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[1]Beyond Spatial Data Infrastructures there are no SDIs – so what

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Abstract
What might Spatial Data Infrastructures (SDIs) look like in 2016? The paper envisions the future of SDI strategically as having three characteristics. First, SDI may loose its distinctiveness and its spatial functionalities become integral part of information infrastructure in general. Second, information infrastructures – including SDIs – may become an institutional property of governance beyond the narrow and traditional limits of the state. Third, the design, implementation and use of information infrastructure are likely to be different at different levels of governance because space is conceived of differently at these levels. Understanding these complex relationships between governance at different levels and the role of information infrastructure requires a genuine socio-technical science in its own right beyond the traditional realm of positivism. Contours are indicated of a needed research practice bringing together the conventional GIScience community, scholars of information systems and those from social sciences (including sociologists and scholars of public administration) into 'communities of practice'.

Keywords: SDI, GIScience, governance, information infrastructure, socio-technical research

1. STRATEGICALLY LOOKING INTO THE FUTURE OF SDI

What might Spatial Data Infrastructures (SDIs) look like in 2016? That was the central question for the International Workshop "Beyond Spatial Data Infrastructures" organised at GIScience 2006 in Münster (Germany), 20 September 2006. This paper further elaborates the author's contribution for the Workshop while taking into account some of the discussions.

At least two different approaches can be followed in envisioning the future of SDI – or of any technology for that matter. First, the future can be understood as

extrapolation of the current trend. This brings the need not only for understanding the actual trajectory of SDI development; what happens and why but also for control of uncertainty. In this approach one needs to distinguish between long-term trends and short-term incremental or sometimes windfall, opportunities for technology development. Second, future developments may be charted and facilitated – how to design, shape and achieve a desirable future. These two approaches in envisioning the future are similar to the distinction by Kieser and Kubicek (1978, pp. 14, 20-72) between the explaining and designing functions of theory. From the outset it must clear, however, that envisioning the future of technology – and thus of SDI – is necessarily speculative. All we can do is to carefully interpret what happens – apprehensive of self-evident truths, as Ostrom (2000) would put it. The paper provides a preliminary exploration only.

1.1 Looking back into the future

To be able and envision the future of SDI it will be helpful to consider and – in retrospect – learn from our ability of foresight in the past. In other words, how accurate and realistic were the developments we then foresaw. Thinking about the future of SDI in the late 1990s in general was rather supply oriented – the perceived needs at the time of large and often national mapping organizations and utility companies. Early initiatives were predominantly 'product-' rather than 'process-based'; oriented towards the linking of available databases rather than managing information assets, respectively (Rajabifard *et al*. 2002, pp. 14, 18–20). But there were alternative views as well. Within Europe, for example, the 'GI2000' consultative project understood the status regarding European geoinformation as one sector of a much wider information market (Rajabifard *et al*. 2002, p. 19; see also Masser 2005, pp. 181–199). At the 4th National Conference on GIS Research in the UK (GISRUK) in 1996, Barr and Masser (1997) argued that from a concern for the common good and for the efficient management of affairs for the whole of society, a basic core of geographic referencing data must be considered part of the national infrastructure (p. 246). Within the framework of GISDATA Scientific Programme of the 1990s, Wegener and Masser (1996) problematized the traditionally pro-innovation bias towards GIS-development. By suggesting four scenarios they portrayed differently possible impacts of GIS on society – potentially beneficial as well as dangerous. All scenarios look 20 years into the future – the year 2015, and thus have almost the same time horizon as the present SDI-discussion 'Beyond SDI' (*viz.* 2016). The first scenario represents what may happen if GIS diffusion continues past trends and reflects the pro-innovation bias in most of the GIS literature at the time – the *Bench mark* scenario. The *market* scenario reflects increased commodification of information and access being restricted to those who have power. The *Big Brother* scenario reflects the potential of GIS for surveillance and control in all aspects of life. Finally, the *Beyond GIS* scenario shows how GIS could also be used to promote wider democratic debate and facilitate grass roots

empowerments. Wegener and Masser considered the possibility of different scenarios for different countries but also the alternative that the global competition would bring a convergence rather than polarization between countries. They anticipated, however, that "the future will contain some facets of each of these scenarios" (1996, p. 19).

