Full Circle:

More than just Social Implications of GIS

Nicholas Chrisman
chrisman@u.washington.edu
Department of Geography Box 353550, University of Washington
Seattle WA 98195-3550 USA

ABSTRACT

Over the past few years, a number of geographers, inspired by social theory of various derivations, attempted to recenter the focus of research about GIS. In place of a technical agenda, they sought to make space for studies of the implications of GIS for society at many scales and through many processes. While much of their critique serves useful purposes, the focus on implications adopts a model of GIS as an inexorable implacable force. This paper argues for a full circle of implication: GIS– the daily practice, the data stored, the software packages – is constructed and maintained by social processes embedded in historical and geographically contingent settings. Only by understanding the full circle of implications can we begin to think about making any attempt to understand or to redirect the direction of GIS development. This paper demonstrates the value of a full circle by reexamining the arguments made in the book *Ground Truth.*

Social Implications of GIS: origins of a movement

In the 1990s, the rest of the field of geography discovered GIS. A subspecialty suddenly emerged in a number of ways; for example, the Association of American Geographers created a GIS Specialty Group and it expanded to become the largest in the organization (though in reality the specialty group does very little). Geographers wanted to be attached to the GIS development. The argument of novelty can hardly be offered. GIS had been developed as a research concentration for over twenty years, so there were many other developments at least as new. It is more likely that the employment market created by the GIS industry and the demand for GIS skills in a variety of other industries is more directly linked to the increase in interest. This is not another paper to marvel at the rapid expansion of the GIS subspecialty, but that rise provides the constant backdrop to the debate over theory that forms the basis of this study.

Criticism and self-examination, long a routine element in any social-science discipline, had begun to be expressed in cartography (Harley 1989; Harley 1990; Wood 1992), often with a distinctly anti-technical message directed towards the uncritical acceptance of GIS. The central argument of Harley and Wood connects maps to power, the imperial

power that links politics, economy and society in the service of the privileged few. As this intellectual debate from inside cartography took shape, the focus shifted more directly to the GIS phenomenon. In a simpler era, the original piece (Dobson 1983) espousing an "automated geography" (a term comprising what became known as GIS) received much attention, the commentary was almost exclusively from other GIS practitioners. The ten-year anniversary (Dobson 1993) attracted a much broader range of comment (Pickles 1993, for example). In other outlets, geographers wrote pieces questioning the nature of the GIS phenomenon in various ways (Curry 1991; Lake 1993; Smith 1992). Intemperate "defense" (Openshaw 1991, among others) attracted more attention (Taylor, and Overton 1991, among others).

The early phase of missed messages and trenchant attacks has fortunately faded. The publication of *Ground Truth: The Social Implications of Geographic Information Systems* (Pickles 1995b) set a new tone, as it included a few GIS insiders (Goodchild 1995, most notably) alongside some more critical voices (Pickles 1995d, most notably). While the title of the book *Ground Truth* has great currency, the neglected subtitle gives a sense of the direction. Because this book has become important as a statement about GIS and Society, its contents will be analyzed more carefully later in this paper. As this movement came in contact with the National Center for Geographic Information and Analysis, the process of articulating a research agenda became more formalized. Following a meeting at Friday Harbor, Sheppard (1995) presented a research agenda with the central focus on the implications of GIS. The first item was an intellectual history of GIS development, giving some attention to the social milieu in which tools were built, but directing most attention on the social outcomes of selecting certain directions. The term "social construction" was used for this stage, though the paper bases most of its theory on Habermas and Heidegger who are more idealists than constructivists. The second and third item in the research were directed solely at the impacts and implications of GIS, as ways of knowing and as practices. This research agenda, through the NCGIA procedures, became the core of Initiative 19 (Harris, and Weiner 1996), whose full title gives a sense of the dominant direction: *"GIS and Society: The Social Implications of How People, Space, and Environment are Represented in GIS"*. Despite some minority attempts (Chrisman 1996) to allow the direction of influence to flow in both directions, the GIS and Society community (now its own subsubspecialty) showed the greatest interest in "impact of GIS" or "social implications of GIS". The social component of Project Varenius concentrated exclusively on implications of GIS in its original proposal (web citation). Similarly, the white paper on the research agenda written in 1996 for the University Consortium for Geographic Information Science (UCGIS) concentrated on implications (web citation). Sheppard's draft of a revised research agenda for UCGIS in 1998 shows a recognition of two-directional influence (web citation).

