationship.

These characteristics of volunteered activity are compared against two of the most common and well-known VGI projects - OpenStreetMap (OpenStreetMap, 2011b) and Wikimapia (Wikimapia, 2011a) - to assess whether or not VGI can really be considered a "volunteer activity".

The first characteristic states that activities should be carried out by individuals, associations or legal entities. OpenStreetMap in June 2011 had 412 thousand

registered users (OpenStreetMap, 2011a) while in March 2009 it had only 79 thousand users (OpenStreetMap, 2011a). Wikimapia entered year 2011 with 1 million registered users and had more than 14 million places added, while in March 2009 Wikimapia had only around 9 million places described by users (Wikimapia, 2011b). The first characteristic for volunteer activity is met in OpenStreetMap and Wikimapia, as GI data in those projects is created/gathered by registered (in most cases) users who are individuals.

The next characteristic of volunteer activity is that such activity should be for the common good. Wikipedia (2011) states that "although there is no definition or list of activities of what is considered to be 'common good', the popular meaning is that common good describes a specific good that is shared and beneficial for all (or most) members of a given community." The main idea behind OpenStreetMap (2011b) is to create a free editable map of the world, and Wikimapia (2011a) has the same intention to describe the whole world. Any user of those projects has access to their GI data, making it available not only to a specific few, but to most individuals who are interested in such data, thus following the common good concept.

The next characteristic of volunteer activity is that such activities are performed by free choice, without any intention of financial gain and outside the framework of any employment. Activities that are performed by contributors to OpenStreetMap and Wikimapia are done by regular people, who contribute their time and resources to help their community, or bearing in mind other non-profit objectives. All these activities are performed by free choice and contributors can stop participating or continue contribution by their free will. Such activities do not rely on contract or any employment, but rather on interest of contributors to be a part of a project. Contributors usually agree to policy terms of the project and not to violate any of the rules, a project has set, but this cannot be looked upon as any kind of employment. Such activities of contributors are performed without any monetary compensation, as well as any payment from either OpenStreetMap or Wikimapia. Although after sites have reached certain 'critical mass' in terms of volunteered data coverage, both OpenStreetMap and Wikimapia founders began making money themselves of the Application Programming Interface (API) they created.

By looking at the characteristics of a voluntary activity and the activities performed by contributors (volunteers) of OpenStreetMap and Wikimapia projects, it can be concluded that VGI is justifiably a part of volunteerism. An outcome of this is that legal norms and cases held and those that would be held in Canada with regards to volunteerism should be applicable to VGI, including legal liability.

3. Liability Concepts and VGI Quality

The questions of who is liable for VGI provided to authoritative public and private geographic datasets, and in what circumstances, are among the most important questions which impact VGI and which this paper is aimed to address. As discussed by

Martinez (2003) the liability issue has two main questions that could be used in correspondence to VGI are: 1) a liability of GI providers to users and third parties for actions performed by volunteers, and 2) a liability of contributors of VGI to users and third parties, that use such data. In order to answer those questions first we need to know which set of legal rules applies to VGI.

The doubt of whether GI products can be looked at as goods, services or information is not currently answered; as a result a question is raised as to which legal norms should apply (Chandler and Levitt, 2011). According to Chandler and Levitt (2011) "Canadian tort law, applies similar negligence principles to the careless provision of goods, services and information that results in physical injury" (p.89). As a result, for the purposes of this paper the categorization of VGI either to goods, services or information is not necessary. In Sea Farm Canada Inc. v. Denton (1991), Canadian precedent was established to "treat errors in spatial data under the rules of product liability" (Chandler and Levitt, 2011). This paper will follow the stated precedent and will discuss the liability issues coming from inaccuracies in VGI under the rules of product liability, which is a sub-field of tort law (Chandler and Levitt, 2011).

A key question in liability with respect to VGI concerns whether or not data is suitable for the specific use (Chandler and Levitt, 2011, p.85) - the so-called principle of "fitness for use" (Devillers and Jeansoulin, 2006). If the users/consumers of VGI employ the data, and the data satisfies their needs, then it is likely that liability issues won't emerge. That outcome might be different if the data employed did not satisfy user needs and/or caused harm to him/her. An important question with respect to fitness for use is "... who bears the responsibility for assessing it?" (Chandler and Levitt, 2011, p.85). Organizations that employ VGI take for granted that such evaluation is within the scope of user responsibility (Chandler and Levitt, 2011; Gervais, 2006). However, this is not always the case. For example, Ontario's Consumer Protection Act (2002) states that "any attempt to contract out of statutory implied conditions and warranties applicable to goods and services provided to consumers is void" (Chandler and Levitt, 2011, p.85-86).

The following paragraphs describe three cases where reliance on maps or other spatial data caused considerable losses and/or loss of life. These cases show that usage of geographic information, including VGI, can cause significant damages. In such circumstances legal cases are likely to be raised, and with that the questions of who is liable for the tragedies happened.

Case 1: Four N.S.W. National Parks and Wildlife Service (NPWS) officers died in the operation to put down the fire. During the operation officers used maps with two possible escape routes, none of which in reality was suitable for that: one route had impenetrable bushes and the other line of cliffs (Cho, 2005). "A conclusion of the Deputy State Coroner was that the original botanical map had not been ground-truthed to include specific details and did not mark areas with safe refuges to retreat to as required in the fire management procedures guidelines" (Brown, 2011, as cited in Cho, 2005).

Case 2: In Sea Farm Canada Inc. v Denton, the plaintiff company with salmon hatchery business sued defendant engineering firm, who prepared report on which the plaintiff based its decision to buy property, which could not be used for the business due to unsuitable flood-prone land. Defendant engineer compensated the plaintiff, but sued the Ministry of Environment on the basis of negligent defects in the map that was used in his report, negligent misrepresentation, as well as failure to warn users of the map limitations of its use (Chandler and Levitt, 2011).

Case 3: Four men at Gretley Colliery, Newcastle Wallsend Coal Company Pty Ltd in New South Wales (N.S.W.), Australia drowned due to unexpected water that came from a long abandoned old working of the Young Wallsend Colliery. A plan that miners used, was approved by the N.S.W. Department of Mineral Resources (DMR) and when the matter was investigated it was discovered that the department had made the original mistake of creating the incorrect maps — "the 'fatal error' that sparked the tragic chain of events" (Cho, 2005).

From the cases described above it can be noted that authoritative GI, and VGI as one of the potential sources of such data, could lead to unintentional circumstances which can even cause loss of life. This paper describes and investigates the potential liability of private GI providers and contributors of VGI in contract and in tort.

4. Liability in Contract

Liabilities in contract are "claims based on breach of contract or warranty including implied warranties at common law, collateral warranties, and other statutory conditions" (Edgell, 2000). The contacts regarding VGI relationships can cover very many aspects, and therefore this section will only cover the general liability principles concerning VGI and liability in contract.

General principles covered in this paper relate to:
- Liability under the contract;
- Parties to the contract;
- Concept of "strict liability".

Liability arises when the norms stated in the contract are broken by any of the parties in the contract. Contractual relations with respect to VGI may arise between the following parties:
- The volunteer contributor of VGI and GI providers;
- GI providers and users/recipients of the information.

Current practice shows that contracts between the volunteer contributor and GI providers are not typically concluded. GI providers in their relationships with volunteers contributing VGI, have no practical need for a contract. By reference to the

definition of volunteer activity described above in this paper, the volunteers contribute VGI based on free will and have no obligation at the very start to contribute such data. They can continue contributing and stop when they wish.

Liability in contract does not typically arise in this relationship, since existence of the contract between these parties is precluded by the definition and perception of voluntary work. Such non-existence of any contractual relationship between GI providers and volunteer contributors to their datasets is the major characteristic that distinguishes them from other GI providers. GI providers that incorporate VGI into their datasets should consider that volunteers do not have any obligations to describe or verify the quality of GI data, and as a result, the data could be of poor quality.

In the case of the second type of relationships, i.e., between GI providers and users/recipients of GI data, the extent of liability to which a GI provider is subject is unclear. Since parties of the contract can agree on their own set of rules, including liability questions, unless those rules contradict the current law. In cases where there is no contractual agreement between the GI provider and user/recipient of such information, and the "GI provider is known to possess some special knowledge, expertise or information in the field that the recipient is likely to rely on the information, a legally enforceable duty to exercise reasonable skill and care in furnishing the information will be present" (Sookman and Tetrault, 1990).

In the event a GI provider fails to meet the standard of care under the contract, organization could be held liable for damages caused by data. In such case organizations that employ VGI in their business processes intend to diminish their liability, by indicating in a contract limitations of their data. For example, GI providers can state in a contract that data is used on the own risk of the user, and the organization disclaims any liabilities for data, or any products or services created from such data.

GI providers should also be aware of the concept of "strict liability". "Strict liability imposes liability on a manufacturer who is shown to have produced a defective product that caused the plaintiff's damages solely on the causation of damage" (Irwin Law, 2011), even though the loss was "neither intentionally nor negligently inflicted" (Linden and Feldthusen, 2011). Although there still has not been a case in Canada which incorporated the concept of 'strict liability', eventually a court case could arise before the Supreme Court of Canada, and if the Supreme Court of Canada will incorporate the strict liability concept (Pahl, 2010), this will certainly make GI providers reconsider their liability policies towards VGI.

5. Liability in Tort

"Tort Law consists of a body of rights, obligations, and remedies that is applied by courts in civil proceedings to provide relief for persons who have suffered harm from the wrongful acts of others" (Free Dictionary, 2011). Tort law in Canada is regulated by

Canadian jurisdiction excluding Quebec, which is covered by the law of obligations (Wikipedia, 2011). The law of torts provides a person who suffered harm with a means of remedies, which are not available in contract. "The torts of defamation, injuries falsehood, conversation, and nuisance have been applied as a means for obtaining compensation where the novel situation fell within well-established principles of law. While those and other torts will continue to be applied to new situations, the most versatile of the actions for obtaining redress will be an action framed in negligence" (Sookman and Tetrault, 1990). "The person who has suffered harm must be able to prove the following five legal criteria to have a chance at getting a judgment of negligence:

1. a duty of care to another person existed
2. the volunteer failed to meet the standard of a reasonable person
3. harm resulted from an act or omission
4. there was a causal connection between the act and harm, and
5. the harm must have been reasonably foreseeable." (Volunteer Alberta, 2011).

VGI volunteers usually have no duty of care to the other users. One of the arguments to support this statement is that volunteers do not know the party/parties using their information, and hence existence of duty of care is very difficult to prove. On the contrary, in other types of voluntary activities (not VGI) it might well be the case that a volunteer owns a duty of care to another person. For example, volunteers, helping in the hospitals, and being in charge of taking senior citizens to the local park have such a duty of care (Volunteer Alberta, 2011). As a result of not knowing who the users are, and their intentions in regards to data, the criteria that "harm must have been reasonably foreseeable" is also not satisfied. This however is not the case for the organizations incorporating VGI.

In Canada according to Trembley (2000) and Chandler and Levitt (2011), there are three categories of product liability which VGI could fall under:

• negligent design of a product;
• negligent manufacture of a product;
• negligent failure to warn.

One of the most common defective product claims involves negligent design. According to Barnstein (2011) the focus of this claim is that, "even if the product was in the intended condition, there was something inherently wrong with the product that caused the damage." It is a "defence to a claim of negligent design that the failed product was used for a purpose for which it was not designed" (Trembley, 2000, p. 1). Errors in VGI could be treated under the negligent design of product when data was gathered, advertised and/or disseminated as fit for the particular purpose, when in fact VGI did not satisfy the requirements for such purpose.

Errors in spatial data "that result from carelessness in gathering, processing, updating, or verifying data might be viewed as analogous to 'manufacturing' errors. Although the courts … do not tend to refer to 'manufacturing' defects, they do look at problems in the production, maintenance, and inspection of spatial data" (Chandler and Levitt, 2011, p. 91). Cassels and Jones (2005, as cited in Chandler and Levitt, 2011, p. 93) note that a design defect occurs "when … goods are manufactured properly but are unduly dangerous because of the way in which they were designed in the first place". The main cases for liability in negligent manufacture might arise when VGI incorporates wrong scale, symbology, accuracy, precision, attributes of data, and many others.

The third category of product liability law deals with "risky but nonetheless useful products" (Chandler and Levitt, 2011, p. 94). A duty to warn arises "when the goods are carefully designed and manufactured but nevertheless carry an inherent danger…. In these cases a manufacturer has a duty to provide proper instructions and warnings, and a failure to do so that results in injury may also result in liability (Cassels and Jones, 2005, as cited in Chandler and Levitt, 2011). A question of what is meant by proper instructions and warnings is discussed in the Can-Arc Helicopters Ltd. v. Textron Inc. (1991) case. In this case a helicopter which used an engine manufactured by the defendant suffered a "sudden loss of power" during the flight, and as a result, had to perform an "emergency landing". The court held that "the failure of the gear was due to its negligent manufacture" (Trembley, 2000, p.5). The defendant stated that it fulfilled its duty to warn its users, by issuing a bulletin in which this issue was addressed. The court stated that "a manufacturer is not liable to a user if it gives clear warning of, including precautious to be taken against, danger from the use of its products, and the user suffers damage by carelessly disregarding that warning and those instructions…. [nature of warning] must be adequate in that it is communicated clearly and understandably and in a manner calculated to inform the user of nature and extent of the danger …" (Trembley, 2000, p.6).

While researching on the liability in tort concerning VGI, the issue of Crown liability should be mentioned, as it has not always been consistent in the tort. Crown or governmental organizations can be providers of authoritative datasets and potentially can be distributing gathered VGI to the general public. Hence, liability could arise the same way as for providers of GI discussed in this paper. Throughout the history, the position of the Crown in tort was much different from that of its subjects (Sookman and Tetrault, 1990, p.14), on the account that Canada, when it was a colony of Great Britain, used a concept that a King (Crown) can do no wrong, and thus cannot be sued (Zehnle, 2011). This however has changed with the introduction of the Crown Liability and Proceedings Act (1985), which stated that the Crown is liable as "if it were a person, it would be liable for", moving it under the law of negligence (Sookman and Tetrault, 1990, p.14). As a result, if the Crown or a governmental organization incorporates VGI into their datasets, and "… make the information available to general members of the public, it is not likely that there will be Crown immunity…." (Sookman and Tetrault, 1990, p.14). However this may not apply if the harm was caused by the data compiled by a governmental organization before the Crown became subject to tort liability.

Liabilities in tort for VGI most likely arise in organizations that incorporate VGI into their datasets, and not to volunteers of VGI. Such risk is present from a failure to warn users about the quality of VGI. As in most cases, metadata describing the quality of VGI does not accompany the product, and users do not have any reference to quality of GI. In order to minimize and/or reduce liability, organizations which incorporate VGI into their datasets should design and follow liability risk management techniques (Martinez, 2003). The following section describes a number of the most important liability risk management techniques which, if incorporated, reduce the chances of having to face liability court cases.

6. Liability Risk Management Techniques

Different organizations manage their liability risks differently (Graff, 2003; Martinez, 2003; McCurley and Lynch, 1996). Based on the information described in this paper, four primary risk management techniques are recommended to GI providers in order for them to manage their liability risk concerned with the use of VGI. The following risk management techniques are summarized in Table 1 – VGI Risk Management Techniques:

No.	Name of Risk Management Technique	Description
1	Identification of Possible Risks	- risk management team - identification and risk ranking - likelihood of occurrence - minimize/reduce risks - application - testing
2	Quality Assurance Procedures	- overlaying with other spatial datasets - satellite / aerial imagery - rating / feedback system
3	Disclaimers in Contract	- liability disclaimer - consultation with experts
4	Duty to Warn about Quality	- duty to warn about VGI quality before use - duty to warn about VGI quality after use

*Table 1.*VGI Risk Management Techniques
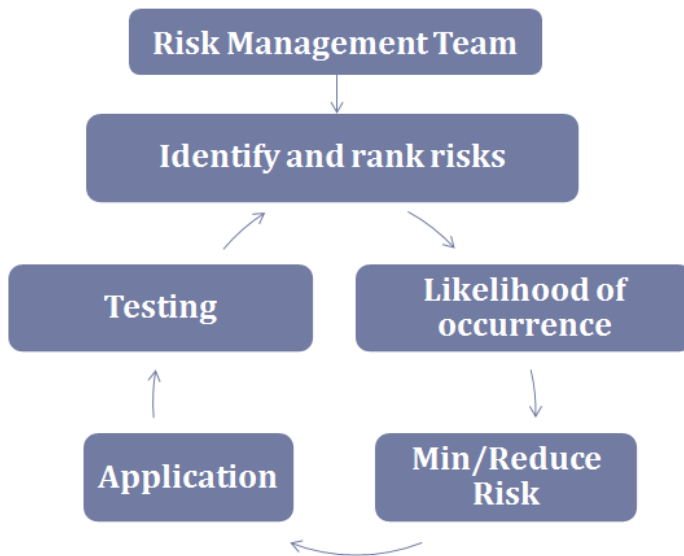
Figure 1. Identification of possible risks

If an organization decides to develop and identify only a few, important risks, there is a chance that more important issues will be omitted due to the fact that not enough time has been devoted to this step (Safritt *et al.,* 1995; Tremper and Kostin, 1993). On the contrary if "a list includes every conceivable risk imaginable [it] is almost as useless as having no risk at all" (Martinez, 2003). GI providers should set up an applicable risk management process to reduce the liability concerns surrounding implementation of VGI, comprising of the following steps:

- ✓ develop a risk management team;
- ✓ identify and rank appreciable risks;
- ✓ evaluate likelihood of risk occurrence against the magnitude of harm; (Martinez, 2003)
- ✓ develop processes/stages to minimize/reduce the most important risks;
- ✓ apply them to identified risks;
- ✓ perform regular checks on samples of data, to verify if risks are still there;
- ✓ continuous identification of new risks.
- • Constant focus on quality assurances of GI, including incorporated VGI. The GI organization can employ existing techniques to check the quality of contributed spatial data such as checking VGI quality against trusted datasets and/or their own, overlaying VGI data on top of aerial/satellite imagery, usage of rating/feedback system which enables expert users in the community to provide feedback concerning the contributed VGI. The GI providers should devote their time and resources to check for VGI quality;

- Usage of disclaimer in the contract. GI providers cannot completely limit and restrict its liability in the contract from all possible damages the use of VGI can bring (Chandler and Levitt, 2011). In the view that VGI can be used in various and unpredictable ways to serve different purposes of users, the GI providers can indicate in the contract or liability disclaimer that before using VGI the user should consult with the expert and/or GI provider if such data can be used for intended purpose (Chandler and Levitt, 2011).
- Inclusion of duty to warn about quality of VGI. As pointed out by Chandler and Levitt (2011), as a minimum the GI provider should always exercise a duty to warn the user/receiver of the information on the quality of the data and indicate any limitations that might come with it. The liability disclaimer should clearly point out that the volunteered information is to be used only for certain purposes, or be employed at the user's own risk (Club TomTom, 2007). It is preferable to indicate disclaimers not only when data is downloaded from the website or other source by the user, but constantly have a communication process between GI provider and the user (Chandler and Levitt, 2011). The organization should keep contact details of their users, at a minimum an e-mail address, to be able to warn users of any new risks or known errors concerned with the use of VGI, which might not have been discovered at the earlier time.

7. Conclusions

"The question of whether GI providers who incorporate VGI and volunteers who donate their time and services to those organizations should be held liable for tortious conduct is, and will remain, a controversial subject" (Martinez, 2003). At present there are no laws, statutes and/or legal cases that would state/describe volunteer responsibilities while performing VGI related activities. In the absence of such legal norms it is proposed that contributors of VGI should follow all legal rules, both federal and provincial, just if they were conducting any other activity (Volunteer Alberta, 2011).

In this paper we have reached a conclusion that VGI falls under the definition for voluntary activity and hence receives all its main characteristics. It is preferable that the Government of Canada and provincial governments should introduce appropriate legislation to govern legal relationships that arise in voluntary activities in respect to VGI, in order to limit the liability of the GI providers and volunteers contributing information to promote use of VGI.

To enjoy and develop a productive spatially enabled society, a broader use and integration of VGI with authoritative datasets is necessary. VGI provides a vast source of spatial information to government, industry and citizens. In the absence of the legislation governing VGI and lack of research in the sphere of liability concerns surrounding VGI, in this paper we have tried to extensively include available risk management techniques that can be used by GI providers. The techniques identified in

the paper include: implementing a risk management process, constant focus on increasing quality and performing quality checks on VGI, advising users not to use VGI without prior consultation with expert and/or GI provider to identify fitness for the purposes, and always exercise obligation on duty to warn about quality and limitations of VGI.

References

Ball, M., (2010), What's the distinction between crowdsourcing, volunteered geographic information, and authoritative data?, V1 Magazine, Retrieved 10/02, 2011, from http://www.vector1media.com/dialog/perspectives/16068-whats-the-distinction-between-crowdsourcing-volunteered-geographic-information-and-authoritative-data.html

Barnstein, S., (2011), Negligent product design, The Sam Barnsterin Law firm. Retrieved 11/10, 2011, from http://www.callsam.com/michigan-personal-injury-cases/defective-products/negligent-product-design

Bishr, M., and Mantelas, L., (2008), A trust and reputation model for filtering and classifying knowledge about urban growth, GeoJournal, Vol. 72(3-4), pp. 229-237.

Brown, M., (2001), Maps led firefighters up paths with no exits, The Sydney Morning Herald, pp. 1-2.

Budhathoki, N. R., Bruce, B., and Nedovic-Budic, Z., (2008), Reconceptualizing the role of the user of spatial data infrastructure, GeoJournal, Vol. 72(3-4), pp.149-160.

Can-Arc Helicopters Ltd. v. Textron Inc. C895167 1 (BCSC 1991).

Cassels, J., and Jones, C., (2005), The law of Large-Scale Claims: Product Liability, Mass Torts, and Complex Litigation in Canada, Toronto:. Irwin Law.

Chandler, J. A., and Levitt, K., (2011), Spatial Data Quality: The duty to warn users of risks associated with using spatial data, Alberta Law Review, Vol. 49(1), pp.79-106.

Cho, G., (2005), Geographic information science: Mastering the legal issues, Australia:. John Wiley & Sons Ltd.

Club TomTom., (2007), Get to know MapShare™, The official blog for TomTom in North America. Retrieved 05/15, 2011, from http://www.clubtomtom.com/general/get-to-know-tomtom-mapshare™

Coleman, D. J., Georgiadou, Y., and Labonte, J., (2009), Volunteered Geographic Information: the nature and motivation of produsers, International Journal of Spatial Data Infrastructures Research, Vol. 4, pp.332-358.

Coleman, D. J., Sabone, B., and Nkhwanana, N., (2010), Volunteering Geographic Information to Authoritative Databases: Linking Contributor Motivations to Program Effectivness, Geomatica, Vol. 64(1), pp.383-396.

Consumer Protection Act, c 30 (2002).

Crown Liability and Proceedings Act, RSCU.S.C. c-50 (1985).

Devillers, R., and Jeansoulin, R., (2006), Fundamentals of spatial data quality (1st ed.). Wiley Online Library.

Edgell, D. F., (2000), Product Liability Law in Canada, Markham: Butterworths.

Elwood, S., (2008), Volunteered geographic information: future research direction motivated by critical, participatory and feminist GIS, GeoJournal, Vol. 72(3), pp.173-183.

Flanagin, A. J., and Metzger, M. J., (2008), The credibility of volunteered geographic information, GeoJournal, Vol. 72(3-4), pp.137-148.

Free Dictionary (2011), Tort Law, Retrieved 11/13, 2011, from http://legal-dictionary.thefreedictionary.com/Tort+Law

Gartner, G., Bennett, D. A., and Morita, T., (2007), Towards ubiquitous cartography, Cartography and Geographic Information Science, Vol. 34(4), pp.247-257.

Gervais, M., (2006), On the Importance of External Data Quality in Civil Law, Fundamentals of Spatial Data Quality, in Devillers & Jeansoulim, pp.283-300.

Goodchild, M. F., (2007), Citizens as sensors: The world of volunteered geography, GeoJournal, Vol. 69(4), pp.211-221.

Goodchild, M. F., (2008), Commentary: Whither VGI? GeoJournal, Vol. 72(3-4), pp.239-244.

Goodchild, M. F., (2009), NeoGeography and the nature of geographic expertise, Journal of Location Based Services, Vol. 3(2), pp.82-96.

Graff, L., (2003), Better safe: Risk management in volunteer programs and community service. Ontario: Linda Graff & Associates.

Huntington, H. P., (2000), Using Traditional Ecological Knowledge in Science: Methods and Applications, Ecological Applications, Vol. 10(5), pp.1270-1274.

Inter-Parliamentary Union, International Federation of Red Cross and Red Crescent Societies and United Nations Volunteers. (2004), Volunteerism and Legislation: A Guidance Note, Retrieved 05/02, 2011, from http://www.ipu.org/PDF/publications/volunteer_en.pdf

Irwin Law. (2011), Canadian Online Legal Dictionary, Retrieved 11/02, 2011, from http://www.irwinlaw.com/cold

Linden, A. M., and Feldthusen, B., (2011), Canadian Tort Law (9th ed.). Canada:. LexisNexis Canada.

Martinez, J. M., (2003), Liability and volunteer organizations: A survey of the law, Nonprofit Management and Leadership, Vol. 14(2), pp.151-169.

McCurley, S., and Lynch, R., (1996), Volunteer Management: Mobilizing All the Resources of the Community, Downers Grove, Ill.: Heritage Arts.

OpenStreetMap. (2011a), Retrieved 05/25, 2011, from http://www.openstreetmap.org/stats/data_stats.html

OpenStreetMap. (2011b), The Free Wiki World Map, Retrieved 05/25, 2011, from http://www.openstreetmap.org/

Pahl, V. J., (2010), Strict Liability in Canadian product liability law: where have we been and where are we going? Retrieved 11/02, 2011, from http://www.guildyule.com/cms/images/M_images/pdf/briefing/vjp%2520paper.pdf

Rajabifard, A., Crompvoets, J., Kalantari, M., and Kok, B., (Eds.). (2010), Spatially enabled societies, Spatially Enabling Society: Research, Emerging Trends and Critical Assessment. Belgium: Leuven University Press.

Safritt, D., Merrill, M., and Nester, N., (1995), A High Stakes Affair: Managing Risks in Volunteer Programs, Columbus: Section of Communication and Technology, Ohio State University Extension.

Sea Farm Canada Inc. v. Denton, C881677 1 (BCSC 1991).

Sieber, R., (2007), Geoweb for social change, Retrieved 05/26, 2011, from http://www.ncgia.ucsb.edu/projects/vgi/supp.html

Sookman, B. B., and Tetrault, M., (1990), Liability of Geographic Information Systems Provider in Contract and Tort, The Ontario Land Surveyor, pp.10-16.

Statistics Canada. (2006), Caring Canadians, involved Canadians: Highlights from the 2004 Canada survey of giving, volunteering, and participating, Retrieved 11/07, 2011, from http://www.givingandvolunteering.ca/files/giving/en/csgvp_highlights_2004_en.pdf

Sui, D. Z., (2008), The wikification of GIS and its consequences: Or Angelina Jolie's new tattoo and the future of GIS, Computers, Environment and Urban Systems, Vol. 32(1), pp.1-5.

Tilly, C., and Tilly, C., (1994), Capitalist Work and Labor Markets, In Handbook of Economic Sociology, pp.283-313.

Titus, T., (2011), Design and Implementation of a Coastal Collaborative GIS to Support Sea Level Rise and Storm Surge Adaptation Strategies. (Unpublished MScE). Department of Geodesy and Geomatics Engineering, University of New Brunswick, Fredericton, Canada.

Trembley, T. B., (2000), Product Liability Law in Canada, Pmlaw.

Tremper, C. R., and Kostin, G., (1993), No Surprises: Controlling Risks in Volunteer Programs, Nonprofit Risk Management Center.

Turner, J. A., (2007), Introduction to Neogeograph, Sebastapol, CA: O'Reilly Media. Retrieved 05/25, 2011, from http://books.google.ca/books?hl=en&lr=&id=oHgDv4feV-8C&oi=fnd&pg=PA2&dq=neogeography&ots=wXt2WFYXeV&sig=QzH-RzLHCs65l9KFRUxPy8WQ-2Q#PPA1,M1

Volunteer Alberta. (2011), Volunteeres and the law in Alberta, Volunteer Alberta: connecting the nonprofit organization. Retrieved 11/07, 2011, from http://www.volunteeralberta.ab.ca/vollaw/volunteeer/sources.html

Wikimapia. (2011a), Retrieved 05/25, 2011, from http://wikimapia.org/

Wikimapia. (2011b), New Year 2011, Retrieved 06/10, 2011, from http://blog.wikimapia.org/

Wikipedia. (2011), The Free Encyclopedia, Retrieved 05/15, 2011, from http://www.wikipedia.org/

Wilson, J., and Musick, M., (1997), Who cares? Toward an integrated theory of volunteer work, *American Sociological Review,* Vol. 62(5), pp.694-713.

Zehnle, R., (2011), Sovereign Immunity Still Protects the Government from Liability, Architects and Engineers for 9/11 truth. Retrieved 11/20, 2011, from http://www.ae911truth.org/en/news-section/41-articles/437-king.html

Model for Assessing GIS Maturity of an Organization

Jaana Mäkelä

Aalto University School of Engineering

jaana.makela@aalto.fi

Abstract

A GIS maturity model can be used as a tool to evaluate how mature an organization is in utilising spatial data in its businesses. A new GIS maturity model was developed in cooperation with the SDI utilization working group of the Finnish National Inspire Network to reinforce spatially enabled industry and government at different administrative levels. The model takes comprehensive account of the internal SDI of the organization, its processes and services in which spatial data could be used, and capabilities such as leadership, the communication of spatial data, and both internal and external cooperation. Three cities, a state institute, and a private company assessed their GIS maturities with the new model and gave feedback about the usability of the model. The results of the assessments highlight both the strengths and the weaknesses of spatial data utilization in organizations and that the development of competence in all key areas is still needed.

KEYWORDS: GIS, maturity model, assessment, SDI, SWOT

1. Introduction

The GIS maturity of an organization indicates the capability and readiness of an organization to utilize spatial data to reach its business objectives. Like a society, an organization too is spatially enabled when spatial data are used widely in its businesses and processes to improve efficiency and to encourage creativity and product development (Rajabifard, 2010). According to the report of the Finnish Business and Policy Forum (EVA), "Finland is no longer at the cutting edge of the development of the information society". We need a productivity jump both in the public and in the private sector. New effective customer-centred online services and ways of working are the tools to tackle the challenges caused by the financial crisis and an aging population (Turkki, 2009). Despite the fact that the role of spatial data and

spatial solutions in increasing productivity can be significant, the full potential of the exploitation of spatial data is still far from being reached in many organizations (Mäkelä *et al.,* 2010). Even if the organizations would like to increase their competence to utilize spatial data in their businesses, it is not always clear which subjects of development are worth investing in. In this state of affairs, a GIS maturity model can be used as a tool to assess the current state of competence, to set a roadmap for organizational improvement, and to assess the effects of development.

The GIS maturities of the organizations that use spatial data are not only an internal matter of these organizations but also highlight the organizations' capability to benefit from a national spatial data infrastructure (NSDI) and direct needs to the development of the NSDI (Mäkelä *et al.,* 2010). Therefore, the GIS maturity of user organizations could be used as one measure when the success of the implementation of an NSDI is being evaluated. In that case, the user organizations should assess their GIS maturities by means of a common maturity model. The SDI utilization working group of the Finnish National Inspire Network and Aalto University commenced a research project in 2010 in order to develop a generic GIS maturity model that would benefit both public organizations and private companies. A preliminary idea was that the model would be implemented later as an open Web application.

The Capability Maturity Model (CMM) introduced at Carnegie Mellon University in 1991 (Paulk et al., 1994) was one of the first maturity models and was developed to improve software development processes. Since then maturity models have been built up to help both private companies and public agencies to improve their ability, for instance in project management, knowledge management, product development, risk management, or in the utilization of information technology or geographic information systems (Rezvani, 2008). The structures of the maturity models are quite similar. A maturity model usually contains five maturity levels, of which the first and lowest level is often called ad hoc or initial. When the organization matures, it can reach, if this is set as a target, the fifth and highest level, which is often called optimized (Paulk *et al.,* 1994; Dalkir, 2005; Lance, 2006; Rezvani, 2008; Babinsky, 2009).

The structure of a maturity model typically has key areas, also called key components or focus areas, and their sub-areas over the five levels (Paulk *et al.,* 1994; *Crawford et al.,* 2002; Kohlegger *et al.,* 2009). The most critical areas for the improvement of the organization must be identified and included in the model. Generally, the areas cover technical, social, and/or management sections. In the development of IT or GIS maturity, attention should be paid to the technical infrastructure, but additionally the role of organizational culture and strong management support should also be emphasized (Paulk *et al.,* 1994; Masser *et al.,* 1996; Somers 1998; Chan *et al.,* 2000; Mäkelä *et al.,* 2010). Usually, at the lowest levels of IT maturity models, the focus is on technology and the internal operations of an organization. At the highest levels, the focus is on business productivity and customers (Coriale, 2007; Moorman, 2010). Every individual's competence and active role in an organization is essential when the organization wants to achieve the highest maturity levels (Senge, 1990; Auer, 1994; Kok *et al.,* 2005). In particular, commitment and a strategic approach on the part of

the management to the development of maturity are essential. Innovation is ignored in several maturity models because it is perceived as a feature of private companies. In the CMM, innovation appears only at the highest maturity level (Paulk *et al.,* 1994).

Mäkelä *et al. (*2010) introduced a competence management model that aims at enhancing the GIS maturity of an organization. According to Mäkelä *et al.* (2010), the main components of the model, internal structures, human capital, and external structures, should be taken into account when GIS maturity is being developed. These components have been taken into account in the Local Agency GIS capability maturity model (GIS CMM) that was developed by the Association for GIS Professionals (URISA) (Babinsky, 2009). The model emphasizes the role of a GIS unit. The National Geospatial Advisory Committee has expressed its interest in using GIS CMM as a metric for the NSDI (Babinsky, 2010).

Maturity models have been criticized for not describing how to perform the required development activities effectively and it has been said that they are often inefficient for small and medium-sized companies (Mettler *et al.,* 2009). Another limitation is that maturity models often only represent a static view of an organization.

Other approaches which are close to maturity models are the multi-view frameworks that are used to assess the readiness of SDIs (Fernandez *et al.,* 2005, Grus *et al.,* 2009, Longhorn, 2009, van Loenen *et al.,* 2008). They focus on the maturity of SDIs at the national or local level and provide useful tools for assessment. The idea of a maturity level is not always implemented into these frameworks but they can be flexible, permitting continual changes (Grus *et al.,* 2008, van Loenen *et al.,* 2008). The basic components of these frameworks usually incorporate human and financial resources, standards, technologies, data sets, and policies. Further, a recommendation of integrated information systems architecture that has an impact on GIS maturity has been published to enhance eGovernment interoperability and to promote the development of the Finnish information society (Ministry of Finance, 2010). It describes four viewpoints: information, technology, information systems, and business processes as a functional entity, and guides the use of information technology in the whole organization.

Despite the flaws, the possibility of contributing to a spatially enabled society through maturing organizations encouraged us to proceed with the development of the new GIS maturity model. The main objective of the research was to develop a tool which both public and private organizations that use spatial data could utilize when they develop their competence to use spatial data. During the study five organizations assessed their GIS maturities by using the model and gave feedback. This paper, for its part, seeks to discern which components should be included in a GIS maturity model so that the model supports the comprehensive development of organizational maturity. Further, how can these components be recognized and how robust is the content of the maturity levels? Not much has been reported in the literature on how to develop a maturity model and how appropriate the assumptions are on which the model is based (Kohlegger *et al.,* 2009, Mettler *et al.,* 2009). This encouraged us to

present not only the new GIS maturity model but also the predefined development process of the model.

The rest of the paper is organized as follows. Section 2 explains the development process of the GIS maturity model. The structure and the detailed content of the new model are described in Section 3. Section 4 introduces results from the maturity assessments and evaluation of the new model. Discussion about the results is provided in Section 5 and the conclusions from the research are presented in Section 6.

2. Development Process of the GIS Maturity Model

The starting point for the development of the new GIS maturity model was that the model should highlight the opportunities that user organizations have at present or will have in the near future. Spatial data infrastructures, for example, have opened up new possibilities by facilitating the discovery, acquisition, and evaluation of spatial data for potential users. The influence of limiting factors, such as technology, that existed during the development of previous GIS maturity models does not have such an important role any more. Therefore, the new model should emphasize other important factors, such as the capabilities of an organization, but should not neglect the technical infrastructure.

The SDI utilization working group started a development process (Figure 1) in order to create a comprehensive GIS maturity model. The members of the SDI utilization working group represented organizations such as the cities of Helsinki, Espoo, Vantaa, Tampere, Turku, Hyvinkää, and Naantali, the Finnish Transport Agency, Geological Survey of Finland, Finnish Environment Institute, Ministry of the Interior, National Consumer Research Centre, CSC – IT Centre for Science, and National Land Survey of Finland.