Ten years after Wegener and Masser formulated these scenarios it is interesting to see whether any of them is becoming reality at present. To do this in any level of detail, however, would be beyond the scope of the paper. Nevertheless, impressions at first glance suggest that clear deviations from continuation of past trends cannot be found anywhere. In other words, the booming development and diffusion of GIS-technology – though impressive – is still incrementally *muddling through* in the sense of 'disjointed' (Lindblom 1959; 1965, p. 178) – *not* in the sense of being trivial. Trends in GIS diffusion therefore may be recognized in retrospect at the moment but can hardly form a basis for extrapolation and foresight. This does not necessarily mean, however, that envisioning the future of diffusion of GIS has been a futile exercise by Wegener and Masser. First, grasping the future or foresight is not just a matter of modelling or extrapolation a narrow set of trends as Miles (2004, p. 28) notices. Such forecasts can be useful if examined critically but analysis of a broader set of factors may indicate developments that undermine a trend or its drivers. Reuter and Zipf (forthcoming) believe that the real value of those technological predictions, extrapolations, or forecasts does not lie in what they say, but in the reactions they provoke in the readers' minds. Wegner and Masser have clearly stimulated such discussions. We now turn to the question of how to envision the future of SDI.

1.2 Looking into the future of SDI is strategic

Like any (socio-) technical construct, SDIs *interact* with their respective context. They are shaped both by choice and strategy (Miles 2005, p. 3) and by contextual factors. Working into a desired future therefore is not by imposing a 'blue print' onto the current situation. It involves a 'mix' of strategic choices of long-term perspectives and allowing for incremental and short-term developments, part of which is beyond direct control. This mixture of long- and short-term decisions is somewhat similar to Etzioni's "mixed-scanning" (1967). Etzioni, however, saw the long-term choices as 'rational' and in contrast with the short-term incremental decision-making. In envisioning the future of technology, one can argue that the adoption of long-term perspectives has more to do with paradigmatic – if not ideological – choice than with choosing the best alternative direction. This choice is *strategic* in that it may influence the dynamics of the development trajectory into the future. Morello (2000) even argued under what conditions technological design might "predict the future". In this sense, envisioning the future of technology is a fundamentally social process. Miles (2005, p. 11 – he speaks of 'foresight' however) understands it as a process of

engaging informed stakeholders in analysis and dialogue. The paper hopes to contribute to this process of envisioning the future of SDI by proposing strategic choices.

In the next sections the paper argues that looking strategically into the future of SDI must consider its context – information infrastructure in general and the wider realm of society, and is fundamentally evolving around the question of how special are SDIs. First, SDI will loose its distinctiveness and must be seen as part of general information infrastructures. Second, SDIs and other information infrastructures are to be understood as structural part of societal governance.

2. SDI LOOSES ITS DISTICTIVENESS AND BECOMES PART OF GENERAL INFORMATION INFRASTRUCTURE

The long-term trend in spatial (or geographic) information technology may be that it becomes less distinct from mainstream information technology. Although impressive developments over the past three decades or so of specialised and complex tools in handling spatial data, convergence of computing towards open systems and interoperability may bring with it that the hardware and software justification for a separate status for GISs. Although over the past three decades or so, there have been impressive developments in specialised and complex tools for handling spatial data, the convergence of computing towards open systems and interoperability may now lessen the justification for a separate status of GI technologies (Reeve and Petch 1999, p. 177–185). Some attribute the convergence of geographic information technology and a variety of other technologies to the widespread availability of the internet and the emergence of location-based services (*e.g*. Jiang and Zipf 2004, p. 89.) Interestingly, Smith *et al*. (2004, p. 26, 41) see SDIs providing an effective framework in which to explore the set of interrelated issues that collectively govern the quality of service delivery in location-based services understood by them as a result of the convergence of position, information, and communication technologies. They admit, however, that to this end the current SDI model needs to be adapted (p. 42). An alternative view would bring location-based services conceptually under the ‘umbrella’ of information infrastructures in general be it with spatial data handling functionalities built in and avoiding the risk of stretching the SDI concept too far.

The remainder of this section aims at supporting the strategic view that SDIs are to become less distinct from other kinds of information infrastructure but no proof can be offered obviously.

