Is there a Future for Spatial Data Infrastructures?

Ulrich Boes[1], Raina Pavlova[2]

[1]URSIT Ltd., Sofia, Bulgaria
South-East European Research Centre, Thessaloniki, Greece
ulrich.boes@ursit.com

[2]Technical University of Sofia, Bulgaria
rsp@tu-sofia.bg

Abstract. This paper provides an account of the status of Spatial Data Infrastructures by today and an estimation of their future evolution by comparing with developments in other areas. The paper starts with the definition of spatial data infrastructures and summarises their implementation world wide. The actors involved are examined. It is shown that developments of the Internet are challenging traditional Spatial Data Infrastructures. These are providing seamless data with new business models. The term "Neo-Geographics" or "Volunteered Geographic Information" has been coined for these developments; we call it collaborative geo-spatial web. Both developments, traditional spatial data infrastructures and collaborative geo-spatial, are compared to understand their similarities and differences. User demand is considered an important point. The hypothesis is put forward that spatial data infrastructures and web developments will converge together into something that we could call a knowledge infrastructure.

1 SPATIAL DATA INFRASTRUCTURES

Spatial data infrastructures aim at making spatial data accessible to all kinds of users. Spatial data are complex from a technical point of view since they are multi-dimensional, voluminous and require many special and time consuming methods for their analysis; many applications require a high degree of accuracy [Longley et al. 2001]. On the business side, they are expensive to create and methods for their access and distribution vary between producers and countries or are often unclear. The most wide-spread definition of a spatial data infrastructure is:

"A Spatial Data Infrastructure supports ready access to geographic information. This is achieved through the co-ordinated actions of nations and organizations …. These actions encompass the policies, organizational remits, data, technologies, standards, delivery mechanisms, and financial and human resources necessary to ensure that those working at the national and regional scale are not impeded in meeting their objectives." [Masser, I., 2005, adopted from the Global Spatial Data Infrastructure Association website (www.gsdi.org)]

Meta data are an essential component of SDIs since they describe who has the data, what are their characteristics and the conditions for access and use. Data are normally accessed in searching a meta data catalogue available on geo-portals.

Following [Masser, I., 2005], spatial data infrastructures (SDIs) had a first milestone in 1986, more than twenty years ago. Since then, SDIs have attracted a lot of attention, many national, regional or local SDIs have been created, much SDI research is done. The European INSPIRE directive [Commission of the European Communities, 2007] in particular has strongly promoted the SDI discussion in Europe. Because of its legal character, it would be realized in all European Union member states, creating a European SDI.

Some authors distinguish two generations or phases of SDIs [Masser, I., 2005, and Williamson, I., et al. 2006]. The first generation is considered product based and focused on data. The second generation emerged around 2000; it is characterized by a process led model and driven by the needs of users. Sub-national governments and the private sector are said to have a greater influence on SDI development [Williamson, I., et al. 2006], since data relevant to people are produced there. The process model of this second generation emphasizes the steps or processes needed to create and execute an infrastructure and provides therefore a communication channel for knowledge infrastructure and capacity building [Rajabifard, A. and Williamson, I. P., 2001]. Further characteristics of this second generation are a shift towards implementation and to decentralized networks, which are a basic feature of the World-Wide-Web [Masser, I., 2005].

According to [Masser, I., 2005], the strengths of SDIs are the diversity of users to access a wide range of geo-referenced data sets, the integrating concept of SDIs, and its use of recent development in location based services, the Internet and the world-wide-web. The weaknesses result from the need for “data sharing on an unprecedented scale”, requiring different organizational cultures to work together, difficulties in achieving consensus and resulting limited commitment by stakeholders.

Lance [Lance, K.T., 2005] points to a further problem, which is identification of costs for SDI development, and which is often neglected or carried out on too general a level. INSPIRE has addressed this problem with its impact assessment. Both costs and benefits of INSPIRE implementation were estimated and it was found that the benefits outweigh the costs by at least six times [Masser, I., 2007]. Estimating these benefits had been rather difficult and an assessment has been done for public sector activities only [Dufourmont, H., 2004]. Gains by the private sector are mentioned by example, and it is admitted that benefits in terms of new products and services cannot be identified.