As the first step, challenging goals for the model were set. The new model should serve both public and private organizations that use spatial data, and if found usable it could function as one measure of the development state of NSDI. Therefore, in the second step the theory of organizational maturity and different GIS and IT maturity models were studied at Aalto University. The members of the working group were instructed in the essentials of the theory of maturity.
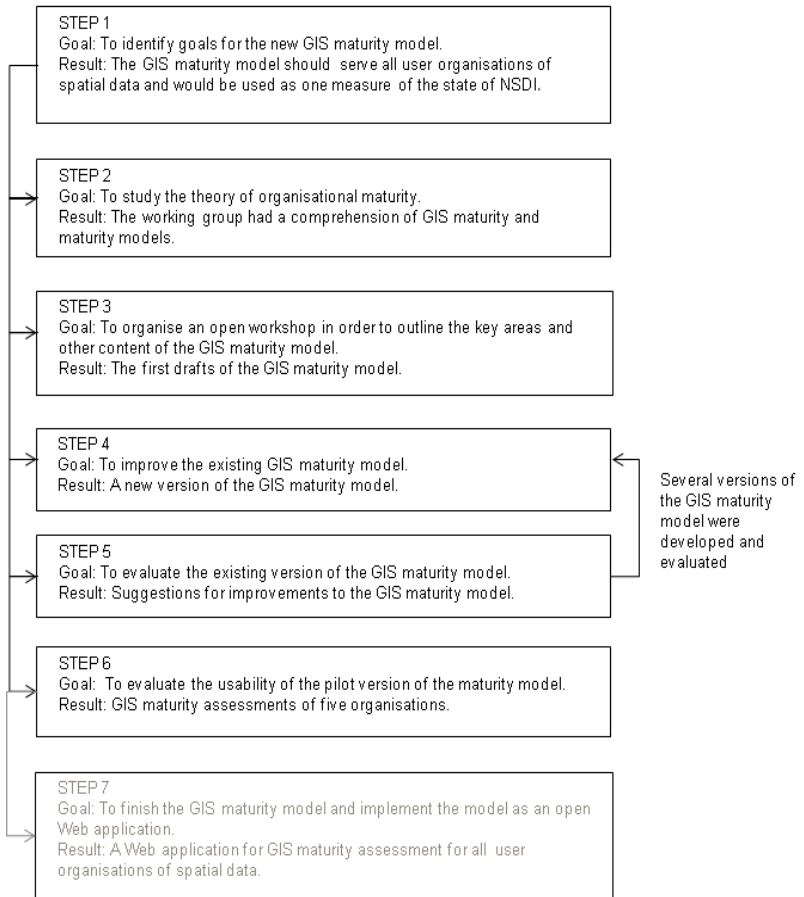
STEP 1
Goal: To identify goals for the new GIS maturity model.
Result: The GIS maturity model should serve all user organisations of spatial data and would be used as one measure of the state of NSDI.

STEP 2
Goal: To study the theory of organisational maturity.
Result: The working group had a comprehension of GIS maturity and maturity models.

STEP 3
Goal: To organise an open workshop in order to outline the key areas and other content of the GIS maturity model.
Result: The first drafts of the GIS maturity model.

STEP 4
Goal: To improve the existing GIS maturity model.
Result: A new version of the GIS maturity model.

STEP 5
Goal: To evaluate the existing version of the GIS maturity model.
Result: Suggestions for improvements to the GIS maturity model.

Several versions of the GIS maturity model were developed and evaluated

STEP 6
Goal: To evaluate the usability of the pilot version of the maturity model.
Result: GIS maturity assessments of five organisations.

STEP 7
Goal: To finish the GIS maturity model and implement the model as an open Web application.
Result: A Web application for GIS maturity assessment for all user organisations of spatial data.

Figure 1. Steps of the development process of the GIS maturity model

The original objective was to apply a top-down approach in the development of the model so that first, the number of maturity levels and their names and the headings of the key areas and their sub-areas would be defined. Second, the detailed contents of the sub-areas over all maturity levels would be completed.

In the third step the National Inspire Network organized an open workshop in order to gain experts' viewpoints on the key areas and other content of the GIS maturity model. In the workshop, the theory of GIS maturity was first briefly introduced. After its introduction, the participants were divided into two groups to discuss the content of the maturity model. As a result, suggestions for key areas and some other content were drafted. One group named processes, competence, data infrastructure, information technology, leadership, and networking as important key areas. The other group found communication, cooperation, processes, resources, and spatial data services to be important areas that should be included in the maturity model.

The workshop produced two preliminary drafts of the GIS maturity model but they still lacked much content. Therefore, in the fourth step the SDI utilization working group continued the development of the model. At a meeting the members described barriers that prevent the comprehensive utilization of spatial data in their own organizations. The barriers were grouped under the key areas that were defined in the earlier workshop in order to outline the sub-areas of the maturity model. Figure 2 represents the results of the meeting of the working group. The key area cooperation includes both internal cooperation and external cooperation and also networking. After the meeting the contents of the GIS maturity model – sub-areas and the detailed content of each maturity level – were developed further at Aalto University.
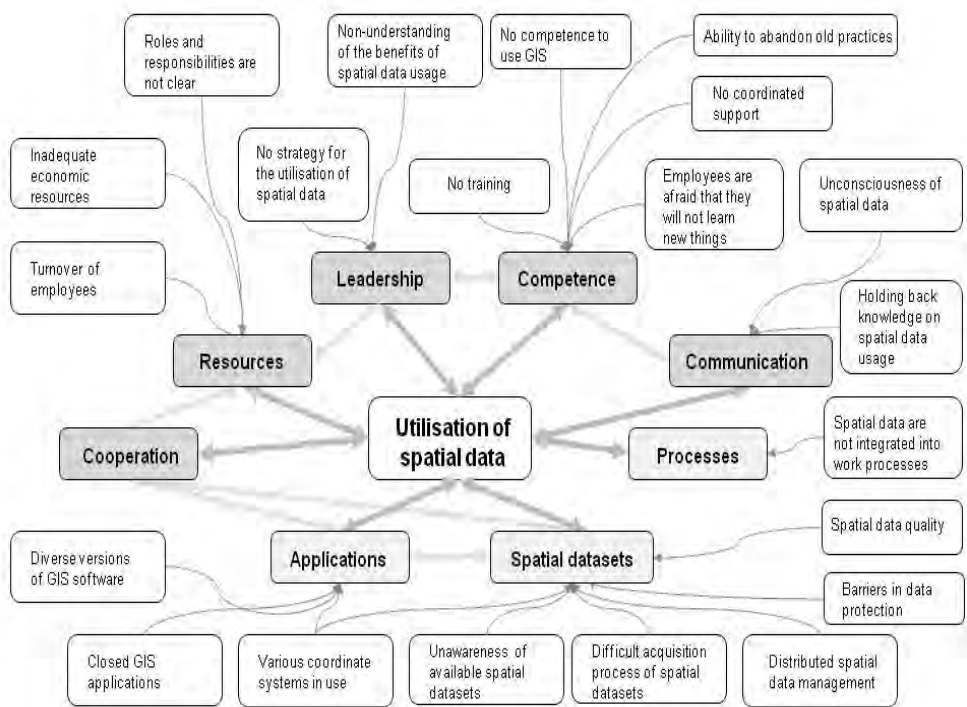

Figure 2. Barriers to the utilization of spatial data in an organization

During the second development round of the model, the results from a large survey were taken into account. The survey was carried out by the SDI utilization working group and studied the current status of spatial data utilization in the public administration in Finland (Mäkelä *et al.,* 2011). Eighty-six organizations that took part in the survey listed success factors that enable or would enable spatial data to be utilized comprehensively in their organizations. The most important factors were leadership and organizational culture, including the commitment of management, the motivation and competence of staff, the improvement of communication, and the

development of coordination. Other important factors were suitable spatial data sets, appropriate tools, and efficacious cooperation with stakeholders. The results of the survey supported the viewpoints of the participants of the workshop and of the meeting of the working group.

In the fifth step, members of the SDI utilization working group and other experts from spatial data user organizations provided their comments on each new version of the GIS maturity model. When both the Management Board of the National Inspire Network and the SDI utilization working group had approved the last version of the model, it was ready for practical evaluation. In the sixth step, five organizations assessed their GIS maturities and evaluated the usability of the model. Three large cities, a state institute, and a large private company were eager to assess their GIS maturities in order to identify sub-areas for the development of their GIS maturity. The coordinators of the organizations were primed for the assessment process. First, each organization defined whether it is a mechanistic, organic, or dynamic organization (Mäkelä *et al.,* 2010). The purpose of the definition was to find out how the types of organizations and maturity levels correlate with each other. Second, they performed a SWOT analysis of their spatial data utilization. A SWOT analysis identifies the internal strengths and weaknesses and external opportunities and threats of the organization. One goal of the SWOT analyzes was to find out what kinds of strengths and weaknesses the organizations would highlight and whether these exist in the maturity model. The other goal was to analyze whether the results of the SWOT analyzes are consistent with the assessed maturity levels. Third, they made a pre-assessment of their maturity level. The idea of the pre-assessment was to discern the reliability of the assessment of the maturity level when it is performed by using for each maturity level only the four key definitions that best describe the characteristics of that level. If the maturity values of the pre-assessment were close to the actual maturity values, the pre-assessment method could possibly be used in "discount maturity evaluation" (Nielsen, 1994, 2009) of a spatially enabled society, especially when rapid and cost-effective results are needed. Fourth, the organizations performed a detailed maturity assessment by using the new maturity model. The coordinators of the organizations reported the final results of the maturity assessment by using the research form. Step 7 has not been executed yet.

3. GIS Maturity Model

The new GIS maturity model has five maturity levels and an additional innovativeness level, and three key areas and their sub-areas. Table 1 shows the structure and content of the GIS maturity model. The maturity levels are as follows:

Level 1 – Decided case-specifically: spatial data are used but the ensemble is disjointed and does not assume a coherent form.

Level 2 – Separately governed in each branch: spatial data are used in certain branches but the ensemble does not work yet.

Level 3 – Concentratedly coordinated: the use of spatial data is coordinated but the organization is not yet able to react to exceptional cases.

Level 4 – Comprehensively managed: evaluation of the use of spatial data provides information about problems and subjects that need development but the information does not always end in action.

Level 5 - Strategically optimized: concrete measures from the evaluation guide the development of the use of spatial data towards strategic goals.

Innovativeness as a part of GIS maturity: the organization is agile and is quick to utilize the new possibilities offered by spatial data sets and spatial technology. The organization is also ready to take conscious risks that are related, for example, to the life cycle of solutions. The capability to utilise spatial data in developing new products, services, or processes or to improve existing ones is important. One way to tackle the financial crisis is to innovate clearly more effective ways of working. This also challenges public sector organizations to make changes to their established ways of serving citizens, for example by introducing new online services. Even if the new services are provided by private companies, it is important that the ideas for change arise from the employees of public organizations.

The following key areas and their sub-areas are considered for each maturity level.

Architectures: the area encompasses the three viewpoints of integrated information systems architecture: information, information systems, and technology. The sub-areas are *spatial datasets*, *GIS software and applications,* and *technologies that support the use of spatial data*. This key area takes into account acquisition and management, discovery and fitness for use evaluation, and the availability of spatial data sets to potential users and thus constitutes the organization's spatial data infrastructure. Appropriate GIS tools, as well as the flexible use of technologies such as desktop, internet, and mobile technology support the utilization of spatial data.

Services and processes: this is the fourth viewpoint of integrated information systems architecture. It describes the role of spatial data both in the organization's *internal core processes*, such as target market planning or the planning of school districts, depending on the mission of the organization, and in *customer services or solutions*. Internet solutions such as a journey planner and service map for citizens are examples of customer services. Spatial data can also be used in the organization's internal *support services or processes*, such as in document or content management.

Capabilities: the organization's internal capability consists of *the management's understanding and commitment*, skilful employees, the continuous *communication* of the possibilities and benefits of the use of spatial data, and *internal cooperation* between people from different branches. *The organization's external networking capability* means active cooperation with stakeholder groups and decision makers at the local and national levels. The model also emphasizes the importance of

cooperation between the public administration, universities, and private companies and the choice of strategic partners in the development of spatial data utilization. This seems to be a prerequisite for new innovations. Because an organization is comprized of individuals, their capabilities, such as *technical competence* to use spatial data and their will to share their knowledge with others, are an essential part of maturity. In the maturity table the individual's role competence means her or his commitment and personal contribution to an increased use of spatial data.

The content of the GIS maturity model developed remarkably during the process. According to the experts, the first two versions of the model were insufficiently challenging. Therefore, the objectives, especially in the maturity levels from three to five, were set to be demanding and they partly reflect the future possibilities for improvement.

Key areas	Subareas	LEVEL 1 Decided on a case-specific basis	LEVEL 2 Separately governed in each branch	LEVEL 3 Concentratedly coordinated	LEVEL 4 Comprehensively managed	LEVEL 5 Strategically optimised	INNOVATIVENESS AS A PART OF GIS MATURITY
ARCHITECTURES	Spatial data sets						
	- Acquisition and management of spatial data sets	Spatial data needs are solved and data acquired case by case. Discrete spatial data management systems.	Spatial data sets are acquired branch by branch. Spatial data management systems serve only the individual needs of each branch.	The multiplicity of purposes of spatial data has been recognized. The acquisition and the concentrated management of spatial data is coordinated.	The operating mode of the organisation enables unhampered real-time use to be made of both the internal and the external spatial data sets.	Spatial data are a part of the organisation's common data warehouse.	The organisation utilizes new alternative spatial data sets such as Google Maps, 3D models, and remote sensing data.
	- Discovery and fitness for use evaluation of spatial data sets (metadata, data quality)	A metadata service that helps the user to discover spatial data sets does not exist. Only the "owner" of the spatial data sets can help the user to discover the data set. Metadata and quality information of single data sets are available simultaneously.	Branch-specific decisions are made on spatial data discovery service that is based on metadata. Metadata also include data quality information. Users get an automatic information about new and updated data sets on the basis of their profiles.	The organisation has a concentrated spatial data discovery service that is based on metadata. Metadata also include data quality information. The data sets also meet certain data quality criteria to ensure interoperability.	Spatial data sets that are acquired must include metadata and information on data quality. The data sets must also meet certain data and fitness for use evaluation services for spatial data are available for data users.	User demanded ontology-based discovery services for risks that arise, for example, from the data quality.	The organisation develops new spatial data products and services. In the development the organisation takes conscious risks that arise, for example, from the data quality.
	- Availability of spatial data sets to use (right to use, standards, data protection)	Standards are not used to improve spatial data use.	Spatial data sets have limitations on rights to use. Rights to use spatial data sets are limited to the branch that "owns" the data sets.	Spatial data sets can be used in applications through standard interfaces from internal and external data services.	Organisation-wide rights to use spatial data sets enable all potential users to use organisation's spatial data sets and data services flexibly through standard interfaces.	Data protection does not hinder the integration and analysis of business information and spatial data. Stakeholder groups are able to use the organisation's spatial data sets and data services flexibly through standard acquisition from web services is possible.	The organisation utilises smart verification and payment systems such as spatial analyses, 3D modeling, and new data projections for future use.
	GIS software and applications	GIS software needs are solved project by project.	Branch-specific GIS software products. The interfaces between GIS and other internal information systems have been developed branch-specifically.	GIS software acquisition is coordinated.	All users have GIS tools based on their user profiles.	Spatial functionalities have been integrated into the organisation's core interfaces.	The organisation tests and evaluates new GIS applications such as spatial analyses, 3D modeling, and new data projections for future use.
	Technologies that support the use of spatial data	Desktop GIS is used.	Single mobile and Internet GIS applications are used.	The technologies that support spatial data use integrate into a functional whole (desktop, Internet, mobile). Server technology supports concentrated spatial data management.	The technologies that are used are flexible and convert to new GIS application fields.	Architectures such as Service-Oriented Architecture (SOA) and cloud computing support the integration of GIS applications and business applications (for example, ERP and CRM).	The organisation wants to improve its performance and get a competitive advantage by searching for weak signals and future trends and by utilizing new technologies that promote the utilization of spatial data.
SERVICES AND PROCESSES	Spatial data in customer services and solutions	Spatial data are used case-specifically in some customer services or solutions. For example, spatial data are used as a background map in information services.	Spatial data are used systematically in some customer services and solutions of a certain branch.	Those central customer services and solutions in the organisation where spatial data are utilized or could be utilised have been identified and documented.	Spatial data are an essential part of interactive e-services for customers/consumers/citizens. The effect of spatial data on the service level of customer services is evaluated. The impact of spatial data on customer services is evaluated on the basis of customer feedback.	The role of spatial data in customer services and solutions is developed on the basis of facts from evaluation.	The organisation is agile and is able to react to customer needs and to develop new spatial data-based solutions. The organisation also takes into account the possibilities that social media give rise to.
	Spatial data in internal core processes	The significance of spatial data in the organisation's core processes has been partly recognized. The utilization of spatial data is sporadic and reactive.	Spatial data are utilised in certain established processes.	Those central core processes where spatial data are utilised or could be utilised have been identified and documented.	The impact of spatial data on the quality of work and the efficiency of work spatial data has been identified as being measured.	Spatial data are an automatic part of all those core processes where the use of spatial data has been identified as being useful.	Forward-looking spatial data analyses are integrated into decision-making processes. These analyses are, for example, risk analyses that help to minimize risks in decision making.
	Spatial data in support processes and services	Support services do not contain spatial data or spatial functionalities.	The role of spatial data in support services varies from branch to branch.	Those organisational support services that can benefit from spatial data and spatial functionalities have been identified and documented.	Spatial data have been productized as a part of support services.	Spatial data are a part of support services that are common to all employees.	Users help to develop support service processes.

Table 1. The GIS maturity model: The key areas and their subareas for each maturity level.

CAPABILITIES				
Internal capabilities of organisation				
- Leadership	An employee skilled in the use of spatial data is not a critical resource. When he leaves the organisation a substitute is not employed.	The branch's own vision of spatial data and its own needs directs the use of, and the investments in, spatial data. The management supports the branch's vision but does not see that a common spatial data vision and strategy is needed to direct the utilization of spatial data.	The management recognizes spatial data as important data sets for the organisation. The organisation has a common spatial data vision and strategy for the utilization of spatial data. An implementation plan of the strategic goals has been promoted at all levels in the organisation. The tangible benefits, such as economic benefits from the use of spatial data, are measured. The organisation has defined the job descriptions in which competence in spatial data use. The utilization of spatial data is as ordinary as word processing.	A strategic-level plan directs the comprehensive utilization of spatial data. The spatial data strategy is a part of the IT strategy.
- Personnel resources	The management have not recognized the possibilities and benefits of spatial data. The management react to spatial data use and they are not for or against the use of spatial data.		The number of spatial data professionals in a branch satisfies only its own operational needs.	Critical resources that are needed to improve the utilization of spatial data have been recognized. All employees have competence in spatial data use. The utilization of spatial data is as ordinary as word processing. All employees have competence in spatial data use. The utilization of spatial data is part of its internal spatial data.
- Communication of spatial data (possibilities and benefits of use)	Communication of spatial data is occasional (in meetings or customer magazines) and is person-dependent.	A branch network, as is the need arises with other similar branches of other organisations or with those branches in the same organisation that are regarded as necessary. Expertise in spatial data use is shared when needed.	The organisation's internal communication of spatial data is coordinated. Persons that are responsible for the communication have been nominated. An official channel for the communication has been created.	Extensive, tailored communication of spatial data, to staff, to customers, and to stakeholder groups. The influence of the communication is followed up. Communication supports the execution of strategic goals. It is both internal and external and it uses different communication channels. The organisation integrates communication channels as a part of its internal spatial data communication.
- Internal cooperation	Internal cooperation is coincidental and bound to a person. Individuals' network on the basis of their own needs and personal competence.	Cooperation in spatial data use is informal. GIS groups that share information.	The organisation has an active horizontal cooperation group that recognizes common needs and benefits in the use of spatial data management. The organisation has an active cooperation network in which roles and responsibilities to promote the utilization of spatial data have been defined and agreed. Best practices in the use of spatial data are shared actively.	Established cooperation processes enable rapid responses to be made both to spatial data and customers' spatial data requirements. The organisation searches for new ways and channels to utilise spatial data and spatial technology.
Individuals' GIS capabilities				
- Technical competence to use spatial data	Competence in the use of spatial data and different application areas have special competence in the use of spatial data. The employees can use GIS software such as COTS products.	Individual employees and teams in different application areas have special competence in the use of spatial data. A support unit helps employees. Certain employees have competence in GIS programming so that it underpins the acquisition of GIS applications.	The organisation has recognised common requirements in the use of spatial data. The organisation has created a training plan to ensure adequate competence in the use of spatial data of all potential employees. Certain employees have competence in the use of spatial data management.	Competence in spatial data use is extended on the basis of the training plan to those utilization areas that are defined in the strategy. Certain employees have competence in the following fields: spatial data quality and metadata. All employees that use spatial data have good competence in using the data. Employees that work in critical business areas have competence in the following fields: spatial analyses, data mining, uncertainty, and visualization.
- Role competence and commitment	Only an employees' own needs regarding the use of spatial data trigger interaction with other employees.	Employees share their knowledge of the use of spatial data inside the branch.	Interaction between employees is open and cross-branch. The interaction is both sharing information and ideas and also enquiring.	One or more representatives from the top management is interested in learning about the possibilities of utilising spatial data in the organisation. He contributes with his own active behaviour to the use of spatial data. Users actively increase their competence in the use of spatial data. Innovative thinking and learning, alone or together with other employees, that happens in the present in order to find solutions to problems that arise. An employee has the will and is capable of using spatial data to solve problems which are related to the efficiency of his duties or to the quality of customer services. A person is committed to doing his best and even more so that the spatial data vision of the organisation will come true.
Organisation's external networking capability				
- Links to stakeholder groups and decision makers	Cooperation in the utilization of spatial data at a local or group level is low and coincidental. The organisation adapts to the current operating environment that exists at the societal level (availability of spatial data, licensing principles).	Cooperation in the utilization of spatial data at a local or group level is formally agreed and bound to projects. The organisation takes part in cooperation development in the development of the national spatial data infrastructure (NSDI). The organisation keeps track of the development of the NSDI. The follow-up of the development of the NSDI is bound to a person.	The form and the objectives of cooperation (production, maintenance, or delivery of spatial data /development of spatial data services and products) at a local or group level have been agreed. Cooperation is based on formal agreements. Predefined organisations participate comprehensively in the development of the NSDI. The organisation cooperates with universities and research institutes and utilises the results from research projects. The organisation is cooperating actively at a local or group level according to predefined roles. The organisation contributes to the development of a local or group spatial data infrastructure. The organisation also contributes actively to the development of the NSDI.	The organisation has identified strategic partners in the field of spatial data utilization. The organisation cooperates and partners in the field of spatial data utilization. The organisation is committed to the implementation of strategic goals that have been set in the national geographic information strategy. The organisation implements results from the research projects of universities and research institutes, such as methods to analyze and visualize spatial data. The cooperation with the strategic partners is based on common goals. It enables resources to be shared and benefits all partners. Cooperation with universities and research institutes is intensive and persevering research that promotes the future development of business. The organisation gives risk funding to unique research into spatial data.

4. Evaluation of the GIS Maturity Model

4.1 Results from the GIS Maturity Assessments

Spatial data users and management in three large cities, in a state institute, and in a large private company, which below are named as City1, City2, City3, the Institute, and the Company, assessed their organizations' GIS maturities with the new model. In City1 and City3 the GIS user groups performed the maturity assessments. The results of the assessments were commented on and accepted by the management. In City2 the coordinators visited three departments and central management. They all assessed their GIS maturities and the coordinators combined the results. In the Institute three assessment groups – spatial data service providers, spatial data users, and the organization's management – performed the maturity assessment independently. Development managers and system managers from two business areas performed the GIS maturity assessment in the Company. The presumption was that the Institute would score highly because a large group of employees use spatial data and solutions in their daily activities and a GIS unit serves the whole organization.

In order to study the correlation between the types of organizations and their maturities the organizations were asked to define whether they are mechanistic, organic, or dynamic organizations. Mechanistic organizations achieve efficiency and minimize costs through automation, repeatability, and routines, and an appropriate internal SDI forms the basis for maturity development. In an organic organization, the activities are customer-driven, and new services and products are developed on the basis of value-added information. Dynamic organizations can be characterized as hectic entities and they need to endure uncertainty and risks. The key elements are networking and self-organization (Mäkelä *et al.,* 2010). City1 defined itself as a mechanistic organization. All the other organizations defined themselves as organic.

In Table 3 the results of SWOT analyzes, pre-assessments of maturity, and the actual detailed GIS maturity assessments are summarized. Before that, the principles of the choice of a maturity level were described and the detailed results of the actual GIS maturity assessments were presented (Table 2).

The organizations applied sensitivity analysis in the detailed GIS maturity assessment. If the evaluators had chosen Maturity Level Two in the pre-assessment, they were asked to read the content of Level Two from the first sub-area, spatial data sets. If the requirements at Level Two were fulfilled in the organization, they marked down Level Two. If not, the evaluators were asked to read the content of both Levels One and Three. If Level One was a better option they marked down Level One and if the organization was about to reach Level Three they marked down 3-. Thus the maturity stage inside one level could be documented. Innovativeness in each sub-area was assessed by defining whether it existed or not. In the calculation of the mean value of the GIS maturity the minuses and pluses were ignored and the whole maturity

numbers of each sub-area were used. The mean value defines the actual maturity level of the organization. The results of the actual maturity assessments are shown in Table 2. In the Table, dark grey shows the areas performing well and light grey the underperforming areas.

Key areas	Subareas	CITY1	CITY2	CITY3	INSTITUTE	COMPANY
ARCHITECTURES	**Spatial data sets** - Acquisition and management of spatial data sets	2	2	3+	4-	3+
	- Discovery and fitness for use evaluation of spatial data sets (metadata, data quality)	1	1	2+	3	1+
	- Availability of spatial data sets (right to use, standards, data protection)	2	3	3-	4	4
	GIS software and applications	2+	4	3+	3+	5-
	Technologies that support the use of spatial data	2	2	3+	2	4+
SERVICES AND PROCESSES	**Spatial data in customer services and solutions**	2-	2	2-	2	2
	Spatial data in internal core processes	3-	2	3	3	3
	Spatial data in support processes and services	1+	1	2+	3	4-
CAPABILITIES	**Internal capability of organisation** - Leadership	1	1	2+	2+	2+
	- Personnel resources	2-	2	3+	1+	3
	- Communication of spatial data (possibilities and benefits of use)	2+	1	4-	3	1+
	- Internal cooperation	3	1	4-	3+	3+
	Individuals' GIS capabilities - Technical competence to use spatial data	3	1	3+	3+	2
	- Role competence	3+	2	3+	3	4-
	Organisation's external networking capability - Links to stakeholder groups and decision makers	3-	3	4+	3+	3
ACTUAL MATURITY VALUE		**1.9**	**1.9**	**2.7**	**2.7**	**2.7**

Table 2. Results from the detailed GIS maturity assessments.

The results in Table 2 show that none of the organizations had identified and documented those central customer services and solutions where spatial data could be utilized which is a prerequisite for Level Three. Therefore, all organizations scored maturity value 2 or less in the corresponding sub-area. Moreover, the lack of a spatial data strategy or a corresponding plan is the main reason why the maturity values in the sub-area leadership are so low in all the organizations.

In Table 3 the maturity values 3 and 3.2 in the key area of architectures show that the Institute and the Company have an internal SDI that supports the use of spatial data. In the SWOT analyzes, the Company defined coordinated data acquisition and data delivery, and the Institute spatial data infrastructure, as internal strengths. They both also defined good GIS tools as internal strengths. City2's internal strengths are enterprise agreement for GIS software Licenses and a web map service. These strengths can also be seen as the higher maturity value of 2.4 in the corresponding sub-area. But despite the heavy investment in GIS tools, the use of spatial data outside the technical and environmental branches is occasional and fragmented. City2 listed this issue as an internal weakness.

Model for Assessing GIS Maturity of an Organization

CITY1	Pre-assessed maturity: 2+	Total maturity in actual assessment: 1.9	
Key areas	SWOT Strengths and Opportunities	SWOT Weaknesses and Threats	Maturity of a key area
ARCHITECTURES	Spatial data production and management (S) A lot of GIS applications (S)	SDI is separate from organisation's other information infrastructures (W) Difficult to utilise external spatial data (W) The city has own local geodetic reference system (W)	1.8
SERVICES AND PROCESSES	Citizens are aware of the possibilities of spatial data use (S) Customers are served by flexible and easy-to-use online services (O)		1.3
CAPABILITIES	A large group of GIS professionals with special skills (S) Networking with GIS software suppliers (S) Management and central administration have reacted to the needs of coordination of spatial data activities (O) Regional cooperation and easy cooperation with the state (O) Innovativeness is possible (O) Training and development at work is possible (O)	Lack of coordination paralyses development (T) The steering of shared projects and processes in the city is weak (T)	2.1

CITY2	Pre-assessed maturity: 2-	Total maturity in actual assessment: 1.9	
Key areas	SWOT Strengths and Opportunities	SWOT Weaknesses and Threats	Maturity of a key area
ARCHITECTURES	Enterprise agreement for GIS software licences (S) Multifaceted spatial data sets (S) To utilise mobile technology in all possible activities (O) Standard interfaces to wider usage (O) To broaden regional cooperation (O) Politicians understand the strength of spatial data in the support of decision making (O) EUREF (European Reference Frame) (O)	Open data policy (T) Strict data protection law in personal details (T)	2.4
SERVICES AND PROCESSES			1.7
CAPABILITIES	Competence especially in the technical branch (S)	Internal communication of the benefits of spatial data is minimal (W) Competence to use spatial data is insufficient in other branches than technical branch (W) Management does not recognise the possibilities of spatial data usage (W) Resistance to change (W) Political decision making (T)	1.6

CITY3	Pre-assessed maturity: 2-3	Total maturity in actual assessment: 2.7	
Key areas	SWOT Strengths and Opportunities	SWOT Weaknesses and Threats	Maturity of a key area
ARCHITECTURES	Basic GIS software and spatial data sets available (S) Spatial data issues are concentratedly coordinated (S) EUREF (European Reference Frame) (O)	Implementation of INSPIRE (T) Availability of spatial data sets / prices (T)	2.6
SERVICES AND PROCESSES			2
CAPABILITIES	Cooperation in spatial data issues (S) Management's understanding (S) INSPIRE (O) Regional cooperation (O) Networks (O)	Lack of spatial data strategy (W) Lack of resources (W) Independence of sectors (W)	3

INSTITUTE	Pre-assesed maturity: 3	Total maturity in actual assessment: 2.7	
Key areas	SWOT Strengths and Opportunities	SWOT Weaknesses and Threats	Maturity of a key area
ARCHITECTURES	Internal SDI (S) Good tools (S) Standard interfaces enable new solutions (O) Technology will develop (O)	Technical restrictions make the system rigid and the implementation of innovations is slow (W)	3
SERVICES AND PROCESSES			2.7
CAPABILITIES	Employees have a high level of education (S) Internal network in spatial data issues (S) Skilled GIS unit (S) Cooperation in the Inspire Network (O) The development of information society (O) Public sector ICT (O)	Lack and allocation of resources (W) Flow of information (W) Awareness of the possibilities of spatial data use is not sufficient (W) Productivity programs (T)	2.6

COMPANY	Pre-assessed maturity: 3	Total maturity in actual assessment: 2.7	
Key areas	SWOT Strengths and Opportunities	SWOT Weaknesses and Threats	Maturity of a key area
ARCHITECTURES	Coordinated data acquisition and data delivery (S) Good tools (S) Standards (O	Quality versus the price of spatial data (T) Limitations on rights to use spatial data (T)	3.2
SERVICES AND PROCESSES	The effective reuse of spatial data with business information (S)		2.7
CAPABILITIES	Success stories (O) Cooperation with other organisations (O)	Lack of spatial data strategy (W) Competence to use spatial data is personified (W)	2.4

Table 3. A summary of the results of SWOT analyzes, pre-assessments, and actual assessments
of GIS maturity

In the key area of *capabilities,* the communication of spatial data and of the benefits of use is minimal in City2, especially between branches. City2 also defined other weaknesses, such as a lack of competence in other branches than the technical branch, and that the management does not understand spatial data, as well as not recognising who could benefit from the use of spatial data. These weaknesses show up as a very low maturity value, 1.6. However, a great potential for the utilization of spatial data exists and City2 hopes that politicians will understand as soon as possible how spatial data can be used in supporting them in decision making. The Organization's capability to benefit from and to contribute to an NSDI is emphasized in the maturity model. But in the SWOT analysis only City3 and the Institute mentioned INSPIRE and the cooperation in the Inspire Network as external possibilities.

City3, the Institute, and the Company obtained the best actual GIS maturity value, 2.7. City3 stands out in the key area of capabilities. According to the spatial data coordinator of City3, in the last five years sub-areas such as resources, cooperation between branches, the coordination of spatial data issues, employees' competence to use spatial data, and communications have been systematically developed in order to improve spatial data utilization in the city. This has been possible because the mayor has made a personal commitment to its development and the coordinator who works in the central administration has the power to foster the development.

When we compare the results of the SWOT analyzes and the GIS maturity assessments we find that the strengths and weaknesses in spatial data utilization show correspondingly as high and low maturity values in the assessment. But the results also reveal that the GIS maturity model contains requirements that the organizations did not find important. They did not find strengths or weaknesses in services and processes, even if this key area seems to be essential from the productivity point of view.

The actual and the pre-assessed maturity values of the organizations are quite close to each other with the actual values being lower. This indicates that the pre-assessment method could possibly be used in cases where a quick and cost-effective understanding of the GIS maturities of a large number of organizations is needed.

The results from the innovativeness assessment show that innovativeness existed mainly in the "strong" sub-areas such as acquisition and management of spatial data, GIS software and applications, internal cooperation, and technical competence to use spatial data. Only the Company considered itself innovative in internal core processes.

The five organizations performed GIS maturity assessments themselves because objective assessments would have been too expensive. Therefore, the results are subjective and the comparison of the maturity values of the organizations is only approximate. But the maturity values serve each organization internally and are comparable when the same people assess their organization's GIS maturity in the future.

4.2 Feedback from the Evaluator Organizations

The evaluator organizations provided feedback with regard to the content of the GIS maturity model and the usability of the model. Inconsistency exists in some sub-areas in which the higher maturity levels do not include all the subjects that exist on the lower levels. This was confusing to some of the organizations and should be improved in the next version. It was also suggested that in the sub-area of *availability of spatial data sets* the contents of Levels Three and Four should be the other way round.

Some of the organizations found the maturity assessment quite easy. Others reported that the Excel format is not optimal for the maturity model or that at least it should be clearer. Some coordinators advised it was difficult to find one maturity level that represents the whole organization. In these cases detailed maturity assessments of each branch have not been performed.

5. Discussion

The development of the new GIS maturity model continued for a year and involved about thirty participants, who represented mainly public organizations. The

participants found the process a valuable learning exercise and obtained the new maturity model for their use as a concrete reward for their trouble as well. The process indicated that it is possible to develop a generic GIS maturity model if diverse organizations commit themselves to its development. This enhances mutual understanding and collaboration that can activate other projects in the context of NSDI.

However, do we need a new GIS maturity model? Why not adopt an existing one? Each nation has its own cultural characteristics and these should be reflected in the corresponding maturity models. For example, in Finland, employees have great influence over their duties. Therefore, the new GIS maturity model emphasizes the development of the GIS competence of all the employees of those branches that would clearly benefit from the utilization of spatial data. In organic organizations this is important and in dynamic organizations extremely significant. On the other hand, for example, the GIS CMM emphasizes the importance, role, and budget of the GIS unit of an organization and the development of the competence of its staff, but in local government in Finland, a GIS unit is usually a part of the technical branch and does not offer a full service to other branches and the unit does not have, for example, financial influence over the other branches.

Despite some inconsistencies, the new GIS maturity model aims to highlight both the present and the future requirements of spatial data and the possibilities for its utilization. These are, for example, standards, data quality, leadership, the importance of an NSDI, and strategic partnerships. The future requirements of the model contribute to the sustainability of the model so that it would be usable for several years. However, the model should not be fully static but able to evolve along with the advances in the information society, such as the opening of public data.

The results of the maturity assessment do not give any representative picture of the level of maturity of organizations in Finland. But after the web application of the GIS maturity assessment is available, it will be possible to gain enough information about the state of maturity of the Finnish organizations to form an overview. This information can be used as one measure when the state of the NSDI is assessed. The results of this project, however, can highlight the need for development and stimulate discussion in organizations. Additionally, mature organizations serve as exemplars and can encourage investment in development. It is not realistic for all organizations to achieve the fifth and highest maturity level. The most important goal is to set a realistic target level and to define a roadmap to achieve the target.

6. Conclusions

A generic GIS maturity model was built in a joint development project between the SDI utilization working group of the Finnish National Inspire Network and Aalto University. The objective of the project was to develop a comprehensive GIS maturity model by which both the public organizations and the private companies could assess their GIS maturities and set targets for future development.

In addition to the internal SDI and GIS software and applications, the new maturity model takes into account sub-areas that have been emphasized in the previous research. The organization's capabilities, such as leadership, the communication of the possibilities and benefits of spatial data, the implementation of strategy, and the commitment of people, were included in the model. The organization's external networking capability and the possibilities that an NSDI can bring were also highlighted

Five organizations assessed their GIS maturities with the new GIS maturity model. The maturity values were validated with SWOT analyzes. The results from the maturity assessments show that the maturity levels of the cities vary according to how much has been invested in coordination and cooperation, and whether the management is committed to the development of spatial data utilization. According to the experts who coordinated the maturity assessment in their organizations, the assessment process promoted organization-wide discussions about the possibilities and benefits of spatial data, even with top management. This process may even commit the managers to the future development of competence.