2.1 SDI and other information infrastructures share similar challenges and dilemmas

In many respects, SDIs are not different from other kinds of information infrastructure in their implementation and use. For instance, as McLaughlin and Groot (2000, p. 273) notice, the essence of the SDI concept is that there is no master architect and that SDIs emerge as almost organic webs of partnerships and relationships. This holds for other information infrastructures as well; at least conceptually. They are not designed by blueprint but by "cultivating a process rather than designing a product" (Dahlbom and Mathiassen 1993, p. 128; see also Aanestad 2002). Next, Monteiro and Hanseth (1995) and Star (1999), for instance, consider development and diffusion of standards as characteristic of information infrastructures. The need for standards in successful implementation of SDIs is also recognised in the literature (*e.g*. Crosswell 2000). Moreover, the multitude of stakeholders involved in any information infrastructure brings the need for alignment of different expectations and interests. (See for the case of information infrastructures in general, Monteiro and Hanseth 1995, Aanestad and Hanseth 2000; and for the special case of SDI, Martin 2000, and Harvey 2001,.)

Finally, SDIs and other information infrastructures face similar challenges (De Man 2006b). Challenges include exclusion (access denial from the infrastructure), fragmentation, technocracy (techno-centricity), isolation (from use), and discontinuity (short-livedness). These challenges also suggest that the development of SDI initiatives and other kinds of information infrastructure is not a linear process. Such infrequent and unruly processes generally tend to be convulsive and revolving around dilemmas, as Argyris and Schön (1974, p. 30-34, 99-102, 114-120) have pointed out. A major dilemma for any information infrastructure is in the tension between standardization and flexibility (Hanseth *et al*. 1996; Rajabifard 2006, p. 738). Related to this is the dilemma between (bureaucratic) control towards uniformity and facilitation of pluralism and deliberation.

2.2 The future of SDI: long-term trends or windfall opportunities?

To envision the future of SDI – strategically at least – as becoming less distinct from other information infrastructures seems at odds with current SDI projects and initiatives many of which point to a rosy future. Moreover, the various legal provisions that may smoothen access to and sharing of spatial data may indicate that SDI is becoming of age as well. Two points need to be made in this respect. First, what we call success depends on the parameters of success as Mol (2002, p. 235) reminds us. The selection of parameters to assess the development of SDI, in turn, would thus depend on one's point of view: technology- or context-centred. Second, it can be argued that these positive developments are merely windfall opportunities in the short run and do not reflect lasting trends.

At present, accessing, sharing and exchange of spatial data is relatively uncontested in society beyond the spatial data community. As of yet, we do not witness widely public discussions on topics like geographic information (super) highways or geographic information society, as this has been the case of the information super highway and the information (and knowledge) society in general. Moreover and notwithstanding rhetoric suggestions otherwise, SDI developments are still predominantly within the public domain. But that may change as for example the European INSPIRE initiative suggests (Craglia and Annoni 2006, p.1). SDI has clearly entered the European political arena. Moreover, the report on assessing the impacts of SDIs resulting from the International Workshop on "SDI Cost-benefit and Return on Investment" (Craglia and Nowak 2006) suggests that much more attention needs to be paid to assessing the social and economic impacts of SDIs across governments and communities of practitioners in spatial data handling now that a significant number of such infrastructures is being established (p. 5).

It would then follow that the current interest in the concept of SDI as distinct technological development in its own right may be professionally and academically parochial rather than out of societal relevance *per se*.

2.3 The danger of isolation for the spatial data community – join-up!

The distinction between long-term trends and short-term fluctuations like windfall opportunities is relevant for the debate about the future of SDI. Confusing windfall opportunities for SDI initiatives with long-term trends will run the danger of creating an artificial world of SDI "practice" that is increasingly detached from reality. This would also bring the risk of continued isolation for the spatial data handling community – both professionally and scientifically. As Reeve and Petch notice (1999: 178), GIS has formed its own community and interactions with the broader sphere of information systems seem not always to have been strong. Indeed, there seems to be a real danger of intellectual isolation for the professional and academic communities in the fields of spatial information technology and of re-inventing the wheel. To put it differently, the paper suggests that understanding even contemporary SDIs and their impacts will benefit more from considering commonalities with other information infrastructures than from focussing on what is special in them. Later in the paper we return to the emerging field of GIScience and its possible relevance for the present discussion.

