John Sherman and the Origins of GIS

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The academic career of Professor John Sherman at the University of Washington spanned a half-century during which the technology of maps and geographic information handling changed dramatically. Sherman participated directly in the development of academic cartography and through this process influenced the nature of the computer-based technology that has developed. Many of the roots of this technology can be glimpsed in his 1957 article on the multiple use of graphical materials in photographically-based cartography. This review of John Sherman's career is based as much on an archeology of his artifacts as it is on traditional textual exegesis.

Revolutions in Technology: Rooted in Things

The twentieth century can be charted as an accelerating expansion of stuff. Each decade has brought new categories of things with the industries and technologies to produce them. This century of high-tech began with the automobile and ends with the GPS wrist-watch. While the expansion of transportation and communication have built new paths for everyday life, the rates of change in the information fields have been the most dramatic, particularly in the second half of the century, the period of John Sherman's academic career. Cartography has not been immune from the overall trends in technology and development. Maps have become more and more tightly integrated into the lives of people far from the academically trained. This is a period of marvelous changes.

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In setting forth the remarkable changes, it is all too easy to slide into a kind of technological determinism (Feenberg 1995). The avalanche of new things, new industries and new technologies seem to be essentially inevitable. The common terminology speaks of "discoveries" like the light bulb or the transistor as if these were territories lying in some hidden landscape waiting for the explorer. The terminology of discovery actually serves to diminish the role of the inventor, because it implies that anyone similarly placed would uncover the same thing. It also reduces the importance of the specific nature of the object created, since there is a kind of Platonic ideal awaiting those able to read the shadows on the cave wall. The paths of technological change are much more complex than this simplified story. The process of innovation branches in mazes of potentiality and comes with no guarantees of success. The particular nature of things intervenes to constrain the actions of later participants.

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This article will chart some of the developments of cartography that served as key stages in creating the technology now identified as "geographic information systems (GIS)." It will center its focus on John Sherman, Professor of Geography at the University of Washington, not because this remarkable cartographer "discovered" GIS in some kind of solitary exploit, but because the personal strengths of this gifted teacher made it possible for others to construct an expanded set of tools that became the GIS technology. Much of the story depends on the artifacts of Sherman's cartography, the photographic materials of darkroom reproduction. Sherman's maps survive, but the final product does not testify to all the intricate gestures required to construct them. Without the skilled practitioners, the pile of negatives curl and crack, left high and dry in a digital world. Because the maps speak most directly, this article is based as much on archeology as on texts.

Theoretical Framework for History of Technology

The common understanding of the history of science places a great premium on the world of ideas. Kuhn's "paradigm shifts" (Kuhn 1962) have moved from an academic classic to the world of self-help books. While there is certainly a role for creative thinkers, the actual paths of change are a lot more complex (Usher 1954; Latour and Woolgar 1986). This paper adopts a "constructivist" approach to the study of technology and science, following the approach of the "strong program" of Barnes (1974) and Bloor (1976) as further developed by Bruno Latour (1987; 1993). To summarize, this body of research describes the close interaction between people, human organizations, material objects and scientific facts. In such mundane objects as door openers and the timing of elevator doors, there are codes of social conduct and traces of cultural values. There is no guarantee that any one of these "worlds" (the social, the political, the ideological, and so on) provides the sole explanation. And it is certainly important to remember that "things" are not necessarily subservient to ideas. Frequently, technological innovations are tied in a series of complex contingencies. This story about the origins of GIS and the role of John Sherman cannot be played out simply in some abstract world of ideas, but it must make reference to the chemical smells of darkrooms, the optical tricks of exposures and lights, and the tangible models of raised relief models and maps for the blind.

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Multiple Use in Cartography

John Sherman did not produce a huge volume of traditional publications; in a complete list of his career work (Velikonja 1997) the list of maps is longer than the list of articles. A key event was the short (two and one half page) article in *Professional Geographer* with Waldo Tobler (Sherman and Tobler 1957) titled "Multiple Use Concept in Cartography." To the casual reader forty years later, some of this article would be obscure. It requires the explanations I can offer from having performed the archeological task of packing up the rooms and rooms of Sherman's cartographic materials.

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The term "multiple use" is connected to the justifications used to support hydroelectric power projects. Certainly the Pacific Northwest of forty years ago saw these dams as the kind of progress portrayed in Woody Guthrie's songs, not with the perspective of dwindling salmon stocks that now dominate the public debate. A few years after this paper appeared, the "Land of Many Uses" signs appeared around National Forests, following the revised enabling act (The Multiple Use-Sustained Yield Act (76 Stat. 215) adopted in 1960). So, Sherman and Tobler positioned cartography in the context of the kind of political discourse used at the time to justify public investment. It connected to the cost-benefit methods and operations-research logistics developed during World War II, though with no explicit references nor ponderous exposition. The paper argues that cartography, when all its little steps were taken into account, amounted to a large effort.