Only large organizations assessed their GIS maturities with the new maturity model and evaluated its fitness for use. Further research is needed to evaluate the usability of the GIS maturity model for small organizations. However, the new model contains requirements that should also be taken into account in all organizations where the utilization of spatial data is developed. Additionally, the use of different weights for sub-areas deserves further study.

The research demonstrated that a common GIS maturity model, which is applicable to diverse organizations, is worth developing. When an open Web application of the new model is released it will be possible to gain valuable information about the maturity levels of a substantial number of different organizations. Furthermore, when the maturity assessments are repeated at intervals they could function as a measure in the evaluation of the success of the implementation of an NSDI.

Acknowledgements

References

Auer, T., (1994), Assessment of IS-related organizational maturity, Publications of the Turku School of Economics and Business Administration, Series D:1-1994.

Babinsky, G., (2009), A Proposed Municipal GIS Capability Maturity Model, a presentation at the 2009 Washington GIS Conference, Available at

http://www.waurisa.org/conferences/2009/presentations/Tues/ManagingGIS IntheEnterprise_Tues_Babinski_KingCounty.pdf [Accessed 9 November 2011].

Babinsky, G., (2010), Managing GIS. A column in ArcNews Winter 2010/2011, at http://www.esri.com/news/arcnews/winter1011articles/urisa-proposes.html [Accessed 16 January 2012].

Chan, T. O. and Williamson, I. P., (2000), Long term management of a corporate GIS, International Journal of Geographical Information Science, 14(3): 283-303.

Coriale, D., (2007), Improve IT Maturity for Greater Technology Value, a white paper, Available at http://www.delcortech.com/Content/RESOURCESFORYOU/ITMATURITYMOD EL/ImproveITMaturityforGreaterTechnologyValue.aspx, [Accessed 28 October 2011].

Crawford, J. and Dekker, M., (2002), Project Management Maturity Model: Providing a Proven Path to Project Management Excellence, New York: Dekker.

Dalkir, K., (2005), Knowledge management in theory and practice, Oxford: Elsevier Butterworth-Heinemann.

Fernández, T., Lance, K., Buck, M. and Onsrud, H., (2005), Assessing an SDI Readiness Index, FIG Working Week 2005 and GSDI-8, April 16-21, Cairo, Egypt.

Grus, L., Crompvoets, J. and Bregt, A., (2008), Theoretical introduction to Multi-view Framework to assess SDIs, in Crompvoets J., Rajabifard A., van Loenen B. and Fernandez T. (Eds.). A Multi-View Framework to Assess Spatial Data Infrastructures. Space for Geo-information (RGI), Wageningen University, pp. 93-113.

Kohlegger, M., Maier, R., Portele, C. and Thalmann, S., (2009), Understanding Maturity Models Results of a Structures Content Analysis, Proceedings of I-KNOW '09 and I-SEMANTICS '09, September 2-4 2009, Graz, Austria, pp. 51-61.

Kok, B. and van Loenen, B., (2005), How to assess the success of National Spatial Data Infrastructures? Elsevier: Computers, Environment and Urban Systems, 29 (2005): pp. 699-717.

Lance, K., (2006), Inter-agency geospatial investment coordination, JRC Cost-benefit/Return on Investment Workshop (13 January 2006), Available at http://www.ec-gis.org/sdi//ws/costbenefit2006/presentations/lance.pdf, [Accessed 9 November 2011].

Longhorn, R., (2009), Evaluating SDI best practices. Workshop 2.2 at GSDI 11 conference, June 15 2009, Rotterdam, Netherlands.

Masser, I., Campbell H. and Craglia, M., (eds.) (1996), GIS Diffusion, The Adoption and Use of Geographical Information Systems in Local Government in Europe, London: Taylor & Francis.

Mettler, T. and Rohner, P., (2009), Situational Maturity Models as Instrumental Artifacts for Organizational Design, 4th International Conference on Design Science Research in Information Systems and Technology", May 7-8, Malvern, PA, USA.

Ministry of Finance (2010), Public sector ICT in Finland, Available at http://www.vm.fi/vm/en/04_publications_and_documents/03_documents/Public_Sector_ICT_in_English.pdf [Accessed 28 November 2011].

Moorman, D., (2010), Is Your IT Function Where it Needs to Be?, Avaialbe at http://www.dynasis.com/2010/05/how-mature-is-your-it/ [Accessed 14 November 2011].

Mäkelä, J., Vaniala, R. and Ahonen-Rainio, P., (2010), Competence management within organizations as an approach to enhancing GIS maturity, International Journal of Spatial Infrastructures Research, Vol. 5: pp. 267-285.

Mäkelä, J. and Hilke, K., (Eds.) (2011), Paikkatietojen hyödyntäminen Suomessa 2010, Osa I Julkishallinnon organisaatiot (Utilization of spatial data in Finland 2010, Part I Public organizations), Helsinki: SDI utilization working group of the National Inspire Network. In Finnish, Available at http://www.paikkatietoikkuna.fi/c/document_library/get_file?uuid=18e702ba-aad8-476d-9867-cc0c3f2306d6&groupId=108478, [Accessed 15 November 2011].

Nielsen, J., (1994), Usability Inspection Methods, Tutorials in the ACM CHI 94 Human Factors in Computing Systems Conference, April 24-28, Boston (MA), USA.

Nielsen, J., (2009), Discount Usability: 20 years. Jakob Nielsen's Alertbox Available at http://www.useit.com/alertbox/discount-usability.html [Accessed 23 January 2012].

Paulk, M. C., Weber, C. V., Curtis, B., Chrissis, M. B. and Longman, A. W., (1994), The Capability Maturity Model: Guidelines for Improving the Software Process, Reading (MA): Addison-Wesley.

Rajabifard, A., (2010), Spatially Enabled Society, GSDI Vision & Activities, a presentation at the GSDI 12 conference, Available at http://www.gsdi.org/gsdiconf/gsdi12/slides/P2c.pdf, [Accessed 26 October 2011].

Rezvani, S., (2008), An Introduction to Organizational Maturity Assessment: Measuring Organizational Capabilities, Thirty-Second Annual IPMAAC Conference on Personnel Assessment, June 8-11 2008), Available at http://www.ipacweb.org/conf/08/rezvani.pdf, [Accessed 26 November 2011].

Senge, P., (1990), The Fifth Discipline, The Art and Practice of the Learning Organization, New York: Doubleday Currency.

Somers, R., (1998), Developing GIS Management Strategies for an Organization, Journal of Housing Research, 9(1): pp. 157-178.

Turkki, T., (2009), Nykyaikaa etsimässä – Suomen digitaalinen tulevaisuus, Helsinki, Finnish Business and Policy Forum EVA. In Finnish at http://www.eva.fi/wp-content/uploads/files/2573_nykyaikaa_etsimassa.pdf [Accessed 20 January 2012]. An English abstract: *In Search of Modern Times – Finland's Digital Future* available at http://www.eva.fi/en/julkaisut/english-in-search-of-modern-times-finlands-digital-future/1555/ [Accessed 20 January 2012].

van Loenen, B. and van Rij, E., (2008), Assessment of Spatial Data Infrastructures From an Organizational Perspective in Crompvoets J., Rajabifard A., van Loenen B. and T. Fernández (Eds.), A Multi-View Framework to Assess Spatial Data Infrastructures, Space for Geo-information (RGI), Wageningen University, pp. 173-192.

Irish Coastal Heritage Viewer Case Studies

Roger Longhorn[1], Gearóid Ó Riain[1], Beatrice Kelly[2], William Hynes[3] and Maria Rochford[3]

[1] Compass Informatics Ltd, Blackrock, Ireland
[2] The Heritage Council, Kilkenny, Ireland
[3] Downey Hynes Partnership, Dublin, Ireland

[1]info@compass.ie; [2]BKelly@heritagecouncil.ie; [3]info@dhp.ie

Abstract

This paper presents a case study describing a project to develop a GIS based approach to enable the comprehensive audit and assessment of the heritage in the coastal areas of eight Irish counties, led by the Irish national Heritage Council. The overall purpose for the Coastal Heritage Viewer is to provide clearer understanding of the heritage and its significance, and to provide a service for spatially enabling government to exercise better management in the future. The project demonstrates how multiple data sources covering disparate themes, from different data owners, and crossing local and regional (county) boundaries, can be integrated to aid conveying information to the public and decision makers at different levels of government. Based on web services standards, the resulting web viewer can be multi-purposed and readily expanded in the future to accommodate new data sources, providing new functionality for different applications and users. The paper follows the development process for the viewer and presents three case studies highlighting how the viewer aids decision makers in preparing various types of assessment reports, examining wind and renewable energy strategy options, and enabling integrated coastal zone management, among other aspects.

KEYWORDS: map viewer, coastal heritage, INSPIRE, assessment, web service

1. Introduction

The Coastal Heritage Viewer project was developed to enable the comprehensive audit and assessment of the built, natural and cultural heritage, as defined in the Heritage Act 1995 (Office of Attorney General, 1995), in the coastal areas of eight Irish counties, led by the Irish national Heritage Council. The partners included Clare County Council, Galway County Council, Galway City Council, Kerry County Council, Limerick County Council, Fingal County Council, Wicklow County Council and Waterford County Council. The national and international policy context within which the project partners are working includes, inter alia, the Water Framework Directive, the Marine Strategy Directive, the Floods Directive, Birds and Habitats Directives, local and national Irish planning legislation, Irish National Monuments legislation, and the forthcoming National Landscape Strategy, County Development Plans, and Regional Planning Guidelines.

One goal of the project and viewer is to provide a clearer view of the inter-relationships between different aspects of heritage affected by, and affecting, the different types of designation, initiatives such as River Basin Plans (RBP), forthcoming Catchment Flood Risk Assessment and Management (CFRAM) studies and multiple government departments with a responsibility for the coastal zone.

2. Approach

The project was broken into two phases, the first, in 2010, being to carry out an inventory and evaluation of data on the Irish coastal zone for the purpose of addressing a range of policy issues. The second phase began in 2011 and builds on the pilot developed in Phase 1.

2.1 Coastal Heritage Viewer Project – Phase 1

 A major task in Phase 1 was to create an inventory of existing digital data on the Irish coastal zone that could be used to address a range of policy issues including heritage tourism projects, integrated coastal zone management (ICZM) policies, offshore energy strategies, land-based development, and landscape management adaptation to climate change, green infrastructure provision, plus general heritage management. This phase included compiling a catalogue of datasets on the coastal zone at national scale and at local authority level, relevant to heritage and its management, which meet the standards of the pan-European INSPIRE Directive (European Parliament and Council, 2007). The catalogue would include information on data format, currency, ownership, access, content, and reasons for data collection.

Core data sets were identified covering the coastal zone from land into the sea and seabed, with particular reference to the land/sea interface. The data sets were to include existing heritage data and other related data that would assist in assessing the opportunities and threats concerning coastal heritage. Historic data sets were also to be considered, for example, historic mapping and bathymetry.

Heritage data was defined as including geomorphology and geology, landscape, biodiversity (terrestrial, intertidal and aquatic), architecture, archaeology (terrestrial, inter-tidal, underwater, and museum finds), and maritime cultural heritage, the latter including currach stands, boat repair areas, seaweed stands, fish palaces, fish storage areas, folklore, and place names. Furthermore, the Irish Spatial Data Exchange (ISDE), the Marine Irish Digital Atlas (MIDA) and ortho-imagery and LiDAR data should be used as the starting points along with the standard digital heritage datasets. In preparing the initial pilot, the following requirements were taken into consideration:

- The viewer should be compatible with existing systems used by the local authorities and Heritage Council (e.g. using ArcGIS and MapInfo GIS software), and initiatives such as the development of River Basin Management Plans.
- It should involve a common approach for data capture, validation, updating and management, and the integration of spatial and tabular information.
- It should consist of a geodatabase with a catalogue of web services where live connections to data are possible.
- It should provide a decision-making Web GIS for intranet delivery to local authorities and the Heritage Council, with the potential of wider access in the future.
- It should meet the necessary standards of the INSPIRE Directive.

In guiding the design and implementation of the viewer, the long-term goal for the project partners was to address policy related questions such as:

- the significance and vulnerability of sections of the coast, or elements of coastal heritage, and the need for monitoring and indicators,
- defining an appropriate approach to heritage management, considering potential climate change impacts, natural coastal processes, and the need to prioritize effort and resources, in line with accepted conservation philosophies,
- enhancing public awareness and understanding of management of the heritage, including natural coastal processes,
- identifying opportunities for improved and appropriate recreational, tourism and educational resources,
- suggesting ways to attain the sustainable development of the study areas in relation to tourism, offshore energy, port development, and land-based development, and
- influencing future intervention in relation to possible coastal protection works.

2.2 Coastal Heritage Viewer Project – Phase 2

The purpose of the second phase of the project, in 2011, was to:

- test the application and relevance of the Coastal Heritage Viewer compared to the phase 1 intentions and goals,
- widen its usage among local authority staff and relevant heritage agencies,
- expand the GIS by developing detailed metadata for heritage data sets, using as far as relevant the experience from the Irish National Biodiversity Data Centre (NBDC),
- develop analytical tools for use in the Coastal Heritage Viewer identified during phase 1 of the project, such as a coincidence button,
- identify key data sets that exist and could be sourced from other bodies and primary data gaps that could be filled via field studies in future County Heritage Plans, and
- continue liaison with national GIS initiatives, such as the Irish Spatial Data Infrastructure (ISDI).

Phase 2 was based on four work packages: data collation, demonstration projects, metadata standards and developing an on-line tutorial. In the data collation work package, two further counties were added to the project (Wicklow and Waterford) with their county data sets, and additional datasets became available for Phase 1 partners. Altogether, 59 new datasets were identified, to join the 170 themes already covered across the themes of heritage, coastal infrastructure, marine natural resources, environment, planning, and tourism, recreation and amenities. Ten areas for demonstration projects were identified. The results of three of these will be reported in the following section.

3. Case Studies for Coastal Heritage Viewer

Ongoing refinement and optimization of the Coastal Heritage Viewer is informed via feedback from a number of Local Authority case studies carried out in tandem with the viewer design process. An imperative consideration in designing the viewer is to ensure that it is a practical tool that is responsive to the needs of policy makers working at various policy levels. The views of the case study participants, as representative of potential end users, are essential to the long-term success and viability of the project and the ultimate usefulness of the viewer.

3.1 Identifying Demonstration Projects

During Phase II of the project, a multi-county, multi-policy review was undertaken, examining the extent to which coastal heritage is currently dealt with at strategic, plan and site specific level – and how. The purpose of the review was threefold:

- to gain an understanding of the current 'state of the art'
- to establish a comprehensive evidence base in terms of coastal heritage and
- to examine the current processes adopted relating to coastal heritage for a number of selected demonstration projects.

Demonstration projects were selected in order to highlight current approaches adopted in providing for, and dealing with, coastal heritage from a number of different perspectives. The demonstration project themes focused on:

- tourist-based heritage sites,
- conducting Strategic Environmental Assessments (SEA) and Appropriate Assessments (AA), and
- wind energy strategies.

Each of these demonstration projects is representative of a different hierarchical level of action, and so provides information on how coastal heritage is dealt with from a number of perspectives, as illustrated in Figure 1.

Figure 1. Demonstration Projects

Following the review, it was necessary to test the viewer by applying it to a series of 'real life' case studies. The case studies (see Table 1) selected incorporate and supplement the demonstration projects focused on in the initial review. Recognising that the range of potential end users of the viewer may extend beyond Local Authorities to include, for example, government bodies, semi-state bodies and NGOs, the viewer was also made available to the Irish Marine Institute and BirdWatch Ireland, allowing for a broader assessment of the viewer.

The next section of the paper presents the key outcomes from three of these case studies, highlighting a range of opportunities identified by Local Authorities for interrogating and utilising the Coastal Heritage Viewer data and identifying any weaknesses of the viewer for correction in future updates.

Case Study	Participants
Strategic Environmental Assessment (SEA) and Appropriate Assessment (AA)	Wicklow County Council
Tourism Projects	Waterford County Council Galway County
Integrated Coastal Zone Management (ICZM)	Fingal County Council
Strategic Integrated Framework for Shannon Estuary	Clare County Council
Wind and Renewable Energy Strategy (WRES) and associated SEA	Kerry County Council
FAME Seabird Project	BirdWatch Ireland
Integrated Marine Spatial Planning – Offshore Renewable Energy project	The Marine Institute

Table 1. Coastal Heritage Viewer - Case Studies

3.2 Wicklow County Council SEA and AA

Wicklow County Council volunteered to test the applicability and potential value of the heritage map viewer in the preparation of the Strategic Environmental Assessment (SEA) and Appropriate Assessment (AA) of the Wicklow Town and Environs Development Plan 2013-2019. The plan sets out the framework for the future development of the area and will be instrumental in determining the future design and location of land uses and the preservation of existing built and natural assets.

Strategic Environmental Assessment and Appropriate Assessment are mandatory planning processes, routinely carried out at Local Authority level for policies, plans and programmes. Both SEA and AA deal with the predicted environmental effects of, for example, County Development Plans and Local Area Plans. Both follow a structured, step-based process and involve the collation and analysis of spatial information.

3.2.1   Strategic Environmental Assessment

Wicklow County Council recognizes the viewer's potential in acting as a single portal to a huge range of information, with major efficiency gains arising for the user. Creation of a central repository with relevant geographical information will allow for the provision of standardized and readily accessible datasets to Council staff. By collating national datasets, the viewer also allows for a better understanding of cross-boundary, cross-county impacts. This ability to view datasets from multiple agencies and across borders is a key aspect of spatial data infrastructure.

Clear benefits in using the map viewer were identified for several stages of the SEA process. The viewer can be used to assist in the identification of significant effects on the environment arising from certain objectives of a plan. Identified opportunities enabled by the viewer in the scoping of SEAs included:

• identification of significant environmental characteristics of the area,
• identification of existing environmental pressures or vulnerable areas,
• enhanced understanding of cross-boundary/cross-county impacts, and
• enhanced understanding of cumulative impacts and commonalities between themes and conflicting areas through overlaying of relevant thematic layers, facilitating a more informed analysis, to better define the focus of the SEA.

There was particular interest in the potential value of the viewer in describing the baseline environment - a key step in the preparation of the SEA report. Specific characteristics and physical information relating to heritage and other environmental features may be identified and assessed against other relevant layers such as, for example, flood maps. Facilitating a more detailed description of environment, the viewer may in turn contribute to the formulation of clearly defined and targeted Strategic Environmental Objectives (SEOs).

The viewer also had potential for assessment of alternative plan scenarios, in line with SEA requirements and as part of broader planning policy documents. This facilitates realistic and convenient assessment of different planning scenarios and their potential impacts, to identify potential conflicts between planning scenarios and environmental characteristics of the area.

With proposed enhancements, planning scenarios such as population projections or employment predictions which are generated using internal mapping systems may also be uploaded onto the viewer. These maps layers can then be viewed and interpreted alongside a range of previously unavailable datasets leading to broader, integrated analysis and saving time which would otherwise be used in the reprocessing of data. Potentially, and subject to data access controls, digital files generated to the specifications of the user could also be downloaded onto the County Councils existing GIS systems for further more detailed analysis.

By helping to identify vulnerable coastal heritage features, and ensuring that they are addressed in the selection of the SEOs, mitigation measures may be targeted to address specific issues or sites. Benefits from the viewer may also be derived in the presentation of the environmental report, e.g. maps may be exported and used to convey important information and to supplement text in the Environmental Report. Maps produced using the viewer may also contribute to greater transparency and enhanced participatory processes.

3.2.2   Appropriate Assessment

The heritage viewer offers similar opportunities to those identified for the SEA process in the preparation of Appropriate Assessment (AA), including the initial screening process and immediate identification of Natura 2000 sites within a 15km radius of the plan area, particularly where county boundaries are crossed. AA screening stipulates that an examination is carried out to determine if the plan or project, alone or in combination with other plans or projects, could have a significant effect on any Natura 2000 site. Locally available datasets of relevance to the plan or project may be uploaded to the viewer and assessed against other relevant datasets, such as zoning objectives of County and Local Area Plans or other permitted developments in the vicinity. In terms of the Natura Impact Statement (NIS), the viewer offers production of maps for an enhanced visual aesthetic.

 The heritage viewer also holds potential in the assessment of alternative solutions stage of an AA. For instance, by examining multiple scenarios using different themes or layers, the map viewer allows the assessment of alternative ways of achieving the objectives of the project or plan that avoid adverse impacts on the integrity of Natura 2000 sites. The viewer can be useful in creating maps to support a case for a plan or project for imperative reasons of overriding public interest (IROPI).

3.3 Integrated Coastal Zone Management

Integrated Coastal Zone Management (ICZM) addresses management of coastal areas. The planning policy review carried out in the early part of the project indicated that ICZM is a feature of most of the Development Plans reviewed relating to the participating Local Authorities. The review identified clear potential to extend the scope of ICZM further, so that it could be used as a comprehensive tool for ensuring that a full range of coastal heritage features are better accommodated at plan level. The map viewer tool enables this, greatly enhancing the effectiveness of ICZM in planning for and managing the coastal area in general and protecting coastal heritage.

The Final Development Plan 2011-2017 for Fingal County introduced ICZM as a tool to achieve a more efficient and sustainable use of coastal resources, so that the coastal area and its unique cultural and natural heritage characteristics are protected. Although there is no formal guidance on the creation of a Coastal Zone Management plan, Fingal County Council is committed to establishing initiatives for ICZM under the following objectives of the current development plan (Fingal County Council, 2011):

- Objective CT07: Designate a Coastal Zone, during the lifetime of the Plan, to provide for the proper planning and sustainable development of the coast, while protecting its landscape and seascape character, its unique natural and cultural heritage, its amenities and economic value, and its role in coastal defence.

- Objective CT09: Promote, support and facilitate coastal zone management initiatives in partnership with the local community, environment groups, user organizations and statutory authorities, including adjoining local authorities.

Fingal County Council recognizes clear opportunities for using the viewer in OCZM, as CZM encompasses the involvement of multiple authorities with responsibility or interest in various coastal issues. ICZM aims to achieve a balance across often competing sectoral interests such as shipping, fishing, aquaculture, oil and gas exploration, aggregate and mineral management, conservation and tourism.

A central element of ICZM is to assess and manage trade-offs between physical, socio-economic and cultural resources of the coast. A key ICZM task at Fingal County Council is to undertake a Seascape Assessment to aid in the designation of a Coastal Zone and to establish sustainable levels of social and economic activities in coastal areas. The viewer offers major potential, by overlaying relevant datasets, allowing examination of competing and conflicting interests in demand for coastal space. Different alternatives or scenarios for planning, development or protection of the coastal zone may be explored, with inputs from internal datasets where appropriate. Coastal areas or specific features which are particularly vulnerable may be identified using, for example, datasets which display information on coastal erosion.

Coastlines, and coastal issues, are notorious for not obeying jurisdictional boundaries. One advantage of the viewer is the availability of data across county boundary divisions, which allows for a more streamlined approach to cross border coastal management. The viewer allows local authorities to see data below the MHW (mean high water) line, as well as offshore marine information datasets and shipping datasets, which are highly valuable as such data is not widely available or easy to source. Datasets that contain geodemographic (population) information within a coastal zone are invaluable to the decision making process. The Irish coastline has suffered much from lack of information and understanding of the inter-tidal zone by local authorities.

Reports such as rapid characterization reports also contribute to more effective ICZM. The viewer provides an effective publication and information dissemination mechanism for data that may not be widely distributed otherwise, providing positive effects on the recognition of heritage related datasets in the planning process.

The benefits derived from the viewer's links to the National Biodiversity Data Centre data management, mapping and reporting system, on which the Coastal Heritage system is based, were also recognized. Upgrades to this system have greatly expanded the functionality available to query the database. For instance, using the viewer it is possible to perform an area based search of the national biodiversity database.

3.4 Wind and Renewable Energy Strategy

Local Authority wind energy strategies are prepared in accordance with the Department of Environment, Heritage and Local Government (DoEHLG) Wind Energy Guidelines (DoEHLG, 2006). The step-by-step approach advised in the Guidelines involves a sieve mapping analysis of important environmental, landscape, technical and economic criteria which must be balanced in order to identify the most suitable location for wind energy development. The viewer is expected to respond well to the structured approach for the preparation of wind energy strategies.

Kerry County Council tested the applicability of the viewer in the preparation of the Wind and Renewable Energy Strategy (WRES) and associated SEA. The purpose of the strategy is to establish the county's strategic approach to the development and management of renewable energy. The WRES is undertaken in accordance with the DoEHLG Wind Energy Guidelines for Planning Authorities - a key first step in the WRES is the assessment of wind potential. For this, the availability of datasets from key data sources such as the Sustainable Energy Authority of Ireland (SEAI) wind atlas would add major value to the viewer in terms of developing the WRES, if available.

The Guidelines propose evaluation of the landscape in terms of scenic quality, rarity, uniqueness and natural and cultural heritage considerations. The viewer may be used for this, using information from a range of relevant datasets, such as conservation designations, Records of Monuments and Places (RMP), hedgerow surveys, archaeology and monument databases, etc. Information on soil type and topography will also be critical in the selection of suitable sites for wind proposals. The viewer could also help in identification of vulnerable areas which may be unsuitable for renewable energy projects, and in exploring the effect of wind energy development on sectors such as tourism and recreation.

In line with Step 3 of the Guidelines, information on landscape evaluation and sensitivity analysis must be overlaid with wind energy information. With datasets for wind speeds, for example, within the viewer, this step could be easily achieved.

4. Strengths and Weaknesses

The case studies were an important way to examine and characterize both the strengths and weaknesses of the Coastal Heritage Viewer for different scenarios. In the case of the Strategic Environmental Assessment (SEA) case in Wicklow County Council, the following strengths and weaknesses were identified. Viewer strengths included:

- enhancing the scoping process,
    - ID of significant environmental characteristics and environmental pressures,
    - enhanced understanding of cross-boundary impacts,

- a strong contribution to description of the baseline environment,
- informs the selection of Strategic Environmental Objectives (SEOs),
- facilitates the assessment of alternative plan scenarios,
- will extract data feeds from viewer for use in internal mapping systems and vice versa (a pending enhancement),
- can export maps to improve the visual aesthetic of environmental reports,
- map generation for enhanced public participation.

In the case of the Appropriate Assessments for Wicklow, the following was observed. Additional viewer strengths included:

- assists the screening process in the identification of Natura 2000 sites across county boundaries,
- facilitates the assessment of alternative plan scenarios, and
- export maps to improve the visual aesthetic of Natural Impact Statement (NIS).

In the case of Integrated Coastal Zone Management, identified strengths included:

- accessibility of huge range of datasets not previously available saving time and resources,
- explore competing interests and identify conflict of interests in demand for coastal space,
- explore alternatives/scenarios for planning, development or protection of the coastal zone,
- examine cross-county boundary coastal impacts,
- identify coastal areas or features vulnerable to threat from erosion and development pressures, and
- reporting functions.

For Kerry County Council's wind and renewable energy strategy case study, viewer strengths indentified included:

- facilitates the evaluation of landscape and its sensitivity for renewable energy developments,
- assists in the identification of areas sensitive to renewable energy developments,
- facilitates the examination of impacts of wind energy development on tourism, recreation and other issues,
- allows for definition of zones of influence, and
- facilitates an integrated, consistent approach to WRES preparation across county boundaries.

Generally, the weaknesses across case studies included:

- data maintenance and update challenges still to be fully assessed, and

- the detail of data within the viewer, as the number of datasets may create navigational difficulties, and
- (for wind energy) the requirement to incorporate additional map layers from SEAI wind, geothermal and bioenergy mapping systems.

5. Benefits

During the case studies, many benefits of using the Coastal Heritage Viewer for quite different applications were identified. For example, one of the main strengths of the viewer identified by Fingal County Council was that it acts a repository or 'one-stop-shop' for a huge number of datasets which were not previously available. They believe that this will contribute to a more efficient management process, saving time and resources in the sourcing of data.

In the wind energy case, Kerry County Council cited the viewer as an example where availability of multiple datasets from a single source will greatly assist the strategy preparation process, with significant gains in terms of efficiency and staff resources.

All case studies mentioned the importance of being able to view information across county boundaries as another major strength of the viewer, enabling a more integrated, informed and consistent approach to the formulation of the WRES, for example.

6. Next Steps

Along with some of the comments relating to perceived weaknesses above, which will be addressed in future project work, the following comments also highlight where more work could enhance the viewer and increase its ease of use and appropriateness to future tasks.

Various personnel expressed concerns relating to the maintenance of data, particularly in regard to keeping data up to date. These concerns could be addressed through more extensive use of web services for data provision, and through provision of on-going data management support of the project. The suggestion that measuring tools be incorporated so that particular areas on a map may be selected for analysis, has been completed as part of the viewer upgrade.

Also noted was that availability of a reporting function allowing for the generation of relevant information to support the maps generated by the viewer would greatly enhance existing planning processes, such as for SEAs, etc.

The display of datasets was discussed in detail, and it was accepted that the huge number of datasets available on the viewer can make it difficult to find particular

datasets. This could be alleviated by improving the side panel display so that it is easier to identify relevant datasets.

 It was also suggested that a potential design feature of the viewer would be for it to respond to particular planning processes, such as the preparation of an SEA. For example, different datasets could be categorized or grouped which are useful for carrying out the SEA. This could essentially act as a roadmap, with users being able to select the process they are following and then datasets of relevance to that process will be returned. Another suggestion was to install a search bar facility, whereby users can enter key words such as 'Strategic Environmental Assessment' and relevant datasets will be returned. In the interim a search facility based on the layer name has been added.

Work on upgrading the viewer in line with some of these suggestions has already been undertaken. For example, there is the facility to carry out searches on the map layer list and reporting tools for biodiversity data have been included.

The case studies demonstrated clearly the practical usefulness of the viewer for spatially enabling local government to better preserve Irish coastal heritage. The user-led approach has led to the rapid recruitment of 16 additional local authorities to the project, including the remainder of the coastal counties, and a substantial number of inland counties, representing fully two-thirds of local authorities in Ireland. For 2012, the project promoters intend to extend its usage to state agencies, government departments and across the border, as resources allow. In order to better inform citizens, if appropriate data sharing agreements can be reached, public access is a long-term aim.

References

DoEHLG (2006), Wind Energy Guidelines, Department of Environment, Heritage and Local Government, Ireland, Available at http://www.environ.ie/en/Publications/DevelopmentandHousing/Planning/FileDownLoad,1633,en.pdf [Accessed 2 November 2011]

European Parliament and Council (2007), Directive 2007/2/EC of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), Official Journal of the European Union L, 108, 1-14.

Fingal County Council (2011), Fingal Development Plan 2011-2017, Fingal County Council, Avaialbe at http://www.fingalcoco.ie/Planning/FingalDevelopmentPlan2011-2017/ [Accessed 22 November 2011].

Office of Attorney General (1995), Heritage Act 1995, Irish Statute Book, Available at http://www.irishstatutebook.ie/1995/en/act/pub/0004/print.html [Accessed 21 November 2011].

PART THREE

PARTICIPATING SPATIAL ENABLING GOVERNMENT, INDUSTRY AND CITIZEN

Spatially Enabled Risk Management: Models, Cases, Validation

Katie Potts[1], Abbas Rajabifard[1], Rohan Bennett[2] and Ian Williamson[1]

[1]The Centre for SDIs and Land Administration, The University of Melbourne, Australia
[2]University of Twente, The Netherlands

kpotts@student.unimelb.edu.au; abbas.r@unimelb.edu.au; bennett@itc.nl;
ianpw@unimelb.edu.au

Abstract

Risk has a spatial nature. All events that result from risks have a link to a specific location or a factor in space. Understanding where on earth these risks are present allows for these risks to be mitigated, avoided, or managed. In order to manage the risks however accurate and timely spatial information about land and property is first needed. Historically, land administration systems have held this information, however, in recent years these systems have been superseded by other infrastructures that have the capability to capture and store information spatially. While these new systems offer the advantages of spatially enabled information, the authoritative information held within land administration systems is necessary for risk management. Land administration systems need to adapt to remain relevant in the 21st century, and coordination between these land administration systems and the new infrastructures is required to increase the ability of stakeholders to manage this information for risk management purposes. A framework targeted at this issue has been developed which proposes a spatially enabled approach for managing risks for governments, industry, citizens and wider society that takes into account the current information infrastructures (including land administration systems), the stakeholders, and the relevant risks that affect land and property. This framework results in the aggregation and dissemination of consistent information about risk to land and property to all stakeholders. So far the proposed framework has not been tested; however the recent floods in Queensland present an opportunity to apply the framework in the post event environment to determine whether the framework is appropriate within the Australian context.

KEYWORDS: Risk, Land administration, Risk Management

1. Introduction

In the last year there have been many natural disasters across the globe. These include large scale events that have caused devastation, disruption, and many deaths, as well as small scale events that create catastrophe and disorder at the local level. Examples of these events include the earthquakes that occurred in Christchurch, New Zealand, the worst of which struck in February 2011 killing 181 people (Bradley and Cubrinkovski, 2011); the 5th largest earthquake on earth in the last 50 years which hit Japan in March 2011 and the tsunami which came after it killing almost 16000 people and leaving a damage bill of US$235 billion (Tappin, 2011); the floods in the states of Queensland and Victoria, Australia in 2011 which resulted in 38 fatalities and a damage bill of A$32 billion; Hurricane Irene in the United States in August 2011 which resulted in 56 fatalities and US$10.1 billion in damage (Ingelsby, 2011; Orlove, 2011; Walsh, 2011); and other events such as droughts, volcanic eruptions, extreme weather, and landslides that affected a number of countries throughout the last year (Woodbridge, 2011).

In order to manage these disasters spatial information including land and property and risk information was utilized during these events. The ability to understand quickly who lives where, what parcels are located in the disaster area and what the zoning of the area is, is critical in risk management and disaster management. Land information, which is considered essential base data required for any risk management system for use in all phases of risk management, and in a broader sense disaster management needs to be easily accessible during these activities.

Currently, in Australia issues arise when implementing risk management and disaster management processes because of the current land information arrangements. The current sharing and aggregation of information inhibits access across organizations and government departments. Accurate and timely information about land and property is required for effective risk management and is critical for all stages of disaster management. An infrastructure to facilitate the coordination, sharing, aggregation and dissemination of consistent information on risk for risk management and disaster management is required.

This paper explores the information sharing issues related to infrastructures containing land, property and risk information which can be used for risk management. The aim is to assess a framework that enables risks on property and the information related to them to be analyzed. The framework can be used to understand failures and strengths of existing information infrastructures. The framework which will be analyzed consists of four main elements: the risk management stakeholders, the information infrastructures, the risk objects, and the risks. The first section of this paper discusses land administration and risk management and how these two processes are inherently related. The relationship and connection between risk management and disaster management is then discussed. The results of the research are then outlined detailing

the application of the framework to a case study, followed by discussion of the framework and conclusions.

2. Method and Approach

In order to develop the framework a number of steps were taken. First, a case study of the Australian context was undertaken. This involved investigation into stakeholders and information infrastructures (specifically land administration systems) currently active in Australia. This enabled a better understanding to be gained of the current land information environment and the provision of information for risk management. Based on this information the framework was developed featuring four key elements - risks, risk objects, information infrastructures, and risk management stakeholders. This framework was then applied to an active risk information environment to determine whether the situation of the land and property information and risk information is revealed through the application of the framework. This then lead to a discussion of the effectiveness and suitability of the framework for this function, and the benefits of this use. The application and assessment of the framework is discussed in this paper.

3. Overview of Current Theory

As outlined in the introduction, the aim of this paper is to assess a framework that enables risks on property and the information related to those risks to be analyzed. The framework introduced was developed to understand the information infrastructure environment of each situation. The outcome of the framework then determines whether spatial enablement of the information is possible. The framework will be assessed by applying each element of the framework to a risk management environment. The elements within the framework all originate from different areas of theory. An understanding of risk and land administration, the relationship between risk management and disaster management, spatial enablement and the risk framework itself is required to interpret the results. A short overview of each component is now given, highlighting the information relevant for understanding and interpreting the framework and the results.

3.1 Risk and Land Administration

The relationship between risk and land administration is one of significance which is highlighted in the framework. The connection originates from the early requirements of society to have a process for managing the complex rights, restrictions, and responsibilities (RRR) related to land and it use. As information about risk has emerged, the management of this information has been incorporated into land administration systems alongside RRR information. Since this integration however, new risks related to issues such as social, economic, and environmental risks inherent to the 21st century have emerged. Land administration systems, largely based on 19th

century models have found difficulty in adapting. Unlike traditional rights, restrictions and responsibilities which are well defined, these new risks are capable of remaining largely unknown, or unrecorded. As a result, often these 21st century risks are not taken into account, leading to inaccessibility to risk information by stakeholders.

Only recently has the importance of understanding and identifying these risks received attention. The recent disasters around the world have demonstrated a need for this issue to be addressed. Timely and accurate land, property, and risk information is needed for effective risk management, and land administration systems have the capability to provide this. The ability to understand the location and the nature of risk can determine the land and property which is threatened. Once this is identified, the information can be used to implement risk management treatments. A new role for land administration systems needs to be defined and articulated to enable collection and dissemination of risk information. The framework presented aims to demonstrate this. The processes of risk management help determine the information required: an understanding of risk management practices is first needed.