Does any of this work on research agendas matter? Arguing over the research agenda is no substitute for doing the research. This paper will give some reasons for expanding

the research agenda away from just the issues of implications. The strategy will be to consider all the impacts and implications, which lead inevitably in a full circle. "Social context influences GIS and GIS influences society." (Chrisman 1996, p. D9). Closing the full circle provides guidance to the theoretical interrogation of GIS, rather than "theoretical turns" (Pickles 1997) that continue to diverge from each other. This paper will proceed with a review on some of the literature about the linkage between society and technology or science, then it will explore some of the implications explored by various chapters in *Ground Truth,* providing a sense of the full circle interpretation missing.

Understanding GIS as a social construction

Proponents often acclaim geographic information technology as the means to make more efficient and socially equitable decisions. These proponents hope to clear away subjective issues and rationalize the process of establishing consensus, so that decisions can be made objectively (Cowen 1988; Dobson 1983; Dobson 1993; Morrison 1994; Openshaw 1991). Most of this literature aligns itself with the "March of Progress" metaphor, an attitude about history with limited utility to detect the choices and inconsistencies involved in technological change (Chrisman 1993). The idea of an automated geography implies that the technology is somehow independent of the people, operating on its own internal logic. Critics of GIS are quite justified in calling attention to flaws in the proponents' claims. The search for the objective through numerical representation is not just a recent phenomenon (Porter 1995), GIS is far from unique in the information system mania of the late twentieth century. Yet, the focus on information about different places makes GIS an interesting special case to illuminate some of the social processes involved.

Arguments about GIS technology often slip into a discourse of technological determinacy. GIS-proponents and critics alike assert, consciously or unconsciously, that technology is intrinsically independent from the social world. This perpetuates the two major tenets of technological determinism:

1) technology engages unilinear progress from less to more advanced systems;

2) technology is an imperative to which social institutions and people must adapt

(Bijker, Hughes, and Finch 1987; Woolgar 1987; Bijker, and Law 1992; Feenberg 1995). Technological determinism leads to the belief that the technology can be studied solely by itself, outside of the context of its construction or use. As a consequence, "implications" remain as the sole issue in studies of technology and society.

Use of the Progress Myth by proponents

Technological determinism suffuses the debate surrounding the development of GIS. The belief in the "march of progress" dominates the new industry’s self-representation (Dangermond, and Freedman 1984; Tomlinson 1984; 1989; Antenucci, Brown, Croswell, Kevany, and Archer 1991). These heralds of progress create the impression that

improvement is inexorable and assured. The GIS bandwagon suggests that jumping aboard is the way to success; technology can fulfill every demand, and bring you the world. Dobson (1983; 1993) places GIS technology on a clear rational path towards a better tomorrow, arguing that "GIS has become a *sine qua non* for geographic analysis and research ... the beginning stage of a technological, scientific, and intellectual revolution" (Dobson 1993, p. 431). The authors of *Ground Truth* made much of the claims of GIS proponents (Pickles 1995d) as well as the advertising of GIS vendors (Roberts, and Schein 1995; Goss 1995). The more arrogant the claim, the better it seems to serve the critics.

The dominant approach to GIS methodology emphasizes the abstract nature of geometry and mathematics as the basis for GIS tools (Goodchild 1987; Goodchild 1992, for example). This view relies upon a form of abstract essentialism (rendered for illustration in its most extreme form): geometric concepts reside in a Platonic world of forms; researchers simply discover eternal truths; technology can rely on iterative approximation to move closer and closer to the ideal essential truth. In this view, issues of society hold low priority, because the only way that society can impede progress is in delaying the inexorable and inevitable. A few papers in the GIS arena have begun to build a connection between the social context and the technical implementation (Chrisman 1987; 1991b; 1991a; 1992; Campari, and Frank 1993; Harvey, and Chrisman 1998). These papers indicate a counter-current inside the GIS community, resisting technological determinism.

Role of the critics

As discussed above, the critics (Smith 1992; Lake 1993; Curry 1991; Pickles 1995b; Sheppard 1995) have focused on the impacts of technology. Thus, they often portray the technology as a force out of social control, something external to the social discourse. They use a somewhat sophisticated form of C.P. Snow's (1959) "two cultures" argument, saying that technologists are not connected to the same literature and not engaged in the same bases of theory. These situations may be true, but they do not mean that technology and technologists do not respond to their own versions of social forces.