What is the status of SDI development today? According to [Rajabifard, A. and Williamson, I. P., 2001], the adoption of SDIs among spatial data communities obeys an S-shaped diffusion curve, referring to earlier research work. Such an S-shaped curve is often used for product adoption showing this adoption over time from inception via early adopters to late adopters and maturity. It may be interesting but difficult to position the current state of SDI development on such a curve, even impossible on a general level. The most detailed investigation of the state of implementation of SDIs has been done for Europe [Vandenbroucke, D., et al., 2008]. The conclusion of this report is that nowhere in Europe an SDI is fully realized. On the S-shaped curve, we could estimate that the early adopter phase is passed but that the late adopter phase is not yet reached. Masser [Massser, I., 2005(2)] describes several SDIs as being in the early majority phase, referring to a survey carried out by the global spatial data infrastructure (GSDI) association.

This raises the next question, why it takes so long to realize spatial data infrastructures, especially in considering the very high benefits estimated by the INSPIRE impact assessment. The answer may lie in their inherent complexity; the major barrier seems to be difficulties in transforming organizations which would be necessary for sharing data. Lance points out [Lance, K.T., 2005] that this required joint up approach is problematic from an administrative standpoint and calls it a “fundamental dilemma” of SDIs.

Looking at the diffusion of spatial information from an economic point of view, Krek and Frank [Krek, A., Frank, A.U., 2000] conclude that geographic data are not a standard economic good with the following characteristics:

- Geographic data are a non rival economic good;
- Geographic data lead to a natural monopoly;
- It is practically not possible to control the consumption of geographic data;
- Geographic data are an experience good.

They propose a value chain concept for the sequence of operations in the production, integration and transformation of geographic data as displayed in figure 1 below [Krek, A., Frank, A.U., 2000].

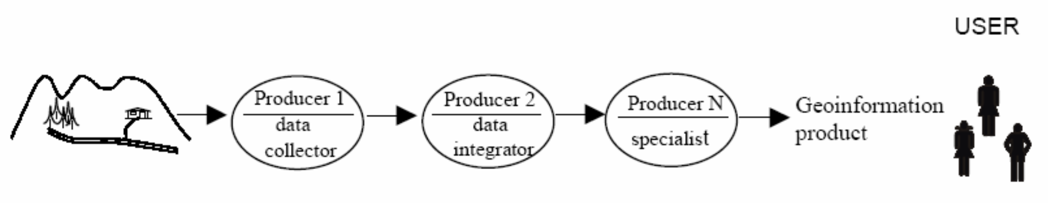

Figure 1: The Geo-information Value Chain, reproduced with permission of the author.

In order to understand the value chain in the context of SDIs, both the market of geographic data and the users – customers – have to be considered. Frank [Frank, A., 2008] distinguishes between two different markets for geographic data, each one with different structures: mass market and specialized market. The mass market uses a few common datasets, whose value increases by combining them with other information; business models are mainly advertisement based. The specialized market is completely different: only a few organizations participate using specialized data sets with a high value and cost. Accuracy of data, completeness and reliability are important.

Having defined the types of the market for spatial data or geographic information, it is important to understand who are the users or the customers in spatial data infrastructures. Vandenbroucke e.a. [Vandenbroucke, D., et al., 2008] define the stakeholder community in SDI as: developers, expert GI users, the broader user community; public authorities, academic and private sector, which is everybody. The authors however admit that very few stakeholders are ready for SDIs. Looking through the SDI literature and examples quoted, users mentioned are: public sector comprising government authorities or public companies, then services and software providers dealing with GIS. Craglia [Craglia, M., 2007] states that SDI would be used by experts only. Gould inquires critically about the usage of data as provided by SDIs [Gould, M., 2007]. He distinguishes between "GI professionals, who normally know what data are available and where … and the general public, who do not search for geodata but rather issue their queries to higher-level web applications".

We conclude from these considerations that the end customer of an SDI is not the final user in figure 1 but rather the specialist, who is the last node in the value chain. Hence, the value chain is incomplete in the case of SDIs, and further determined by the value chain paradox [Krek, A., Frank, A.U., 2000]: under normal circumstances, the value of the information and the sequence of tasks in a value chain are defined by the user, which means from the end. In the case of SDIs however the end value is determined by the high fixed costs of data collection that occur in the beginning of the value chain.