If SDI will loose its distinctiveness from other information infrastructures this does not mean, of course, that space and geography are not important and that there is no need for specialised tools to handle spatial data effectively and efficiently. Nor it means that spatial data professional and scientific communities are obsolete. What is needed is to develop an outward looking rather than an

inward-looking approach to spatial data handling. Therefore, the paper suggests a distinction be made between concrete SDI-artefacts and SDI as a concept. The SDI-concept is dynamic and refers to a verb (*structuring*) rather than to a noun (*structure*; a thing). Essentially, SDI is about representation, processing and communicating spatial perceptions of reality. In this respect, operationalization of the SDI-concept and its functionalities will require skills and knowledge of – hence, research in – geographic information technology. But this is not necessarily the same as developing SDIs as distinct artefacts (things). To the contrary, SDI-functionalities need to be built in information infrastructures in general. The other side of the 'SDI-coin' is that they not only emerge by design and implementation. They also emerge because they are used. Therefore, understanding usage and critical factors and conditions in this respect will be prerequisite in pursuing the SDI-concept "and beyond". To achieve these ends, the paper suggests the spatial data professional and scientific communities to join-up with the field of mainstream information technology and other (relevant) disciplines.

3. SDI AND OTHER INFORMATION INFRASTRUCTURES AS INTEGRAL PART OF GOVERNANCE

As this has been mentioned earlier, geographic information technology, like any other technology, implies context. Information infrastructures – and thus SDIs – are about facilitation and coordination of the exchange and sharing of data. Their contexts are characterized by multitudes of heterogeneous actors. Hence, the context of any information infrastructure is social – if not: societal. As Ciborra (2005, p. 260, 261) has pointed out, the relationship between information infrastructures and their contexts is beyond the technical and instrumental. It is about enabling and aligning processes within the host social (or societal) system. "The essence of modern technology is a way of revealing that challenges the world by ordering it, that is by ordering resources, processes, people, and relationships" (p. 261). This section explores the societal context of information infrastructure and argues that information infrastructure is an institutional property of governance. Essentially, this issue revolves around the question of "what sort of ICT-enabled society we wish to be" (Rajabifard et al. 2006, p. 738).

3.1 Governing by information infrastructure – government or governance?

Information technology in general and information infrastructure in particular, is relevant to governing and decision-making in society. For governing cannot be conceived of without accessing, processing, analysing, and communicating information. Governing also implies some form of authority and, consequently, of subjects. The skilled use of technology has always been at the centre of what is to govern (6, 2001, p. 67). But the balance between government and citizens – or

civil society – is not fixed nor given. And so is the distribution of the use of technology in society. Seen from the viewpoint of government, Perri 6 (2001, p. 70, 71) distinguishes between two attitudes towards technology. One is outward looking and focused on the regulation of private activity while the other is internally focused and concerned with augmenting the technical capabilities of public agencies. The paper deals in particular with the outward looking attitude.

One may expect that information infrastructure in particular both shapes and is shaped by governing and societal decision-making – in other words, by *governance*. Although the concept 'governance' has different meanings in the literature, they all are concerned with the problems of governability, accountability, and, hence, legitimacy (Van Kersbergen and Van Waarden 2004, p. 144). The term 'governance' as used in the paper is not limited to 'government'.

It then follows that the strategic adoption of 'governance' as societal context for information infrastructure helps in broadening the scope of understanding of information infrastructures beyond efficiency and means-ends discourses.

The evolution of 'governance' into *networked governance* seems of particular relevance to the debate on the future of SDI but on the future of any information infrastructure. For governance is then essentially about developing and communicating *frames* between publics and by doing so creating dynamically a provisional sense of community (Hajer 2003; for the notion of 'frames' see also Perri 6 2005).

3.2 Information infrastructure as institutional property of governance

Information infrastructure – as any technology – does not emerge out of thin air. Technology develops through human agency but at the same time will shape it – the duality of technology (Orlikowski 1992, p. 406). Moreover, human actors are generally subject to social conditions in their behaviour. Therefore, technology emerges out of interplay between human actors, social conditions and technological artefacts. Each of these elements will continuously change in this interplay – be it differently. In this section the paper draws on two complementary strands in the literature that may help in understanding the dynamic relation between information infrastructure and governance. Actor network theory will help in understanding that the development of an information infrastructure is a potentially unruly and ongoing process of negotiation and aligning the various expectations and other interests of a (wide) variety of heterogeneous actors, whereas the theory of 'structuration' draws attention to possible sources of stability in this process.