Technological determinism, proclaimed by proponents or implied by critics, obscures the relationships between GIS technology and society largely by neglecting some linkages. The contention between progress-believing technologists and humanistic-orientated social theorists omits the people involved with the technology and the complex interactions required to maintain it. GIS technology serves to extend human capabilities by other means, not a superorganic force in itself. The people who use GIS are not mere instruments of progress towards better information systems nor are they simply victims of its social consequences. The systems now in place reflect many layers of negotiation between social goals and technical capacity to respond. The simplistic metaphors must be replaced with more nuanced understanding of interactions between people and technology.

Rather than a vast superhuman realm, GIS technology is the result of localized social construction. This construction occurs when the technology is created, and continues as it is configured for each application. The march of progress myth must be replaced with a careful examination of the development of geographic information technologies in their specific localized context. No one historical schema or ideology can explain the complex interactions at one place, let alone the variability between places. For example, the implementation of a GIS in any county of the United States involves combinations of ideas including Roman concepts of persons and corporations, medieval frameworks for ownership, Enlightenment concepts of equality, and more recent concepts of environmental responsibilities (Chrisman 1991a). This situates geographic information technology as a carrier of multiple concepts simultaneously, including the capability for conflicting ideas to coexist simultaneously in the same institution (see Latour, 1993, p. 73). Aspects of temporal melange have been evident in empirical practice of GIS, but such observations conflicted with the dominant abstract essentialism of the research discourse. In addition, a very strong force in the development of science and technology is the use of temporal rhetoric, the process of allying one's work with progress, and thus making something "irreversible" (Latour 1993, p. 51). In some paradoxical way, GIS research was meant to study a timeless, ideal state of universals, and also to produce visible progress.

Society and a variety of social structures influence the nature of geographic information representations. In turn, certain characteristics of geographic information can influence society. Research in GIS rarely takes account of this two-directional flow of influence. Most research on GIS has taken an instrumentalist approach, trying to improve the technology to fulfill defined purposes. Originally, GIS research was conceived without consideration of social factors. GIS principles are still presented as universals, derived from abstract laws of geometry. Social, cultural and historical contingencies of GIS use are considered aberrations, deflecting the logical trajectory of the technology. Many use a "barrier" model in which the seemingly natural and predetermined spread of GIS technology is impeded by some irrational social factors (Croswell 1991; Onsrud, and Pinto 1991). Technological innovation is not some hydrostatic force, but a much more complex interaction of economic, institutional, political, social and cultural components.

A source of assistance: Studies of Technology and Science

In place of the technological determinism common in treating GIS, this paper draws specifically on recent theoretical insights from a number of interlocking literatures including the sociology of scientific knowledge (SSK), studies of technology and science (STS), history of technology and of science, philosophy of science and related fields. The twentieth century began with a fairly coherent appreciation of the cumulative development of scientific knowledge (Carnap 1966). By midcentury, the logical positivists seem to have conquered all opposition, broadcasting a message of method as a path of coherent science. Kuhn (1970) introduced an observation that science in this

period was by no means as linear as it was meant to have been. The development of relativity in physics, for example, required replacing the whole "paradigm", not just the incremental accumulation of adjustments to earlier schemes. Kuhn's approach left science (and thus technology) fairly independent from social concerns. Kuhn's work was so pervasive that the quantifiers in geography adopted the terminology of paradigms (Berry 1973, for example), a basically anti-positivist theory of knowledge. Some recent studies in the history of science (Galison 1997) demonstrate further refinements in understanding how science operates, extending the concept of paradigms to allow for greater ambiguity in the negotiations between theorists and instrumentalists. The assurance that a particular scientific method always works has been strongly questioned (Feyerabend 1993). Thus, the history and philosophy of science no longer provide support for the old mythology of inexorable progress.

Studies of science and technology (Barnes 1974; Bloor 1976; Latour, and Woolgar 1986, for example) provide strong documentation of complex networks linking social organization, political structure, economic interaction, and cultural foundations to the development of a technology. The sociology of scientific knowledge developed a "strong program" of researchers (Bloor 1976; Collins 1981) who argued that social relationships underpin the development of science and technology. This strong program argues against the study of "impacts" from technology to society. The constructivist literature (Latour, and Woolgar 1986; Bijkerand others 1987; Bijker, and Law 1992; Woolgar 1987; Latour 1987; Latour 1988; Latour 1993), though inherently quite diverse and far from unambiguous, modified the unidirectional direction providing a more complex dynamic of mutual constitution. Latour (1993) argues that the division between “nature” – a realm of scientific enquiry – and “society” – a realm for human creation – obscures intricate interactions required to sustain the hybrid networks of current technology.