As a summary of the above considerations, we conclude:

1. Much conceptual and research work has been done for SDIs, and implementations of SDIs have started. Maturity and general acceptance of SDIs have however not been reached, although SDIs are in their second generation. Major difficulties are the need for reorganization and a resulting lack of motivation to implement SDIs.
2. Stakeholders participating in SDI development are mostly public sector administrations. Participation by the private sector or by citizens is rare

and their benefits are indirect only. Craglia calls an SDI such as INSPIRE a government to government initiative [Craglia, M., 2007].

3. There is a lack of awareness of SDIs. Direct participation requires a high level of expertise. Use of SDIs beyond the specialist community is limited.
4. SDIs are operating in a specialized (or niche) market and are not designed for the mass market. The value chain is incomplete and the related value chain paradox, along with the special characteristics of spatial data, constitutes a basic difficulty for SDIs from an economic point of view.

2 SPATIAL DATA AND THE WORLD-WIDE-WEB

The World Wide Web has after its creation in 1989 quickly become a tool to display maps and related services. One well-known early example is Mapquest; in Bulgaria, bgmaps.com has become a universal tool to find a location in the country. More recently, some sites have attracted much attention, such as Google maps, Yahoo! Local Maps and Windows Live Local. “Google maps” or “Google Earth” was made available in 2005 and is considered a breakthrough in availability and easy use of geo-spatial data. Recent developments would not have been possible without new technological innovation. Advances have been made in capturing images of the earth via high resolution digital cameras and in the production of true orthophotos from aerial photographs or satellite images. Cameras mounted on airplanes achieve a ground sample distance of 20 cm, the latest satellites (World View) of 50 cm [Konecny, G., 2008]. Those images are produced by private companies, not any more by the public sector. Possibilities of 3D modeling lead to unprecedented possibilities to present our world. The World-Wide-Web has undergone a new revolution with Web 2.0, providing completely new ways of sharing information and communicating, quickly taken up by the public. The open source community drives many of these new developments, and standards play an important role.

The widespread availability of GPS coordinates in particular contributed strongly to the use of maps and location referenced information by the Internet audience. Now it is possible to geo-reference any type of information and distribute or share it via the Internet. [Erle, S., Gibson, R., Walsh, J., 2005] call this geocoded hypermedia and predict a big disruptive innovation. A new research area was borne, which some call Neo-geographics, others Volunteered Geographic Information (VGI) [Goodchild, M. F., 2007]; we call it here the collaborative geospatial web. Google maps as one of the first sites providing maps of the whole globe offered an API to access the maps and many mash-ups were created using these maps. Web sites were developed allowing users to create and edit maps; OpenStreetMap is a prominent example. Maps are easily combined with other content and tools from various sources, so-called mash-ups, commonly called part of the Web 2.0. Tools are created that make mash-ups available even to non-programmers such as Yahoo! Pipes (http://pipes.yahoo.com). Mash-ups link into social networking sites. The difference between geo-spatial data, considered by many as very complex, and other content becomes blurred; some Internet content just adds location in order to get to a place on the earth; Geo-RSS is an example.

The geo-spatial semantic web develops ontologies for geo-spatial data with the goal to increase understanding of such data by machines. Meta data as a tool to find spatial data are not a topic; maps are simply available, being rather a means to get to other information such as specific features on the earth, hotels, restaurants, businesses and others. As this author pointed out in earlier papers [Boes, U., 2006 and 2007], maps and use of maps was made easy, to the reach of the masses, opposed to GIS, which is a specialist tool.

This Internet driven use of spatial information is a mass market phenomenon, driven by the community of Internet users who do not have deep knowledge of geography. Providers are private sector companies, and business models are clearly established; in most cases costs are paid by revenues from advertisement. Comparing the process again with the value chain model proposed by [Krek, A., Frank, A.U., 2000], we recognize that all steps of the whole value chain are included. In this case, the total value as also the costs of the processing steps are determined by the users' needs and not by the fixed costs of producing the raw material, which is the spatial data. On the S-shaped curve, we would position these developments somehow around or before the early majority.

These developments have of course also been noticed by the SDI community. [Masser, 2005] considers it as a strength of the SDI concept that is includes recent developments of the Internet and location based services. However, he is also concerned "that the GI/SDI sector will be swallowed up by these broader debates and lose its identity in the process. As a result some of the special qualities of geographic information may not be adequately considered in future applications." These "broader debates" he refers to are those related to Information Society aspects and the digital revolution, as well as discussion around public sector information as for example manifested in the EU's Public Sector Information Directive. He did not explicitly mention the geospatial web as a threat.