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The multiple use concept is not presented directly with graphic examples; it is actually referenced to some published and unpublished maps produced at the University of Washington. The "medium and small scale maps" for which this technique was originally applied were most likely the Washington State 1:500,000 produced by the US Geological Survey. Lying in a neatly crafted box, deep in a pile of Sherman's materials, I found a large (2 m by 1.5 m) poster display taken to some conferences in this period. It shows how the graphic materials used to produce the USGS state map can be reused to produce other presentations. The readership of *Professional Geographer* were expected to have seen these displays, perhaps.

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In addition, the article says: "the concept has proven of equal validity for large-scale (engineering type) maps (p. 6)." I have discovered an experimental series of positive and negative graphical materials for a facilities inventory of the University of Washington campus illustrating this approach. Each graphic layer (labelled from A through V) holds a different class of objects (roads, wires, pipes, buildings) or the lettering for another layer. These layers were intended to be used to produce a graphic product with virtually infinite flexibility in choosing the color or grey tone of each feature. While such flexibility might seem totally obvious to a graphics professional raised with AutoCAD as a part of their cultural heritage, this was the era when the graphic materials were equated with the inks for a particular product. There was no "road" layer; some roads would be on a black plate, and others on a red plate. But, there would be no direct way to extricate the roads from the other symbols on the black plate.

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The article defines the multiple use concept as "the complete separation of all elements (even in the case of a map to be reproduced in black and white) at the drawing stage and later selective reassembly depending on purpose (p. 6)." In Sherman's map of the University of Washington campus (first produced in 1959, but firmly based on the principles of this article), there were over forty graphic separates. For example, the buildings that had libraries are on a distinct layer since the library system required a version of the map that indicates the location of all branch libraries. While the article talks about flexibility to respond to unforeseen demands, the decisions on which elements belonged on distinct layers required substantial understanding of the content.

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The multiple use concept, as expounded by Sherman and Tobler, signals a change in how cartographers positioned themselves. Instead of executing a specific design for a particular printing technology, as it had to be when there was no technology to transfer the engraving from one copper plate to another, the photographic method permitted new combinations. As with many innovations, the darkroom techniques were first used to automate the prior view of the map. The press plate translated directly to a single manuscript and negative. The new possibilities are latent until recognized and mobilized. It is important to refrain from using the word "discovered," a term that implies that the technology lies somewhere "out there" so that any mariner sailing west from Iceland will certainly encounter the same Greenland. The ways in which technical potentials could be mobilized are not so fixed or certain. There is no guarantee that other teams will do the same thing. The essential leap involved moving from the goal of reproducing a particular design to representing the attributes of features to support any design.

The multiple use approach led Sherman to propose a "New Horizon" for cartography at the first full meeting of the International Cartographic Association in Stockholm (Sherman 1961a). His vision of automation was influenced by the remote sensing potentials of early weather satellites, but it also included a call for a "universal world data bank" in computer form. This proposal depended upon a number of rash assumptions about technical feasibility [that were quite clear when Sherman reflected on this later (Sherman and Turner 1987, p. 81)]. At its root, the multiple use concept was concerned with map content, not a particular optical photographic technology. Sherman's developments were intimately tied to his experience in the darkroom, but there was also a sense that he mobilized these tools for larger purposes.

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Origins of GIS

It is extremely easy to misread the past as a single track of inevitable progress from one stage to another. The story of geographic information systems is frequently recorded in this manner (Chrisman 1993). A simple chronology of developments is not enough to establish which ideas and techniques influenced others. Prior discovery does not necessarily ensure a direct influence.

Sherman's co-author on the multiple use paper was Waldo Tobler, and the paper was written when the original gang of graduate students in the Department of Geography were plotting the original campaign of what turned into the quantitative revolution. While the connection is direct, there is only the most tenuous sign of multiple use cartography in the statistically-oriented view of progress. Berry's Ph.D. thesis (Berry 1960) made an attempt to explain factor analysis as a multilayer set of maps, but the analogue does not hold, since the space in which factors operate is based on the attribute values, not any cartographic or spatial axes. This lack of connection between the Sherman cartography and the quantitative geography of the period may explain why GIS emerges from other threads (Chrisman 1997).

Sherman's view of cartography was not confined to geography. He developed and maintained strong connections to related academics, particularly in Civil Engineering at the University of Washington. Around 1960, Professor Edgar Horwood began teaching courses about geocoding and the use of computers to make maps. Sherman's students took Horwood's courses, and I have found samples of computer-produced maps from Sherman's seminar in 1961 (archive of Professor William Beyers). The fact they were of Michigan by county demonstrates the firm connection that Sherman retained with Tobler. Then a geography student, William Beyers was Horwood's assistant in giving a workshop on automated cartography at the Regional Science meetings in Chicago. The workbook produced for the event (dated January 1963) is full of the minutiae of punched cards and a software package nowhere near the polish we now expect. Of all those in attendance, it was an architect, Howard Fisher, who became motivated to take the next steps (Chrisman 1997, for more details on the connection to Harvard). The crude nature of line printer maps did not meet Sherman's demands for artwork, but he did support the adventurous explorations of the digital pioneers.