3.2 Risk Management and Disaster Management

The requirement of land, property and risk information for effective risk management and disaster management is well established. Risk management and disaster management are both processes developed to manage events related to land, and therefore require land, property and risk information in their decision making processes. Risk management is focused on understanding the risk and taking action to identify, analyze, evaluate, treat, monitor and review the risk in order to prevent the risk from becoming an event (Standards Australia, 2009). Disaster management, while similar, has a focus on the mitigation, preparedness, response, and recovery aspects of an event caused by risk. The requirement by both for risk information forms the relationship. Based on the information available risk management implements one of four options to treat the risk: avoidance of the risk, reduction of the risk, transference of the risk, or retention of the risk. This process is reflected in the framework. If the risk treatment fails or is ineffective and a large scale event occurs as a result, then disaster management processes are initiated (Figure 1).
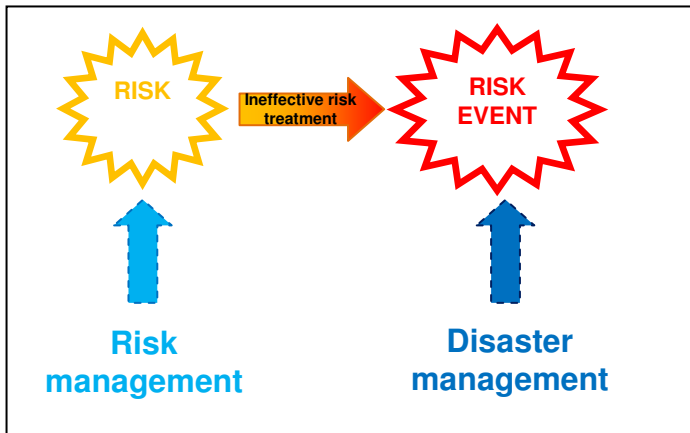
*Figure 1.*The relationship between risk management and disaster management

If the risk management practices are effectively implemented though, then a risk event may never occur. The access to relevant risk information can substantially increase the effectiveness of risk management processes; particularly the risk treatment which relies on relevant information available to guide selection of the most appropriate treatment. The framework will demonstrate this: the ability for this critical information to be disseminated to the stakeholders is dependent on the coordination and sharing of the infrastructure environment. If the treatment of the risk is effective, which is determined by the information available for decision making, then the likelihood of a large scale disaster is reduced. Furthermore, if the risk information is available for disaster management in the earlier phases of mitigation and preparedness then valuable preparation and response can be commenced. The availability of this information is therefore critical. Reliable, accurate and timely information is required for these decisions to be made. An understanding of the information environment facilitated by the framework is first needed. Once the environment has been assessed solutions such as spatial enablement can be proposed to solve problems of information accessibility.

3.3 Spatial Enablement of Risk

Spatial enablement of information in recent years has been shown to solve problems associated with access, sharing and dissemination of information. The term 'spatial enablement' is used to represent the management of information in a spatial way, or the utilization of the spatial or geospatial components of the information (Rajabifard, 2010). The geospatial components of information indicate 'where' the information relates to, which is a powerful tool when seeking to understand the relationship between different datasets or data types. In applying this to risk, spatially enabling risk would result in the organization of all information relevant to risk in a spatial way to allow risk to be viewed from a perspective of 'where'. For risk management

stakeholders, the ability to apply risks to a specific location or place would allow for a better understanding of the risk, and more effective risk management to result. The advantage to this type of perspective is often demonstrated by the risk management stakeholder business group. Insurance companies, as a business related risk management stakeholder are often most interested in the location of individual properties to determine the risks that affect that parcel of land and the property on that parcel. Using flood as an example, spatial enablement of risk information can be used to determine the risk of flood and subsidence. Using the geospatial nature of the information flood risk can be calculated using an intersection of property location, digital map information containing river location, and other available information such as meteorological information for the area (Hart and Dolbear, 2007). Applications of this type can bring great advantages to stakeholders in the risk management and disaster management field. This is because information such as this underpins informed decision making and community resilience. In order to implement spatial enablement. However, the nature and relationships between the infrastructures containing the information must first be understood.

3.4 Risk Framework (Australian Context)

The risk framework, shown below (Figure 2) was developed from preliminary research carried out in the Australian context. The framework was developed as a response to the recurring issue in Australia of no infrastructure existing to facilitate the coordination, sharing, aggregation, and dissemination of consistent information on risk. As a consequence, the ability of governments, industry, and citizens to manage risks to land and property has become limited. The case study involved a study into the arrangements of the current information infrastructures, particularly the land administration systems, as well an investigation into the risk management stakeholders. Research into problem cases identified as resulting from risks was also carried out. The results of this case study found that accurate and timely spatial information and land and property information is fundamental for effective risk management. Based on this, the risk framework (Figure 2) was developed. The framework gives an overarching view of the current arrangements of all stakeholders, information infrastructures and risks in Australia currently. Within the Australian context the problems associated with coordination, sharing, aggregation and dissemination of information, which are exacerbated by out of date land administration systems are highlighted in the framework. Further issues surrounding the presence of and relationships between stakeholders in the Australian context are also incorporated in the framework (Potts *et al.,* 2011).

The framework consists of four different layers; each layer of the framework representing a different issue or element. The risks, risk objects, information infrastructures and stakeholders are all reflected in the framework by a different level. Explanation of each layer is detailed below.
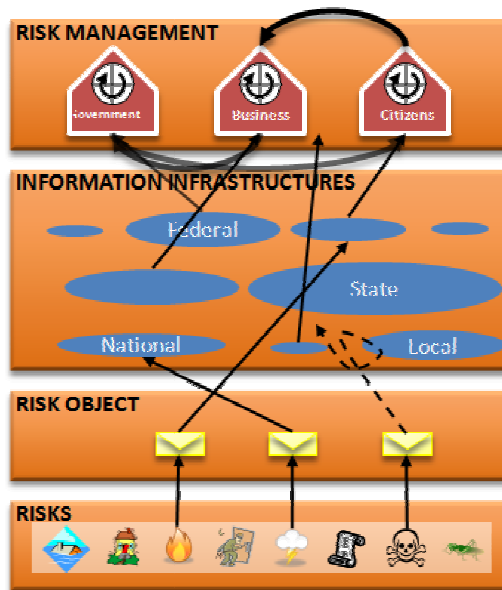
Figure 2. The risk framework (Australian context)

- **Risks**

The risks affecting land and property that are present (within any context) are represented within the layer section of the framework. In this layer the information available describing the nature of each risk accompanies the risk. Examples of risks affecting land and property that can be applied to the framework are flooding, sea level rise, earthquake, fraud, storms, rights restrictions and responsibilities, asbestos, and pests. All of these risks, if they were to eventuate into a risk event would affect in some way land and property.

- **Risk object**

The risk object layer represents the recognition of a particular risk affecting land and property by the person who has a connection or relationship to that particular risk. If this relationship is realized then this is reflected in the framework by the presence of an envelope. If no relationship exists between the person and the risk then no risk object can be created. Similarly, if a relationship exists between a person and a risk, however no realization or recognition has occurred, then the risk object will not be created.

- **Information Infrastructures**

The information infrastructures layer represents all infrastructures that store information about land and property. This includes information about rights, restrictions, responsibilities and risks. This information is critical to all stakeholders, as decisions regarding the tenure, value, use, and development of land are made based on the information available. If the infrastructures holding this information are not

coordinated and restrict accessibility to this information, then the use of this information is reduced, potentially leading to poor decisions regarding the management of land.

- **Stakeholders**

The stakeholder layer in the framework represents all the parties which have an interest in the management of risks to land and property. Within this layer the stakeholders gather the information required to implement effective risk management. In order to obtain the information from the lower layers of the framework, robust infrastructure must exist. If this strong infrastructure exists then the information from all levels of the framework should be disseminated to all the relevant stakeholders, however if the infrastructures are not adequate or well structured, then the information may be prevented from reaching the stakeholders. Embedded within the risk management stakeholders layer is the risk treatment cycle. The cycle is represented by the rotation figure in the framework. The information about risk received from the lower layers is used to inform decisions regarding the treatment of risks. Within this layer the implementation of risk treatments is reflected by each different stakeholder transferring the risk (via an arrow) to other stakeholders. If the information required to make these risk management and risk treatment decisions is not available then the most appropriate decision may not be made by the stakeholders, which may result in problems related to risks in the future.

As each level of the framework interacts the current risk information environment is revealed. If the risk information cannot be disseminated from the bottom of the diagram to the risk management stakeholders then the framework will identify where the problems are occurring. Once the problems are diagnosed then action to resolve the issues can be set in motion. Figure 3 illustrates an operational model, and an effective environment.
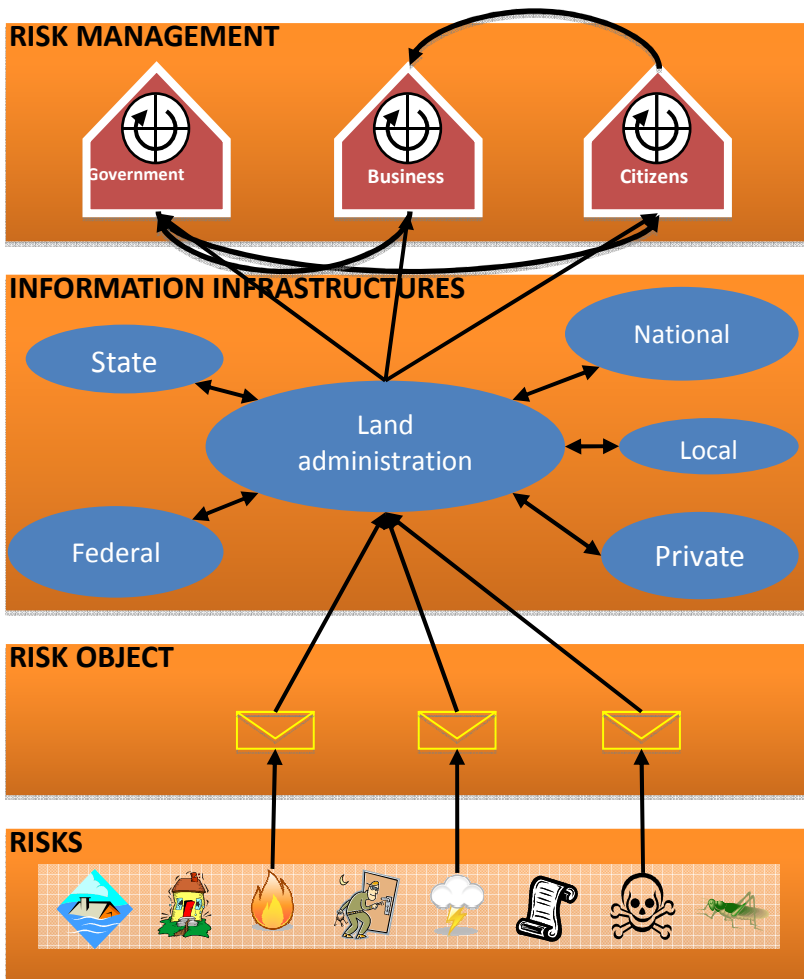
*Figure 3.*The risk framework – operational model

Within this proposed framework (Figure 3) the information infrastructure layer reflects a coordinated environment, where arrangements have been established to allow for sharing of information. The information at the lower levels can be disseminated easily for all risk management stakeholders to access. In this framework the land administration system acts as the central infrastructure to all of the other information infrastructures. The 'overarching' infrastructure is depicted as a land administration system due to earlier discussions branding land administration as key to effective risk management, and as most suited to the role. Land administration systems already adequately manage the collection, recording and dissemination of information regarding land tenure, value, use, and development. Therefore, the incorporation of risk information is not outside the scope of their role.

If realized then a framework modelled from Figure 3 above would create within the Australian context a land administration system which could provide aggregated land, property and risk information from all jurisdictions. Access to this system would facilitate the implementation of effective risk management, disaster management, and a spatially enabled approach to risks for all stakeholders.

4. Results and Discussion – an Assessment of the Framework

Accurate and timely spatial information and land and property risk information is fundamental for effective risk management and disaster management as demonstrated above. In the context of risk management, the coordination, sharing, aggregation and dissemination of consistent information on risk is necessary. The ability of government, industry and citizens to manage risk to land and property is dependent on this information. The risk framework discussed above is now applied within the context of Australia and the Queensland floods disaster.

Analysis of the Queensland floods situation revealed the stakeholders involved and the information infrastructures used during this disaster. The different stakeholders involved and their role in the disaster as well as the information infrastructures involved are detailed. The arrangements and interactions that took place are discussed within the context of the overarching framework. The application of this context to the framework will provide some real data to input into the framework and validate whether the arrangement of the framework is reflective of the Australian environment. The details of the particular case are discussed below.

In December 2010 unprecedented summer rain following a decade of drought caused a series of floods in Australia, primarily in the state of Queensland. The floods that ensued soon forced the evacuation of thousands of people from towns and cities, including the state capital Brisbane. In a short timeframe at least 70 towns and over 200 000 people had been affected. The damage from the flood, initially estimated at A\$1 billion, totalled A\$30 billion by the time the water had subsided and the flood passed. As a result of these floods, three quarters of the state of Queensland was declared a disaster zone.
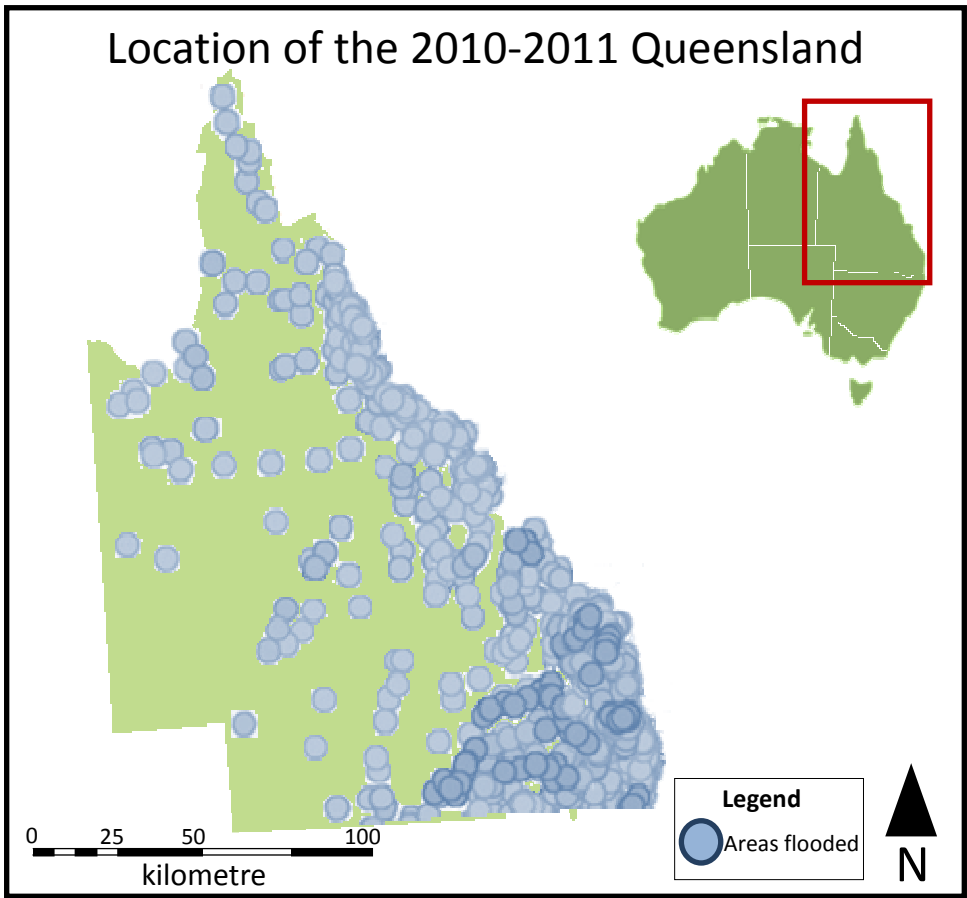
Figure 4. Areas flooded in the 2010-2011 Queensland Floods

4.2 Application of the Framework to the Queensland Flood Disaster

From the investigation carried out into the use of spatial, land and property, and risk information in the Queensland flood event, the details regarding the risk stakeholders and information infrastructures were revealed. This information was then applied to the framework detailed above to produce Figure 5.
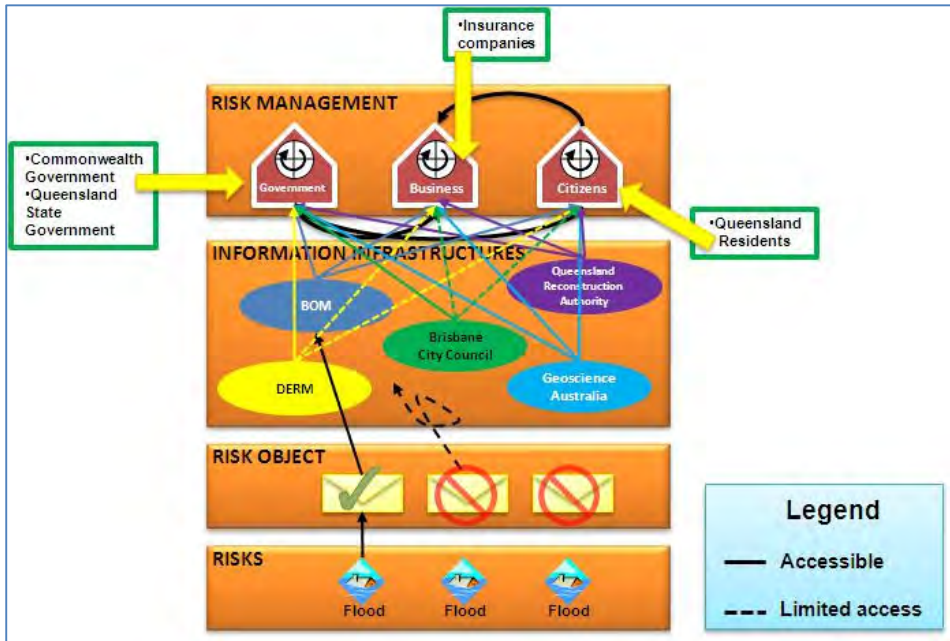
Figure 5. The risk management framework – applied to the Queensland Flood Disaster

As shown in the framework above a number of stakeholders and information infrastructures were identified. An overview of the stakeholder and the information infrastructures, and their role in the event is now given:

- Risk management stakeholders

  In the context of the Queensland disasters, three main groups of risk management stakeholders were identified: government, industry, and citizens. Citizens as a whole were the most affected by the disaster with a large number revealed to have implemented little or no risk management treatments for flooding. The involvement of industry was related primarily to insurance companies who had accepted the risk in the treatment form of transference from both governments and citizens. The government in this event were largely involved at both the commonwealth and state level with the coordination of many departments across the state and Australia. Each stakeholder and the role they had in the event are detailed below.

- Information Infrastructures

  In the Queensland flood event many information infrastructures were utilized. The major infrastructures and the information they provided are described below.

- o Bureau of Meteorology (BOM): provided weather information and warnings based on potential rainfall, storms, cyclones, and other weather related phenomenon. This information is made available free to the public through their website, and was made available during the time of the disaster, in all phases.
- o Department of Environment and Resource Management (DERM): stores all the land administration information for the state including surveying infrastructure data, cadastral data, and topographic information. Other information held by DERM includes aerial imagery of the flood extent, town before and after maps, catalogue and key maps, international charter products, basin inundation maps, disaster relief arrangement maps, GIS modelling and analysis, and radar satellite imagery.
- o Queensland Reconstruction Authority: hosts a website active only for the short term. The website generated queries related to flood lines, eligibility for funding maps, aerial imagery and interactive before and after maps (supplied by DERM).
- o Geoscience Australia: provided basic flood information, detailed reports on floods in Australia, flood capabilities, and research into floods in Australia.
- o Brisbane City Council: provided through their website information on flooded suburbs, suburbs predicted to flood, flood level maps, flood flag maps, and flood wise property reports (which includes the data: January 2011 river flood levels; estimated flood levels; source of flooding including river, creek, defined overland flow or storm tide; minimum and maximum ground levels; and minimum habitable floor level for building and development) (Planning and Building, 2011).

What the framework above reflects is the stakeholder and information environment for the Queensland flood event. What is shown is that there are a number of infrastructures providing information to the majority of stakeholders. Due to the scale of the disaster much of the information was made available free to all stakeholders. It is important to note that within the framework above, the interactions, coordination and accessibilities of the infrastructures between each other is not reflected. Based on the results, the information which is made available to all stakeholders by the infrastructures (Bureau of Meteorology (BOM), Queensland Reconstruction Authority, and Geoscience Australia) would share the information to all other information infrastructures. For the other two infrastructures, which have limited accessibility for industry and citizens, it can be assumed that the limitations would be extended to all other non-government bodies, including the information infrastructures. The information with limited access within the infrastructures, shown in the framework as the Department of Environment and Resource Management (DERM) and the Brisbane

City Council, is limited as a result of its content (certain land administration data – held by DERM), limited by its value (not freely available), or limited in it use.

A strength of the framework is that is depicts the relevant information in an easily understood way which can help facilitate further analysis of the environment. One way this could be used, based on the information shown in the framework (Figure 5), is to assess the development stages of the information infrastructure. Kok and van Loenen (2005) present an assessment framework which is able to determine maturity stages of spatial data infrastructures. The framework has a series of stages (stand alone/initiation, exchange/standardization, intermediary, and network) which reflect the maturity level and a series of aspects (vision, leadership, communication, self-organizing ability, and financial sustainability) which can be used to determine the maturity level. Application of the maturity framework to Figure 5 enables the maturity of the infrastructures within the environment describes to be established. This information can then be used to determine whether the operational model (Figure 3) and spatial enablement of the environment will be possible.

Due to the flexibility of the model, the application of the information specific to the event and specifically to the infrastructure environment is simplified. The framework, with its many possible applications has assisted in revealing the information sharing environment of the Queensland flood event. The role of each stakeholder and the access that is available to each stakeholder has been shown. Moreover, the available infrastructures and the information contained within each have been reflected in the framework. Based on this the framework can be considered effective for detailing the information environment. The benefits of the framework are that it reveals the interactions between each stakeholder and the information infrastructure. This quickly reflects whether coordination, sharing and dissemination of the information is occurring. From the above example as demonstrated by the framework, further coordination is required between infrastructures to enable dissemination of the information held in the infrastructures to stakeholders. Coordination from all of the above infrastructures (which includes the land administration system) incorporated with arrangements for sharing could allow for a spatially enabled approach to be implemented.

4.3 Moving Forward – a Spatially Enabled Approach

Spatially enabling information about risks to land and property is the future. Arranging information in this way enables citizens, governments, and industry to easily understand risks and how risks affect them. Permitting access to this information as a result leads to better risk management and better disaster management.

The arrangement of infrastructures in Queensland leads to a simplified 'spatially enabled system'. However without integration between the infrastructures, spatial enablement will not be realized. Moreover, the resulting 'system' exists only as a post-disaster development, with data collected largely after the event. While this is useful

and sought after during the recovery phase, the real value of the system is never realized.

A system put in place at the discovery of a large risk affecting many interests, would allow for the population to gain access to this information at times of land purchase, development, deciding on insurance plans and would result in a more informed and prepared community. If citizens are able to understand 'where' risks exist, and the places the risk might affect, then the management of the risk can take place more effectively. Allowing access to this information enables stakeholders to make intelligent well-informed risk management and disaster management choices. Figure 6 below demonstrates this idea, where all risk information is spatially enabled, and accessible by stakeholders.
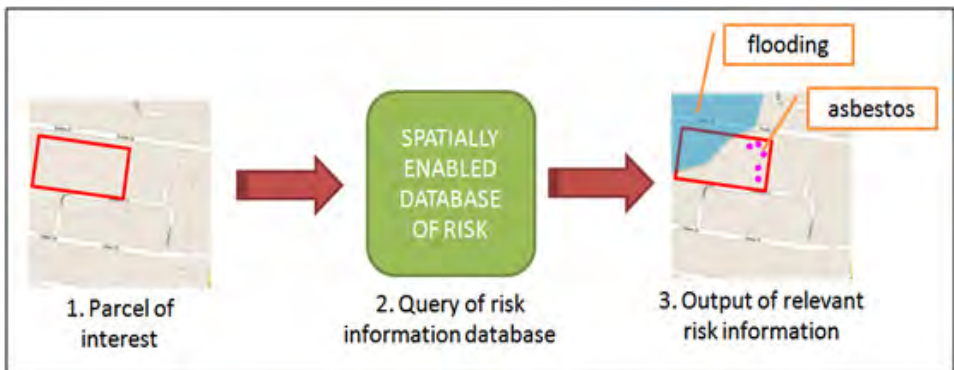
Figure 6. Spatially enabled risk information

Based on this approach a stakeholder would be able to enter into the system a real address or parcel of interest and search for all risks that affect that parcel within the system. If the system was spatially enabled then more complex queries could also be incorporated into the search allowing for specific types of risk, or risks shown only for a certain period of time. If the idea is extended even further then the possibility of including crowd sourced data into the database and then restricting the search to only authoritative or crowd sourced would be possible also.

Firstly, however, the upfront problems within Australia of implementing an infrastructure that facilitates the coordination, sharing, aggregation, and dissemination of consistent land and property information (including risk) must be overcome.

5. Conclusions and Future Direction

Accurate and timely spatial information and land and property risk information is fundamental for effective risk management and disaster management. In the context

of a disaster the coordination, sharing, aggregation and dissemination of consistent information on risk is necessary. The ability of government, industry and citizens to manage risk to land and property is dependent on this information.

In the application of the developed model to reveal the spatial information environment of a post-disaster Queensland, the relevant stakeholders, information custodians and providers have been revealed and the accessibility of the information shown. What is required now is further investigation into the risk management stakeholders, and the identified information infrastructures to determine their capabilities and potential for spatial enablement.

In summary, the framework presented demonstrates the value of spatial enablement to government, industry and citizens, showing the possibilities for the future if administrative arrangement problems can be resolved to allow for coordination, sharing, aggregation and dissemination of consistent information on risk.

References

Bradley, B.A. and Cubrinkovski, M., (2011), Near-source Strong Ground Motions Observed in the 22 February 2011 Christchurch Earthquake, Seismological Research Letters, 82(6): 853-865.

Geoscience Australia., (2010), About Us, *Geoscience Australia,* (November), at www.ga.gov.au, [Accessed 8 November 2011].

Hart, G. and Dolbear, C., (2007), What's So Special about Spatial, in Scharl A., and Tochtermann, K. (Ed). The Geospatial Web. London, Springer-Verlag, pp. 39–44.

Inglesby, T.V., (2011), Progress in Disaster Planning and Preparedness Since 2001, *The* Journal of the American Medical Association, 306(12): 1372-1373

Jacoby, S., (2011), Queensland Floods and Tropical Cyclone Yasi: Importance of Sharing Spatial Information, Information Sharing for Emergency Response and Recovery, July 27-28, Brisbane, Australia.

Kok, B., van Loenen, B., (2005)*,* How to assess the success of national spatial data infrastructures*?, Computers, Environment and Urban Systems,* 29(6): 699-717

Orlove, B., (2011), Waiting for Hurricane Irene in New York, Weather, Climate, and Society, 3(3): 145-147

Planning and Building (2011), Rebuilding and development after the flood, Brisbane City Council, (August), at http://www.brisbane.qld.gov.au/planning-building/Rebuilding-and-development-after-the-flood/index.htm, [Accessed 8 November 2011].

Potts, K., Bennett, R., Rajabifard, A., Williamson, I.P., (2011), Spatially Enabling Risk for Management of Land and Property, SSSC2011 Conference, November 21-25 2011, Wellington, New Zealand.

Rajabifard, A., (2010), Spatially Enabled Government and Society – The Global Perspective, FIG Congress 2010: Facing the challenges – Building the Capacity, April 11-16, Sydney, Australia.

Standards Australia and Standards New Zealand (2009), *AS/NZS ISO 31000:2009* Risk management – principles and guidelines.

Tappin, D., (2011),The March 2011 Japan Tsunami, *Teaching Earth Sciences,* 36(2): 7-9.

Walsh, M.W., (2011), Irene Adds to a Bad Year for Insurance Industry, *New York Times,* (August), at http://www.nytimes.com/2011/08/29/business/irene-damage-may-hit-7-billion-adding-to-insurer-woes.html?_r=1&hp, [Accessed 8 November 2011].

Williamson, I.P., Enemark, S., Wallace, J., Rajabifard, A., (2010), Land Administration for Sustainable Development, Redlands, California, ESRI Press.

Woodbridge, M., (2011), Horn of Africa tested by severe drought, *BBC News,* (July), at http://www.bbc.co.uk/news/world-africa-14023160, [Accessed 8 November 2011]

An Assessment of the Contribution of Volunteered Geographic Information During Recent Natural Disasters

Kevin McDougall

Australian Centre for Sustainable Catchments,
Faculty of Engineering and Surveying, University of Southern Queensland, Australia

mcdougak@usq.edu.au

Abstract

In recent years, improved information communication infrastructure (primarily the internet), the growth publicly available spatially enabled applications (such as Google Earth) and accessible positioning technology (GPS) have combined to enable users from many differing and diverse backgrounds to share geographically referenced information. In an increasingly spatial enabled society, user generated or volunteered geographic information is now becoming the first point of response in the immediate aftermath of a natural disaster. With the prediction of more severe weather events in the coming decades, emergency response personnel must be prepared to react quickly and utilize the latest information and communication technologies where appropriate. Crowd source mapping platforms can be operation in a matter of hours of a natural disaster occurring and can utilize the information provided by citizens on the ground to collect timely and relevant information with respect to the disaster. Information can be contributed through multiple channels to inform others of the impact of the event. This paper examines the growth and development of volunteered geographic information over the recent years. The use of volunteered information and social networking in three natural disasters during 2011 are explored. The timeliness of the responses, the types of information volunteered and the impact of the information during and after the natural disasters are assessed. The relevance of these initiatives to the ongoing development of spatial data infrastructures and their contribution to formal response efforts and authoritative mapping is discussed.

KEYWORDS: Volunteered geographic information, social networking, natural disasters

An Assessment of the Contribution of Volunteered Geographic Information during Recent Natural Disaster

1. Introduction

The Intergovernmental Committee on Climate Change (IPCC) has outlined the scientific case for climate change and global warming. Along with the risk of drought, the IPCC has indicated that there is an increased chance of intense precipitation and flooding due to the greater water-holding capacity of a warmer atmosphere (Solomon et al. 2007). Some of these weather extremes have already been observed and are projected to continue. The modelling indicates that future tropical storms and cyclones could become more severe, with greater wind speeds and more intense precipitation. Studies suggest that that the average number of Category 4 and 5 storms per year has also increased over the past 30 years. In February 2011, Queensland experienced one of the largest tropical cyclones in history, Tropical Cyclone Yasi, a category 5 cyclone which was over 500km in diameter and influenced the weather of much of northern Australia.

During the first few months of 2011, New Zealand, Australia and Japan experienced a series of natural disasters that resulted in severe damage to property and the environment and the loss of thousands of lives. During January 2011, Australia and the State of Queensland in particular, was hit by damaging floods which caused billions of dollars in damage and the loss of over 20 lives. In February 2011, Christchurch New Zealand experienced a magnitude 6.3 earthquake cantered only 10 km from the city. Almost 200 lives were lost and many parts of the city and surrounding suburbs will need to be demolished. Shortly thereafter, in March 2011, large areas of northern Japan were devastated after a tsunami swamped entire towns following a magnitude 8.9 earthquake that was centred off the Japanese coastline. The death toll from the tsunami totalled almost 20,000 people (Earthquake Report, 2010).

During each of these natural disasters crowd sourced information was utilized to map the current status as it unfolded on the ground. This volunteered geographic information became an important part of the information sharing during the critical early stages of each disaster. The capacity for citizens to share information, including location information, has increased exponentially with advances in information and communication technologies and the growth of social networking platforms. Users are now playing a much more active role in participating with volunteered initiatives particularly in the provision of geographic data (Budhathoki *et al.,* 2008; McDougall, 2010)

This paper examines the use of crowd mapping during three natural disasters in 2011 and the deployment of the systems during and after the disaster. Issues that contributed to the success of the volunteered efforts will be discussed together with the broader issues of volunteered geographic information in the context of the development of spatial data infrastructures and spatial enablement.

2. Volunteered Geographic Information and Social Networking

2.1 Volunteered Geographic Information

In recent years, the maturing of mobile information services (primarily the internet), the growth of publicly available spatially enabled applications (such as Google Earth), and accessible positioning technology (GPS) have combined to enable users from many differing and diverse backgrounds to share geographically referenced information. This information has been termed by Mike Goodchild and others as volunteered geographic information (VGI) (Goodchild, 2007; Kuhn, 2007). Volunteered geographic information is not new, but it has emerged gradually from efforts in areas such as participatory GIS (PGIS) where opinions and perspectives are canvassed through GIS portals either online or within constrained environments.

Volunteered information is information that is freely shared by individuals through a variety of portals and communication channels. The volunteering of the geographic dimension of information has been facilitated through two main developments. First, geographic portals such as Google Earth and others have brought geography and spatial information to the people. Digital imagery captured by an array of satellite sensors and presented through various geographic portals has enabled citizens to identify real world features and location with relative ease. The other primary source of volunteered geographic locations is generated through Global Positioning Systems (GPS) receivers which are now readily available in smart phones. Most of this software and functionality has emerged in the past 5-7 years which is a remarkable achievement.

Volunteered geographic information represents a new and rapidly growing resource. Its near real-time capability has been utilized in the emergency and disaster management environments to broadcast the conditions and status on the ground (De longueville *et al.*, 2010; Goodchild and Glennon, 2010; Zook *et al.*, 2010). In the absence of other rapid response mapping which invariably is delayed by days or even weeks, VGI may become critical (Goodchild and Glennon 2010). VGI is also proving to be valuable where traditional sources of fundamental spatial information do not exist or are not publicly accessible. In the case of the Haitian earthquake, the disaster response resulted in an increase in access to geographic information through the assistance of platforms such as the Geocommons (Zook *et al.,* 2010). The absence or lack of accessibility to suitable geographic information can also be a motivator for the collection or utilization of volunteered geographic information.

As volunteered geographic information continues to become integrated into mainstream information platforms, issues of reliability and credibility need to be considered (Bishr and Janowicz, 2010; Flannigan and Metzger, 2008). However the quality of VGI contributions can match or exceed existing databases. The existing issues faced by users of GPS car navigation systems with errors caused by lack of data

or out of date information is evidence that not all geographic databases are reliable (McDougall,2009).

2.2 Social Networking

A social network is a network of nodes formed through relationships that may have been established through friendship, ideas, values, hobbies or other linkage mechanisms. Social networking theory is the study of these networks and the mapping of these relationships as they may apply to wide range of human organizations, from small groups to entire nations (Ethier, 2009). The power of social networks is of considerable interest to researchers and organizations, particularly their power to influence group or public opinion. It has been shown that individuals will increase their interest to participate in public processes if they are connected with others with a higher level of influence (or motivation) (Boudourides, 2002). Citizen participation in social networking forums such as Facebook, Myspace, Friendster and others has grown dramatically in the past few years with many having over 100 million listed members.

Social networking has been identified by a number of industries and organizations as a potential contributor to a range of areas including innovation, building staff networks, solving complex problems or extending the market reach of products. By its very nature, social networking involves a series of one-to-one or one-to-many connections that require the active participation of individuals. During times of natural disasters, conventional emergency contact channels such as the telephone are inundated with calls. Social media via Twitter, Facebook and Youtube have become a preferred channel for communication for an increasing number of people during natural disasters. In the Australian floods, emergency services quickly moved to establish communication via Facebook and Twitter to keep residents updated on important developments.

Private businesses, such as IBM, have realized the growing importance of social media. IBM launched an internal social networking site for employees in 2007 which was designed to blur the boundaries of work, home, professional, business and fun (DiMicco *et al.,* 2008). The system, which was called Beehive, was hosted as an experimental platform for studying the adoption and usage of social networking in the workplace. Initial findings indicate that the value to employees include being able to promote ideas more effectively and to build their social capital within the organization.

An understanding and quantification of the impacts of social media and social networking can be achieved through analyzing the interactions across the network and actors. Social network analysis (SNA) is the analysis of relationships between actors in a social network and has some important implications for the sharing of information across a social network. Having power within a network may mean that an actor may potentially have better access to information, resources or social support (Mori *et al.,* 2005). This concept is important in times of emergencies where authoritative information and sources are sought by individuals.

In order to gain an understanding of the impacts of crowd mapping and social media on the outcomes of natural disasters, three recent natural disaster events were investigated. Each case is described in section three in terms of the initial and post event responses. A comparison of the three cases is then undertaken to identify the similarities and differences and to explore where these volunteered activities sit with respect to the formal disaster response frameworks.