This literature argues that science and technology are constructed from a multiplicity of viewpoints, and that this construction is distinctly local, not universal. Multiple social forces interact in the process of developing a complex technology such as GIS. Implementation of any technology depends on the specific local environment that strongly constrains how actors interact with the artifacts they construct. This literature digs deeper than the argument of ‘inherent logic’; any logic in a technology was put there by developers through some process and adopted by users for another set of reasons.

It is increasingly difficult to separate technology from science, an argument that surely applies to the tight enmeshing of GIS with the disciplines that use GIS tools. Social constructivist approaches provide a theoretical framework for examining and understanding the tight linkages between the actions of people and the technology they create and use. The web of technology and society consists of many complex relationships between artifacts and people, institutions and data, software and

researchers. Mack (1990) recounts the interactions that led to the Landsat sensing system, a result by no means determined by inexorable forces. Eugene Martin (submitted to this conference) has applied this actor-network approach to demonstrate how different GIS organizations interact in Ecuador. The GIS literature has recognized for a long time that institutional factors intervene in making one system fail while another prospers, but there have been very few concrete markers that can predict these different outcomes. The stability of the network offers a useful way to assess the viability of a GIS organization.

Mediation of diverse interests occurs in the construction of artifacts; negotiations are necessary to create coherent operations. Star, Greisemer (1989) and Fujimura (1992) develop the relationships between multiple actors and artifacts through what they call *boundary objects*. Boundary objects mediate between different groups; they don't provide a common understanding or consensus between participants. Instead, they serve a dual function: at the same time they serve to distinguish differences, they also supply common points of reference (Harvey 1997; Harvey, and Chrisman 1998). Institutions and disciplines play a crucial role in formulating boundary objects that allow for stable translations between different perspectives on the same phenomenon. Galison (1997) provides a further development of these boundary concepts that may apply more directly to the interdisciplinary nature of GIS practice. He argues that translation implies too much mutual comprehension; he uses the linguistic metaphor of a pidgin dialect operating in a "trading zone". This concept offers an important insight for the design of GIS technology.

In GIS, every data sharing arrangement requires boundary objects. These could be physical structures, concepts, or standardized approaches. The layers in the multi-purpose cadastre come to mind as an example for boundary objects: each agency populates a layer that remains in their jurisdiction, but is tied together through a common coordinate system with the products of other groups. Not merely an instrument or toolbox, each particular GIS presents a unique collection of artifacts that enable multiple social groups, with divergent, or even contradictory values, to mediate these differences and construct more technological artifacts that multiple groups can share. At best, the social construction of technological objects is only stable for a specific moment and subject to constant renegotiation.

Reassessing Ground Truth

While there has been continued attention to the issues of GIS and Society in the years since its publication, *Ground Truth* is recognized by many as a key event in formulating the research agenda. Even among the technically inclined, this book appeared at the top of David Mark's informal poll of important literature in GIS by a large margin. Like many citation classics, it might be cited without being carefully read. This paper will review each chapter of the book especially focused on the directionality of implications.

Much of the book consists of theoretical arguments, but the case studies provide more opportunity to explore alternatives. When possible, I will present some counter arguments about the full circle that was left out.

Preface

In the unattributed preface (clearly written just prior to publication from the use of the "information highway" buzzword that had just come into the collective glossary), the editor describes the content of the book:

> *Ground Truth: the Social Implications of Geographic Information Systems* is, first, a book about the transformation of data handling and mapping capabilities that have emerged in the past two decades, and the impact they have had within the discipline of geography. Second, it is a book about the constellation of ideas, ideologies, and social practices that have emerged with the development of new forms of data handling and spatial representation. Third, it situates GIS as a tool and an approach to geographical information within wider transformations of capitalism in the late 20th century: as a tool to protect disciplinary power and access to funding; as a way of organizing more efficient systems of production; and as a reworking (and rewriting) of cultural codes – the creation of new visual imaginaries, new conceptions of earth, new modalities of commodity and consumer, and new visions of what constitutes market, territory and empire. (Pickles 1995c, p. viii)

The first element describes the changes, and targets changes not on society but on one of the disciplines implicated in GIS. The second broadens out the mission in a very hazy way. The third promises more than it delivers; it suggests that GIS will be explained inside a larger framework of modern capitalism. As we shall see, the actual chapters avoid discussing the mechanism by which GIS is influenced by its surroundings. There is a long discourse decrying the ideology of progress, then it asserts that "all (chapters) treat GIS as both technique and social relation" (Pickles 1995c, p. x). However, these chapters are all "motivated in one way or another by a deep concern for the impacts of *unmediated technical practices* on the discipline of geography and other arenas of social life" (Pickles 1995c, p. x emphasis in original). Thus, the social relation seems to operate in one direction only from the start. All in all, the preface seem to wish to speak for all the authors, while prefiguring the final chapter with much attention to the "virtual sign" and other concepts not mentioned until the end of the book.

