3 The Internet and Multimedia Cartography

Michael P. Peterson

Department of Geography, University of Nebraska at Omaha, Omaha, USA

3.1 Introduction

Although the Internet has been in existence in some form since 1969, only since the mid-1990's, with the widespread use of the World Wide Web, has the Internet became a major medium for cartography. Within a matter of years, millions of maps were being delivered to users through this new medium, and cartography was freed of its dependence on a physical medium for the exchange of geographical information. The image search option in most search engines makes it possible to quickly find a large number of maps in the GIF, JPEG and PNG raster formats. Although many are of poor quality and some are even illegible, static maps in the raster format persist despite the availability of more advanced and interactive products. The ease with which such static maps can be placed on the Web and how quickly they can be found still makes such maps a mainstay for the Internet map user. This chapter examines the Internet phenomenon, particularly the current status of the Internet, Internet map use, and contemporary research related to maps and the Internet.

3.2 Internet development

From its beginnings in 1969 up until the mid-1990s, the Internet was used almost solely by academic research scientists and the military. Besides being restricted to specific users, the system was difficult to use. The simple process of sending and receiving files required memorizing arcane text commands. At the beginning of the 1990s, in a research laboratory in Switzerland, Tim Berners-Lee created the hypertext Internet links that formed the basis of the World Wide Web. But, the initial version consisted only of text. Making the Web mainstream would take until the mid-

dle of the decade and require the implementation of a graphical browser. The first such browser was made freely available on March 14, 1993 and called Mosaic. The program was written by Marc Andreesen and Eric Bina at the University of Illinois' National Center for Supercomputer Applications (NCSA). They introduced the program as a "consistent and easy-to-use hypermedia-based interface into a wide variety of information sources." The concept, Andreessen says, "was just there, waiting for somebody to actually do it."

NCSA Mosaic enjoyed almost immediate success. Within weeks it was the browser of choice for the majority of Internet users. More Mosaic users meant a bigger Web audience. The bigger audiences spurred the creation of new content, which in turn further increased the audience on the Web and the demand for Mosaic. Not everyone was pleased with Mosaic. Tim Berners-Lee, who designed the Web only a few years before, lashed out at Andreesen at a public meeting by telling him that adding images to the Web was going to bring in a flood of new users who would do things like post photos of nude women. Andreesen later admitted that Berners-Lee was right on both counts.

The success of Mosaic led to the release of a re-written and faster commercial version called Netscape in October of 1994. It became the pre-eminent 'browser' software until rivaled by Microsoft's *Internet Explorer* when it was introduced in 1996, leading to the "browser war" of the late 1990s. Standards were developed for HyperText Mark-up Language (HTML) by the WWW Consortium (W3C). Further work led to a standard for Dynamic HyperText Mark-up Language (DHTML for Netscape) and dHTML (for Microsoft), VRML (Virtual Reality Mark-up Language) authoring (Murie 1996), XML and a variety of derivatives – including Scaleable Vector Graphics (SVG).

At the end of 1994 there were only 13 million users of the Internet. By late 1995 this number had risen to 23 million, plus an additional 12 million using electronic mail of various kinds (Parker 1995). The Web grew one home page every four seconds and doubled every 40 days. It had over 40 million users worldwide in early 1996 (van Niekerk 1996). There were only 200 million Internet users at year-end 1998. It grew to 533 million at year-end 2001. The figure was 935 million in 2004 and. reached 1 billion sometime during 2005. In terms of Web servers, the Internet grew from 130 in 1993 to an estimated 660,000 in early 1997 (Peterson 1997) and by late 1998 servers numbered over a staggering 3.5 million (The Netcraft Web Server Survey 1998). It is clear that the Internet and its use have grown very quickly and now represents the major form of information distribution for a large portion of the world's population.

3.3 Maps and the Internet

The development of map distribution through the Internet was affected by general trends that influence the spread and adoption of the technology. Three major eras in the development of the Internet can be identified that influenced the development of the Internet as a medium for cartography. In the first stage, the distribution of maps via the Internet was a novelty with no specific purpose other than to demonstrate that maps could be quickly distributed in this way. In the second stage, beginning in about 1997, the Web emerged as a major form of delivery for certain types of maps, particularly for interactive street maps. In the current third stage, various forms of user input to maps, including *community mapping*, are being developed. The continued development of the Internet for map delivery is dependent on solving specific problems. Solutions to these problems are both technical and philosophical and will have a major influence on how cartography as a whole develops in the future.