3. Review of Recent Natural Disaster Crowd Mapping

This section reviews the events and crowd mapping that occurred during the 2010/11 Australian Floods, the 2011 Christchurch earthquake in New Zealand and the 2011 tsunami in northern Japan. A common theme among the three cases is that the Ushahidi platform was utilized during each of the natural disasters. Ushahidi is a non-profit technology company that specializes in the development of free and open source software for information collection, visualization and interactive mapping (Ushahidi ,2011). Crowdmap is an on online interactive mapping service, based on the Ushahidi platform (Crowdmap, 2011). It offers the ability to collect information from cell phones, email and the web, aggregate that information into a single platform, and visualize it on a map and timeline. Ushahidi was originally created to coordinate information relating to riots that broke out after the disputed Kenyan election in 2007. Since then, the platform has been used extensively, ranging from spreading information during the Haitian earthquake in January 2010 to dealing with snow removal in New York City.

3.1 The Queensland and Australian Floods in 2010/2011

During December 2010 to February 2011, Australia and the State of Queensland in particular, experienced a series of damaging floods which caused billions of dollars in damage and the loss of over 20 lives. Major flooding was experienced at over 30 cities, towns and rural communities over southern and western Queensland including significant inundation of agricultural crops and mining communities. Consistent rain during the Australian spring resulted in many of the large catchments becoming heavily saturated and the larger storage reservoirs and dams reaching capacity. These conditions were further exacerbated by the presence of a number of tropical cyclones which in addition to heavy rainfall resulted in significant property and landscape damage due to cyclonic winds. Damage to property, agriculture and mining production was estimated at over AUD $12 billion

In the case of the Queensland floods, the news media, particularly the radio media began to field calls from flood victims all over the state and was seeking a mechanism to geographically display these instances. In January 2011, the Australian Broadcasting Corporation launched Queensland Flood Crisis Map – a crowdmap of the Queensland floods (ABC 2011). The crowdmap allowed individuals to send flood-related

information via email, text message, Twitter, or via the website itself (Australian Broadcasting Commission, 2011). This information was then available to anyone with an internet connection.

In the first days of the floods, the map provided a near real-time account of flooding across a large geographical area (over 32 million km2) including local flooding, road closures and the location of evacuation centres. As the disaster moved into the recovery phase, the information being volunteered began to change. Instead of flood locations, the volunteered information included the locations of bottled water supplies, disposal bin locations, clean team locations, and lost and found pets. During the floods almost 100,000 reports were received from various sources during a 30-day period. The crisis map allowed the reports to be classified into categories such as hazards, evacuations, help services, roads affected, property damage and trusted reports. Reports were verified where possible by volunteers from other corroborating information and in total the level of verification reported was approximately 99%.

In addition to contributing to the crisis flood map reports, social networking also played a major role in keeping people informed during the January 2011 flood. The social networking service Twitter <www.twitter.com> allowed people to post and receive short text based updates about the flood in real time. Photos and videos could also be attached to these updates. Similarly, the website Facebook <www.facebook.com> allowed groups such as the Queensland Police Service to provide flood information updates to users who browsed their Facebook page. Finally, YouTube <www.youtube.com> provided a forum for people to connect and inform through the use of user-generated and contributed videos. Photography and imagery of the floods across different regions were posted on sites such as Flickr which were linked to a location through the map. Individuals had the opportunity to add comments and additional information regarding the context of these images. The posting time was also time-stamped by the system. These images provide an excellent historic and current record of the flood events and features in the imagery can easily be used to reference flood heights at a particular time.

At the peak of the Queensland floods there were between fourteen and sixteen thousand tweets per hour on the 'qldfloods hashtag' which was used to coordinate the conversation around the flood event itself (Burgess and Bruns, 2011). These peaked at around the time Brisbane and the surrounding areas began to become inundated. Agencies and organizations alongside members of the community began using the Twitter platform as a place to distribute 'raw' footage and information, and began to trust and 'follow' particular accounts.

The response to the Queensland floods by all levels of government and the community was widely applauded. Information and mapping on the extents of the various floods across Queensland were pivotal in prioritizing resources, distributing emergency relief and clarifying the inevitable insurance issues.

Under international disaster agreements, the Australian and Queensland governments were able to access a variety of mapping resources including satellite imagery during and after the floods. This information was utilized together with high-resolution imagery to assist in the emergency efforts. A special agency called the Queensland Reconstruction Authority launched an interactive map which detailed the areas which were flooded or inundated. This was a valuable source of information for individuals, community organizations, governments and private sector organizations such as insurance firms. However, much of this official or authoritative data was not fully available to the public until some weeks after the disaster.

3.2 The Christchurch Earthquake

In February 2011, Christchurch New Zealand experienced a magnitude 6.3 earthquake which was centred only 10 km from the city. It followed an earthquake in September 2010 which had also inflicted significant damage to Christchurch. The February earthquake caused widespread damage across Christchurch, especially in the central city and eastern suburbs, with damage exacerbated by buildings and infrastructure already being weakened by the September 2010 earthquake. It was one of the most damaging natural disasters in New Zealand history with 181 people killed and over NZ $20 billion in damage.

Within a couple of hours, the Eagle Technology Group Ltd had a Christchurch Earthquake Incident Viewer up and running which showed social media information as it was being fed from the ground. The Ushahidi Christchurch Recovery Map website was launched less than 24 hours after the earthquake. The site mapped locations of services such as food, water, toilets, fuel, ATMs, and medical care. Information was gathered via Twitter messages using the #eqnz hashtag, SMS messages and email. The site was founded by a group of web professionals, and maintained by volunteers (McNamara, 2011).

Another instance of the Ushahidi crowdmap was also established by stuff.co.nz, an information and news service under the Fairfax Media group. However, after discussion it was agreed that a single crowd map instance would be more beneficial to the maximizing the efforts and reduce duplication. Esri also deployed an editable social media map viewer that organized geo-tagged Ushahidi posts and relevant YouTube videos. The crowdmap achieved over 100,000 visits during its establishment and provided a range of report notifications including road closures, hazards, emergency facilities, clean drinking water locations and damage to buildings and infrastructure. The crisis group also provided customizable printed maps from the data

3.3 Japan Earthquake

In March 2011, large areas of northern Japan were devastated after a tsunami swamped entire towns following a magnitude 8.9 earthquake that was centred off the Japanese coastline. Massive waves of water, up to 10 metres high in some parts,

travelled more than five kilometres inland. The quake was estimated at over 100 times more powerful than the Christchurch earthquake and sent walls of water over towns in northern Japan including Sendai city and Kamaishi on the Pacific coast. The sheer devastation of the tsunami resulted in a death toll of over 20,000 people (National Police Agency). The physical damage to infrastructure and buildings and loss of production has exceeded US $300 billion.

Within hours of the earthquake, a member of Japan's OpenStreetMap community launched a dedicated Crisis Map for the disaster. A few hours later, Japanese students at The Fletcher School (which is where the Ushahidi-Haiti Crisis Map was launched) communicated with the Tokyo-based OpenStreetMap team to provide round-the-clock crisis mapping support. Over 4,000 reports were mapped in just 6 days and the crowd map was used by a number of foreign embassies to track the possible location of their citizens (http://irevolution.net/2011/03/17/crisis-mapping-libya-and-japan/).

The sinsai.info site established an Ushahidi instance to pinpoint locations where people may be trapped, dangerous areas that should be avoided, and supplies of food and clean water. Prior to the earthquake, Japanese volunteers had been working with Ushahidi to prepare for the possibility of an earthquake. The development work that was undertaken for the Haitian earthquake enabled the software to become much more sophisticated and much easier for people to create a version of Ushahidi tailored to their needs (http://www.technologyreview.com).

As the full destruction of the tsunami became evident, the damage to the nuclear power plant at Fukushima came under close scrutiny. In an effort to bring additional information to the public regarding the radiation levels around the plant, an organization called Safecast began mapping and publishing radiation maps across northern Japan. The group of volunteers used both fixed and mobile sensors to map the areas around Fukushima and to collect more than a million data points. The volunteers worked on the premise that it is better to have this information available to the public rather than undisclosed or unreported by governments or monitoring agencies. The Safecast system was deployed within a week of the tsunami and has been assisted by a core team of around 100 volunteers.

4. Discussion

The three natural disasters described provide a clear pattern of well-organized volunteer efforts to establish a mechanism for citizens to report their location and status and alert others of any potential areas of risk. The overall success of the initiatives has been astounding when considered in the context of each disaster. The Queensland and Australian floods had been ongoing for a period of a month or more before the more serious events occurred. The crowd map provided an opportunity for Australians and international citizens to visualize geographically the location of various flood events and the progress of the flood as it advanced down the different river catchments. Although other emergency information was available through the media,

particularly via radio broadcasts, people were seeking more information about location of the flooding. The floods had also occurred over the Christmas vacation period and consequently there were many people who were travelling and were seeking locational information on the flooding to help plan their movement.

The Christchurch mapping response was also excellent, and from the reports available provided some very useful insights into the early developments of the crisis mapping system. Again the volunteer efforts were mobilized quickly through groups and organizations such as CrisisMappers (http://crisismappers.net/) and Crisis Commons (http://crisiscommons.org/about/). These groups can call upon hundreds of volunteers worldwide to mobilize the teams to commence the crowd map. Many are experienced programmers and system analysts and so technical issues can be solved through a collaborative process. In the case of Christchurch where multiple crowd maps were being deployed, the project team contacted the other groups and agreed on a single main source to maximize the effort and outcomes. The work of the crowd mapping team was handed over to the emergency response agencies which had established a more systemized map to assist in the reconstruction efforts.

In the Japanese disaster, the crisis mapping was facilitated through the Openstreetmap movement and volunteers from the Fletcher School of International Affairs, Tufts University, Massachusetts. After the initial response from the Openstreetmap community, an Ushahidi solution was established through the volunteer community connected to the CrisisMappers. The implementation required input from the Japanese community and local volunteers to process the reports.

The characteristics of the three volunteered crowdmap instances are shown in Table 1. The Christchurch map was replaced as an authoritative source reasonably quickly after the disaster as emergency response team established control. It was removed to ensure that a single point of control and contact could be established for emergency efforts. In all cases the response time for establishing these sites was well in advance to the official response mapping efforts which typically took weeks to make maps available. In the case of the New Zealand and Japanese responses the establishment time was effectively a matter of hours.

From all the available sources investigated, there is little evidence of deliberate postings of spurious information and, in general, the quality of information in respect to context and relevance is high. In the Queensland floods crowdmap, approximately 99% of reports were verified or collaborated through a large number of volunteers. In the case of the Japanese crowdmap the number of verified reports is noted as being just over 6%. The Japanese crowdmap has significantly different statistics to Queensland in both the volume and the level of verified data. The reason for the relatively low volume in Japan is not well explained but may be a combination of a cultural reluctance to share information publically, a lack of corroborating evidence and perhaps a reflection on the level of devastation and hence lack of communication infrastructure or access to the disaster area.

The verification process followed by each instance of the crowdmap is a function of the individual volunteer group. As a general rule, the Ushahidi guidelines for verification of reports recommend the following:

- Information from multiple reports;
- Multiple and different sources, e.g. messages from different phone numbers regarding the same incident;
- Message from different platforms such as phone, email, Twitter and news;
- A site administrator who can confirm reports from local knowledge or who has spoken to volunteers or authorities;
- Collaborating photos or videos; or
- Reports from a known or trusted reporter.

The high level of trusted and verified reports in the Queensland case also can be explained by the willingness for Australians to volunteer and support others during times of disaster. Australia has a very high level of volunteerism in comparison to other countries around the world. During the flood recovery stage, volunteers came from all over Australia and overseas to assist in the recovery and re-building efforts. This illustrates a willingness to assist others and to also share useful information during times of need.

Characteristic	Queensland Floods	Christchurch Earthquake	Japanese Tsunami
Site establishment time	Approximately 48hrs	12-24hrs	6-12hrs
Utilization	Alerts, photo, blocked roads, recovery points	Hazards, road closures, drinking water, building damage	Trapped people, dangerous areas that should be avoided, and supplies of food and clean water
Lifecycle	Active for approximately 5 weeks	Active for approximately 3 weeks	Active 8 months after tsunami
Reported quality	99% verified reports	unknown	6.1% verified
Availability of site	Data currently accessible	Site not available	Active
Number of reports	98,000	>100,000	>12,600

Table 1. Characteristics of Crowd Maps for the three disasters

With the exception of the Japanese crisis map, the initial maps ceased taking further reports within approximately a month of the initial disaster as emergency services and reconstruction efforts took over. In each of the three cases it was evident that the crowd sourced maps filled a gap in the emergency response efforts. In particular, in

the early chaos of the disaster there is a gap before emergency response efforts establish their information and control structures.

Most emergency response efforts follow a "command and control" approach where high level command structures are established with a formal control centre where most, if not all, communication is channelled. This approach ensures that clear messages can be communicated based on all of the information available from the various response units. However, the establishment of these structures takes time and often requires usurping the powers of existing emergency and government authorities which can result in some confusion of efforts until the hierarchical control system is fully functional.

This "top down" approach has similarities to the first generational approaches of SDI development where it was necessary to establish a policy framework to provide direction from a national level. Over time, the direction setting has moved from the high level jurisdictions to the sub-national and local levels. However, with advances in information and communication technologies and the wider spatial enablement of communities, it is the citizens that are now interacting and contributing information within the SDI framework. Just as the hierarchical approaches of SDI are now being supplemented with less structured network approaches through citizens, emergency or crisis mapping is now being revolutionized through crowd sourced data provided by citizens within the disaster.

As pointed out by Tim McNamara in his commentary on the Christchurch response (McNamara, 2011) one of the points that struck him was the level of collaboration that occurred in a very short space of time amongst the volunteers. He attributes this collaboration to the open source platform that was used for the crowd mapping. Open source developers also bring with them many collaborative skills such as being able to work in many time zones simultaneously and manage issues such as remote communication and version control. These skills are extremely valuable at the time of a crisis where coordination is critical and projects are resource and time poor.

Many of the volunteers in this community bring with them excellent credentials, experience and a positive attitude. In some instances, the volunteers hold positions of influence in organizations such as Google Inc which provide a network of contacts and the ability to access additional resources or data. This is not a criticism of the excellent skills and co-operation that is present when public sector agencies and emergency response groups come together. However, the bureaucratic agencies bring with them a degree of conservatism and protocols which have a tendency to inhibit development by placing conditions and obstacles in the way.

McNamara also identified another factor that contributed to the success of the Ushahidi approach of open source and not for profit was the fact that the platform was vendor neutral. This meant that the project gained a high level of trust within the community and did not attract the issues associated with competitive vendors in the commercial environment. The neutrality enabled information to flow from a variety of

organizations into the crowd map and also provided the freedom allowing the team to provide essential service information as well as information that may have been considered by an emergency management team to be non-essential.

Crowd mapping and the groups of volunteers also managed to create a degree of cultural interaction and diversity which presents both challenges and opportunities. Some of the challenges with establishing an operation within a different country requires the cooperation of volunteers and needs to respect the cultural nuances within a different culture. Some terms and practices that may be acceptable or taken for granted in one country may need to be considered more carefully in another more conservative environment. Conversely, it may be important to begin to challenge the existing norms within a particular environment in order to more effectively engage the users or the citizens in the process. The Safecast approach to collecting information on the radiation levels is an example of an approach where providing greater access to information will hopefully encourage authorities to become more accountable and open.

Crowd mapping generates a huge volume of relevant, timely and incident related information during the early stages of a disaster. This information proved extremely valuable in a variety of circumstances during the period of the natural disaster, but the information is also valuable after the event. Post disaster assessment and analysis can provide an excellent insight into how the disaster unfolded including critical events and happenings. In the case of the Queensland floods, comments from the citizens has proved useful in understanding what support was being provided on the ground and photography from the crowd sourced reports and other sites such as Flickr provide a historical record of the event and flood levels. Some of this information can be utilized by mapping agencies to map the flood heights and also to assist in insurance claims. The question arises as to how should this information be preserved and who should take the initiative to undertake this preservation.

5. Conclusions

The three case studies provide an insight into the operation and value of volunteer driven crowd sourced mapping during different natural disasters. The advances in information communication technology has made the development and deployment of a "not for profit" service not only possible, but also extremely successful. The impact on the service in the three different countries has yielded different outcomes and different approaches. In each case the crowd sourced mapping provided a unique perspective on the disaster that would not have been possible from a conventional emergency service "command and control" structure or implementation.

In a few short years the Ushahidi platform has been developed and refined to the stage where it can be deployed in a matter of minutes. Unlike vendor developed solutions, it can be rolled out with limited technical knowledge, although a support network of volunteers are standing by to provide various levels of assistance.

Proposed new functionality in Ushahidi, such as a "check-in" facility, will allow a user to identify them as being in a disaster zone for safety or security reasons. This will extend the already significant capability of this system. This proposed addition will also potentially assist in the coordination of individuals or groups within a disaster and move closer to a more useful emergency management tool.

The value and utility of crowd sourced or volunteered geographic information continues to grow in the disaster management arena. Although the crowd sourced mapping does not comfortably fit with the more conventional models of hierarchical control for information management, it has now been utilized successfully in a number of natural disasters. Crowd sourced information is now considered a valuable addition to emergency response efforts and has begun to break down the barriers in the efforts to spatially enable society. The value of the open source software and the camaraderie engendered through the open source and volunteered collaborative approach is refreshing. There is no doubt that the movement will face challenges as it continues to operate in these difficult environments, but if the past performance is any indication of future developments, the movement will have a bright future.

References

Australian Broadcasting Commission(2011), ABC QLD Flood Crisis Map. 20 February 2011, <http://queenslandfloods.crowdmap.com/reports/>.

Bishr, M. and Janowicz, K., (2010), Can we Trust Information? - The Case of Volunteered Geographic Information. Proceedings of Towards Digital Earth Search Discover and Share Geospatial Data Workshop at Future Internet Symposium.

Boudourides, M., (2002), A review of network theories on the formation of public opinion. Proceedings of EURICOM Colloquium, Nijmegen, Netherlands, 9-11 October, 2002.

Budhathoki, N.R., Bertram, B. and Nedovic-Budic, Z., (2008), Reconceptualising the role of the user of spatial data infrastructure.,GeoJournal 72(149-60.

Burgess, J. and Bruns, A., (2011), Social Media in the Queensland Floods. 20 June 2011, <http://www.cci.edu.au/presentations/social-media-use-queensland-floods>.

Crowdmap (2011), Crowdmap Website. 15 May 2011, <http://crowdmap.com/>.

De longueville, B., Annoni, A., Schade, S., Ostlaender, N. and Whitmore, C., (2010), Digital Earth's Nervous System for crisis events: real-time Sensor Web Enablement of Volunteered Geographic Information. *International Journal of* Digital Earth 3(3): 242-59.

DiMicco, J., D. Millen, Werner, G. and Casey, D.,(2008), Research on the use of social software in the workplace. San Diego, California, 8-12 November 2008.

Earthquake Report (2010), National Police Agency Report. 20 October 2011 2011, <http://earthquake-report.com/2011/08/04/japan-tsunami-following-up-the-aftermath-part-16-june/>.

Ethier, J., (2009), Current Research in Social Networking Theory. 20 January 2009, <http://www.ccs.neu.edu/home/perrolle/archive/Ethier-SocialNetworks.html>.

Flannigan, A.J. and Metzger, M.J., (2008), The credibility of volunteered geographic information, GeoJournal 72(137-48.

Goodchild, M. and Glennon, A., (2010), Crowdsourcing geographic information for disaster response: a research frontier, International Journal of Digital Earth 3(3): 231-41.

Goodchild, M.F., (2007), Citizens as sensors: the world of volunteered geography, GeoJournal 69): 211-21.

Kuhn, W., (2007), Volunteered Geographic Information and GIScience. NCGIA, UC Santa Barbara, 13-14 December, 2007.

McDougall, K., (2009), Volunteered Spatial Information For Building SDI. Proceedings of Spatial Sciences Institute Biennial International Conference, Adelaide, Australia, 28 September – 2 October 2009

McDougall, K., (2010), From Silos to Networks - Will Users Drive Spatial Data Infrastructures in the Future? FIG, Sydney, Australia, 11-16 April, 2010.

McNamara, T., (2011), The Power of Ushahidi. New Zealand Computer Society, 10 November 2011, <http://www.nzcs.org.nz/newsletter/article/94>.

Mori, J., Sugiyama, T. and Matsuo, Y., (2005), Real-world orientated information sharing using social networks. ACM, Sanibel Island, Florida, 6-9 Novenmber 2005.

Solomon, S., Manning, D. Qin, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L., (2007), Climate Change 2007: The Physical Science Basis. Cambridge University Press, Cambridge, United Kingdom.

Ushahidi (2011), Ushahidi Mission Website. 20 May 2011, <http://www.ushahidi.com/about-us>

Zook, M., Graham, M., Shelton, T. and Gorman, S., (2010), Volunteered Geographic Information and Crowdsourcing Disaster Relief: A Case Study of the Haitian Earthquake. Policy Studies Organization Commons 2(2): 7-33.

CHAPTER 12

Are 'Smart Cities' Smart Enough?

Stéphane Roche[1], Nashid Nabian[2], Kristian Kloeckl[3], and Carlo Ratti[4]

[1] Centre for Research in Geomatics, Université Laval, Québec, Canada, and SENSEable City Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA

[2] SENSEable City Laboratory, Massachusetts Institute of Technology, and Harvard Graduate School of Design, Cambridge, Massachusetts, USA

[3] SENSEable City Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA, and University IUAV of Venice, Italy

[4] SENSEable City Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA

Stephane.Roche@scg.ulaval.ca; nnabian@gsd.harvard.edu; kloeckl@mit.edu; ratti@mit.edu

We live in the Global Location Age. "Where am I?"
is being replaced by, "Where am I in relation to everything else?"
Introduction of PennState Geospatial Revolution Project
(http://geospatialrevolution.psu.edu/)

Abstract

In our contemporary societal context, reconfigured by wide spread impact of Geo-localization and wikification on urban population's everyday work and life, two related concepts, "spatially enabled society" and "smart city", have emerged from two different but related fields: the Global Spatial Data Infrastructure community drives the former while practitioners and researchers in urban planning, urban studies and urban design are more concerned with the latter. We believe that technology enhanced, ICT-driven solutions that spatially enable the members of urban populations, contribute to smart operation of cities, and we suggest that a dialogue between the communities that foster these two notions needs to be established. We seek to provide an ontology of categorically different, but still related, spatial enablement scenarios along with speculations on how each category can enhance the Smart City agenda by empowering the urban population, using recent projects by the MIT SENSEable City Lab to illustrate our points.

1. Introduction: Can We Have a Smart City without a Spatially Enabled Urban Population?

Geo-localization and Wikification have spread throughout society, including citizens' everyday work and life. Now is the age of Googlemap-mania where everything is about geo-location and geographical information, and the era of Wikinomics manifested in the current trend in day-to-day social organization towards democratization of access to information, peer-to-peer information sharing, and crowdsourcing the mass production of collaboration-based Information. Under such circumstances, sensor networks, real-time information flow and location (of everybody and everything) become important parts of today's life, especially urban life.

In this reconfigured societal context, two concepts have recently emerged: "spatially enabled society" and "smart city". These two concepts come from two different disciplinary fields, two different communities. The Global Spatial Data Infrastructure - GSDI- community mainly drives the discourse on spatial enablement; while smart city, as a concept and a mode of operation, emerges from practitioners and researchers involved in urban studies, architecture, urban infrastructure, and engineering. In this article we maintain that a city cannot fulfill the requirement of being smart in its most comprehensive sense unless the technologically enhanced, ICT-driven urban solutions that are considered in smartening up the city, are also contributing to the empowerment of the urban population by spatially enabling them. Yet, in its present form, we lack a cross-disciplinary dialogue about these concepts: the "smart city" and the "spatially enabled society". Only very few formal references are made by both of their reference communities regarding each other's work. In this paper, we try to address this disconnection and explore possible contributions of the notion of 'spatial enablement' to the 'smart city' debate in the age of Geo-location and Wikification.

2. Smart City and its Relation to Technology

2.1 Providing a Comprehensive Definition of "Smart City"

As for smart cities, the urgency for improving the cities' capacity for competitiveness and sustainable growth has focused the attention of city officials, place makers and policy makers on securing a desired level of quality in areas such as housing, economy, culture, and social and environmental conditions. This challenge fuels the worldwide obsession with making cities smart, and to this effect, the Smart City as a label,

concept, and agenda has been quite fashionable in place-making discourse and practice in recent years.

Based on our literature review of the field, we believe that in providing the most comprehensive definition of smart cities, urban performance should be gauged against a city's hard infrastructure and its attention to the environment;[1] the accessibility to and use of information and communication technologies (ICTs), for both urban population and public administration (Graham and Marvin, 1996; Roller and Waverman, 2001); as well as its human and social capital, manifested in decisive factors such as the presence of a creative class (Florida, 2002), the education level of urban population (Berry and Glaeser, 2005; Glaeser and Berry, 2006), and the generation of Localized Knowledge Spillovers (LKS), originated from face-to-face contact between peers in an urban environment (Breschi and Lissoni, 2001; Fu, 2007; Capello, 2009). Furthermore, the smartness of a city should be measured by its participatory governance, its smart economy, its smart urban mobility, its smart environmental strategy and management of natural resources, and the presence of its self-decisive, independent, and aware citizens leading a high-quality urban life. In collaboration with the Centre of Regional Science at the Vienna University of Technology (lead partner), as well as with the OTB Research Institute for Housing, Urban, and Mobility Studies at the Delft University of Technology and the Department of Geography at University of Ljubljana, a European Smart City research project was carried out from April 2007 to October 2007, aiming at ranking 70 mid-sized European cities in terms of smartness, based on an evaluation model developed by the research group.[2]

In its current state, the vision of a smart city is one-sidedly fostered by a technologically enhanced worldview of the urban condition. This idea is in line with the European Union's focus on achieving urban growth in a "smart" way for its metropolitan areas, manifested in the OECD and EUROSTAT Oslo Manual of 2005, featuring a wired, ICT-driven form of development.[3] Furthermore, Caragliu, Del Bo and Nijkamp (2011) wrote an article providing an interesting set of decisive factors in identifying smart cities. In visions that companies such as CISCO and IBM offer through their initiatives for smart cities, the latter are envisioned as wired cities with connectivity as the main source of their growth and the driver of their effective performance, which are saturated with ICT-driven solutions to urban problems that

---

[1] Many recent books are revisiting the importance of urban form in shaping the experience of urbanites. A well-known aphorism by Winston Churchill goes: *"We shape our buildings, and afterwards our buildings shape us."* The same belief lies behind Jan Gehl's latest book (2011). In the first chapter, he states: *"First we shape the cities – then they shape us."*

[2] For more information on the project and results, please see the website at http://smart-cities.eu, as well as their final report titled "Smart cities Ranking of European medium-sized cities," available at
http://smart-cities.eu/download/smart_cities_final_report.pdf http://www.smart-cities.eu/model.html

[3] http://epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/OSLO/EN/OSLO-EN.PDF

are deployed top-down by city officials and governmental agencies. For example, the Cisco's Smart+Connected Communities initiative is geared towards the use of intelligent networking capabilities to connect people, services, community assets, and information into a single pervasive solution by leveraging real-time information and applications, with the network as the underlying service delivery platform. Following the same route, in December 2010, the Brazilian city of Rio de Janeiro and IBM signed an agreement to build a public information-management center for Rio de Janeiro. The plan is for the Center to integrate and interconnect information from multiple government departments and public agencies to improve the city's responsiveness to various types of incidents, functioning as a modern, urban-scale control room. The operators of this control mechanism will be provided "with a single, unified view of all the information that they require for situational awareness." Since the Center will be equipped with a platform for consolidating data from urban systems for visualization, monitoring, and analysis, it will enable city leaders to make decisions in emergency situations based on real-time information. Pedro Almeida, Smarter Cities Director for IBM Brazil, predicts that this IT platform will soon be able to gather data on all incidents and events occurring in the city. This means that the operators of Rio's Center will soon be given access to an unblinking eye monitoring the city, so that governmental and public employees can anticipate events in time to provide efficient response.[1] Most of the time this technological view does not take into account the role an empowered human and social capital could play in transforming our cities into intelligent operating mechanisms.

2.2 "Smart City" and Conception of Technology as In-use

The deployment of connected sensors and immersive information technologies that suffice for a city to become 'smart' has its tradition in a positivist perspective that sees technology as salvation to both perceived and unperceived problems, examples of which date back to Friedrich von Knauss' "Wundermaschine" (miracle machine) from the mid-eighteenth century (Argyris and Schön, 1995). In this vision, the deployment of technology itself, and its magical, awe-inspiring effect on the observer, cannot solve problems while disregarding the way by which technology is used and embraced by a user community. Contrary to the view of technology as detached from the specificity of its context of use, is the so-called "technology-in-use" perspective, common to the Science and Technology Studies domain. Whereas the espoused technology is what we buy and install as predefined integrated modules in hardware and its accompanied software, how we use it is not predefined by any means and depends on the context within which we use technology according to our needs, skills and interests. Inquiring into these two different aspects of technology, Argyris and Schön (1995) demonstrate that there is often a contradiction and a certain level of conceptual separation between the two. Moreover, both in theory and practice, what matters in evaluating the global efficiency of a technology is not the predefined commitments of a certain technology, but its regular use in the real world.

---

[1] http://www-03.ibm.com/press/us/en/pressrelease/33303.wss

Beside the specific performance measures of a technology, this approach focuses on the broader dynamics of technology as a part of organizational structures, use modalities, workflows and socio-cultural meaning systems tied to it. Troubles arising from smartening up our cities using ICT-driven solutions to meet urban challenges, do not relate to technological inefficiency. Indeed, when a smart card public transport ticketing system introduced in Jakarta breaks due to a limited consideration of the operational environment, or, the one in Venice does not deliver origin-destination data due to the specific implementation, it is not the *raison d'être* of technology that should be reconsidered, but the implementation that lacks integration and coordination into existing contexts and their dynamics. The results of such oversights are not neutral. They are considerable due to costly investments made without the rightfully expected direct and indirect value return for citizens, and they might also compromise previously successful solutions that may not be reversible after a systematic change in technology.

To this effect, envisioning smart city related technologies as technologies-in-use (such as sensing, actuating and information technologies in cities) means to begin with the study and consideration of existing dynamics of specific urban contexts, and its spatial and socio-economical organizational structures, in order to empower urban communities to successfully tackle the challenges they face. The technologies deployed in the process of smartening up our cities will succeed if they are embraced and integrated into the modalities people chose to live their cities and they will fail if their deployment is seen as the end of a process instead of a beginning.

As a matter of fact, the proliferation of digital technologies has greatly enhanced opportunities of leap-frogging. Once in place, disruptive technology systems can change the underpinnings of how things are done, and enable solutions to be developed, though previously unthinkable, as for the cellphone adaption in African countries without landlines and the diffusion of the Internet. Yet, neither of these systems offers solutions. Instead, the more they are accessible to people in their daily routines, the more they are powerful. When planned and implemented carefully, technology connections allow citizens themselves to become actuators in their city, enabled to interact meaningfully with and through space. This coincides with the core idea of spatial-enablement.

3. Smart City and its Relation to Spatially Enabled Society

3.1 Technological Enhancement of the [Smart] City and Spatial Enablement of Urban Population

A "spatially enabled society is an evolving concept where location, place and any other spatial information are available to governments, citizens and businesses as a means of organizing their activities and information" (Williamson *et al.,* 2010). Basically,

following the previous definition, spatial enablement refers to the concept of location as a way to organize and manage spatial processes. Though in this context a spatially enabled society appears to be limited to governance, multi-purpose cadastre management, and land tenure and administration issues, its reality is broader in scope, and it theoretically includes a wide spectrum of users, as well as various levels of practices. At the same time, this theoretical broadness makes it unclear. Therefore, the concept of spatial enablement needs to be better defined. What does it mean really? What should a spatially enabled society be? And, to what extent spatial enablement could make smart cities more efficient?

Most recent definitions state that to be considered as spatially enabled, an organization (city, local Government, society), must first consider location and spatial information as common goods, and then make it available in order to stimulate innovation. To this effect, three necessary conditions are envisioned as necessary to become a spatially enabled society. First, citizens have to be "spatially literate". Secondly, spatial enablement requires "A conducive environment for sharing spatial data", and this is essentially the aim of Spatial Data Infrastructures initiatives. Last but not least, there is no possible spatial enablement without globally unified Geospatial standards (Africa, 2011).

This third condition fits with the view of spatially enabled society as "dependent on the development of appropriate mechanisms to facilitate the delivery of data and services". But to be spatially enabled an organization has to: (1) accommodate in its very operational logic, a more effective and transparent political and electoral process by making relevant geographical information accessible to citizens; (2) foster economic market improvement through the development and diffusion of public geographical information products and services; and (3) allow monitoring environmental sustainability by using spatial indicators provided by distributed sensor networks (Rajabifard, 2009). Therefore there is a general agreement on the need for a "service-oriented infrastructure on which citizens and organizations can rely" to have access to geographical information and location-based services (Rajabifard *et al.,* 2003). Such infrastructure (basically close to the last generation of SDI) is seen as the key basis to any spatially enabled society, since it provides stakeholders with faster and direct information updating and downloading capabilities; and deploys mobile and monitoring applications offering augmented and virtual reality capabilities for instance (Uitermark *et al.,* 2010).

Furthermore, in a move towards a user-centric view of SDI, that is to say a more individual perspective of spatial enablement, it can be argued that SDI could contribute to a spatially enabled society. As such, users' preferences have to be taken into account within SDI, in order to increase user's satisfaction and individual spatial enablement. Also, even if citizens do not necessarily need raw data, they need spatial information extracted from raw data, as well as location-aware or context-sensitive services providing access to the data that meet their interests and enhance their way of thinking by taking into account their spatial context. Furthermore, basic spatial

knowledge can be used to improve data sharing and information retrieval processes (Abolghasem *et al.,* 2010).

Indeed, from a practical point of view, "spatial enablement" refers to the individuals' ability to use any geospatial information and location technology as a means to improve their spatiality, that is to say, the way they interact with space and other individuals on/in/through space (Lussault, 2007). Hence, in the present social context, individual spatiality should not be considered detached from possibilities offered by information-enabled mobility (info-mobility), and real-time geo-communication (location-based communication). Therefore, we argue more fundamentally that a spatially enabled citizen is characterized by his ability to express, formalize, equip (technologically and cognitively), and of course consciously -or unconsciously- activate and efficiently use his spatial skills.

3.2 Spatial Skills Activation by Using Geospatial Technologies and Information

Spatiality refers to any individual or collective condition and practice related to the position - geographical location - of both individuals and groups relative to one another. It typically reflects the spatial actions achieved by individuals, social groups, or organizations (Lussault, 2007). In order to efficiently manage their spatiality and mobility, citizens tend to improve their spatial thinking capacities and use spatial skills. According to Lussault (2009), human spatiality is based on the five following basic spatial skills.

(1) Metrics skill refers to the ability to measure distances, and to distinguish the near and far using the Euclidean metric (measurement of distance in meters and kilometers), or in non-Euclidean metrics such as distance-time, distance-cost, distance-number of connections.

(2) Location skill is a matter of finding the "right" place and proper location to be or to do something, based on one's context including the relative location of other objects, people and services.

(3) Scale skill refers to the capacity to put one's actions in perspective; to compare different phenomenon or objects with regard to their spatial resolution or level of granularity; to discriminate the small and the big.

(4) Zoning skill refers to the ability to delineate areas and define the spatial limits of one's actions, movements within space, and living or inhabiting the space.

(5) Crossing skill refers to the ability to cross through different kinds of barriers, obstacles, and security check-points, thresholds, etc.

Geospatial technologies and Location-based services offer users various direct and indirect ways to activate - and to some extend improve - their basic spatial skills. Nevertheless, availability and even use of such technologies does not necessary and directly imply spatial skill improvement, or, in other words, spatial enablement. As explained in section 2.2 above, the inherent tension between espoused technology (the way technology is pre-defined to work) and technology-in-use (the way that it will work in the context of its use) might seriously reduce the potential of geospatial technology regarding its contribution to users' spatial enablement.

Moreover, the pervasiveness of technology, the era of wikinomics, and the juxtaposition of physical and digital spaces, which represent characteristic factors in both the wikified and the Geo-localized world, transform human spatiality. Relation to space is no longer the same. Today, the digital and physical are so intertwined that an enabled citizen can just as much be fully "here" and "now", as "there" and in the "past" or "future". By this we mean that in a space resulting from a hybridization of the physical and the digital, the physical distance can be bridged by using telecommunication technologies allowing real-time transactions of digitally encoded messages between locations far apart from each other, while temporal distance is bridged by real-time access to memory of past events, thus providing people with tools to revisit the past or even to catch a glimpse of the future. Indeed, people can recognize patterns in the past through a certain number of algorithms, so as to be able to anticipate what is to come in the near future, or to predict the status of spatial systems in a far future. Whereas bridging physical distance is possible through telecommunication networks, the same process regarding temporal distance implies radical transformations as regard to how we collect, store and manage vast amount of information. Telecommunication technologies on the one hand, and memory collection, management and storage technologies on the other hand, not only drastically change the forms of human spatiality, but also the nature of spaces themselves. These new forms of spatiality are actually mostly co-spatialities. Co-spatiality refers to spatial actions people undertake to manage their relations with/in/through distant spaces and distant people mediated by technologies (Lussault, 2009). Managing co-spatiality requires individuals not only to mobilize the basic spatial skills mentioned above, but also to develop complementary skills, necessary for the adoption and use of geo-communication and location-based technologies. It particularly requires a new capability to connect to/disconnect to/ switch from one distant space and its occupants to another.