Representations in an Electronic Age: Geography, GIS and Democracy

In the first chapter, Pickles (1995d) puts his primary energy towards the progress myth and the writings of the proponents of GIS. He cites a smattering of postmodernists and social theorists (Foucault, Derrida, Soja and Giddens), but the clearest guidance about technology and society come from citing Heidegger (and echoing Marx self-

consciously) (Pickles 1995d, p. 19) about the "essence of technology": "Everywhere we remain unfree and chained to technology". Despite the postmodernist rhetoric, this places Pickles inside what Latour terms the "Modern Constitution" that requires firm separation between nature and society, between science and the humanities. The role of this chapter is to set the stage, to criticize the unbridled optimism of GIS proponents, not to investigate the social processes that contribute to the emergence of GIS as we know it.

GIS and Geographic Research

Goodchild (Goodchild 1995) gets the second slot, in true debating format. Like a skilled debater, he attempts to change the question. He decries the "cacophony of position taking", and describes GIS mostly in terms of data models and research agendas. He professes his thoroughly positivist leanings, attributing them to his physical sciences background. His scientific observers are meant to be as "objective" as possible, hence enforcing lines between nature and society. At the outset, Goodchild expects the reader to discount the presence of power in a soil map (p. 32), but later on (p. 38) he mentions the years of training invested in soils maps, and the disciplinary roles in selecting models (p. 47-48). Somehow he expects the social elements to come with clear labels, in the traditional roles of politics, economics, and everything else. There is a hint that his understanding of the disciplinary roles in data models could be developed into a stronger two-way relationship between social structures and GIS representations. Again, it requires a reinterpretation of what Latour calls the Constitution.

GIS and Geography

Taylor and Johnston (1995) produced a chapter that was still connected to their prior debates with Openshaw. Their attacks on a "purely empirical" GIS aim at the vision of a Geographical Analysis Machine, not at GIS as practiced in most installations. Curiously, Taylor and Johnston, like Openshaw, come from exactly the spatial analysis school of quantitative geography that they now find so devoid of theory. The issue here is the disciplinary history of geography, not the impacts of GIS and society. As writers of histories of revolutions, these are Kuhnians who see data as steeped in social relations. Thus they disagree with Pickles on the autonomy of GIS, though they try to join Pickles in the criticisms of GIS in geography. It is in calling for theory that they show there intention to disconnect geography from political contamination. They still hope to create the kind of scientific purity that Goodchild expects, though through somewhat less positivist paths. If they consider their statements about "handmaidens of the state" more carefully, they should begin to see that GIS is pervaded with social (disciplinary, economic, political and so on) influences, and that these are not bad, but the very reasons for doing GIS in the first place.

GIS and the Inevitability of Ethical Inconsistency

Curry (1995) produced a discourse on metaethics, arguing that GIS necessarily creates certain conflicts between inherent principles. He admits that these ethical

inconsistencies are well-recognized, but he tries to argue that they become particularly concentrated in GIS. He describes technology as autonomous, beyond human control due to its complexity. In concluding he offers the possible solution that people seem to be able to mediate a set of overlapping social commitments and obligations without incurring the consequences of the inconsistencies. This would certainly be the reading of the boundary object literature, people manage to agree to differ. If Curry could disengage from his strong divisions between technology and people, he might come to see that his ethical inconsistencies are just another part of the complexities of a social world without a unifying philosophical stance.