As such, information infrastructures encompass both technical and social elements and may therefore be regarded as socio-technical assemblies. Information infrastructures – and thus SDIs – are socio-technical actor networks of human actors, technological artefacts and informational artefacts (data and information). The question as to whether technology is primarily technical or primarily social has been extensively dealt with in the literature, notably in the realm of actor network theory (ANT). This perspective views the process of developing information infrastructures as emerging out of interplay between heterogeneous actors – human actors and technological and informational artefacts tied together in actor-networks and continuously negotiating and aligning various interests. Understanding SDI – or any information infrastructure for that matter – as actor network may help in tracing the multitude of diverse interests that have to be aligned. This, in turn, may help in identifying conditions for relative stability. Participation of (potential) allies in the early phase of an SDI initiative, for example, not only makes them 'problem owners' too but also convert them into (co-) proponents of the initiative. The (lengthy) process of consultation and collaboration in the European INSPIRE initiative illustrates this point (Craglia and Annoni 2006; Masser 2005, pp. 181-220. See for a brief overview of ANT in the literature for example Callon 1980 and 1986; Bijker 1995; Bijker and Law 1992; Law 1992; Monteiro and Hanseth 1995; Latour 1999; Law 2000; Law and Mol, 2002; and for applications of ANT to geographic information technology for example Martin 2000; Harvey 2001; and De Man 2006a, 2006b).

Information infrastructure however, is also about *structure* and therefore about some degree of stability. This is the other side of the technology-development coin. Stability in the development process of information infrastructure ultimately depends on the behaviour of the actors involved and is in relation to its context – its host governance system. Information infrastructure and governance may have a dual relationship in the view of Giddens' *structuration* theory. Social structure enables or facilitates social practice and at the same time is reproduced by patterned social practice and action (Giddens 1984, p. 19, 25-28). Structural properties shape social practice into social systems and do this to varying degrees. The most deeply embedded structural properties are *institutions* (p. 17). Institutions are social mechanisms – clusters of norms and normative behaviours. Institutions are the cornerstone of our trust (Zijderveld 2000, p. 73) and develop over time – *institutionalization*.

We will now explore how information infrastructure may develop as institutional property within the praxis of governance. The impact on human behaviour is central. If information infrastructure – or any information technology for that matter – is supposed to influence practices of exchange, sharing, accessibility, and use of data, it must be valued and trusted by those concerned (De Man 2000, p. 145). Institutionalization refers to the process whereby this impact becomes strong and (almost) normative. In the case of SDI, institutionalization

refers to the ongoing process within a social (or societal) system – the specific spatial data community – whereby it gains a strong and normative impact on exchange, sharing, accessibility, and use of spatial data. A major condition in achieving this is *feedback* – stakeholders continuously perceive the SDI as relevant and useful for their commonly perceived needs in spatial data handling.

Information infrastructure as structural property of governance implies duality. Orlikowski (1992, p. 406) – following Giddens' structuration theory – understands technology as both the product of human action under prevailing structural (institutional) properties within social systems and as assuming structural properties by itself – once applied, technology tends to become reified and *institutionalised*. (See also De Man 2000, 2006a, 2006b.) In the case of SDI, duality of the institutionalization process means that it shapes behaviour regarding exchange, sharing, accessibility, and use of spatial data within the spatial data community, and that at the same time, this institutional property is shaped by stakeholders continuously putting this behaviour effectively into practice. Institutionalization of information infrastructure does not mean, however, that the infrastructure necessarily becomes or remains an institution. First, the aforementioned feedback mechanism may also bring with it that the institutionalisation process dies out whenever the information infrastructure does not satisfy anymore collectively perceived needs. Second, as Perri 6 (2003, p. 398-405) points out, *viable* sets of institutions are not necessarily static but need to have the capability for being sustained within their dynamic environment through modest adaptation.

It would follow that, over time, effective information infrastructures tend to become integral and characteristic part of the institutional aspects of the governance system in which they are implicated. Because governance is a societal and deliberative practice, effective information infrastructure as integral part of governance facilitates deliberation and learning between heterogeneous actors. This functionality goes beyond the provision of processed data only. Design, implementation and use of information infrastructure – and thus of SDI – itself become a social process.

The aforementioned European initiative on infrastructure for spatial information (INSPIRE) illustrates major parts of the institutionalization process, emphasizing partnership, social networks, and multi-sectoral collaboration. Major conditions for effectiveness and sustainability are set in place (Craglia and Annoni 2006, p. 12). But whether the institutionalization of INSPIRE really goes beyond the official rules (*e.g*. the 'Directive') can only be seen in the future.