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Perhaps the most direct connections between Sherman's multiple use concept and the development of GIS comes in the tangible products of cartographic production. The last sentence of the 1957 article talks about the more rapid completion of mapping for the whole country. Through his efforts supporting the Topographic Division at the US Geological Survey (Sherman 1961b), the National Research Council's Cartography Panel, and the series of proposals for a National Institute of Cartography (Sherman and Heath 1959; Sherman 1969), Sherman promoted his approach to separations. While it is difficult to alter existing programs, this method was adopted in the 1970s for the 1:100,000 series. Feature separates (and the consequent ease of digital scanning) was a key reason that

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the TIGER project selected the 1:100,000 as the source for the TIGER project in the 1980s (Starr and Anderson 1991, p. 16). Perhaps the 1:100,000 series would have been designed in this way without the efforts of Sherman; perhaps a more accurate TIGER would have been developed from the 1:24,000 series. But, given the state of scanning technology at the time, TIGER could not have been completed in time for the 1990 Census from the traditional separation plates of the 1:24,000 series. Availability of TIGER early in the transition to digital data sources provided the multiple use resource of Sherman and Tobler's vision.

CONCLUSION

John Sherman became captivated by the challenge of maps for the blind, and did not pursue the multiple use concept. Yet, the concept contributed to the evolution of cartography into its current form.

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The physical artifacts used for this chapter were examined through the duty of moving Sherman's collected materials out of various rooms in Smith Hall. The University of Washington Archives in the Allen Library now have the bulk of the material mentioned.

REFERENCES

Barnes, B. 1974: *Scientific Knowledge and Sociological Theory*. London: Routledge & Kegan Paul.

Berry, B. J. L. 1958: *Shopping Centers and the Geography of Urban Areas: A Theoretical and Empirical Study of the Spatial Structure of Intraurban Retail and Service Business*, unpublished Ph.D. dissertation, University of Washington.

Bloor, D. 1976: *Knowledge and Social Imagery*. London: Routledge & Kegan Paul.

Chrisman, N. R. 1993: Beyond spatio-temporal data models: A model of GIS as a technology embedded in historical context. *Proceedings Auto-Carto* 11: 23-32.

Chrisman, N. R. 1997: Academic origins of GIS. In *History of Geographic Information Systems*, ed. T.Foresman. London: Taylor & Francis.

Feenberg, A. 1995: Subversive rationalization: Technology, power and democracy. In *Technology and the Politics of Knowledge*, eds. A. Feenberg and A. Hannay. Bloomington: Indiana University Press, 3-22.

Kuhn, T. 1962: *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Latour, B. 1987: *Science in Action*. Cambridge Massachusetts: Harvard University Press.

Latour, B. 1993: *We Never Were Modern*. Cambridge Massachusetts: Harvard University Press.

Latour, B. and Woolgar, S. 1986: *Laboratory Life: The Construction of Scientific Facts*. Princeton NJ: Princeton University Press, 2nd edition.

Sherman, J. and Tobler, W. 1957: The multiple use concept in cartography. *Professional Geographer* 9(5): 5-7.

Sherman, J. C. 1961a: New horizons in cartography: functions, automation and presentation. *International Yearbook of Cartography* 1: 13-19.

Sherman, J. C. 1961b: Recognizing and meeting the map requirements of the population explosion in the Western United States. *Topographic Division Bulletin*. US Geological Survey.

Sherman, J. C. 1969: *The National Institute of Cartography: A Proposal*. Draft proposal National Research Council.

Sherman, J. C. and Heath, W. R. 1959: Preliminary proposal regarding a National Institute of Cartography. *Second Cartographic Conference*. Institut fur Angewandte Geodasie, Series II, no 7, 81-85.

Sherman, J. C. and Turner, E. 1987: Interview. *The American Cartographer* 14: 75-87.

Starr, L. E. and Anderson, K. E. 1991: A USGS perspective on GIS. In *Geographical Information Systems: Principles and Applications, 2* , eds. D. J. Maguire, M. F. Goodchild and D. W. Rhind. Harlow, Essex: Longman's Scientific and Technical, 11-22.

Usher, A. P. 1954: *A History of Mechanical Inventions*. Cambridge Massachusetts: Harvard Press, 2nd edition.

Velikonja, J. 1997: John C. Sherman May 3, 1916 - October 21, 1996. *Chronicle of the Department of Geography*, University of Washington 11:4-10.