3.3 Info-mobility and Geo-communication Skills

In a spatially enabled society, with highly developed spatial skills as elaborated above, mobility is one of the key components of people's spatiality. It eliminates or reduces the operational or performative distance between social realities, and thus reduces remoteness by bridging places. Within "societies of mobile individuals" moving is no longer an end in itself, but a fully-fledged activity in which travelling routes, costs and times are optimized (Stock, 2005). For mobile citizens, the question is not so much

"Where am I?" as "What is around me?" (services, people, traffic, disturbances, shops…), "What can I expect?" and "How do I get there?". To do so, individuals increasingly, and more and more systematically, use communication and information technologies (CIT), sensor-based networks and, more specifically geospatial-distributed technologies (Roche and Caron, 2009). As a consequence, mobility is enriched (increased) with dynamic information on the spatial location and environment (topology, social neighborhood, transportation schedules…) of users. This type of mobility, delivered to users through the mediation of technological artifacts such as GPS navigation devices, smart phones, and sensor-based networks, is referred to as "info-mobility". It characterizes the interactions established between mobile individuals and the informational resources that guide and assist their orientational and navigational choices (Kauber, 2004; Sheller and Urry, 2006). These new spatial practice modalities, fitted with informational and communicational devices, mainly rely on the proliferation of Location-Based Services (LBS). These user-centered services "push" contextual information to users, that is to say information providing details about their location and context - characteristics of their environment, and also if necessary of their ongoing state of mind and specific objectives. They can be envisioned as pull services providing contextual information on demand. While the use of communicating mobile terminals (smart phones or personal navigation devices) is becoming commonplace, these tools are emerging as the key interfaces (mediators) of both the physical (real) and digital (virtual, partially intangible) space.

Geo-communication is indeed another related practice. Basically it refers to another skill developed by people to respond to the ubiquitous challenges they face. Geo-communication is communication between mobile individuals related to their place, supported and mediated by geo-communication technologies - arising from the convergence between mobile/telecommunication technologies and location-based technologies. For spatially enabled citizens, the use of geo-communication technologies is a way to project themselves into - to switch to - distant spaces and to establish communication with others from their remote position. This is actually a way for individuals to converge the "here" and "there", and thus to develop a quasi-capacity for ubiquity. Basically, this ability to disconnect from the "here" and to connect to the "there" is a way for spatially enabled citizens to compress space and reduce it to places where the Euclidean metric is no longer relevant. Each of these connected and augmented - with virtual and tangible information - places becomes a "space concentrate" from where the whole human space is accessible. Therefore, citizens' spatial enablement relates more to the linkage between explicit and tacit knowledge than just to spatial skills.

3.4 Converting Spatial Knowledge

Citizens' spatial literacy is a basic condition of spatial enablement as mentioned in section 3.1. This spatial literacy could not occur outside a recurrent learning process. An interesting description, as well as relevant to our study, of this learning process is based on the paradigm of knowledge conversion, which is achieved through

socialization, externalization, combination and internalization (Nonaka and Takeuchi, 1995) (Figure 1):

- Socialization (tacit to tacit) is the process of learning by sharing experiences, thus creating tacit knowledge as shared mental models and professional skills (for instance, acquiring new understanding of the notion of place through informal exchanges of feelings with other members of a social network).

- Externalization (tacit to explicit) is the process of converting tacit knowledge into explicit knowledge (for instance making comments about a personal experience related to a specific location, and sharing them with members of a social network).

- Combination (explicit to explicit) is the process of enriching the existing explicit knowledge to produce new sets of knowledge (e.g. mashing-up forecast data with traffic data to feed an online transportation support system).

- Internalization (explicit to tacit) is the process of individual learning by repeatedly executing an activity using explicit knowledge (e.g. applying some travel recommendations, and using GPS navigation tricks as new personal tacit knowledge).
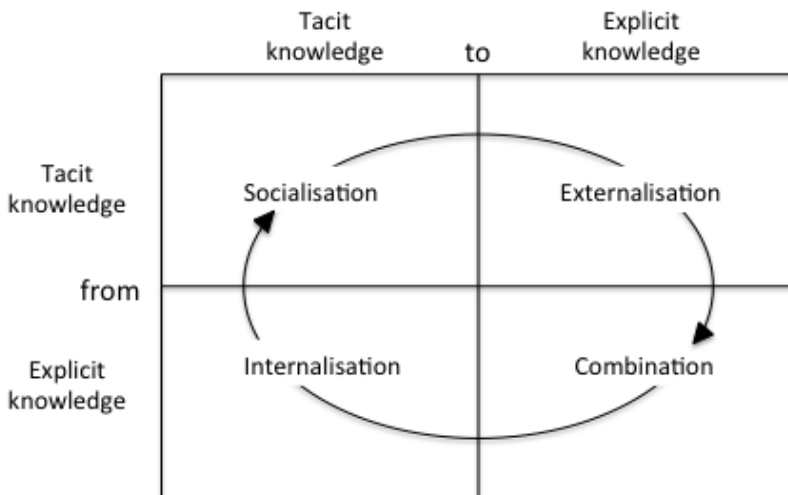
Figure 1. The knowledge conversion processes (from Nonaka and Takeuchi, 1995)

For these four modes of knowledge conversion social networking becomes central. In the context of a spatially enabled society, mobile location-based services can also support geo-spatial networking, whereas the device allows sharing location with

others, exchanging information with others as well as navigating the physical and virtual space by searching for information. The capacity to share Geo-location with others through mobile devices along with social networking applications, and real time communication (phone calls, text messages, and video calls) transform the spatial and temporal modalities of exchanging and interacting with others, and consequently impact the spatial knowledge conversion processes by allowing for what can be defined as spatially enabled social networking.

In such a context, "Location-based Social Network" aims at locating contacts, notifying users of their proximity and allowing them to engage/disengage communication. This practice converts info-mobility and geo-communication into opportunities for social gatherings (InstaMapper, Google Latitude, Foursquare or Facebook Place for instance). A few services (e.g. Spotme) even mention the location of unknown individuals, according to the principle of linking ("matchmaking"). Combining the potentials of geo-location and social networking with real-time communication spatially enables citizens to mash up their (virtual) network with their (material) physical space, and then to share "real" experiences in the "virtual" world and vice versa. In such hybrid spaces, people can share, through different types of technological solutions, their successive locations and movements with members of their network, while tracking them in return. They can also enhance their geo-communication skills and enrich shared knowledge gained from "friend generated geographic content".

3.5 Spatially Enabled Citizens as Human Sensors to Feed SDI

User generated geographic content and geo-crowdsourcing are indeed two other major characteristics of a spatially enabled society as well as a smart city. Spatially enabled citizens increasingly use technology, particularly mobile technology, to voluntarily contribute and provide local information and share place-based knowledge on their networks. Users become both producers and consumers of this information. Citizens, as sensors, are able to provide their (social) network with real-time information about their spatial experiences: recording and sharing personal memories, reporting on inefficiencies and problem areas within the city, or rating the services provided in different locations. In this type of user-contribution-based service, community is shaped through LBS and, in return, these services rely on community, considered as a source of information. This concept of "citizens as sensors" (Goodchild, 2007) is also an important issue for Spatial Data Infrastructures (SDIs). Spatially enabled citizens could be considered as a dynamic source of information to feed the SDI data flows, (Craglia, 2007) as well as the monitoring system of smart cities.

If citizens can unconsciously provide useful information to fuel smart city (when their traces, their spatial behaviors, or even their tweets for instance are tracked and analyzed to better understand new dynamics in the city) they also can consciously participate to city life and actuation. Similarly, in the context of spatial enablement citizens could take advantage of existing Spatial Data Infrastructures while creating

and sharing spatial knowledge, as sensors in their own right. To this effect, volunteered Geographical Information (VGI) becomes the most prolific source of information to characterize places.

As we saw previously, spatially enabled society and smart cities have much in common, and they both benefit from Spatial Data Infrastructures as enabling platforms improving access, sharing and integrating spatial data and services. Yet they are still conceptual and technical challenges remain to achieve a fully functional system (Rajabifard, 2009). A smart city as an actuating source of spatial enablement might possibly provide solutions to overcome these challenges. In the following sections we seek to provide thoughts and ideas to move forward to this direction.

4. An Ontology of Spatially Enabling Smart City Technologies

In the context of smart cities, spatial enablement particularly refers to the capacities that add functional depth to the space of a city via a series of technologically enhanced transformations of spatial practices.

First of all, bridging the distance between individuals and different locations is the key feature of smart cities. Material and human resources travel through the space of the city in a streamlined manner, using different mobility technologies, the efficiency of which is maximized by a constant regulation of the system through real-time monitoring. At the same time the city has become a heavily networked space, so as to allow multiple-bridging to connect disseminated locations. Telecommunication networks represent a major bridging tool, enabling real-time exchange of digitally coded messages, with a higher than ever resolution and multi-modal formats (textual, audio, video transmission, etc.).

Secondly, building on the capabilities offered by both bridging technologies and those accommodating on-line social networking (boosting/fostering social organization), new dispersed communities emerge, as well as new associations between their members. These on-line, geographically remote communities develop ties with each of their members. Sometimes, these ties are stronger than place-based ties established between members of communities living in the very same location.

Third, the technologies of memory retrieval and management have given us the prospect of a world of "total recall" (Bell and Gemmel, 2009) where nothing is forgotten and the digitized log of any occurrence is at hand anywhere and anytime. This means that what we can access defines our very being.[1] Take the practice of

---

[1] *MyLifeBits* is a Microsoft research initiative looking at the prospect of a digitally implemented total memory. The project is a decade-long effort to digitally record everything in computer-science researcher Gordon Bell's life including what he did, saw, read, ate, and felt. Basically, the project examines the possibility of creating a total memory of a given subject's life experience.

taking photographic pictures as an example. In its pre-digital version, someone would use photography to keep record of his/her life experience as a series of stand-alone memory objects; that is, photographs. Then, photographs would be taken, developed on paper, stored in albums and boxes, disconnected from the world, and would eventually decay and disappear due to the degenerative impact of time on all material things. Once the practice was digitized, the pictures would acquire a theoretically eternal dimension: since they were not stored as material objects, they would not decay, and they could be now searched, retrieved on-demand and cross associated with other forms of information. With the introduction of on-line social networking platforms and user-generated content, stand-alone digitized personal memories were gradually aggregated to a comprehensive, collaborative, ever growing database of human living memory. Once cross-associated with their temporal, geographical and social context, they have become an extremely powerful tool to describe our environment. This condition is ubiquitous across many other practices as well. Our capacity to collect, store and manage huge amounts of data has allowed us to maintain log files from many day-to-day activities that are mediated through digital and telecommunication technologies. Every time a phone call is made, a credit card is used, a text message or an email is sent, a Google query is submitted, a Facebook profile is updated, a photo is uploaded or tagged on Flickr, or a purchase is made on a major on-line mega store such as Amazon.com, an entry with the time and location of this action is added to a dataset on a central server (on the cloud) administered and maintained by the organizational entity providing the platform for these, and hundreds of other day-to-day operations. This huge amount of data is really changing the relationship that we have with information and with our information-rich environment. This change represents a driving force for ICT-driven solutions to urban problems in smart cities.

Fourth, while memory-retrieval and management technologies give us the prospect of a world of "total recall," where nothing is forgotten and the digitized log of any occurrence is at hand anywhere and anytime, the post-human factor is also added to this mix. Consequently, using mobile technologies extends each individual digitally by providing him or her with a mini-computer equipped with a plethora of embedded sensors, and a small portal for the delivery of information. Such a device is capable of establishing a data connection both to the infrastructure of mobile networks, and to the more localized, ad hoc networks that are of a peer-to-peer nature. This gives us a Pandora world of hyper-connection; as fantasized in the 2009 movie *Avatar*, where everything and everybody can be connected to everything and everybody else through space and time, and the connection can be fostered by hierarchical infrastructures such as cellular networks, or peer-to-peer ad hoc networks mediated through Wi-Fi and Bluetooth technologies.

Fifth, memory and data-retrieval technologies allow bridging the temporal distance between incidents, and to provide access to the hybridized universe whenever it is needed. Wired and wireless communication technologies allow bridging the physical distance between incidents, so that the analog world, translated into digital format, can travel through space and provide users with access to the hybridized universe

wherever it is needed. However, we still have a missing link here. Real-time data reception and transmission technologies enable data-scapes to take form based on networked entities. Yet, in order to achieve a thoroughly hybrid, spatio-temporal phenomena, the information layer needs to be situated within the physical world. The series of binary 0s and 1s must to be attached to the actual, global locations they represent via sensed data. Entities that populate the physical world and their digital counterparts in the virtual layer, that is data about them, need to be cross-referenced. Technologies of geo-localization allow us to locate digital content within the physical realm by annotating a given geographical location with data, or cross-referencing data with a geographical location. This makes it possible to envision two different but connected typologies of information-rich geographies in the context of smart cities, where the urban landscape is conceived as the cradle of real-time relevant information regarding urban processes. In what we define as real-time localities, the virtual representation of space is the interface through which information is acquired and delivered. It is similar to a dynamic, interactive Google map that is populated with placeholders of various real-time information, and accessed by a sedentary user behind a computer screen. In what we identify as geo-taggable/geo-cacheable spaces, the physical space itself becomes the interface for the acquisition and delivery of digital content. Agents dynamically geo-tag and geo-cache information based on their real-time locations. This is the case for almost all location-based services that users gain access to via their smart phones, while on the run and navigating the city.

In short, the capacity to have real-time access to distant locations and/or to those who inhabit or occupy these locations using the services offered by wireless or wired tele-communication networks, as well as the capacity of being accessible via the same networks, the capacity to annotate space with digital information, and the capacity to access annotations based on the real-time location of the user who is seeking to retrieve contextual information in a digitally annotated space, all of this will provide us with a basis for a working ontology of spatially enabling technologies-in-use.

To illustrate our ontology at work, we can use three projects by MIT SENSEable City Lab that we believe are relevant examples of how a technology-at-work will empower and spatially enable the urban population, and hence contribute to smartening the city they inhabit:

(1) CO2GO is an iPhone applet that makes use of the embedded sensors of the device (accelerometer, GPS, etc.), and deploys a context-aware algorithm to calculate in real-time the carbon emissions of the user, by automatically detecting his/her transportation modes and tracking the distance covered. This information assists users in making smarter individual transportation choices to collectively reduce carbon emissions in cities. This smart solution is built on the citizens' vision as sensors of the processes contained within the smart cities on

one hand, and the citizens' spatial enablement via social networks on the other hand.[1]

Figure 2. CO2GO Screen shots of Mobile Application, MIT SENSEable City Lab ©

(2) Aida (Affective Intelligent Driving Agent) is a smart navigation system aiming at estimating a driver's likely destination based on collective mobility patterns in the city and individual profile information - such as past riding behavior and online calendar entries - and providing relevant information to the driver accordingly. In order to deliver this information, Aida's interface brings the virtual augmented map closer to the actual physical city seen through the windshield. This is achieved by incorporating the unused area on the dashboard to establish a direct and seamless connection between the actual street and its representation on the digital map. The project is very much in line with the improvement of navigation-related spatial skills using geographical information and techniques for annotating spaces with digital information discussed in this paper.[2]

---

[1] For more information on the project please consult its dedicated web entry at
http://senseable.mit.edu/co2go/
[2] For more information on the project please consult its dedicated web entry at
http://senseable.mit.edu/aida2/
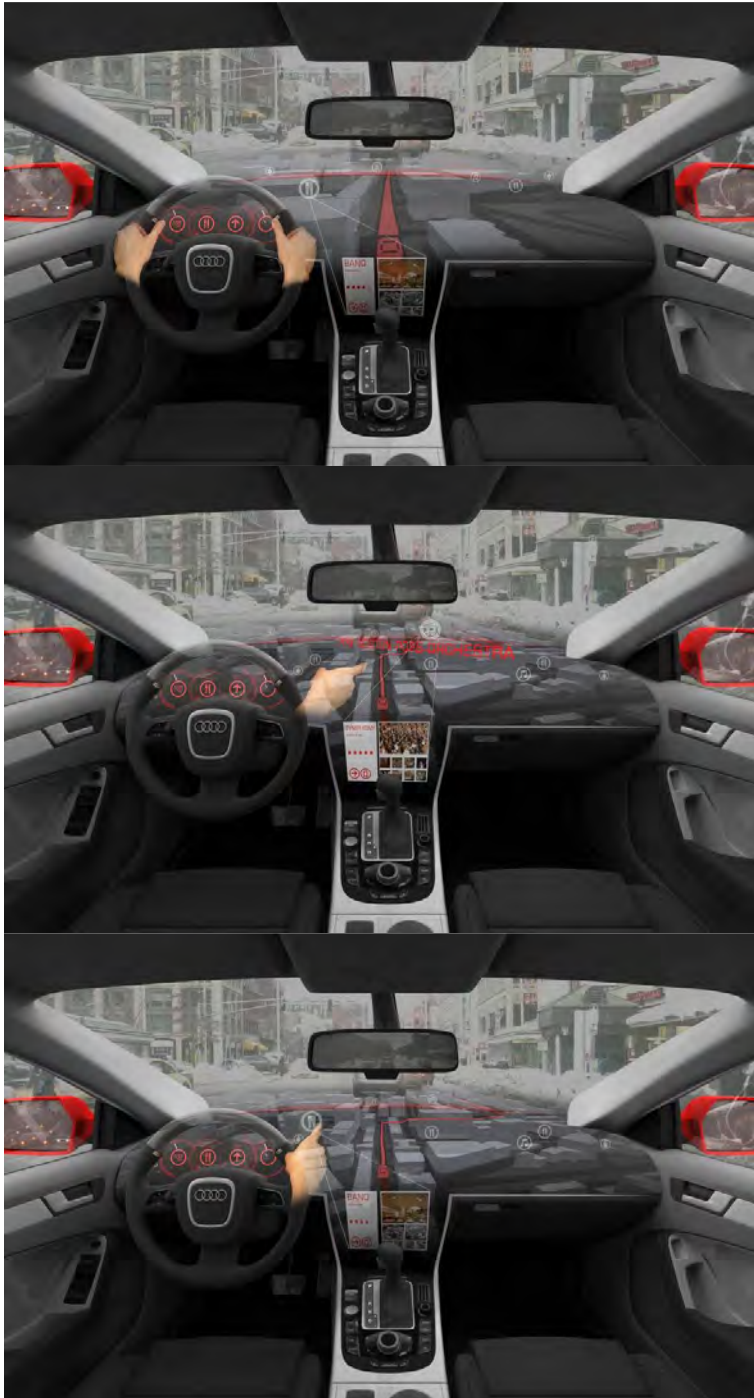
Figure 3. AIDA interaction scenario on the digitally augmented dashboard to retrieve location-aware information while driving, MIT SENSEable City Lab ©

(3)   Copenhagen Wheel which retrofits a conventional bicycle and transforms it into a mobile sensing device. Controlled by the cyclist's smart phone, as he/she cycles, the wheel's sensing unit captures his effort level and information about his/her surroundings, including road conditions, carbon monoxide, NOx, noise, ambient temperature and relative humidity. The cyclist can also share this data with friends, or with his/her city – anonymously - and contribute to a fine-grained database of environmental information that then can be accessed through a phone or the web. Again, the project is apparently built on the potential offered both by embedded sensors to crowdsource the process of collecting geo-referenced information regarding the city and social networks to disseminate this information and democratize access to it.[1]

Figure 4. Copenhagen Wheel and its embedded technologies, MIT SENSEable City Lab ©

---

[1] For more information on the project please consult its dedicated web entry at http://senseable.mit.edu/copenhagenwheel/

Figure 5. Copenhagen Wheel retrofitting a conventional bicycle, MIT SENSEable City Lab©

Figure 6. Copenhagen Wheel screen shot of mobile social network applet for sharing collected information MIT SENSEable City Lab ©

These three projects, and others within the same field that considers the deployment of sensors, networks and location technologies to empower the urban population in their day-to-day lives, add a technologically enhanced performative and functional depth to the city.

5. Conclusions

In smart cities that are reliant on ICT-driven solutions to address urban problems on one hand and to spatially enable citizens on the other hand, urbanity merges with digital information so that the built environment is dynamically sensed and synchronously actuated to perform more efficiently, intelligently, and sustainably. Under such circumstances geographical information systems, in combination with telecommunication networks that provide access to real-time information on these systems, as well as for place-based or context-aware social networking, blur the distinction between "here" and "there"and between "present", "past" and, "future". Bridging the spatial and temporal distance is a contributing factor to the spatial enablement of the citizens of smart cities in the near future. Perhaps a future research direction should concentrate on the ability to blur these distinctions to contribute to the smart cities' agenda? Why and how this empowers people to tackle challenges they face in urban planning and management? To what extent these tasks can be crowd-sourced to a spatially enabled, technologically aware population, capitalizing on informal competences of citizens as opposed to limiting the realm of production of space or spatial knowledge to a limited team of experts? How SDI could contribute to smartening up cities in the context of spatial enablement? And in return, how spatially enabled citizens could contribute to the smart city?

References

Abolghasem, S.N., Rajabifard, A., Kim, K., Seo, J., (2010), Ontology Based SDI to facilitate Spatially Enabled Society, GSDI 12 World Conference, "Realising Spatially Enabled Societies", 19-22 October 2010, Singapore.

Africa, C., (2011), What does it take to be spatially enabled? http://www.futuregov.in/blog/2011/may/25/what-does-it-take-be-spatially-enabled/

Argyris, C., and Schön, D., (1995), Organizational Learning II: Theory, Method and Practice, Reading, MA, Addison-Wesley, 1995.

Bell, G., and Gemmell, J., (2009), Total recall: how the E-memory revolution will change everything, New York, N.Y., Dutton.

Berry, C.R., and Glaeser, E.L., (2005), The Divergence of Human Capital Levels Across Cities, Papers in Regional Science, 84(3): 407–444.

Breschi, S. and Lissoni, F., (2001), Localized Knowledge Spillovers vs. Innovative Milieux: Knowledge 'Tacitness' Reconsidered, Papers in Regional Science, 80(3): 255–273.

Capello, R., (2009), Spatial Spillovers and Regional Growth: A Cognitive Approach, European Planning Studies, 17(5): 639–658.

Caragliu, A., Del Bo, C., and Nijkamp, P., (2011), Smart Cities in Europe, Journal of Urban Technology, 18(2): 65-82.

Craglia, M., (2007), Volunteered Geographic Information and Spatial Data Infrastructures: when do parallel lines converge? , Position paper for the VGI Specialist Meeting, NCGIA, Santa Barbara 13--14 December 2007.

Florida, R.L., (2002), The Rise of The Creative Class and How It's Transforming Work, Leisure, Community and Everyday Life, New York: Basic Books.

Fu, S., (2007), Smart Cafe´ Cities: Testing Human Capital Externalities in the Boston Metropolitan Area, Journal of Urban Economics, 61(1): 87–111.

Gehl, J., (2011), Cities for People, Washington, Covelo, London: Island Press.

Glaeser, E.L., and Berry, C.R., (2006), Why Are Smart Places Getting Smarter?, Taubman Center Policy Brief 2006-2, Cambridge, MA: John F. Kennedy School of Government.

Goodchild, M., (2007), Citizens as sensors: The world of volunteered geography, GeoJournal, 69: 211–221.

Graham, S., and Marvin, S., (1996), Telecommunications and the City: Electronic Spaces, Urban Place, London: Routledge.

Kauber, M., (2004), The Emerging Market of Infomobility Services, in E. Bekiaris, & Y. J. Nakanishi (Eds.), Economic impacts of intelligent transportation systems: innovations and case studies (1st ed., pp. 69-90). Amsterdam, Boston, Elsevier JAI.

Latour, B., (2009), Spheres and Networks: two ways to reinterpret globalization, a lecture at Harvard University Graduate School of Design, February 17, Harvard Design Magazine 30: 138-44 (Spring/Summer 2009).

Lussault, M., (2007), L'homme spatial: la construction sociale de l'espace humain, Paris, Seuil.

Lussault, M., (2009), De la lutte des classes à la lutte des places, Paris, Grasset.

Mitchell, W. J., (1996), City of bits, Cambridge, MIT Press.

Nonaka, I., and Takeuchi H., (1995), The knowledge-creating company, Oxford, Oxford University Press.

Rajabifard, A., Feeney, M.E.F., Williamson, I.P., and Masser, I., (2003), National SDI Initiatives, Chapter 6, Development of Spatial Data Infrastructures: from Concept to Reality, ISBN 0-415-30265- X, Taylor & Francis, U.K.

Rajabifard, A., (2009), Realizing Spatially Enabled Societies – A Global Perspective in Response to Millennium Development Goals, 18th UNRCC-AP Conference, 26-30 October 2009, Bangkok, Thailand.

Roche, S., and Caron, C., (2009), Organizational Facets of GIS, London, Wiley – ISTE.

Roller, L.H., and Waverman, L., (2001), Telecommunications Infrastructure and Economic Development: A Simultaneous Approach", *American Economic Review*, 91(4): 909-923.

Sheller, M., and Urry,J., (2006), Mobile technologies of the city, New York, Routledge.

Sloterdijk, P., (2009), Spheres theory: talking to myself about the poetics of space, a lecture at Harvard University Graduate School of Design, February 17, Harvard Design Magazine 30: 134-8 (Spring/Summer 2009).

Stock, M., (2005), Les sociétés à individus mobiles: un habiter poly-topique? L'exemple des pratiques touristiques, EspacesTemps.net (http://www.espacestemps.net/document1353.html).

Tapscott, D., and William, A.D., (2009), Wikinomics: How Mass Collaboration Changes Everything, New York, Penguin Group.

Uitermark, H., Van Oosterom, P., Zevenbergen, J., and Lemmen, C., (2010), From LADM/STDM to a Spatially Enabled Society: a Vision for 2025, The World Bank Annual Bank Conference On Land Policy And Administration, 26-27 April 2010, Washington D.C., USA.

Williamson, I., Rajabifard, A., and Holland, P., (2010), Spatially Enabled Society, Proceedings of the FIG Congress 2010, "Facing the Challenges – Building the Capacity, Sydney.

Factors Affecting Geographic Information Systems Implementation and Use in Healthcare Sector: The Case of OpenHealthMapper in Developing Countries

Zeferino Saugene[1], Márcia Juvane[2] and Inalda Ernesto[2]

[1]University of Oslo, Department of Informatics
[2]Eduardo Mondlane University, Department of Mathematic and Informatic

zsaugene@gmail.com; racyjuvane@gmail.com; inaldamarina@gmail.com

Abstract

Geographic Information Systems are one of the most widely used information technologies to assist governments in the management of spatial related problems such as those of healthcare practitioners in developing countries. As a follow-up of the challenges faced while customising *OpenHealthMapper* in Malawi and Guinea Bissau, this paper uses the case of Mozambique to highlight significant differences between the ways geospatial stakeholders approach the issue of *geodata*. Empirical data illustrates that boundary complexity and weak coordination are behind the problems encountered in the *geodata*. With an emphasis on *geodata* needed to perform healthcare analysis, the article analyzes the role of boundary objects and how their quality is influenced by the tensions between the communities managing them. The analysis demonstrates how boundary objects are devices that maintain relationships and also creates tensions. Based on Carlile's knowledge integration framework, the development of an integrated *geodata* management approach is discussed, i.e., the paper suggests a management mechanism focused on the notion of *transfer*, *translation* and *transformation* which is used to conceptualize the role of boundary objects as elements that helps to reduce the boundary complexity and strengthen community members' coordination.

KEYWORDS: Geographic information systems, healthcare sector, boundary interaction, boundary objects, geodata management, developing countries.

1. Introduction

One of the most interesting developments in recent years has been the increased adoption of spatial enabled applications to assist government to manage its information and processes using spatial concepts and technologies: a process that has come to be known as spatially enabled government (Masser *et al.,* 2008). The vision of this process is to establish enabling infrastructure that facilitates the provision of the place or where or location to all human activities, and government actions, decisions and policies (Holland *et al.,* 2010; Masser *et al.,* 2008). Realising this vision is dependent on the development of appropriate mechanisms to facilitate the delivery of data and services. Among others these mechanisms embody efficient management of geodata.

Health Information Systems Programme (HISP), for instance, has been for many years assisting healthcare managers of developing countries through a Geographical Information Systems (GIS) tool called OpenHealthMapper. The primary function of this tool is to graphically display aggregated data managed by District Health Information Software (DHIS2) application as maps with layers of information. However, its use for supporting decision-making is not only limited by combining the different datasets, but to efficiently access, retrieve and apply health data and indicators without substantial effort to rummage around map storages or visiting sources or, conducting many diverse queries, merging different data and bringing all the data into the same map view. However, despite its benefits the implementation has been proved as complex, for both technical and institutional reasons: see some examples in Saugene and Sahay (2011). Technically, the complexity is caused by difficulty in handling emerging problems, the ability to deal with the advanced JavaScript frameworks such as MapFish, OpenLayers, Ext JS and GeoExt, and the conversion of geodata between coordinate systems and formats. Institutionally, tensions arise from various sources including the need for consensus on standards and the inclusion of users in the standardization activities.

Recognizing that management and use of geodata is the responsibility of every institution dealing with geodata, this paper examines those factors affecting the implementation of GIS applications in healthcare settings of developing countries. Based on OpenHealthMapper customization achievements in Malawi and Guinea-Bissau and the prospects of the Mozambican experience toward management of geodata, issues of developing countries are discussed. Two questions guide our research: first we investigate the factors surrounding geodata production and sharing; and secondly, we discuss the approach that may be used to address geodata tensions and problems.

Our empirical work highlights the existence of geodata related problems originated mostly from lack of trained manpower and un-coordinated effort among the GIS user institutions, as well as financial concerns. Hence, we borrow the concepts of boundary interaction and boundary objects to study what happens between and across the GIS community in Mozambique, the interfaces or translation devices, and the practices

used to make such translations happen. Through Carlile's cross-border knowledge integration framework (2004), the development of an integrated geodata management approach is discussed whereby mechanisms focused on the notion of transfer, translation and transformation are discussed together with syntactic, semantic and pragmatic processes. These processes overlap iteratively between each other.

The article proceeds as follows: section 2 describes a theoretical framework by discussing the complexity of GIS boundaries. Then, we will describe the approach used to gather data for this paper in section 3. Section 4 presents and explores our empirical work. Then, in section 5 we return to our main research question and through analysis of empirical findings we discuss and present the concluding remarks of the paper.

2. The Complexity of GIS Boundaries

GIS is one of several geographic information technologies that have evolved rapidly in recent years (Goodchild, 2001), and are becoming a standard tool for information management, storage and data interpretation (Hoffman, 1998) in most developing countries. In the healthcare sector, for instance, GIS is used to predict the outbreak and spread of disease (Montana, 2008) and to display and analyze statistics on health services and social programs such as immunization compliance and maternal/high-risk infant programs (Hall, 2004).

However, implementation of these applications is context sensitive (Martin, 1998), i.e., given that most are imported from the developed world, their adoption require careful evaluation and analysis of cultural differences, institutional context and organizational arrangements. In this section we examine social negotiations taking place within the GIS community through the concepts of boundary interaction and boundary objects. Since the negotiation between different groups is fundamental to the construction of GIS, the Carlile (2004) framework on cross-boundary knowledge management opens new ways to address the challenges faced because of the relationships between the technology and the people.

2.1. Boundary Interaction and Boundary Objects

Kerosuo (2001) defines boundaries as places of division between what is familiar and what is unknown. Considering that effective adoption and use of GIS requires commitments on data from different users, its implementation can be conceptualized as a boundary interaction whereby each individual/user institution besides being a member of a GIS community has a (specific) culture related to its own workplace. These cultural differences define their boundaries. Crossing them means connecting both sides; however, since each of the sides has its own people, objects and practices, joining them will create some kind of complexity which according to Akkerman and Bakker (2011) may cause a sandwich effect for objects located between the sites.

Through the concept of boundary interaction scholars have studied how people at work enter onto territory in which they are unfamiliar and, to some extent unqualified (Suchman, 1994) and based on their fresh look at the long-standing practices and assumptions, create deep learning (Tsui and Law, 2007).

These interactions help to reveal the real story of GIS implementation and its functionality (Martin, 1998). For instance, being boundary objects (e.g. data with low quality) one of the most challenging implementation problems affecting the implementation of OpenHealthMapper in developing countries, unpacking its complexity require investigating the objects that are shared during the boundary crossing activities. Thus, concentrating on the interactions mean paying attention to the process of negotiation and combination of data from different contexts (Akkerman and Bakker, 2011; Engeström *et al.,* 1995).

The boundary object concept was used by Huvila (2011) and Bowker and Star (1999) to refer to abstract or physical artefacts (including tools, techniques and ideas, stories and memories) residing in the interface between communities that are capable of bridging assumed and experienced differences. By building on re-conceptualization of the relations between humans and non-humans, boundary objects are used in studying how multiple groups engage each other in the construction and use of technology. They form crucial intersections and translation between different worlds (Harvey, 1999).

Geodata are examples of these boundary artefacts which besides being objects function as mediating artefacts and represent varying viewpoints and interests. Because of that, they can support the adoption of GIS, and its effective usage require communication and collaboration (Hunter, 2008), as well as management (Akkerman and Bakker, 2011) mechanisms. However, they can also fail to address their purposes. If, for example, the artefacts do not capture the meanings and perspectives needed to address specific problem, they will not be able to help the decision makers. Akkerman and Bakker (2011) presented a case where message boxes with system-related information about a medical technology failed to be supportive because the concerns and interpretations of users were not accounted for. Problems may also be experienced if geodata do not represent a consensus of the various stakeholders or if "... changes occurring in boundary crossings do not occur within the limits of the boundaries, thus, destroying existing boundary objects" (Huvila, 2011). In this regard, the challenges involved in producing, archiving, and sharing the boundary objects, more specifically, the poor availability of spatial information in developing countries (Bishop *et al.,* 2000) require proper consideration and management.

2.2. Managing GIS Objects across Boundaries

The potential of GIS when combined with other information technologies is clear and means much more than data visualization. It is in fact, a collection of knowledge archived as single geodata objects. Due to factors like resources (human and financial), single institution cannot provide geodata on a continuing basis. In this regard sharing might be considered. Darr and Kurtzberg (2000) define sharing in context of knowledge as a process whereby people acquire knowledge by learning other's experience. This process demand proper management, which consequently will require understanding the mechanisms of transfer, translation and transformation of data objects. Carlile's (2004) cross-boundary knowledge integration framework deals with the above three mechanisms as well as the syntactic, semantic and pragmatic boundary perspectives.

According to Edenius *et al.* (2010) the syntactic approach refers to the information processing perspective, where organizational members are seen as instrumental in their knowledge sharing behaviours, i.e., is conceived as the process of sending and receiving messages, and is useful in conditions of low novelty and highly shared context. Breakdowns and difficulties in knowledge sharing arise from incompatible codes, lack of information, routines and/or protocols. Semantic perspective builds on syntactic, but also recognizes the importance of interpretation and meaning that can vary across knowledge communities (Lervik *et al.,* 2007). However, Edenius et al. (2010) stresses that differences in meanings, assumptions and contexts are not easily tackled. Even if different ways of knowledge sharing are adopted, such as the use of shared language, meanings or collective stories, many occurrences make it difficult to share. Hence, a pragmatic perspective that incorporates syntactic and semantic approaches was introduced to pay special attention to recognising that new knowledge in one domain may have costs in other domains, requiring joint problem-solving and negotiations of interests and trade-offs (Lervik *et al.,* 2007).

As depicted in Carlile's framework in an effective cross-border management, knowledge on the syntactic level might be fairly well-known to the actors. When the common lexicon (language) sufficiently specifies the differences and dependencies among actors, the boundary is experienced as unproblematic and the focus of boundary management is "simply" to transfer knowledge. The translation from a syntactic to a semantic boundary occurs when the degree of novelty of an innovation is increased, and makes knowledge differences and dependencies unclear or the meaning ambiguous. The transition from a semantic to a pragmatic boundary arises when the further increasing novelty of the innovation results in the emergence of different interests among actors in the social system (Edenius *et al.,* 2010). Finally, the forth element focus on progressive development of common understanding and alignment of interests, i.e., the iterative cycling process that permits executing the above three steps over and over again as long it is required with special emphasis on negotiation and consensus building.

3. Research Approach and Methods

The research takes the form of case study and the epistemological stance is interpretive (Walsham, 1995; Walsham, 2006). The research relies also on the qualitative research tradition which, according to Iivari (2010), is characterized as a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible. This study is based on a series of events that occurred over a period comprehended from January 2009 to August 2011 toward the adoption of OpenHealthMapper in a couple of developing countries. The results are drawn from empirical work performed in Guinea-Bissau, Malawi and Mozambique; three developing countries located the first in west and the last two in southern region of Africa.

3.1 Background

DHIS2 is a customizable Free/Libre Open Source Software (FLOSS) application and data warehouse framework that supports the collection, validation, analysis, and presentation of healthcare data. The features of DHIS2 application are organized in modules which include DHIS2 Routine, used for the management of routine data, DHIS2 Tracking, used to manage community data, DHIS2 mHealth, for management of health data using mobile devices, and DHIS2 GIS or OpenHealthMapper, a mapping client used as data display and analysis based on aggregated data.