4. BEYOND SDI: SPACE STILL MATTERS – BUT DIFFERENTLY AT DIFFERENT GOVERNANCE LEVELS

When SDI looses its distinctiveness this does not imply that space and geography are not important anymore in the design, implementation, and use of information infrastructures beyond the obvious spatial hardware and software components that are needed. This section argues that space is differently structured and conceived of at different spatial. Information infrastructures may be different in content, role and degree of complexity at different governance levels.

4.1 'Space' means different things at different spatial levels

Various arguments can be found in the literature to support the view that 'space' is conceived of differently at different spatial levels. (For a review of some of the literature see De Man 2006b.) In short, the argument is as follows. First, space matters for what it offers, provides or furnishes. Consequently, space (or environment) and activities (or behaviour) are intertwined into *physical-behavioural units* (Smith 2001) – recurrent types of settings, which serve as the environment for human activities. Similarly, Ünlü Yücesoy (2006) argues that boundaries of use and appropriation of public space are continuously constructed, negotiated, re-constructed, and expressed.

Space tends to be more integrated into wholes at higher spatial levels whereas behavioural conditions tend to be more specialized and fragmented at those levels. Moreover, physical-behavioural units tend to be less intimately connected to human and social conditions and values at higher geographical and governance levels than at the intimate and local level of the concerned actors. Second, space is a setting for social life. The intensity of social encounters and social life in general, can be characterised by the degree of *social capital*, which refers to the connections among individuals – social networks and the norms of reciprocity and trustworthiness that arise from them (Putnam 1995, p. 67). To the extent that social capital has a different intensity and therefore a different impact at different spatial levels, space will be structured and conceived of differently at these different levels.

4.2 Content, role, and complexity of information infrastructures are different at different governance levels

This sub-section explores possible consequences of the differentiated notions of space at different levels, for the development, adoption, and application of information infrastructures. The discussion is important because it may shed some light on possible reasons why some local governments perceive national

SDI initiatives as of little support to their needs (Harvey and Tulloch 2003 and 2006, p. 760, 765; see also Craglia and Annoni 2006, p. 6). Some possible opportunities and challenges regarding their contents, role and degree of complexity can be postulated though only speculatively at this stage. First, at higher governance levels one generally deals with issues *about* lower-level physical-behavioural units and concerned actors rather than *with* them. Therefore, data requirements may tend to be dominated by technical and bureaucratic values at higher levels of governance whereas social and human values and issues seem to play a more pronounced role at local and intimate levels of physical-behavioural unit. It then follows that the desired content of information infrastructures would be differently conceived of at different spatial levels. Particularly at lower and local levels, much of the information is informal by nature – beliefs, values, expectations, and other interests. As a consequence, the selection of core or framework data may well turn out to be more contentious in multi-level information infrastructures than initially anticipated. Second, information infrastructures play different societal roles at different spatial levels. For instance, their role in the shaping and integration of social systems is likely to be different at different spatial levels. Third, the degree of complexity required in development, adoption, and application of information infrastructures may be higher at local levels because of the complex worldviews and structural (institutional) properties that are generally met at these intimate levels. Scott (1998, pp. 1-8) argues that modern statecraft relies on simplification by rationalization and standardization – "seeing like a state". He makes a case for the indispensable role of practical (local) knowledge, informal processes, and improvisation in the face of unpredictability. This would necessitate specialised approaches to capture such local, indigenous knowledge adequately. Practical experiences with community-based mapping approaches like Participatory GIS, community mapping and sketch mapping demonstrate both potentials in this respect as well as the complexities that are involved when integrating this knowledge into the "official' knowledge (Pickels 1995, p. 9-11, Harris *et al*. 1995, Craig *et al*. 2002, Carver 2003, and the "Open Forum on Participatory Geographic Information Systems and Technologies" – Ppgis.net). Moreover, information infrastructures at local levels may have to compete with existing, intricate, and often informal institutional arrangements for information sharing and communication.

A final point needs to be made here. If information infrastructures were different in content, role and degree of complexity at different governance levels, this would challenge the hierarchical structure as the only possible – or even most desirable model for the information infrastructure concept where higher-level infrastructures can be subdivided into, and are built upon, lower-level ones (for instance Rajabifard et al. 2003, pp. 28-37). They may not add up (De Man 2006a, p. 330; 2006b, p. 1). Rajabifard *et al*. (2006, p. 738) emphasize the challenge in developing multi-level SDI: to find ways of ensuring some measure of

standardization and uniformity while recognizing the diversity and the heterogeneity of the different stakeholders.