Formal research in cartography related to the Internet began in about 1995. The North American Cartographic Information Society (NACIS) dedicated its annual meeting to the Internet in 1996. The international dimension to this research was aided by the creation of the ICA *Maps and the Internet* Commission in 1999. Meetings of this international body were held in 2000, 2001, and 2002, 2003, 2004, 2005, in the United States, China, Germany, South Africa, Japan, and Spain respectively. These meetings have addressed issues of Internet map use and Internet map delivery. These areas of research are represented in the 2003 publication *Maps and the Internet*, a publication of the International Cartographic Association. The purpose here is to outline each of these areas and present the major focus of each. We first examine the growth of the Internet and the growth of Internet map use.

3.4 Internet use and Internet Map Use

The development of map distribution through the Web is largely dependent on the growth and expansion of the Internet as a medium of communication. According to the Computer Industry Almanac (2004), there are 935 million Internet users or nearly 16% of the world's population (see Table 1). This is up from 533 million Internet users worldwide at year-end 2001 which at that time represented only 8.7% of the world's population (see Table 2). There were only 200 million Internet users at year-end 1998. It is expected that this figure will reach 1 billion by mid-2005 and

1.46 billion by 2007. Most of the current 935 million Internet users, are located in the top 15 countries (see Table 1). The major growth in the use of the Internet is coming from the East and South Asia, Latin America, and Eastern Europe. India is now ranked 5th in terms of the share of world Internet users. In 2001, India was not even in the top 15. The rate of usage and growth in usage is remarkable considering the complexity of the required computing and communications infrastructure.

The growth in the use of wireless Internet via cell phones is especially strong. The wireless Internet share is currently 16% or 85 million people. This is expected to rise to 42% in 2004 and 57% in 2007. This means that by 2007, there will be 829 million users of wireless Internet. The number of wired Internet users will only be 632 million – an increase of only 184 million. These figures indicate that most of the growth in the use of the Internet will come from the wireless sector. However, it is likely that a wireless Internet user will also use a wired network.

Table 1. Top 15 nations in Internet use at year-end 2004. The last column indicates the percent of the world total. Data for some countries are not available.

0Rank	Nation	Internet Users 2004 (millions)	1Share of World Users
1	United States	186	19.86%
2	China	100	10.68%
3	Japan	78	8.35%
4	Germany	42	4.48%
5	India	37	3.96%
6	UK	33	3.54%
7	South Korea	32	3.39%
8	Italy	26	2.73%
9	France	25	2.72%
10	Brazil	22	2.39%
11	Russia	21	2.27%
12	Canada	20	2.19%
13	Mexico	14	1.49%
14	Spain	13	1.44%
15	Australia	13	1.39%

Source: Computer Industry Almanac (2004)

Table 2. Top 15 nations in Internet use at year-end 2001. The last column indicates the percent of the world total. Data for some countries are not available.

Rank	Nation	Internet Users 2001 (millions)	Share of World Users
1	United States	149	41.92%
2	China	33.7	9.48%
3	UK	33	9.29%
4	Germany	26	7.32%
5	Japan	22	6.19%
6	South Korea	16.7	4.70%
7	Canada	14.2	4.00%
8	Italy	11	3.10%
9	France	11	3.10%
10	Russia	7.5	2.11%
11	Spain	7	1.97%
12	Netherlands	6.8	1.91%
13	Taiwan	6.4	1.80%
14	Brazil	6.1	1.72%
15	Australia	5	1.41%

Source: Computer Industry Almanac (2001)

Another trend in Internet usage is the return of a browser war. All of the major browsers, especially Microsoft's Internet Explorer, are losing ground to upstart Firefox which now accounts for nearly a fourth of all web browser activity (see Table 3). Firefox is viewed as a faster, trimmer Web browser that isn't subject to the crashes and security gaps that afflict the market-leading Microsoft Internet Explorer. Table 4 shows the market share of each operating system.

Table 3. Browser market share in the last four months of 2005. Explorer is losing market share to Firefox.