OpenHealthMapper is developed as web-based client-server tool inspired on HISP_SpA (module working in versions 1.3 and 1.4 of DHIS application in India) and HealthMapper (WHO tool used by many countries to perform spatial analysis in healthcare sector). Both its client and server sides are integrated within DHIS2 (Øverland, 2010). The client side is developed using JavaScript frameworks which comes with Mapfish, OpenLayers, Ext JS and GeoExt; and it reads JavaScript Object Notation (JSON) as a data-interchange format, GeoJSON as a format for encoding a variety of geographic data structures and Scalable Vector Graphics (SVG) as a language for describing graphical applications in XML (Saugene and Sahay, 2011). The server is Java based. The three layers architecture of the module are handled by the store layer where the communication with the database is made through Hibernate and the service layer where the objects, service functionalities (logic) and application programming interface (API) are implemented.

The tool has embedded the basic features of any GIS application. Additionally the tool has user interface with ability to add new WMS layers to the map, possibility of running DHIS2 datamart automatically when indicator, period and level are selected, organization unit level drill down when a polygon is clicked, ability to display data elements ("raw data") as well as indicators, capability of filtering map extent: the map showing only a limited area such as a province or district, an interface suitable for all international users, organization unit profiles as pop-ups which show values for all

indicators in an indicator group and ability to export map, legend and comments as external file.

3.2 Data Collection and Analysis

Concerning data collection and analysis, the research relies on the qualitative research tradition (Iivari, 2010), considered as an activity that locates the observer in the world, supported by mixed methods including interviews, observations, and reflective discussion. Data was also collected from conversations (email, person-to-person, etc), documents and papers, and operational procedures. A total of sixteen (16) institutions dealing with spatial data were approached. The interviews followed a semi-structured manner, and the questions had been made available for the interviewees beforehand. Throughout the entire study reflective discussion was performed together with the interviewers.

Data transformation mechanisms applied in this study follows interpretive philosophy and its deductive process was possible through data reduction, data display and conclusion and verification steps of a data analysis framework (Miles and Huberman, 1994). Data was then organized, and compressed in a manner that permitted drawing conclusions easily in forms of text and diagrams.

4. Empirical Insights and Analysis

4.1 Introduction

The DHIS2 mapping client evaluated in the current study relies on GeoJSON files and GML file formats. These files are usually created from coordinates (latitude and longitude) stored within shapefiles. These files in most developing countries such as Mozambique, Malawi and Guinea-Bissau are produced by different institutions. The customization of *OpenHealthMapper* in these countries has presented many challenges. For example, Saugene and Sahay (2011) mentioned problems faced in Malawi and Mozambique which included among others:

(a) Districts not being reflected in the existing maps: e.g. in Malawi two new districts Likoma and Neno were not represented, yet in the existing maps and two DHIS2 organizational units (Mzimba South and Mzimba North) were part of the same spatial administrative district boundary. Figure 1 below illustrates these problems with the Malawian *geodata*.

(b) Existence of technical limitations in manipulating *geodata*: for instance, we have identified problems in generating GeoJSON and GML files from the shapefiles. Addressing this issues required support from external experts.
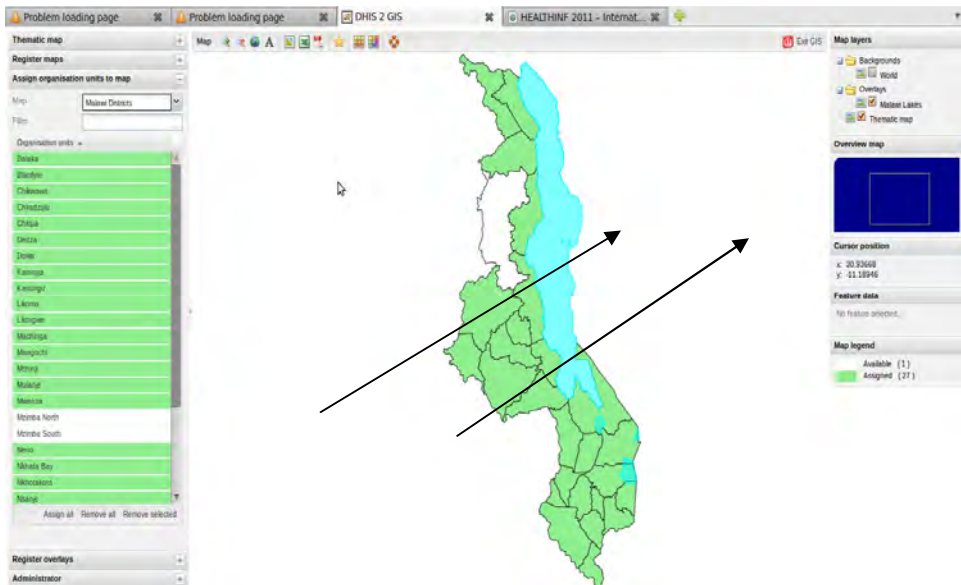
Figure 1. Example of problems identified with geodata while customizing OpenHealthMapper in Malawi

During the customization of the DHIS2 mapping client in the settings including Malawi and Guinea-Bissau, observed recurrent problems included:

> Mismatch of administrative boundaries among government institutions. Figure 2 illustrates problems with the Guinea Bissau *geodata*, i.e., administratively the country is divided into 9 regions but the Ministry of Health has split some of the regions and in total has 11 regions. For example, sectors and health facilities from Oio region were split and aggregated under two regions, Farim and Oio. However, the administrative shapefiles presenting the 9 regions were not updated to reflect this new classification and as a consequence some of the DHIS2 data collected in the missing regions cannot be displayed in the maps.

As previously referred to, the reasons for these problems are related to technical as well as organizational issues. Aiming at understanding these reasons the next sections present and discuss lessons from our findings.

Figure 2. OpenHealthMapper map displaying dropout rate for TB patients with Bk+ in the regions of Guinea Bissau in the second quarter of 2011 and the challenges with geodata

4.2. The Major GIS Opportunities and Constraints

Adoption of GIS applications in Mozambique has increased recently. Many of these initiatives have been taken in isolation and without necessary synchronization and cooperation. The institutions adopting them, for instance the healthcare sector, face various types of challenges here summarized:

(i) Despite the existence of a government institution responsible for handling *geodata*, its availability is fragmented amongst different institutions. There is a lack of data collection coordination and networking between users which results in duplication of data (Ernesto, 2010; Juvane, 2009). Institutions with limited resources (human, material and financial) are forced to rely on base maps which are outdated and compiled by different agencies with different map scales. Most of the users are still learning GIS potentialities and the absence of guidelines makes users employ data formats, practices, etc, defined by the *geodata* holders and GIS processing software vendors. In some instances the data formats are specific to the needs of particular institutions and not intended to meet the needs of a broader range of users. Although a large amount of data is now available in digital formats, most is derived from analogue maps produced by CENACARTA (Juvane, 2009). Even though accessing such data is not difficult, its use has been limited by lack of metadata. In fact, metadata of *geodata* is

collected together with the data while in field; however, its organization varies between institutions. Usually paper forms are compiled with details of the *geodata*, but only the information requested by GIS applications is recorded. The paper forms are kept but not shared along with the digital files.

Institutions	DNGA	IIP	INE	CENACARTA	CMM	DINOT	CENOE	DINAPOT	ARA-SUL
Total workforce	2	4	12	20	4	2	2	5	10
Fulltime workforce	1	0	12	12	4	2	2	3	10

Table 1. Number of GIS professionals working in some of the visited institutions[1]

(ii) Since GIS is still new for most institutions, it is difficult to say with certainty whether the workforce is appropriate or not to institutional needs. However, we have found discrepancies in the number of available human resources within staffing groups in the institutions. For instance, even though CENACARTA, INE and ARA-SUL have considerable GIS personnel for their activities, most of the staff does not participate in data collection and the percentage of time spent for carrying GIS activities is very low. Table 1 presents this observation across selected institutions. Further, besides being comprized of recently graduated staff lacking experience to conduct specific activities, the available staff do not continuously update their skills and knowledge. Continuing education for the GIS personnel is fragmented and uncoordinated explaining why institutions such as CENACARTA do not repose confidence in *geodata* collected by other institutions. Some institutions have capacity building plans, however their implementation is slow resulting in personnel not being up-to-date with the latest GIS technologies. Users in some institutions have benefited from capacity building activities. Mostly these activities are funded by ONGs, concentrated on their areas of interest and not integrated with the overall capacity building plans within the institutions.

4.3 Institutional Interactions

Since obtaining the most current *geodata* is a question of resources, a single agency may not be able to provide that on a continuing basis. Almost every institution using GIS is involved in data collection activities. Similar data is repeatedly collected, resulting in multiple standalone versions of "the same" data themes. This is caused by

---

[1] National Directorate of Environmental Management(DNGA), Fisheries Research Institute (IIP), National Center for Cartographic and Remote Sensing(CENACARTA), Municipal Council of Maputo City(CMM), National Directorate of Territorial Planning(DINOT), National Emergency Operating Center (CENOE), National Directorate of Planning and Land Management(DINAPOT), and Regional Water Administration of Southern Mozambique(ARA-SUL).

a lack of 'strong' leadership. Institutions such as CENACARTA, INE and CMM, which have specific units or departments responsible for GIS activities, are not committed to establishing standards. In fact, in 1998 a document that could be used as a guideline while creating, processing, handling or storing *geodata* was drafted. This document did not successfully attract the GIS community members and enough professionals to contribute to its implementation and adoption with the consequence that the document has not been finalized and the effects of its absence is visible and expressed through the quality of data available. Because the successful application of GIS technology is largely dependent on how well the data from different sources can 'talk' or communicate, absence of such standards hamper information sharing, communication and improvement of *geodata*.

Furthermore, there is no single network, either technological or social, that connects all institutions, but several 'social' networks which are constructed and dissolved as needed. Most of them were boosted during interactions while taking courses, for example, at faculty or in the cross-disciplinary meetings. To easily perform their activities users need to belong to multiple networks. Through this, they can 'always' find someone who can assist to address their problems, either technology-related or data-related. These partnerships also work as 'bridges' for gaining access to geodata. For instance, NGOs that funded capacity building activities or having a common pool of interests have used this linkage to access data produced or managed by non-related institutions, i.e., since free access to data is unavailable where the institution does not have an agreement, some institutions have requested data on behalf of others.

Institutions seem to understand geodata sharing differently; very few see data sharing as a mechanism for improving its quality and availability. This results in stakeholders operating in isolation from one another and is exacerbated because of the absence of a coordinated GIS strategy. For instance, while some institutions still do not share their data, others such as the national mapping body, CENACARTA, have undergone a shift where digital data is provided online and free of charge for the public. This might maximize its reuse and minimize the need for collecting similar data themes.

5. Discussion and Conclusion

GIS can reform government and societal functions by uniting disparate information sets and displaying them as a simple mechanism for people to understand. Developing an integrated computer system that ties, for instance, healthcare data with GIS assets can simplify tasks, assist with planning and management, and lead to more efficient decision-making (Melnick, 2002). To enable governments to perform spatial analysis of, for instance, healthcare data, their applications draw geodata from GIS databases. However, geodata has been reported, by scholars and also through our own experience in customizing OpenHealthMapper in developing countries, as the major problem limiting the effective adoption and use of GIS.

Efforts to deal with this problem have made governments rethink their roles with respect to the availability of geographic information. Spatial Data Infrastructures (Masser *et al.,* 2008; Silapathong, 2004), for instance, have emerged as a result of this government process. With this paper we sought to contribute to this field by providing insight into what happens at the interaction between GIS boundaries and the tensions of geodata sharing. For that two research questions were formulated, whereby the first aimed at investigating the factors surrounding geodata production and sharing; and the second directed towards the approach that may be used to address the tensions identified by the first question.

In relation to the first question, our findings reveal that geodata have been created by individual agencies to meet their specific needs, and usually with very little coordination among them. Due to this lack of coordination, the adoption of healthcare management technologies such as the OpenHealthMapper application face challenges of not being able to provide accurate results or even not being fully customized. Hence, even if institutions and agencies interact to reduce data collection efforts, problems (in quality, standard, and format) found in the data files, forces them to (i) engage in data collection activities, and (ii) lack confidence in using data collected by unknown individuals.

Moreover, since GIS users (public and private institutions) represent one single community which share identities represented by and in the boundary objects, they were supposed to "allow the definition of consensual sharing of data" (Harvey, 1999). However, each user has a different culture which represents the boundary between them and is manifested through the 'hidden' impediments of geodata sharing. From our empirical work these impediments are presented as results of absence of metadata, technical expertise in providing the necessary quality, and infrastructure that enables the transfer of data, all originating from the absence of coordination and the high costs associated with production of data and different data units and reference systems. In short, based on their own needs each institution manages geodata using its own approach, i.e., geodata is encoded in an uncoordinated way, without consideration of compatibility and interoperability with other utility systems.

Much like geographic boundaries these boundary objects separate different social groups while at the same time delineating important points of reference between them (Akkerman and Bakker, 2011). Thus, given that sharing and capacity to integrate geodata across boundaries is vital for effective use of GIS, our second research question concentrates on discussing how the principles behind Carlile's cross-boundary knowledge integration framework can help to address the impediments or factors that impact on the adoption of GIS for healthcare management. Through this iterative framework we join with scholars such as Lervik *et al.* (2007) who support the idea that GIS adoption does not only depend on making explicit information available in repositories across institutions or agencies, but, in efficiently facilitating the access through sharing and integration across domains and/or institutions. Since many institutions and agencies have already invested in GIS technologies, establishing a link that builds upon them may be possible through syntactic, semantic and pragmatic

processes, i.e., an approach for removing geodata conflicts need to be characterized by the following features:

(a) Since *geodata* is managed (collected, stored and managed) differently, its effective exchange (send and receive) must boost the development of a common dictionary or standards among the institutions and agencies and also avoid duplications through the emphasis on the syntactic process. Syntactic process, according to Sheth (1999), refers to the difference in data type and format. Initiatives such as that by CENACARTA related to the provision of data and its metadata free of charge and electronically, and the development of guidelines, if taken seriously can syntactically help to make data more exchangeable.

(b) Access to timely and accurate data is vital for proper reporting and monitoring of healthcare activities. However, accessing by and of itself is insufficient; there is a need for developing mechanisms for analysing *geodata*, checking the inconsistencies and duplications, i.e., perform semantic checking. The semantic aspect of *geodata* refers to differences in naming conventions and conceptual groupings in different organizations (Harvey, 1999). Since *geodata* captured by each institution take into consideration its own specific needs, a standardization process that considers the varying interpretation and meanings across these institutions and agencies needs to be recognized and supported by all. For example, our findings have illustrated that institutions collect the 'same' data themes in an uncoordinated way, whereby semantically identical data items are named differently or semantically different data items are named identically; through access to metadata and documentation to assist integration work, techniques like Ontology mapping (Buccella *et al.,* 2011; Stoimenov and Djordjević-Kajan, 2005) while helping to define a common vocabulary can assist to reconcile heterogeneous cognitive issues reducing in this regard semantic problems. However, problems with availability of metadata may hinder this process.

(c) These features do not incorporate the fact that partnerships between the GIS users also involve interests. Through our findings we have presented examples whereby partnerships created by funding training were used as channels toward access to *geodata*. Lessons also illustrate that the keys to successfully permit the 'communication between *geodata*' do not only result in high-quality and accurate data or well-designed processes that recognize the differences across the data providers, but also the recognition that *geodata* capture requires huge investments in resources (material, human and financial), i.e., recognition that '*geodata* is power' (Lervik *et al.,* 2007). Through this perspective we argue that, instead of every institution being involved in capturing the 'same' data themes, investments should be made in strengthening the partnerships and negotiation of interests.

(d) Since the integration of multiple spatial datasets managed by different institutions in different utility domains raises a number of conflicts, their recognition is an

important step, but special attention needs to be directed to providing a 'good' approach. In this regard, execution of the above processes must be iterative whereby negotiation activities overlap syntactic, semantic and pragmatic processes, i.e., *geodata* is checked for consistent geometry and the appropriate projection. The encountered problems being automatically corrected; each *geodata* extended with metadata fields, which are then populated along with the data. These boundary objects are expected to stabilize the relationships and the negotiation of differences may be crucial in providing flexibility and dynamic coherences (Harvey and Chrisman, 1998). Hereafter, since institutions are in different adoption levels, as presented in our findings, negotiations which involve the three features above must be seen as an ongoing process where users are aware about the need for interacting between each other in order to arrive at a standardized data which all the institutions will accept and recognize.

Given the existence of a vast number of geodata producers, decision-making activities often rely on geodata from distributed GIS sources. However, distributed data sources and their heterogeneity are the main problems for institutions adopting GIS. The social constructivist framework concentrated on an interactive process towards the production of qualitative boundary objects is one reasonable approach. By deepening and extending our understanding of geodata problems and proposing Carlile's framework as a strategy for addressing geodata conflicts, we have brought a theoretical understanding of what happens within the GIS world and how a theoretical approach may be applied to guide future adoption and paths regarding GIS application adoption.

References

Akkerman, S. F., and Bakker, A., (2011), Boundary Crossing and Boundary Objects, Review of Educational Research, 81(2), 132-169.

Bishop, I. D., Escobar, F. J., Karuppannan, S., Williamson, I. P., Yates, P. M., Suwarnarat, K., and Yaqub, H. W., (2000), Spatial data infrastructures for cities in developing countries - Lessons from the Bangkok experience, Cities, 17(2), 85-96.

Bowker, G. C., and Star, S. L., (1999), Sorting things out : classification and its consequences, Cambridge, Mass.: MIT Press.

Buccella, A., Cechich, A., Gendarmi, D., Lanubile, F., Semeraro, G., and Colagrossi, A., (2011), Building a global normalized ontology for integrating geographic data sources, Computers & Geosciences, 37(7), 893-916.

Carlile, P. R., (2004), Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge Across Boundaries, Organization Science, 15(5), 555-568.

Darr, E. D., and Kurtzberg, T. R., (2000), An Investigation of Partner Similarity Dimension son Knowledge Transfer, Organizational Behavior and Human Decision Process, 82(1), 28-44.

Edenius, M., Keller, C., and Lindblad, S., (2010), Managing knowledge boundaries in healthcare when innovation is desired, Knowledge Management & E-Learning: An International Journal Hong Kong : The University of Hong Kong.

Engeström, Y., Engeström, R., and Kärkkäinen, M., (1995), Polycontextuality and boundary crossing in expert cognition: Learning and problem solving in complex work activities, Learning and Instruction, 5(4), 319-336.

Ernesto, I. M. P., (2010), Modelo de Integração de Dados Espaciais, Eduardo Mondlane University, Maputo, Mozambique.

Goodchild, M. F., (2001), Geographic Information Systems, in J. S. Neil and B. B. Paul, (eds.), International Encyclopedia of the Social & Behavioral Sciences. Oxford: Pergamon, pp. 6175-6182.

Hall, J. P., (2004), Development of an implementation plan for a geographic information system: case of Lincoln County, International Journal of Information Management, 24(3), 267-275.

Harvey, F., (1999), Designing for Interoperability: Overcoming Semantic Differences, in M. F. Goodchild, C. Kottman, and M. J. Egenhofer, (eds.), Interoperating Geographic Information Systems, Norwell, MA, USA: Kluwer Academic Publishers, pp. 85-97.

Harvey, F., and Chrisman, N. (1998), Boundary objects and the social construction of GIS technology, Environment and Planning A, 30(9), 1683-1694.

Holland, P., Rajabifard, A., and Williamson, I., (2010), Towards an assessment framework for spatially enabled government , L. U. Press, (ed.) GSDI 12 World Conference: Realising Spatially Enabled Societies. City: The University of Melbourne.

Hunter, S., (2008), Living documents: A feminist psychosocial approach to the relational politics of policy documentation, Critical Social Policy, 28(4), 506-528.

Huvila, I., (2011), The politics of boundary objects: Hegemonic interventions and the making of a document. ournal of the American Society for Information Science and Technology.

Iivari, N., (2010), Discursive construction of [`]user innovations' in the open source software development context, Information and Organization, 20(2), 111-132.

Juvane, M. N. A., (2009), Understanding the Dynamics around Spatial Data Integration: A case study from Mozambique, University of Oslo, Oslo.

Kerosuo, H., (2001), 'Boundary Encounters' as a Place for Learning and Development at Work.

Lervik, J. E., Easterby-Smith, M., Fahy, K., and Elliott, C., (2007), Limits to Information Transfer: The Boundary Problem, Ariadne(50).

Martin, E., (1998), GIS Implementation and the Un-Theory: Some useful concepts from ANT, City: University of Washington Ph.C.

Masser, I., Rajabifard, A., and Williamson, I. P., (2008), Spatially enabling governments through SDI implementation, International Journal of Geographical Information Science, 22(1), 5 - 20.

Melnick, A. L., (2002), Introduction to geographic information systems in public health: Jones & Bartlett Learning.

Miles, M. B., and Huberman, A. M., (1994), Qualitative Data Analysis: Newbury Park.

Montana, L., (2008), Geographic Information Systems, in H. Kris, (ed.), International Encyclopedia of Public Health. Oxford: Academic Press, pp. 56-59.

Saugene, Z., and Sahay, S., (2011), THE CHALLENGE OF CUSTOMIZING GLOBAL OPEN SOURCE SOFTWARE TO LOCAL COUNTRY CONTEXTS: THE CASE OF DHIS GIS FOR HEALTH MANAGEMENT IN MALAWI, City: University of Oslo: Oslo.

Sheth, A. P., (1999), Changing focus on Interoperability in Information Systems: From System, Syntax, Structure to Semantics, in M. F. Goodchild, C. Kottman, and M. J. Egenhofer, (eds.), Interoperating Geographic Information Systems. Norwell, MA, USA: Kluwer Academic Publishers, pp. 5-29.

Silapathong, C., (2004), Development and Implementation of NSDI in Thailand ,GIS Development.

Stoimenov, L., and Djordjević-Kajan, S., (2005), An architecture for interoperable GIS use in a local community environment, Computers & Geosciences, 31(2), 211-220.

Suchman, L., (1994), Working relations of technology production and use, Computer Supported Cooperative Work (CSCW), 2(1), 21-39.

Tsui, A. B. M., and Law, D. Y. K., (2007), Learning as boundary-crossing in school–university partnership, Teaching and Teacher Education, 23(8), 1289-1301.

Walsham, G., (1995), Interpretive case studies in IS research: nature and method, European Journal of Information Systems, 4(2), 7.

Walsham, G., (2006), Doing interpretive research, European Journal of Information Systems, 15, 320-330.

Øverland, J. H., (2010), An Open Source Approach to Improving GIS Implementations in Developing Countries, University of Oslo, Oslo.

Multi-view SDI Assessment of Kosovo (2007-2010) - Developing a Solid Base to Support SDI Strategy Development

B. Nushi[1], B. Van Loenen[1], J. Besemer[1] and J. Crompvoets[2]

[1]TU Delft, Delft, the Netherlands
[2]Public Management Institute, Katholieke Universiteit Leuven, Leuven, Belgium

*b.nushi@tudelft.nl; B.vanLoenen@tudelft.nl; j.w.j.besemer@tudelft.nl;
joep.crompvoets@soc.kuleuven.be*

Abstract

This paper presents the multi-view assessment of SDI status in the Republic of Kosovo performed in 2007 and in 2010. The main objective of this research was to assess the SDI of Kosovo and to define the driving forces needed to support SDI strategy development.

The research assesses the status of SDI implementation of Kosovo using SDI readiness Index (Delgado *et al.,* 2005), INSPIRE State of Play (Vandenbroucke *et al.,* 2008), and Maturity Matrix (Kok and Van Loenen, 2005) as assessment approaches. Each approach treats the assessment of SDIs from a different view and context and so with a different purpose in mind. An SDI readiness survey questionnaire was submitted to the SDI stakeholders in Kosovo in 2007 and 2010. The INSPIRE State of Play was assessed for the 5 countries of Estonia, Lithuania, Latvia, Slovenia and Luxembourg and an attempt to define the State of Play for SDI of Kosovo was also part of the assessment. The last assessment was defining the Maturity Matrix for the SDIs of Slovenia and Kosovo.

This research has led to 6 driving forces selected to support the development strategy of SDI at the national level in Kosovo.

KEYWORDS: SDI, Kosovo, multi-view assessment, Readiness Index, Maturity Matrix.

1. Introduction

The assessment and evaluation of SDI initiatives is difficult due to a number of reasons. Many researchers have tried to assess SDIs (Crompvoets, 2006; Delgado-Fernandez and Crompvoets, 2007; Delgado-Fernandez *et al.,* 2005; Kok and van Loenen, 2005; Masser, 1999; Onsrud, 1998; Rodriguez-Pabon, 2005; Steudler *et al.,* 2004). All these attempts, though useful and valuable, either concentrate on one aspect of SDI, or are bounded by one region, or describe SDI development in only a few particular countries, or are still conceptual in nature.

In order to improve the SDI development of Kosovo, this paper assumes that defining 'the lessons learnt' and 'identification of good practices' during the implementation of SDIs in other similar countries is needed. This research also explores how to define the driving forces that could support further sustainable development of the SDI of Kosovo. Defining and drawing the comparison between the SDI Readiness Index of Kosovo in 2007 and 2010 and investigating the INSPIRE State of Play programmes of five different European countries (Estonia, Latvia, Lithuania, Slovenia and Luxembourg) supports this research.

1.1 Republic of Kosovo

The Republic of Kosovo has about 2.2 million inhabitants in an area of about 11.000 km^2. There are 30 municipalities with five of them Serbian dominated and eight as ethnically mixed municipalities. Kosovo shares borders with Serbia to the north and east, the Republic of Macedonia to the south, Albania to the west and Montenegro to the northwest. The largest city and the capital of Kosovo is Prishtina.

Kosovo declared independence on 17 February 2008. Currently, about 80 United Nations states recognize the independence of Kosovo and it has become a member country of the IMF and World Bank as the Republic of Kosovo.

The "new-born" Republic of Kosovo is in an intensive stage of development after the independency declaration in February 2008. The Government has declared its priorities in the comprehensive "Program of the Government of Republic of Kosovo, 2008-2011" and is gradually implementing the Ahtisaari plan including decentralization issues also affecting land administration. One of the Government's aims is to take steps towards European integration.

1.2 Background of Kosovo's SDI

The awareness for SDI was extremely low in the first years after the violent conflict in Kosovo. Yet for several early adopters in Kosovo, efficient and transparent spatial information and management was of a special importance for the future of Kosovo. With hasty and technocratic development in Kosovo regarding the Geographic Information System (GIS) and its applications, more and more unsynchronized and

scattered information has been generated. There was a vast amount of datasets stored in different places and in different formats, but awareness of reusing and sharing the information for new applications was very limited. Unfortunately this diversity in information can be still seen in different governmental departments. Standardizing geographical information and sharing is still a big challenge for the sustainable development of SDI in Kosovo.

The Land Administration Policy (LAP) adopted in 2003 was aimed at defining and then implementing a modern land administration framework. The LAP has also suggested outlining the policy for NSDI implementation in Kosovo. The Kosovo Cadastral Agency (KCA) is only one of the stakeholders among others in land administration. Other stakeholders have responsibilities for planning, land use, zoning, building management, utility infrastructure and mining – activities that contribute to effective administration and management of land and immovable property.

An SDI Council was established to lead the all-embracing sector implementation of SDI. In Kosovo, however, it might be more suitable to charge the Inter-Ministerial Land Administration Committee to lead the all-embracing sector implementation of NSDI. The committee could have an advisory role towards the Government and the KCA.

Aerial photo production in accordance with a long-term plan is foreseen during the planning period. Aerial photographs are available for the whole territory of Kosovo (Spring 2009). Production of rather simple topographic vector maps, in addition to the existing cadastral maps, aerial photos and digital terrain model (DTM), is marked as the start of developing a sustainable National Spatial Data Infrastructure for Kosovo in compliance with the EC INSPIRE Directive.

A permanent GPS Network available for users in Kosovo will also be implemented based on the proposal presented in the General Feasibility Study: 'Continuously Operating Reference in Kosovo', (CORN, August 2006).

It is important to mention in this context that the Republic of Kosovo and the Republic of Slovenia have entered into an agreement on cooperation in the field of geodetic activity. An Outline of terms of reference on technical assistance for establishing the Kosovo Spatial Data Infrastructure with support from the Surveying and Mapping Authority of the Republic of Slovenia has already been drafted.

2. SDI Assessment of Kosovo

The research assesses the status of SDI implementation of Kosovo using SDI Readiness Index, INSPIRE State of Play and Maturity Matrix as assessment approaches. A questionnaire-based SDI readiness survey was conducted on the SDI stakeholders in Kosovo in 2007 and 2010. The INSPIRE State of Play is assessed for 5 countries of Estonia, Lithuania, Latvia, Slovenia and Luxembourg and an attempt to define the State of Play for SDI of Kosovo was also part of the assessment. The last assessment was defining the Maturity Matrix for SDIs of Slovenia and Kosovo.

2.1 SDI Readiness Index

The SDI-readiness approach (Delgado, 2005) aims to measure the degree to which a country is prepared to deliver its geographical information to the community. This approach is directed at measuring the following aspects of SDI readiness: organizational, information, access network, human resources and financial resources.

According to Delgado (2005), the SDI Readiness Index can be defined as a composite measurement of the capacity and willingness of countries to use SDIs. The index incorporates organizational, informational, human resources, technological and financial resources factors and the determination of the index value is based on a survey that only authorized experts of a country are able to complete. Most of the factors that are included in the SDI readiness model are qualitative rather than quantitative. A basic seven-tier classification system is used — from Extremely High to Extremely Low.

The SDI Readiness Index approach was applied in Kosovo in two time periods: in Summer 2007, when this research started; and in Summer 2010. In two different time frames, a selected group of ten (10) SDI experts from Kosovo were consulted to give their opinion on the most important variables needed for SDI Readiness assessment Index of SDI in Kosovo. Very few of the experts were part of the private organization that was using GIS but most of them were involved in GIS activities within different government ministries of Kosovo. Most of the participants were of middle management with few from the executive management level.

The 10-question questionnaire is considered to be representative, considering the fact this was a targeted research, and the research results are to be considered valid.

SDI Readiness Index assessment in 2007

The first SDI Readiness Index assessment was held in summer 2007. In this period we have conducted several individual discussions with key experts involved in different activities regarding the SDI developments in Kosovo. The concepts of SDI were not always understood in the same way and there was no priority for SDI at that time. SDI awareness at the level of institutional leadership was at a very low level. At this time

the Kosovo Cadastral Agency had identified the need to begin developing an NSDI for Kosovo.

All the statements have been organized in a database in order to be able to track and identify changes and perform the data calculations needed to quantify the SDI Readiness Index. The selected 10 statements were organized into a 7-cell matrix related to the 7 possible levels of responses according to the questionnaire. For example, for the first organizational factor 'Political vision regarding SDI' a score in the last (seventh) cell means that the respondent's view is that '*No vision exists as well as no intention exists to formulate a vision regarding the importance and development of the national SDI*', while a score in the first cell indicates that there is an '*Extremely high vision regarding the importance and development of the national SDI*' according to the respondent.

At the conclusion the SDI Readiness Index of Kosovo for 2007 was calculated as presented in Table 1 and Figure 1.

Factor	Decision Criteria		SDI Index
Organizational	Political vision regarding SDI	Ov	0,18
Organizational	Institutional leadership	Ol	0,15
Organizational	Umbrella legal agreement(s)	Oa	0,21
Informational	Digital cartography availability	Ic	0,33
Informational	Metadata availability	Im	0,22
People	Human Capital	Pc	0,21
People	SDI culture	Ps	0,22
People	Individual leadership	Pl	0,15
Access network	Web connectivity	Aw	0,21
Access network	Telecommunication infrastructure	At	0,16
Access network	Geospatial software availability	As	0,27
Access network	Own geoinformatics development	Ad	0,15
Access network	Open source culture	Ao	0,16
Financial Resources	Government central funding	Fg	0,24
Financial Resources	Return on investment	Fr	0,21
Financial Resources	Private sector activity	Fp	0,16

Table 1. 2007 SDI Readiness Index of Kosovo

The score of 0.26 in the range up to a maximum of 1.0 is obviously very low. The determinants in this score are the low values for the organization, human and financial resources factors.
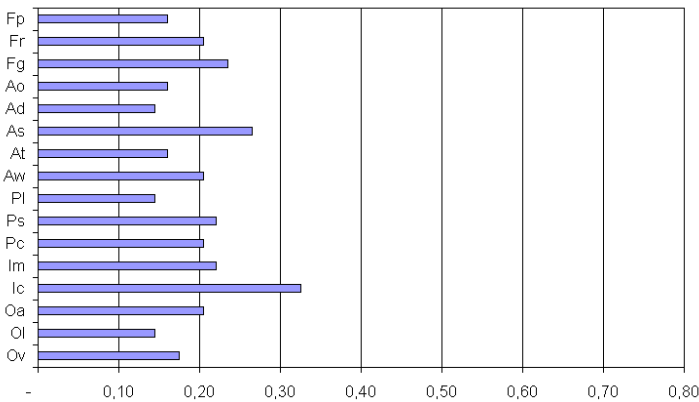
Figure 1. 2007 SDI Readiness Index of Kosovo

This result is at the same time very important for Kosovo seeing that this is the first attempt ever for assessing the SDI of Kosovo. By actively participating in the survey, the key experts demonstrate their interest for SDI initiatives. As a consequence the key experts can now take advantage of the best practices of other SDIs, once they have identified the shortcomings of the Kosovo SDI as disclosed by the 2007 survey.

SDI Readiness Index assessment in 2010

In the summer of 2010 we again measured the SDI Readiness Index for Kosovo. Not all the key experts from the 2007 survey were available for 2010 assessment (seven participated in the 2007 assessment). The questionnaire was sent by email to all participating experts. The same calculation model built earlier is used to calculate the SDI Readiness Index of Kosovo for 2010 as presented in Table 2 and Figure 2.

Factor	Decision Criteria		SDI Index
Organizational	Political vision regarding SDI	Ov	0,24
Organizational	Institutional leadership	Ol	0,36
Organizational	Umbrella legal agreement(s)	Oa	0,33
Informational	Digital cartography availability	Ic	0,42
Informational	Metadata availability	Im	0,25
People	Human Capital	Pc	0,36
People	SDI culture	Ps	0,33
People	Individual leadership	Pl	0,30
Access network	Web connectivity	Aw	0,27
Access network	Telecommunication infrastructure	At	0,28
Access network	Geospatial software availability	As	0,31
Access network	Own geoinformatics development	Ad	0,18
Access network	Open source culture	Ao	0,16
Financial Resources	Government central funding	Fg	0,36
Financial Resources	Return on investment	Fr	0,30
Financial Resources	Private sector activity	Fp	0,33

Table 2. 2010 SDI Readiness Index of Kosovo

The SDI Readiness Index score of 0.36 is an improvement compared with the 2007 score of 0.26 but still very low. Despite the improvements in the Organizational factors, the Human and Financial Resources factors remain low.
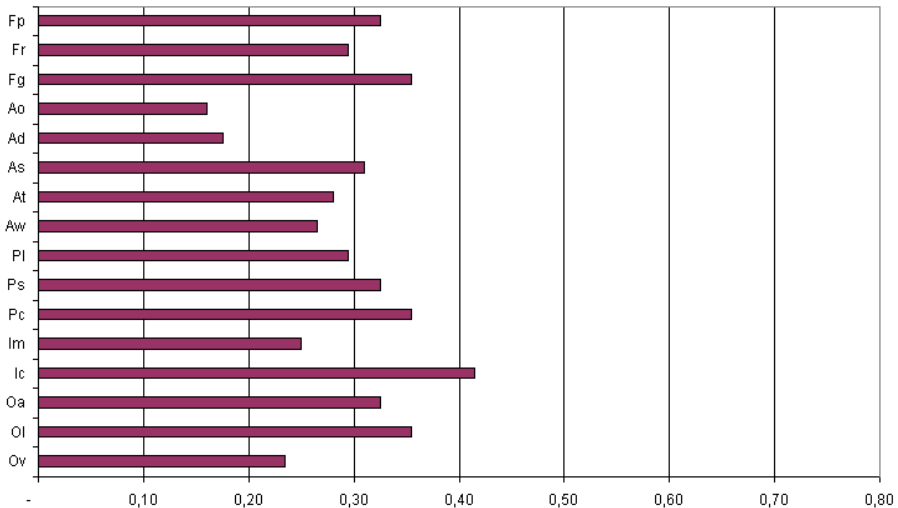
Figure 2. 2010 SDI Readiness Index of Kosovo

The comparison of SDI Readiness Index 2007 and 2010

Based on the data gathered, the following results were obtained.

			SDI R2007	SDI R2010	SDI R-delta
Organizational	Politician vision regarding SDI	Ov	0,18	0,24	0,06
Organizational	Institutional leadership	Ol	0,15	0,36	0,21
Organizational	Umbrella legal agreement(s)	Oa	0,21	0,33	0,12
Informational	Digital cartography availability	Ic	0,33	0,42	0,09
Informational	Metadata availability	Im	0,22	0,25	0,03
People	Human Capital	Pc	0,21	0,36	0,15
People	SDI culture	Ps	0,22	0,33	0,11
People	Individual leadership	Pl	0,15	0,30	0,15
Access network	Web connectivity	Aw	0,21	0,27	0,06
Access network	Telecommunication infrastructure	At	0,16	0,28	0,12
Access network	Geospatial software availability	As	0,27	0,31	0,05
Access network	Own geoinformatics development	Ad	0,15	0,18	0,03
Access network	Open source culture	Ao	0,16	0,16	-
Financial Resources	Government central funding	Fg	0,24	0,36	0,12
Financial Resources	Return on investment	Fr	0,21	0,30	0,09
Financial Resources	Private sector activity	Fp	0,16	0,33	0,17

Table 3. SDI Readiness Index in Kosovo for 2007 and 2010.