5. BEYOND SDI: A SOCIO – TECHNICAL RESEARCH ORIENTATION FOR INFORMATION INFRASTRUCTURE WHEN SPACE MATTERS

To sum up, the paper proposes to envision the future of SDI *strategically* as having three characteristics. First, SDI may loose its distinctiveness and become part of information infrastructure in general – but SDI *functionalities* remain important. This means that skills and knowledge of, and research in spatial data handling hardware and software remain important. Second, SDI and other information infrastructures may develop as institutional (structural) property of governance. Third, 'space' is not so much to differentiate between SDI and other information infrastructures but rather to differentiate between information infrastructures at different spatial levels of governance in their content, role, and complexity. This vision is strategic because it does offer a direction for focussed research and actual development rather than suggesting the future of SDI can be predicted realistically by extrapolating trends. Though this foresight is inevitably speculative, it is hoped that the presented arguments demonstrate its plausibility well beyond 'wishful thinking'.

The paper started off by briefly looking "back into the future" in order to learn from the past (to paraphrase Robert Zemeckis' famous movie title). The opposite would be to learn from envisioning the future of SDI and contribute to its actual and current development. This may have consequences for the research paradigms presently in vogue.

The remainder of this final section briefly discusses what research is needed to contribute to 'SDI development and beyond'. First, the contours of this research are sketched by looking at the sparse SDI literature in this respect, and the noted convergence in governance and information systems thinking. Then we see whether contemporary GIScience is able to accommodate the needed research orientation. Finally, the paper concludes that SDI relevant research needs a reflective and interpretive, and socio-technical action-research *practice* that may go beyond contemporary GIScience.

5.1 Reflective and interpretative research for 'SDI development and beyond'

Contours of the needed research for multi-level and service oriented SDI development can be found in the literature. For instance, Masser (2006, p. 21) concludes, in pondering what is special about SDI related research, that SDIs must be viewed as social phenomena and that there is a continuing need for interaction between those involved in the critical study of SDIs and scholars who

are familiar with mainstream social science research. De Man (2006a, pp. 331, 339) emphasizes the need for a multi-faceted view in understanding the complexities of SDI – "where people, institutions, and technology meet". Rajabifard *et al*. (2006, pp. 736-739), see the development of SDI moving to a next generation of service oriented infrastructure on which citizens and organization can rely. They anticipate future research revolving around bottom-up SDI development, and specifically addressing multi-level stakeholder participation, cultural conditions, data sharing, and a multitude of contextual issues. Georgidadou *et al*. (2005, pp. 1124-26) identify four elements of a research agenda for SDI implementation: (1) dynamics of implementation where complexities, in both technical and institutional terms, are addressed; (2) process and dilemmas of standardization; (3) scope of the design process as participatory and 'cultivation' (Dahlbom and Mathiassen 1993, p. 128), and improvisation rather than top-down; and (4) the rigour of empirical research that relies on an interpretative rather than only on a positivistic philosophy of science. Finally, Carver (2003, p. 68) notices that the future research needed in participatory approaches increasingly will be characterized by "multiplicity" multiple stakeholders, multiple criteria, multiple objectives and multiple scales, together with differential levels of access, training and finance to differentials in spatial cognition, education and cultural background. Carver believes that the main route by which the GI research community can take this forward is through the development of real-world applications and learning from our actions – in other words, "real people using real systems to address real problems".

The research orientation needed for 'SDI development and beyond' does not simply bring together technical sciences and social sciences with their respective paradigms but, instead, aims at developing a genuine socio-technical science in its own right and beyond the realm of traditional positivism. At the heart of SDI – or any information infrastructure for that matter – is the *problem of agency* in information technology – the both alleged and contested interplay of human and machine agency. Rose *et al*. (2005a, 2005b) see the resolution of this problem as prerequisite if the information technology discipline is to develop a consistent socio-theoretical vocabulary. Focus of the research needed will be on *questioning* rather than on *answering per se*, on *deliberative, interpretative frameworks* rather than on *empiricism* only, on coping with *dilemmas* rather than on designing *best solutions*, on *pathology of information technology* – or 'madness' as Margetts (2003) puts it – rather than on the *modernist's belief in its inherently benefits*, on handling *different research foci simultaneously* rather than *single-focus research*, on *subjective accounts and narratives* rather than on *objective observations and measurements*, on *cultivating judgement* both among policy makers and among publics rather than on *modelling decision-making* as such. (Perri 6, 2001, p. 70, 87-91) has emphasized the central skill of judgement in decision-making under uncertainty.]