Computer Innovation and Adoption in Geography: A critique of conventional technological models

Veregin (1995), a GIS analyst who studied with Goodchild, made more of an attempt to address the question of impacts than his mentor. He paints a picture of the ways that technology becomes embedded in human affairs. He refers to Winner's (1977) process of "reverse adaptation" in which the technology changes the society, clearly an indication of the direction that Winner and Veregin find missing. Like many cartographers and GIS researchers, Veregin attaches these effects to psychological processes, not social ones. He brings in the 'social context of technological innovation", but does not investigate the degree to which the social forces produce a given technology. He decries the "technological imperative" (even "technological exuberance") that has one technology leading to another in the service of some hidden and nefarious goals. While he stands on solid foundation in attacking the neutrality of tools, he does not recognize that these ultimate goals are not necessarily inherent in the technology, but come from a complex set of social actors. The literature on the social networks of technology provide a lot more depth in the twists of these processes (Shapin, and Schaffer 1985; Bijkerand others 1987; Bijker, and Law 1992; Latour, and Woolgar 1986; Latour 1987; Woolgar 1987; Bowker 1995). The creation of a "black box" (Latour, and Woolgar 1986) that encapsulates a whole scientific understanding (a theory, a measurement system, a standard, an interpretation) requires some rather complex and social steps, developed quite clearly in *Science in Action* (Latour 1987). Veregin is quite close to an understanding of the social interactions of technology in describing "orgware" - the institutional accommodations required to deal with technology. He does understand that people make the changes to computer code, but he doesn't provide a mechanism inside an essay structured around implications.

Manufacturing Metaphors: Public cartography, the market and democracy

McHaffie (1995) follows in the footsteps of Harley in considering the relationships of power, this time in the labor processes of cartography. This is clearly a situation of attaching the technical results (the cartographic databases) to the social (political, economic, cultural) forces that pay for that activity. Yet, somehow he infers that a narrow elite must be profiting from this activity. Certainly there are many ways that economic power is concentrated, but the relationship between that concentration and

the nature of the GIS databases is not as direct or obvious as his analysis would have us believe. His essay, clearly written in 1993, predates some radical redirections of the federal mapping establishment of the USA towards the "National Spatial Data Infrastructure". While there are certainly limitations on the decentralized nature of the framework (which is meant to populate the national database with pieces contributed by local jurisdictions), there are certainly forces moving in opposite directions to those he describes. Similarly, while the Internet still does not reach a major fraction of the world's population, the conversion of the US society to the web is much more pervasive than the 1% figure apparent in 1993. This in itself is an example of a convergence of social demands that reshape technical expectations.

Marketing the New Marketing: the *strategic* discourse of geodemographic information systems

Goss (1995) provides more of a case study of a particular niche in the GIS industry. Geodemographics refers to a suite of techniques that link economic activity to a broader set of social characteristics in order to allow businesses to plan various activities. Goss describes the grand claims of the competing software vendors, the vast databases employed in this effort, and the peculiar vision implied about consumer behavior. This certainly makes a case for the ways in which the technology is changing the ability of corporations to target their messages. Much of Goss's claim makes sense if viewed in this perspective. GIS is certainly a part of the development of surveillant aspects of economic power. However, the process is not as unitary as he portrays it. Much of the database he describes was developed by the US Census Bureau. He does not deal with the complex lobbying efforts used by the marketing industry to create a census questionaire that would serve their needs, in addition to the rather simple count of person required by the Constitution. He does not deal with the large dependence of the federal government allocations of many flows of funds on these numbers. The content of the database is a field of contention, the outcome is influenced by economics, grand social goals like the War on Poverty, and strict partisan interests like gerrymanders and undercounting minorities. The very concept of address-matching that lies at the root of geodemographics was not a technological concept, but an attempt by Census Bureau to save money in its 1970 operations by using pre-existing address lists from a commercial source to send out questionaires (mail-out mail-back). The address lists were not developed for state surveillance, but to sell Ivory Soap. Viewed from any one position, this cycle of influence and power seems to rotate in one direction. Yet, the inexorable force of Census data was itself shaped by complex forces in the past. There are many contingencies about how a particular society constructs compromises about privacy and public records. Some countries require registration of personal movement with the police, but would be horrified at the economic information held by US credit reporting agencies. In the US, the system is equally capitalist, but the solution is very different. There does not seem to be a lockstep of implications from technology to the specific implementation.

Earth Shattering: Global Imagery and GIS

Roberts and Schein (1995) focus on the use of global images for advertising purposes. They use a model of the social production of space from Lefebvre (Lefebvre 1991) that provides a clearly circular path connecting representational spaces (GIS) to representations of space (advertisements) to social practices and back to representational spaces. So far, so good; a circular model provides the ability to come full circle. Yet, their choice to study the advertisement gives a rather indirect connection to the operations of the technology. It seems that the most exterior surface view of GIS is exactly their target, consistent with a relatively common approach in culture studies to examine newspapers and advertising. In the end, the "representations of space" here are not the content of the map, but a quick image used by some art director to portray what the audience will quickly see as a map. Other chapters of the book have spent much time on the inherent logic of point, line, and area to structure views, but this chapter has no such direct connection to what GIS imposes on its users. The STS literature would counsel an investigator to examine the black boxes long before they are closed (Latour 1987), to look at the inner working of the GIS to see the imprint of the social negotiations.