2005	IE 6	IE 5	Ffox	Moz	NN 7	O 8	O 7
December	61.5%	6.5%	24.0%	2.7%	0.4%	1.3%	0.2%
November	62.7%	6.2%	23.6%	2.8%	0.4%	1.3%	0.2%
October	67.5%	6.0%	19.6%	2.6%	0.4%	1.2%	0.2%
September	69.8%	5.7%	18.0%	2.5%	0.4%	1.0%	0.2%

IE	Internet Explorer
Ffox	Firefox (identified as Mozilla before 2005)
Moz	Mozilla
O	Opera
NN	Netscape

Source: http://www.w3schools.com/browsers/browsers_stats.asp

Table 4. Operating system market share in the last months of 2005.

2005	Win XP	W2000	Win 98	Win NT	Win .NET	Linux	Mac
December	71.6%	13.6%	2.6%	0.3%	1.7%	3.2%	3.3%
November	71.0%	14.6%	2.7%	0.4%	1.7%	3.3%	3.3%
October	70.2%	15.0%	2.8%	0.4%	1.6%	3.3%	3.2%
September	69.2%	15.8%	3.2%	0.5%	1.7%	3.3%	3.1%
December	71.6%	13.6%	2.6%	0.3%	1.7%	3.2%	3.3%
Source: http://www.w3schools.com/browsers/browsers_stats.asp							

An interesting aspect of Internet use is the disparity in the number of male and female users, particularly in certain countries. In 2000, male-female ratio ranged from 94:6 in Middle East to 78:22 in Asia, 75:25 in Western Europe, 62:38 in Latin America, and finally 50:50 in USA (Dholakia, et.al, 2003). Updated data are presented in Table 5. In many European countries, local telephone calls are metered. This means that the home user of the Internet would pay a telephone fee for every minute of connection time. This cost structure would limit home use of the Internet, which may affect women more than men.

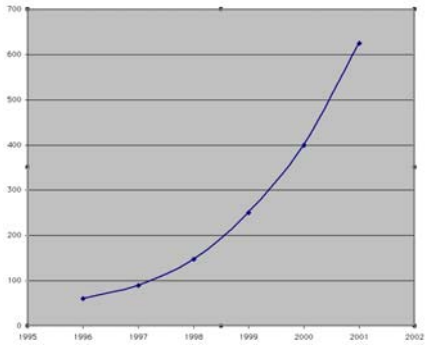
Table 5. Internet use gender differences by country ranked by disparity in male usage.

Internet Users by Gender		
Country	**Male %**	**Female %**
Germany	63.4	36.6
France	61.9	38.1
Italy	60.9	39.1
Spain	60.9	39.1
Belgium	60.6	39.4
Netherlands	59.8	40.2
Brazil	59.7	40.3
Switzerland	58.7	41.3
Japan	58.4	41.4
Austria	58.1	41.9
Norway	58.0	42.1
UK	57.2	42.8
Israel	57.1	42.9
Hong Kong	56.6	43.4
Singapore	56.5	43.5
Denmark	55.9	44.1
Taiwan	55.8	44.2
Ireland	54.8	45.2

Sweden	54.8	45.2
South Korea	54.4	45.7
Mexico	54.0	46.0
Finland	53.9	46.1
New Zealand	52.5	47.5
Australia	51.6	48.4
Canada	49.0	51.0
United States	47.3	52.2

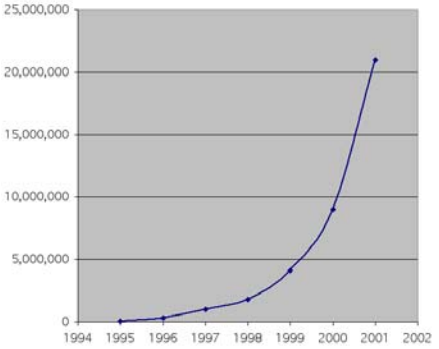
Source: Nielsen/NetRatings, 2003.