Some national mapping authorities follow these developments very closely; one main example is Ordnance Survey of the United Kingdom. Vanessa Lawrence, Director General and Chief Executive Officer of the

British Ordnance Survey said in an interview at the AGI conference in Stratford-Upon-Avon [Thurston, J., 2007] that Ordnance Survey strives to meet the needs of those people as well who are involved in mashups and data sharing. Ordnance Survey had developed their own API to access Ordnance Survey mapping data, called Open Spaces, which due to legal restrictions never made it to the market.

3 CONCLUSION: THE FUTURE

Two different worlds for the diffusion of spatial information seem to exist: one traditional geo-spatial world created by the public sector as data provider, where spatial data infrastructures are the dominant theme; a second one where the Internet community makes data available, driven by the private sector with obvious business interest. Both seem to be independent of each other, and the question arises where this will lead to – to the prevalence of either or the merging of both.

SDIs are created by specialists for specialists with the goal to make diverse and heterogeneous spatial data available and accessible; the major tool used in an SDI is a GIS. SDIs can be considered as a top down approach [Gould, M., 2007]. The Internet and the World-Wide-Web have become the main tool to supply spatial data via meta data.

On the other hand, the Internet community, mainly pushed by the availability of GPS coordinates has added location to its content. Mash-ups have made it possible to combine satellite images or digital maps and geo-referenced content. Geo-referenced content is created and made available by users in the mass market in an easy way. This is a bottom-up approach, contrary to the development of SDIs. We further observe that provision of location based content goes much beyond traditional paper based maps in offering access to 3-D views, video and other multi media content.

The following table 1 is an attempt to contrast important characteristics of SDIs and the collaborative geospatial web, which admittedly provides some simplified view.

Contrasting the two different approaches or worlds, the question for the future arises inevitably. There may be three different scenarios:

- Both approaches will continue to develop and exist independently;
- One approach will continue to develop independently with the other one disappearing;
- One approach will submerge the other one and consequently both will merge.

Table 1: Tabular comparison between SDIs and the collaborative geospatial web.

Category	**Spatial Data Infrastructure**	**Collaborative Geospatial Web**
Value chain	Public Data Producer → Specialist	Private Data Producer → End user
Major Stakeholders	Public Sector	Private Sector, Internet Users
Revenue model	Cost recovery (varies between countries)	Advertisement, affiliate
Content	Spatial Data	Geocoded Hypermedia
Technology	GIS, Web Portals	Web 2.0 tools
Competition	Low (natural and legal monopoly)	High
Major Strength	Existence of data sets	Uptake by industry and users
Major Weakness	Need for re-organization	Unfit for mission critical applications

In order to be able to answer the question, we need to consider that SDI development has a strong organizational component and is public sector oriented. The geospatial web is not organized but is pushed by technology. Research areas such as the geospatial semantic web are followed by both areas. One important argument is that solutions needed by users focus on all kind of content integrated into the solution and the work flow, with location as one component. This will eventually lead to treating geo-spatial data as any other content. The concept of a map will have to be revised as a model of the human's mind of places on the earth. Traditional GIS, along with specialized data sets and meta data, will remain the realm of some specialized applications only. The hypothesis is put forward that spatial data infrastructures and web developments will converge together into something that we could call a knowledge infrastructure. Spatial data infrastructures as an area of itself will cease to exist, and we agree to the concern by Masser [Masser, I., 2005] that the GI/SDI sector might loose its identity.

SDI stakeholders should consider completing the value chain for providing spatial data and think about different, new business models so that their spatial data can be made available to end users. They have to acknowledge the existence of the collaborative geospatial web and achieve stronger collaboration with the geo-spatial web. Some have already started this collaboration as the example of Ordnance Survey shows.

4 REFERENCES

Boes, U. (2006): “Cartography in the Internet World”, First International Conference on Cartography and GIS, Bulgaria, 25-28/01/2006.

Boes, U., Pavlova, R. (2007): “The Web 2.0 – A New Challenge for GIS and Cartography?”, Intergeo-East 2007, Sofia, Bulgaria.