Pursuing Social Goals through Participatory GIS: Redressing South Africa's Political Ecology

Harris, Weiner and coauthors (1995) present a case study in South Africa where they wish to mobilize a GIS to serve an oppressed community in their struggle for more equitable allocation of land, irrigation water and other resources. On the face of it, this research is almost an attempt to demonstrate that the technology can be redirected to serve "progressive" goals, though the authors try to disavow it. Actually, the model of participatory GIS does not reach very deep within the guts of the GIS. Like many forms of participatory planning, the outside experts still operate the black boxes, ask the key questions, and interpret the results. Of course any more complex research strategy might take decades to execute, during which time the whole nature of the South Africa political economy might be completely transformed. This paper takes up the charge to make GIS work for different groups than it normally does. This research strategy has many risks, in that the experts might misinterpret their local requirements through a complex crosscultural communication channel. Yet, misinterpretations lurk at every disciplinary boundary in the routine GIS for an average US county. The Kiepersol GIS is a strong demonstration of the local construction of each system. Somehow this example at the back of the book did not influence the other theorizing very directly.

Conclusion: Towards an economy of electronic representation and the virtual sign

Pickles (1995a) took the last chapter to present his conclusions from this rather divergent set of essays. He launches into a dense argumentation from a dozen or more postmodern writers that does not reduce itself to a simple abstract. Despite the fact that none of the prior essays have dealt so directly with virtual signs and intertextuality, he

brings these out as the conclusions of the book. He finds plenty of theoretical support for the impacts of representational technology on society. Though he places these postmodern writers in opposition to the positivists, I find this chapter to demonstrate how Latour (1993) has characterized this work. In constructing his 'amodern" approach, Latour rejects the postmoderns as still separating nature from culture, science from nature. Latour calls for a "nature-culture" that gives a place for even inanimate elements of nature in a "Parliament of Things". While all of this theorizing might seem rather distant from the mundane world of GIS, this chapter still limits the potential for a circular connection that engages the social in reshaping the technology.

Turning the Circle: Realms of Influence

Much of the discussion of GIS presents the system as an integral unit. After all, a "system" can be as inclusive as one wants. In charting the paths of influence, it makes sense to discern some distinct realms in the operation of a GIS. There are many ways to divide up a GIS into subsystems, but describing the software, the data and the results covers some of the distinct paths in which society influences GIS and GIS influences society.

Software

For most of the authors of *Ground Truth*, software is some unitary force, not something constructed at great expense and difficulty by individuals. The current size and market power of a few software firms belies the more typical nature of software construction, particularly for GIS. First, software involves relatively few people working in few places around the world. Programmers tend to be fairly highly trained and, at least in the past, closely linked to the research community. Programmers are heavily influenced by the solutions they know about, and the approaches they learned from earlier work. Paradigms in computing pass like fashions at the mall. At one time it was band-sweep algorithms (Bentley 1980), then it was spatial indexes, then it was various forms of object-oriented interfaces. Each of these makes it easier to do some target operations, but makes others seem hard to accomplish. Programmers create artifacts – programs – that become actors in their own right. How many times do people say "ArcView won't let me do that."? In this regard, the software sets the outer bounds of what a GIS does, yet the limits are very difficult to plot. The end users make the final choice of which parts of a complex package they will actually use. Also, they construct combinations not originally conceived by the designers, and push the package to do things far from the original plan.

With the many levels of abstraction, computer programming mobilizes all the metaphors about negotiation. Various modules persist in the same space, sending messages, receiving messages, hiding internal details, sharing results. Viewed from one perspective, it is just a shifting bitstring, marks inscribed by a moving Turing machine. Yet, the illusion of objects can be called into being. Each module has its view of the

process, negotiated using advanced forms of boundary objects. It is virtually impossible to debug programs without visualizing the social world of communication that your program codes has kicked into being. Usually this society has fatal flaws, expectations not fulfilled, boundaries of behavior overstepped. Deft programmers build their worlds like model train setups, so that they can withdraw and let the interactions operate on their own. These are often the ones characterized as anti-social nerds, though their skills in social interactions are very highly developed, though perhaps misplaced.