5.2 Convergence in governance and information systems thinking – networking and cultivation

Indications of the research needed can also be found in the convergence of new vocabularies in governance and information systems thinking – current terminology appears to be inadequate to describe what happens. For example, Hajer and Wagenaar (2003, pp. 1-30) refer to *governance*, *institutional capacity*, *networks*, *complexity*, *trust*, *deliberation* and *interdependence* as a new vocabulary in describing developments in public policy and political science. Ciborra (1998) speaks in terms of *care*, *hospitality*, and *cultivation* to describe developments in information systems thinking. Van Zoonen (2005, p. 3) speaks of politics as "entertaining the citizen" because politics has to be connected to the everyday culture of its citizens if it is not to become an alien sphere that is occupied by strangers no one cares and bothers about. In order to matter, information and communication – or 'the media' – have to attract attention (Simon 1976, p. 294-96) and 'entertain' as well. Moreover, information domains may be managed as political economies as Homburg and Beckers (2002) suggest. Calabrese (2004, p. 9, 10) emphasizes the need for critical political economy studies on information and communication. To him, this encompasses empirical questions regarding the production and circulation of meaning within and between different audiences, market studies and media concentration, regulation and policy, technological impacts on particular media sectors, information poverty, and media access.

These issues can be lumped together as 'networking and cultivation' and are of prime importance in understanding any information infrastructure that is assumed to become an institutional part of governance.

5.3 Is GIScience an asset or liability for SDI research?

With this admittedly brief and impressionistic account we now turn to the question of to which extent the (still) emerging GIScience can accommodate the apparently reflective and interpretive socio-technical research that is needed to effectively contribute to SDI development "and beyond". (Needless to say that this research is necessarily multi-, inter-, or trans-disciplinary.) Two conditions are important in this respect: (1) the degree in which GIScience is techno-centred and (2) the degree in which the GIScience community is inward or outward looking. Indicative to the former condition are the exploratory findings by Georgiadou and Blakemore (2006) that the mainstream GIS journals continue a primarily technological theme, with some of them showing limited engagement in potential implications on the human, organisational and social world, and that the focus within this literature is predominantly positivist, with expectations of technical benefits overwhelmingly dominating reflexivity and critique. Although Georgiadou and Blakemore do not report on this, references in the literature

seem to have a narrow disciplinary coverage as compared with literature within the fields of information science and information systems research in general. This would then be indicative for the latter condition.

The preliminary conclusion may be that the contemporary GIScience will find it difficult to accommodating the research orientation needed that is reflected in the paper. It would follow that the SDI community must engage itself in cross-pollination and cross-learning with relevant other scientific communities (Bernard *et al*. 2005)

5.4 Learning by doing in 'SDI development and beyond' – communities of practice

Finally, we turn briefly to the question of *how* a socio-technical research that addresses the wider issues of networking and cultivation, is to be practiced so that it may contribute to the development of SDI as this is anticipated in the paper. In other words, how may GIScience possibly address the challenges posed by SDI relevant research? To begin with, the SDI concept embodies the tension between dynamic – often unruly – structuring and some minimum degree of stability. As this have been mentioned before, Actor-Network Theory (*e.g*. Callon, 1980 and 1986) on the one hand, and the notion of 'duality of technology' (Orlikowsky 1992, based on Giddens' 'structuration' theory), and 'institutionalization of GI technology' (*e.g.* De Man, 2000 and 2006) on the other, address these two aspects respectively. It follows that a multitude of actors with different and often competing interests and world views are involved in the ongoing shaping of 'SDI development and beyond'. Moreover, research that contributes to the development of information infrastructure needs to be practice-centred and resembles Argyris' notion of 'action science' (Argyris 1983, pp. 115-17) or 'action research'. Learning-by-doing or situated learning is essentially a social process and comes largely from day-to-day practice. Situated learning involves a process of engagement in a 'community of practice' (Lave and Wenger 1991, Lesser and Storck 2001). SDI relevant research may therefore go well beyond contemporary GIScience.

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