Commission of the European Communities (CEC) (2007): “Directive 2007/2/EC of the European Parliament and the Council of 14 March 2007 establishing an infrastructure for spatial information in the community (INSPIRE)”, Official Journal of the European Union L 108/1-14.

Craglia, M. (2007): “Volunteered Geographic Information and Spatial Data Infrastructures: when do parallel lines converge?” Position paper for the VGI Specialist Meeting, Santa Barbara 13 - 14 December 2007.

Craglia, M. – Sheffield University (contractor), (2003): “Contribution to the extended impact assessment of INSPIRE”, Creator INSPIRE Framework definition support (FDS) working group.

Dufourmont, H. (Creator) (2004): “Extended Impact Assessment of INSPIRE based on revised scope”, Results Task Force XIA, ESTAT

Erle, S., Gibson, R., Walsh, J. (2005): “Mapping Hacks, Tips & Tools for Electronic Cartography”, O’Reilly, Series: Hacks (O'Reilly book Mapping Hacks), ISBN: 0-596-00703-5, 564 pages.

Frank, A. U. (2008): “Economics of Geographic Information”. In: Encyclopedia of Geographic Information Science. (K. Kemp ed.) Thousand Oaks, CA, Sage Publications.

Goodchild, M. F. (2007): “Citizens as Sensors: the World of Volunteered Geography”, Position paper for the VGI Specialist Meeting, Santa Barbara 13 - 14 December 2007.

Gould, M. (2007): “Vertically interoperable geo-infrastructures and scalability”, Position Paper, Specialist Meeting on Volunteered Geographic Information, 13-14 December 2007. Santa Barbara.

Janssen, K. (ICRI), Vandenbroucke, D. (SADL) (2006): “Spatial Data Infrastructures in Europe: State of play 2006, Summary report of a study commissioned by the EC (EUROSTAT) in the framework of the INSPIRE initiative (Under Framework Contract REGIO/G4-2002-02-Lot 2)”, Publisher K.U.Leuven (SADL + ICRI).

Konecny, G., 2008: “Recent Technological Advances and Their Impact on Mapping, Paper to Intergeo East Conference 2008, Belgrade, Serbia, February 19, 2008

Krek, A., & Frank, A.U.(2000): “The Economic Value of Geo Information'” In Geo-Informations-Systeme - Journal for Spatial Information and Decision Making, 13 (3), pp: 10-12

Lance, K.T. (2005): “Cross-Agency Alignment of Geospatial Investments for Spatial Data Infrastructure Development”, ISPRS Workshop on Service and Application of Spatial Data Infrastructure, XXXVI (4/W6), Oct.14-16, Hangzhou, China, Proceedings, 17-28.

Longley, P.A., Goodchild, M.F., Maguire, D.J., Rhind, D.W. (2001): “Geographic Information Systems and Science”, John Wiley & Sons, Ltd.

Masser, I. (2005): “The Future of Spatial Data Infrastructures”, ISPRS Workshop on Service and Application of Spatial Data Infrastructure, XXXVI (4/W6), Oct.14-16, Hangzhou, China, Proceedings, 7-15.

Masser, I. (2005): “GIS Worlds – Creating Spatial Data Infrastructures”, ESRI Press, ISBN 1-58948-122-4.

Masser, I. (2007): “Building European Spatial Data Infrastructures”, ESRI Press, ISBN 978-1-58948-165-7.

Rajabifard, A. and Williamson, I. P. (2001): “Spatial Data Infrastructures: Concept, SDI Hierarchy and Future Directions”, Geomatics’ 80 Conference, Tehran, Iran

Thurston, J., (2007): Geographical Perspectives: 3 People - 3 Views, http://vector1media.com/article/event-coverage/geographical-perspectives%3a-3-people-%11-3-views/, accessed on 17 May 2008.

Vandenbroucke, D., Janssen, K., Van Orshoven, J. (2008): “INSPIRE State of Play: Development of the NSDI in 32 European countries between 2002 and 2007”, Tenth International Conference for Spatial Data Infrastructure, St. Augustine, Trinidad, February 25-29, 2008.

Williamson, I., Rajabifard, A. and Binns, A. (2006): “Challenges and Issues for SDI Development”, International Journal of Spatial Data Infrastructures Research, 2006, Vol. 1, 24-35.