Software has its own historical process. To some extent, software is a very new field, so ideas about software are fairly recent. Decisions about a storage format or a standard for interchange can become a huge barrier to entry or a target for much future work fixing up the cases not handled. The decision to continue using two-digit years in some software packages has led to huge investments of labor in this last year of the 1900s. Decisions made in operating systems long forgotten still persist as limitations in the most current. Very little novelty is possible if the whole arrangement of interactions is to survive. Similarly in GIS, old mistakes become enshrined as "standards" while the laboriously adopted standards languish in disuse (for very good technical reasons). Technical solutions taken for perfectly good reasons at one time might look much worse in the light of a shift in the relative costs of various components of a computer system. The classic tradeoff between memory and computing shifts as the relative price of processors shifts with respect to memory.

Despite having an internal dynamic and the rampant idealism involved in the abstractions of computer languages, software responds to its users. Systems grow to respond to the marketing department, nicely designed, but less flashy parts lie neglected. User demands go in phases. In maintaining a large package, some stupid error will sit unnoticed for years, then suddenly the user community will happen upon it. Not just a single call, but often two or three on the same day will discover this long-fallow bug.

Thus, despite its isolation from the social messiness, the world of software gets tied to external concerns. The software shapes social relationships and is shaped by them.

Data

Many of the authors of *Ground Truth* reflect on the ways that GIS databases respond to political and economic forces. Taylor and Johnston point to the connection between wealth and GIS resources. Such correlations would be surprising if they did not occur, what is more interesting is to examine the geography of geographic information (Chrisman 1991a; Chrisman 1997) a bit more closely to reveal the unexpected variations. The political and institutional structures for national mapping vary from purely civilian organizations with a natural resource interest, through engineering interests to security-driven military mapping. Some countries have highly centralized organizations, like Sri Lanka with nearly 95% of mapping professionals working for the national mapping

agency. In other countries, the private sector is much larger, as in Japan with 940 mapping professional per 1000 square km. Clearly the kinds of maps produced in these highly different circumstances are radically different. The social purposes they serve are controlled differently. Of course these differences will translate into differences in the uptake of technology.

Goodchild (1995, p. 47) points out that geomorphologists are best prepared to select a data model for topography, not a computer scientist. This shows his attachment to the goals of effective representation. Of course, the computer scientist might produce a more efficient data structure, considering some other metric by which to judge the topographic representation. The roles of disciplines are much deeper than the variations between countries. A discipline is a self-appointed institution that imparts a certain way of knowing. Neophytes voluntarily go through their disciplinary indoctrination to learn the terminology and techniques. Disciplines are a form of social technology. Some are more flexible than others, some use their power to control access to resources and to ensure their perpetuation (Chrisman 1992). Others seem more committed to an intellectual discourse, and rearrange their content more readily. The most appropriate metadata for some kinds of GIS data sources are the manuals used, the definitions employed, the scientific papers cited. GIS data is not some commodity to be purchased by weight or number of coordinates. It involves a professional judgement of specific individuals. At the start of this century, the topographic maps were each signed by the topographer (who had done field surveys with his plane table and other equipment). As the photogrammetric production technology changed the labor process towards greater accuracy, the product became anonymous, a matter of replaceable parts. In the final decade, the metadata standard has brought back individual identities.

The data resources available for GIS make the generic software capable of working in a specific place, with specific people, to serve the specific need. Hence there is a great potential for circular connections from the social situation to the GIS and reverse.

Results

It is most important to observe that the software and the data do not preordain the results. These resources can be put together in many ways to serve different purposes. The tools available even in the simplest GIS permit many different products to be produced (Tomlin 1990; Chrisman 1997). Many of these make no sense, and there is no general rule to protect the user from themselves. Hopkins (1977) tried to avoid some of the worst excesses, but to little avail. In the end, the results will have to be accepted by people relying on some system of trust. Porter (1995) describes the growth of quantification as a technology of trust. This certainly applies in accounting (Riahi-Belkaoui 1995), as well as in geography. Accounting has developed highly formalized ways to restrain creativity so that corporate finances can be interpreted by others. Similarly, maps formalize and simplify, though the rules might not be so easily written down.

It suffices to say that the results from a GIS are not just the product of an inexorable technical force. Some person still clicks that mouse.

CONCLUSION

There is a large body of literature about the social construction of technology and science. The GIS research community has just begun to realize the ramifications of this work on understanding how GIS works. The community has been hampered by the prevalence of various forms of technological determinism. By turning full circle, connecting from social needs to technical issues then back to the social realm, we avoid the flaws of isolating implications from their causative environment.

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