From the Organizational index perspective the Institutional leadership as criteria has
the greatest increase (from 0.15 to 0.36) while the political vision regarding SDI
(increasing from 0.18 to 0.24) has the smallest increase. An Increase in the People
indices is relatively consistent in all decision criteria. The largest increase is for Human
capital (from 0.21 to 0.36) and Individual leadership (from 0.15 to 0.30) while for SDI
culture (from 0.22 to 0.33) is slightly lower.
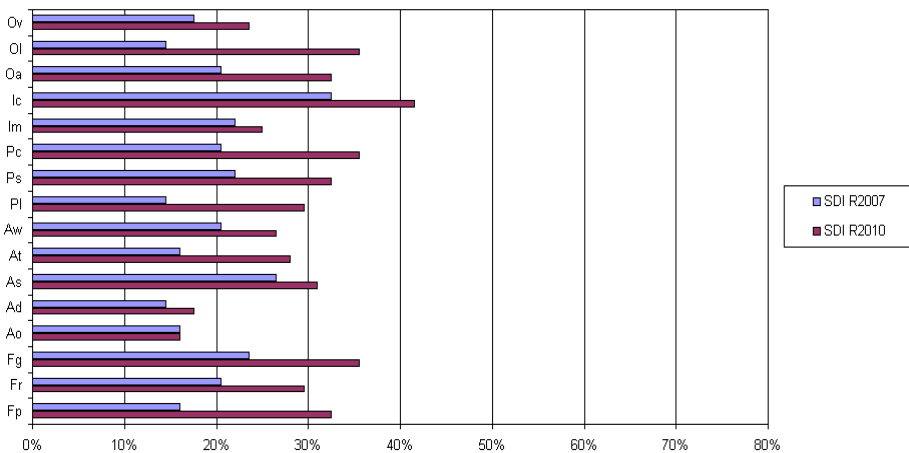
Figure 3. Comparison between decision criteria SDI readiness index in Kosovo for 2007 and 2010.

As these results indicate, there is a large spread of the performance between the different factors. For instance, the technology performance seems to be related to income, as opposed to the organizational factor which has a different outcome regarding income. In the Kosovo SDI it is important to highlight the organizational aspects as a key to the success of its SDI. A stronger organizational and legal framework aims to strengthen the coordination role ensuring a more powerful and sustainable SDI is developed.

Factor		SDI R2007	SDI R2010	SDI R-delta
Organizational	O	0,17	0,30	0,13
Informational	I	0,28	0,34	0,06
People	P	0,19	0,32	0,14
Access network	A	0,43	0,50	0,07
Financial Resources	F	0,20	0,33	0,12
SDI Readiness Index (2010)		0,26	0,36	0,11

Table 4. SDI Readiness Index in Kosovo 2007 and 2010.

This comparison of the SDI Readiness Index of Kosovo over time (Table 4) demonstrates a self-effecting increase. It is clear that the main merit for this increase is the very low SDI Readiness Index score of 0.26 in 2007. As explained earlier, the scope of this research was not to compare the SDI Readiness Index of Kosovo with other countries, but it becomes obvious that the present score of the SDI Readiness Index of 0.36 for 2010 is still very low. We can assume that although the SDI of Kosovo has made considerable progress, there are still many challenges towards an effective implementation of a National SDI in Kosovo.

The increase along the SDI readiness scale signifies considerable progress, but there is room for much more improvement. However, some conclusions can be made at this stage. The largest increase is in the People Factor (from 0.19 to 0.32) and the Organizational Factor (from 0.17 to 0.30) index. The lowest Readiness Index increases are for the Informational Factor (from 0.28 to 0.34) and Access Network Factor (from 0.43 to 0.50) index. This is also due the relatively high score in these two indices in 2007. This is represented in Figure 4.
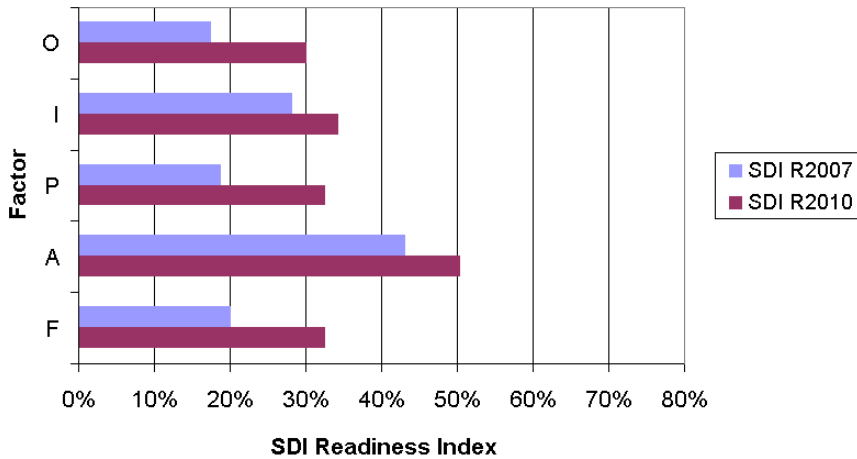
Figure 4. Comparison between factors and SDI readiness index in Kosovo for 2007 and 2010.

Using the SDI Readiness Index we can specify the driving forces towards further implementation of a National SDI for Kosovo. The evolution of SDI readiness of Kosovo from 2007 to 2010 is evident. This period marks the transition from when the government of Kosovo was led by the United Nations Mission in Kosovo (UNMIK) to independence and the democratically chosen Kosovo government. There is a small number of SDI professionals. In addition, there is a lack of relevant legislation, applicable working methodology, relevant standards and proper coordination of their activities as well as enforcement processes.

Although all the formal and fundamental institutional elements of an SDI are present, the SDI organization is still undersized and under-skilled for the challenges it faces. The effective horizontal communication and top-bottom planning approach are still missing in Kosovo. A noticeably huge effort was undertaken in the policy area. Several strategy documents have been produced (most by foreign experts or under their supervision), e.g. the Business Plan 2009-2014 for the Cadastral Agency (KCA) and the Cadastral Sector in Kosovo bringing a comprehensive list of recommendations and actions for the development of the KCA and the Cadastral Sector in Kosovo.

Performance results are less satisfactory in the legislative field. Primary legislation is gradually being adopted by amending the former UNMIK regulations with support from international donors. Whilst this has advanced in the sense that it is approaching European harmonization, the secondary legislation is lagging badly behind. This lag inhibits implementation of modern administrative tools for a countrywide SDI in Kosovo.

2.2 INSPIRE State of Play

This paper compares SDI developments in Kosovo with four other European countries in transition (Estonia, Lithuania, Latvia, and Slovenia) and one country with a relatively high level of socio-economic development (Luxembourg). The Luxembourg SDI was included in the sample set because of the geographical similarities with Kosovo. By reviewing SDI initiatives of these countries, differences and similarities between the SDI developments can be observed.

Based on existing frameworks, procedures and literature review, the SDI of Kosovo is carefully investigated and compared with the five case study countries.

Cross-country comparison using INSPIRE State of Play analysis

This research examines in detail the SDI status of the five case study countries, as well as their development between 2003 and 2007. The main results of this research step are finding similar examples of good practices regarding the organizational approaches as they are being applied in these five countries in transition. This should not be seen as attempt to clone SDI "recipes" from other countries to Kosovo because that is no guarantee of sustainable SDI development. Furthermore, this step describes some of the key issues for successful SDI development of Kosovo during the coming years.

The assessment of the SoP of SDI studied has been made in terms of whether or not: (1) it is in full agreement with the statement, (2) it is in partial agreement, (3) it is not in agreement or (4) there is no information available. Table 5 contains a summary of the information compiled for the SDIs in the 5 case studies. An attempt by the authors to project the State of Play of Kosovo in 2007 is also presented in this Table. It should be taken into account that the input for SoP is received from national representatives of SDIs who may be subjective.

The colours indicate whether the studied SDIs are in substantial agreement (dark blue), partial agreement (light blue) or no agreement (yellow) with the statements about the SDI-building blocks (Table 5).

Table 5. Assessment matrix of 5 case countries and Kosovo SDIs for 2007

Based on the research of Grus *et al.* (2008) the scores for each case country in the SoP assessment approach are presented as a percentage of the maximum possible score. The motivation for presenting the scores as percentage values is to make the SoP assessment results easily comparable with each other. Furthermore, normalising the results to percentage values makes the results more comprehensible. In this case if a statement of an SDI is in large agreement the maximum score possible is given (100%). For statements in partial agreement 50% is given. No agreement is treated as 0%. Results are presented in Table 6 with the different average scores arranged from highest to lowest.

2007		Organisational issues							II. Legal issues and funding									III. Data						IV. Metadata			V. Access and other services							average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
Slovenia	SL	100%	100%	100%	0%	0%	0%	100%	50%	50%	0%	100%	0%	100%	100%	50%	100%	100%	100%	0%	0%	100%	100%	100%	100%	100%	100%	100%	50%	0%	0%	100%	100%	67%
Estonia	EE	100%	50%	100%	0%	0%	50%	0%	100%	50%	0%	50%	100%	0%	50%	50%	100%	100%	50%	0%	100%	100%	100%	0%	100%	100%	0%	50%	0%	0%	100%	50%		58%
Lithuania	LT	100%	100%	100%	0%	0%	0%	100%	100%	0%	50%	0%	50%	0%	50%	50%	50%	100%	50%	100%	50%	100%	50%	100%	50%	0%	0%	0%	0%	0%	0%	50%	100%	47%
Luxembourg	LU	100%	50%	100%	50%	0%	50%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	50%	0%	50%	50%	0%	0%	0%	0%	50%	50%	36%
Latvia	LV	100%	50%	100%	0%	0%	0%	100%	0%	50%	50%	100%	0%	0%	0%	0%	50%	0%	50%	0%	100%	50%	50%	0%	0%	0%	0%	0%	0%	0%	0%	50%	100%	34%
Kosovo	KO	100%	50%	100%	0%	0%	0%	100%	0%	0%	0%	0%	50%	0%	50%	0%	100%	0%	50%	0%	100%	100%	50%	50%	0%	0%	0%	0%	0%	0%	0%	50%	50%	33%

Table 6. Normalized results of 5 case countries and Kosovo SDIs for 2007

As can be derived from Table 6, all case countries have a similar level of SDI development and are developing a truly national SDI. It is also the clear intention for Kosovo to develop a truly national SDI. Only Slovenia and Lithuania have reached a significant level of functionality regarding one or more components of the SDI. In all case countries the officially recognized coordinating body of the SDI is a NDP or a comparable organization. In almost all case countries (besides Luxembourg) the producers and users of spatial data are not involved in the SDI processes because only public sector agencies are participating in the SDI. Furthermore, it is clear with regard to legal issues and funding the ambiguity persists. An example is the case of Estonia which is confusing because on one hand only the public sector is participating in the SDI while according to indicator 9 there exists a true PPP or other co-financing mechanisms between public and private sector bodies. Further, there is still no clear information available on the legal status of the SDI in the respective countries. Some of the legal issues results of the SoP analysis are debatable from the modern SDI perspective. On the other hand, data, metadata and services are quite developed, especially in Slovenia and Estonia. Other countries are working hard in this field. It is clear that standardization is becoming an important aspect for all case countries.

Figure 5 presents the assessment results of the 5 SDIs using the INSPIRE state of play approach.
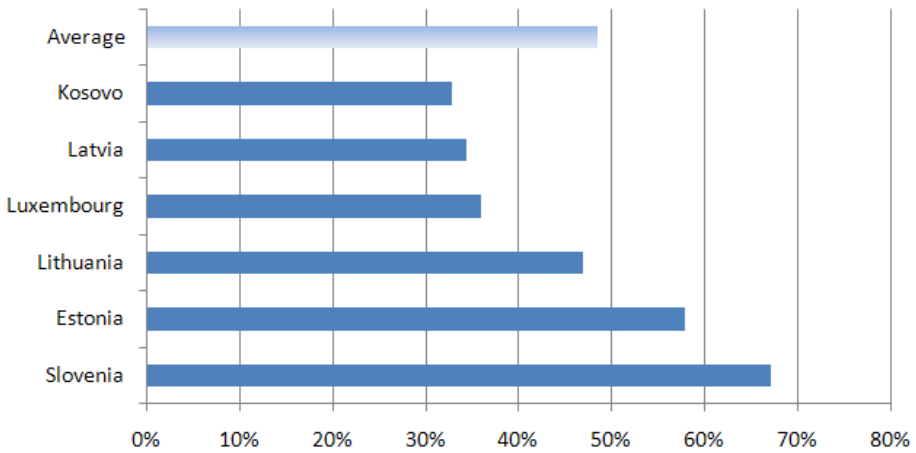
Figure 5. INSPIRE SoP scores per case study (in %)

From the INSPIRE State of Play assessment Slovenia has the highest score of 67% followed by Estonia with 58%. Lithuania scores lower with 47%. Two other countries score lower than the sample average (48%). Luxembourg scores 36% followed by Latvia 34%. The attempted projection of SoP of SDI in Kosovo resulted lowest with 33%.

2.3 Maturity Matrix

The organizational assessment approach is based on research by Kok and van Loenen (2005) on the evaluation of the different stages of development of geographic information infrastructures, when viewed from the organizational perspective. This approach measures the development of SDI for the following aspects: vision, leadership, communication, self-organizing capacity, awareness, financial viability and status of the delivery mechanism. The important point of this approach is the developmental perspective of evaluation as it measures SDI development from an organizational perspective.

The SDI Maturity Matrix consists of four stages of SDI development: *stand alone, exchange, intermediary*, and *network* stages. In the first network stage different organizations seek to build their own infrastructure. In the network stage, ultimate, most advanced stage, it is commonly understood what an SDI consists of and what its objectives and ideals are. In this idealistic view, leadership, open communication channels and a pro-active geographic information sector have resulted in a capacity that is such that the SDI enjoys broad support at all levels, resulting in sustainable funding for SDI development. (Van Loenen, 2006).

The aim of this research step was to measure and analyze the development of the
Kosovo and Slovenia SDIs using the Maturity Matrix method. Subsequently, the above
results of SDI developments of Kosovo and Slovenia are projected in an SDI maturity
matrix.

Our motivation to choose the SDI of Slovenia is based on the fact that the Republic of
Kosovo and the Republic of Slovenia have entered into an agreement on cooperation
and technical assistance for establishing the Kosovo SDI. Another aspect is that the
Slovenian level of SDI development is a realistic and an achievable aspiration for
Kosovo.

SDI Slovenia

The SDI of Slovenia can be classified in between the phases 'Exchange and
Standardization' and 'Intermediary' of the matrix. Especially the components Self-
Organising ability and awareness for GII need to be developed further. Maturity Matrix
findings are based on a desk research of the literature but mainly on the recent work
of Ažman and Petek (2009), Lipej and Modrijan (2010) and SoP reports for Slovenia.

Table 7 summarizes the conclusion for Slovenia presented by defining the stage (   )
of Slovenian SDI for each aspect of maturity matrix.

Table 7. Maturity of the Slovenian SDI

SDI Kosovo

The SDI of Kosovo is in almost all aspects classified within the 'Stand-alone / Initiation' stage. The component 'Communication' only is somewhat in the 'Exchange / Standardization' stage. The Maturity Matrix findings for the present state of SDI in Kosovo are based on desk research of the literature but mainly on the reports "Business plan 2009-2014" and "Development Strategy 2009-2011" for The Kosovo Cadastral Agency and The Cadastral sector in Kosovo. Table 8 summarizes the findings by defining the stage (   ) of the Kosovo SDI for each aspect of the Maturity Matrix.

Stage \ Aspect	Stand alone/ initiation	Exchange/ standardization	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; 'champion'
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
Awareness for GII	Professionals in one organisation: organisational 'SDI'	Professionals of organisations together: SDI	Awareness at many levels incl. decision making	Commitment at all levels/continuous support in politics and management
Financial sustainability	Limited to projects	Neutral	Guaranteed for certain period	Sustainable but frequently reviewed

Table 8. Maturity of the Kosovo SDI

For the purpose of being able to combine the results with other assessment methods in this research we have translated the four stages of the organizational approach into percentage values (%) (see also Grus *et al.,* 2010, p.87). The scores indicate respectively the following stages: stand-alone (25%), exchange (50%), intermediary (75%) and network (100%). The gap between the SDI developments in Slovenia and Kosovo are clearly shown in Figure 6.
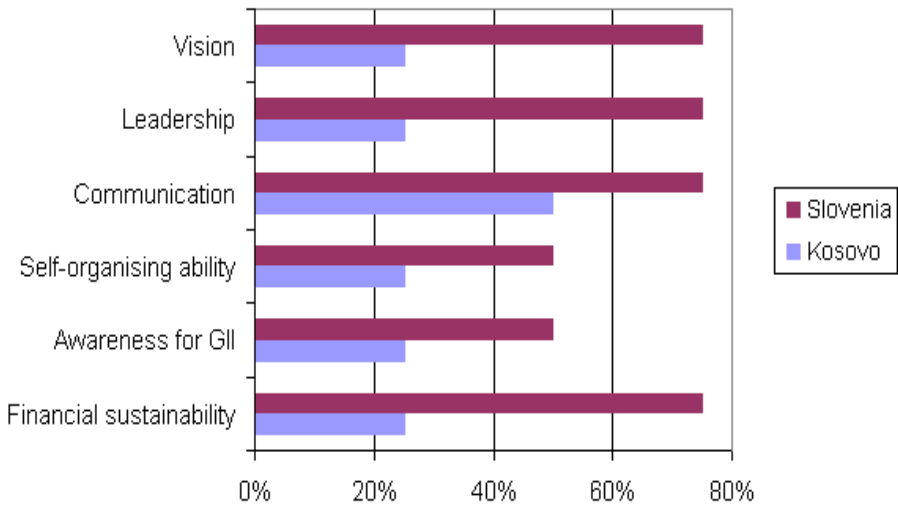
Figure 6. Maturity Matrix approach scores for Slovenia and Kosovo (in %)

Most significant gap occurs in Vision, Leadership and Financial sustainability in which the SDI of Kosovo requires a large leap from stage 1 (stand alone) to stage 3 (Intermediary). The reason for this lies, most likely, in the lack of common vision, undefined leadership and inadequate budgeting processes. The traditional human resource management is also of big influence. On the other hand the gap between the SDIs of Kosovo and Slovenia is slightly smaller in Communication (stage 2 to 3), Self-organizing ability and Awareness for GII aspect (stage 1 to 2).

The results of the Maturity Matrix prove that improving the Kosovo's SDI is totally necessary and justifiable. In other words, preservation of the current state of the SDI of Kosovo is not acceptable, not from organizational perspective nor from financial sustainability. It is important to accentuate that there are no identical SDIs in the world, and it is impossible to replicate a model from one country to another. Kosovo, considering its uniqueness, social needs and the present SDI development stage, needs to develop its own model of the SDI. But the SDI of Kosovo can follow the development trend of the SDI of Slovenia to be geared up to meet all challenges and future needs in line with INSPIRE directives. Improvement of the existing SDI of Kosovo is to be treated as a public project of permanent character, in which before defining the particular activities and resources at all levels, an efficient improvement strategy should be created. Of greater importance is that Kosovo should build such a strategy by itself.

3. Discussion of the Results

By applying the multi-view assessment framework we sought an objective overview of the present stage of SDI development in Kosovo and to test its applicability to assess SDIs. In this chapter we present the assessment results by using the three assessment approaches mentioned before: SDI Readiness Index, State of Play and Organizational Maturity Matrix. The special concentration is given to the Organizational aspects of SDI Readiness and SoP.

By synchronized use of the three assessment approaches we expected to create a much broader and more comprehensive picture of the Kosovo SDI. In that way the assessment is more objective because we are not limited to one view on an SDI. Furthermore converging on the Organizational aspects of multiple assessment approaches allows easier identification of the important driving forces that require more attention than others. Table 9 and Figure 7 presents the final results of the application of the multi-view SDI assessment of Kosovo.

Assessment aproach	Kosovo
SDI Readiness Idex	36%
SDI Readiness Index - Organisational	30%
INSPIRE SoP	33%
INSPIRE SoP - Organisational Issues	50%
Maturity Matrix (average)	29%

Table 9. Multi-view approach scores for SDI of Kosovo (in %)

It is interesting to notice that the average scores of different assessment approaches are in relatively balanced. The higher score is that of the SDI Readiness Index (36%) while the lowest score is of Maturity Matrix (29%). The average score of the multi-view assessment for SDI of Kosovo is 33%.
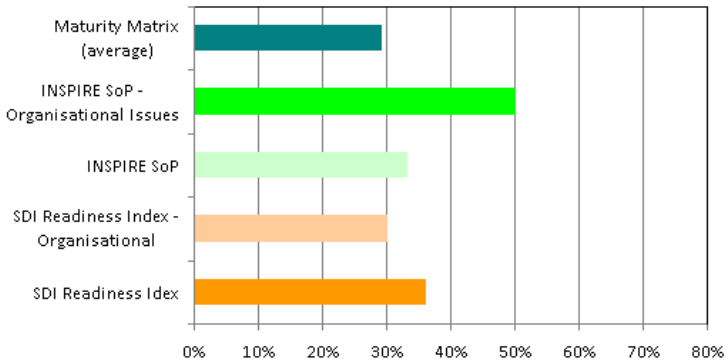
Figure 7. Multi-view approach scores for SDI of Kosovo (in %)

If we direct our attention to the organizational aspects of each approach one can see that the SDI of Kosovo scores higher in the organizational aspects of SoP (50%) than in the total score of SoP (33%). In the case of the SDI Readiness Index, it is the opposite result where Organizational aspects scored lower (30%) than the total Readiness Index (36%).

To ensure the future development of the SDI in Kosovo it is obvious that almost all Organizational aspects of SDI have to be improved. Therefore the driving forces should be to support this improvement.

3.1 The Driving Forces of SDI in Kosovo

The analysis and comparison of the SDI of Kosovo and the case study countries provide insight into the driving forces behind the SDI development of Kosovo. In this research step the differences and similarities between the initiatives and the driving forces behind the initiatives have become apparent. A compilation and combination of the issues has led to 6 driving forces selected for the purpose of sustainable development of SDI at the national level in Kosovo. These 6 driving forces have been chosen due to their particular relevance to local conditions in Kosovo and the perceived contribution of each driving force in developing a solid base to support SDI strategy development of Kosovo. Driving forces for future improvement of SDI of Kosovo could be: *SDI Awareness, Political Support, Coordination & Cooperation, Financing certainty, Communicate the benefits and Appointment of the SDI champion.*

As shown in Figure 8 each of 6 defined driving forces are aiming at a particular aspect of Organizational development of SDI in Kosovo.
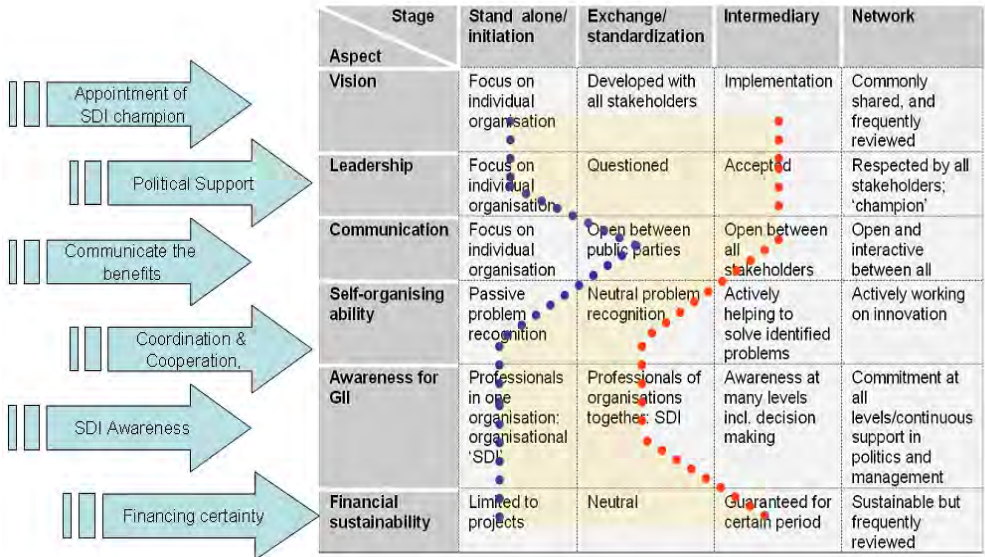
Figure 8. Driving forces projected in the Maturity Matrix
(Red - Maturity of Slovenian SDI, Blue - Maturity of Kosovo SDI)

Results of the Maturity Matrix assessment of the Slovenia and Kosovo SDIs clearly identify the gap in SDI development of Kosovo. The most significant gaps occur in Vision, Leadership and Financial sustainability in which the Kosovo SDI should achieve its greatest improvement from stage 1 (stand alone) to stage 3 (Intermediary).

3.2 Prioritizing the Driving Forces of Kosovo.

Based on this research the driving forces are prioritized in a logical order seeking to eliminate the largest gaps between the SDI development of Kosovo and Slovenia. Figure 9 could be seen as a roadmap for the future sustainable development of the Kosovo SDI.

Figure 9. Prioritizing the driving forces of Kosovo.

The driving forces presented in this chapter serves as a proper foundation for creating a vision and a national strategy for Kosovo's SDI enhancement. First, an SDI champion has to be appointed and then political support needs to be established. After the financing certainty has been guaranteed, the SDI awareness will be improved. After communicating the benefits, the coordination & cooperation will be seen as the next logical step.

4. Recommendations

To contribute to the improvement of a solid base to support SDI strategy development of Kosovo we have formulated the following recommendations:

- The SDI of Kosovo must not be developed in haste, but a clear vision is needed, which is to be based on organizational, human and financial resources.
- Stimulate the natural individual leadership in person of GIS Champion wherever it could be appreciated.
- It is recommended that politicians be encouraged to take an active role in all committees involved in establishing and steering the development of the Kosovo's SDI.
- Encourage international capacity building projects, for instance, from SDI or other international institutions with authority in the topic.
- To coordinate with national organizations in raising awareness at the political level through the dissemination of use-cases and pilot projects that have a

- direct relation to political top priorities such as environment and e-government. It is recommended organizing the Strategic Coordination to support the development of National SDIs and to ensure that policies and actions at the European level are consistent with the development of the SDI in Kosovo.
- Creation of an independent multidisciplinary body is to be considered, which would be independent of the government policy, and on the other hand represent the interests of a wider community of users and citizens of Kosovo.
- The vision for the future development of SDI should be clearly expressed and widely communicated
- Improvement of the existing SDI of Kosovo is to be treated as a public project of permanent character, in which before defining the particular activities and resources in all levels, an efficient improvement strategy should be created. Of greater importance is that Kosovo should build such a strategy by itself.
- The introduction of SDI in Kosovo will take many years. A step-by-step approach is, therefore, suggested for the implementation of the SDI.
- The users should be engaged as far as possible in the future development and implementation of the SDI in Kosovo and to base the work on user requirements.
- Conduct cost/benefit analysis emphasizing the merits of SDI to convince decision makers about the importance of investing in geospatial matters.

5. Lessons Learned

- The research showed that the three different SDIs assessment tools are useful to assess SDIs in transition countries, such as Kosovo. Additional research should provide evidence which assessment tool might be used best in which specific country.
- In this respect we should note that the three assessment methods appear to have many organizational aspects in common. Further research may develop from these three independently developed methods a fourth method which incorporates the common elements in the existing assessment tools.

References

Anderson, B., (2008), Business plan 2009-2014 and Development Strategy 2009-2011 for The Kosovo Cadastral Agency and The Cadastral sector in Kosovo.

Ažman, I., Petek, T., (2009), Spatial Data Infrastructure at the Surveying and Mapping Authority in Slovenia, 3rd INSPIRE conference. Netherlands

Bačić, Ž., (2009), Process of Transition and SDI: Interaction, effects and the role of the NMCA.

Craglia, M. and Campagna, M., (2009), Advanced regional spatial data infrastructures
        in Europe. Luxembourg: Office for official publications of the European
        Communities.

Crompvoets, J., Bregt, A., Rajabifard, A., Williamson, I., (2004), Assessing the
        worldwide developments of National Spatial Data Clearing House, In
        International Journal of Geoinformation Science, Vol 18, no. 7,pp 665-669
        London, Taylor & Francis.

Delgado (2005), Assessing an SDI Readiness Index, In FIG Working Week, 2005, and
        GSDI-8, From Pharaohs' to Geoinformatics, Cairo, Egypt. April 16-21 2005.

Eelderink, L., (2006), Towards key variables to assess National Spatial Data
        Infrastructures (NSDI) in developing countries. GIMA, MSc thesis, ITC,
        Enschede, the Netherlands May, 2006.

Fernández, T. D., Lance, K., Buck, M. and Onsrud, H. (2006), Assessing an SDI readiness
        index, From Pharaohs to Geoinformatics. FIG Working Week 2005 and GSDI-8,
        April 16-21 2005, Cairo, Egypt.

Grus, L., Crompvoets, J., and Bregt, A., (2007), Multi-view SDI Assessment Framework.
        In International Journal of Spatial Data Infrastructures Research, pp 33-53..

INSPIRE STATE OF PLAY REPORT, (2007), Homepage of Infrastructure for Spatial
        Information in Europe.

Kok, B. and van Loenen, B. , (2005), How to assess the success of National Spatial Data
        Infrastructures? Computers, Environment and Urban Systems 29: 699-717.

Lipej, B. and Modrijan, D., (2010), NSDI IN THE CONTEXT OF INSPIRE – SLOVENIA'S
        STATE OF THE ART AND PRIVATE SECTOR CHALLENGES, International
        Conference SDI 2010 – Skopje; 15-17.09.2010.

Masser, I., (2006), What's special about SDI related research? International Journal of
        Spatial Data Infrastructures Research, 1: 14-23.

Nobert, D., (2008), SDI Cookbook, Wiki version, September 2010,

Nushi, B., (2010), Multi-view SDI assessment of Kosovo - Developing a solid base to
        support SDI strategy development". GIMA, MSc thesis, TU Delft, The
        Netherlands November, 2010.

UN (2005), UN Global E-government Readiness Report 2005: From E-government to E-
        Inclusion, UN e-government survey 2005.

UN (2008), UN Global E-government Readiness Report 2008: From E-government to E-
        Inclusion, UN e-government survey 2008.

Van Loenen, B. and van Rij, E., (2008), Assessment of Spatial Data Infrastructures from
        an organizational perspective, in A multi-view framework to assess spatial
        data infrastructures. Melbourne: University of Melbourne. pp. 173-192.

Van Loenen, B., (2006), Developing geographic information infrastructures; The role of information policies. Dissertation.

Vandenbroucke, D. and Janssen, K., (2008), Spatial Data Infrastructures in Europe: State of Play 2007. Leuven, Belgium.

Publication Sponsors

Global Spatial Data Infrastructure (GSDI) Association

The GSDI Association is an inclusive organization of organizations, agencies, firms, and individuals from around the world. The purpose of the organization is to promote international cooperation and collaboration in support of local, national and international spatial data infrastructure developments that will allow nations to better address social, economic, and environmental issues of pressing importance.

Centre for SDIs and Land Administration (CSDILA), the University of Melbourne

CSDILA Provides a focus for research in Spatial Data Infrastructures and Land Administration by building on ongoing research relationships and creating new links through extended collaboration both nationally and internationally. The centre undertakes original worldwide research in land policy, land management, land information, spatial data, technical applications and other areas. It also supports spatial data developments and land administration particularly in the Asia-Pacific region.

Department of Geodesy and Geomatics Engineering, the University of New Brunswick

The Department of Geodesy and Geomatics Engineering at the University of New Brunswick in Canada provides accredited undergraduate degrees in Geomatics and Geomatics Engineering, as well as postgraduate degrees at the Master's and Doctoral levels. Founded over 50 years ago, well over 1400 of the Department's graduates from 58 different countries have used their leading-edge education to build careers for themselves. Working with partners in industry, government and universities worldwide, UNB's GGE Department faculty members have earned international reputations for their research in the fields of engineering surveys, geodesy and GPS, remote sensing, ocean mapping, land administration, GIS and spatial data infrastructure.

SPATIALLY ENABLING GOVERNMENT, INDUSTRY AND CITIZENS

RESEARCH AND DEVELOPMENT PERSPECTIVES

From both theoretical and practical viewpoints, this scholarly book presents the latest research by international experts in the area of spatial enablement and SDI for citizens all levels of government and industry. All the chapters together give an overview of the current concepts, foundations, activities, connections, participating and involved in spatial enabling government, industry and citizens in the world with an aim to further contribute to the understanding of, and address the issues, challenges and requirements in achieving a spatially enabled society. The chapters presented in this book have gone through a full peer review process as part of the Global Spatial Data Infrastructure (GSDI) 13 World Conference in 2012.
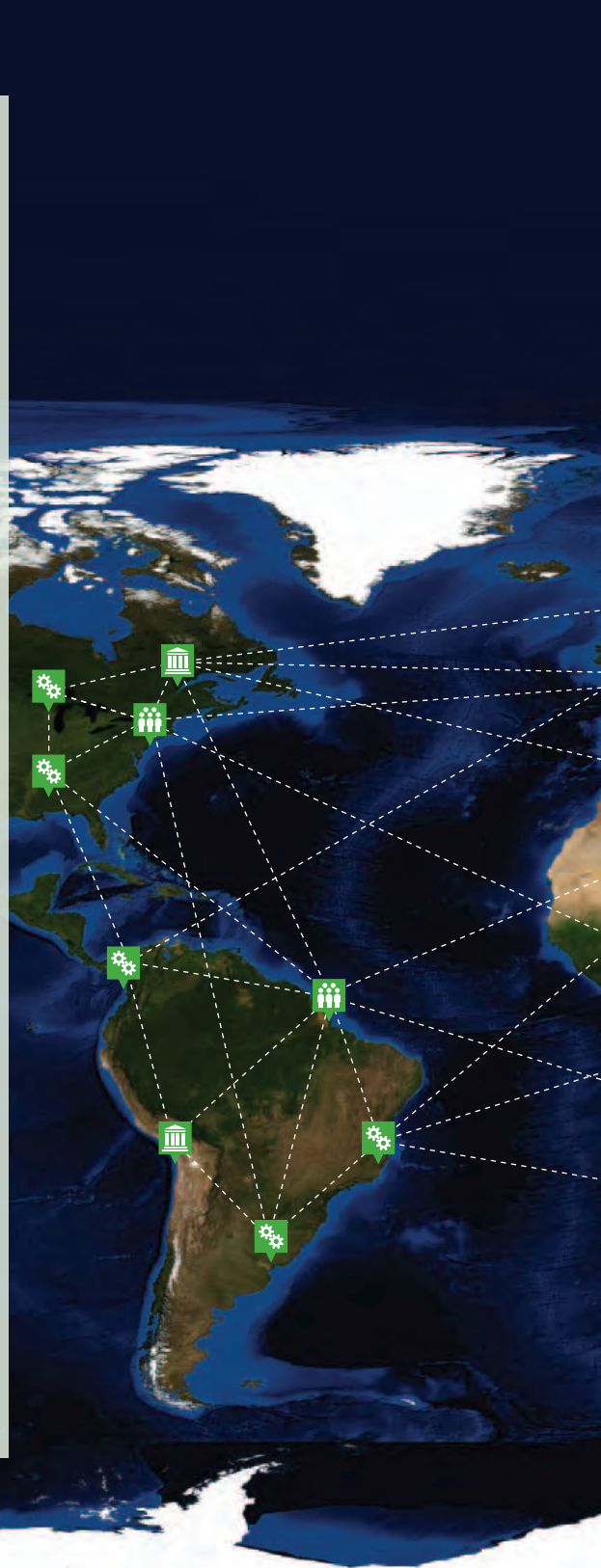
EDITORS

Abbas Rajabifard is a Professor and Head of Department of Infrastructure Engineering and Director of the Centre for SDIs and Land Administration at the University of Melbourne. He is President of the GSDI and a member of Victorian Spatial Council (VSC). He was Vice Chair, Spatially Enabled Government Working Group of the UN supported Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP). He has been also consulted nationally and internationally on spatial data management, SDI, land administration and spatial enablement.

David Coleman is a Dean of Engineering and a Professor of Geomatics Engineering at the University of New Brunswick. Prior to obtaining his PhD, he spent 15 years in the Canadian geomatics industry — first as a project surveyor and engineer, then a general manager and vice-president with one of Canada's largest digital mapping firms, and later as an owner and partner in a GIS and land information management consulting firm. He is a Fellow of the Canadian Academy of Engineering, a member of two Boards of Directors, three federal government advisory boards, and has acted as a consultant nationally and internationally.

Image Credit: Reto Stockli, NASA Earth Observatory. visibleearth.nasa.gov

GSDI ASSOCIATION PRESS | PRINTED IN CANADA

THE UNIVERSITY OF MELBOURNE

CSDILA
THE CENTRE FOR SPATIAL
DATA INFRASTRUCTURES
& LAND ADMINISTRATION

UNB
UNIVERSITY OF
NEW BRUNSWICK

GSDI
Global Spatial Data
Infrastructure Association