The number of maps that are distributed through the Web was tracked at four major sites since 1997 (Peterson 2003a). The results indicate that usage grew rapidly, particularly at commercial sites. Figure 1 presents a comparison of the growth in Internet use vs. the growth of Internet map use through 2001. Both growth rates are strongly exponential. It is probably not surprising that the growth in the use of maps through the Internet is exceeding the growth rate for the Internet itself. It is far more difficult for a non-Internet user to get the initial equipment and Internet connection to become an Internet user than it is to get an existing Internet user to access maps through the Internet. It is interesting that people have adapted so easily to using maps through the Internet and that the growth the usage is expanding at such an exponential rate.



Growth in the Use of the Internet in the number of new users per year.

$e^{0.45}$



Growth in Internet Map Use in Number of Maps Distributed per Day

$e^{0.80}$

Fig 1. A comparison between the growth of the Internet and the growth of Internet map use. Both growth rates are exponential. Internet map use is growing at a faster rate, approximated by an exponent of $e^{0.80}$, where e is the base of the natural logarithms.

3.5 Research in Internet Cartography

The Maps and the Internet commission of the International Cartographic Association have identified a number of areas of research. These areas are:

Internet Map Use – The purpose of this research is to investigate the growth in the use of the Internet, the growth in Internet map use, methods of Internet map use, and approaches of improving Internet map use.

Internet Map Delivery – The purpose here is to find better methods of transmitting maps through the Internet. Research involves exploring new Internet protocols and graphic file formats for cartographic applications.

Internet Multimedia Mapping –This area of research attempts to integrate multimedia elements with maps and make them available in an efficient and educational manner through the Internet.

Internet Mobile Mapping – This direction examines the use of mobile phones for map delivery and display. The major challenges are to reduce the map to a small display and update the map relative to the position of the user.

3.6 Theory to support Internet Cartography

3.6.1 Dimensions of internet map use

A number of chapters in the Maps and the Internet (Peterson 2003) volume address different aspects of Internet map use. Krygier and Peoples (2003) describe the integration of the Internet in a college-level course to create a basic geographic information literacy. The course attempts to engage "students (who are mostly non-geography majors) in active learning about mapping, but also critical thinking about the nature of maps and mapping sites on the WWW (World Wide Web), a skill that is more necessary than ever." (Krygier & Peoples, p. 17).

Richmond and Keller (2003) explore Internet maps and their use in web-based tourism destination marketing. They examine 181 "maps within 40 official national tourism destination websites" (p.77). They conclude that the "designers of tourism websites need to put more thought into the location of maps within their sites" (p. 94) because the maps are often very hard to find.

Mooney and Winstanley (2003) look at the publishing of public transportation maps and the cognitive processes involved in understanding

these maps within the medium of the Web browser. They found that "computer generated route maps often disregard many of the techniques and principles that guide cartographers" (p. 306). Among other things, they argue that transportation maps need to be more up-to-date because over a given day many changes occur on a public transportation network. The Internet can help deliver more current transportation maps to the Internet map user.

Monmonier (2003) examines how online maps are being used to invade privacy. He points out that: "Web cartography" is especially valuable—and potentially threatening—because it not only greatly expands the audience of potential watchers (Peterson, 2000) but also allows for unprecedented customization of maps that describe local crime patterns, warn of traffic congestion and inclement weather, disclose housing values, or - thanks to the Global Positioning System (GPS) and the new marketplace for "location-based services" - track wayward pets, aging parents, errant teenagers, or unreliable employees" (p. 98). He concludes that: "As society and government work through the significance of locational privacy and decide what legal limitations, if any, are appropriate and permissible, the debate will turn to possible restrictions on Internet cartography, which many consider invasive because of the increased accessibility of information about where we live, the size and condition of our homes and real property, and the quality and safety of our neighborhoods" (p. 111).

3.6.2 Internet map delivery

The purpose of this line of research is to find better and more efficient ways of distributing maps through the Internet. This work is influenced by the open source movement that seeks to maintain a body of software through a combined effort of numerous, independent individuals.

Herzog (2003) describes the freely available Mapresso software for choropleth and cartogram mapping. He points out that the "World Wide Web offers cartography an ideal platform for making communication with maps more feasible" (p. 117). He argues that cartography "has not taken sufficient advantage of the Internet" (p. 129). He concludes by arguing for a different model for how software is developed for Internet mapping:

Considering a broader model of cartographic development on the Internet, small applets, as the one presented here, could be the result of a common effort of different actors in this area – from writers of the code for basic utility classes and for applets and related products to compilers of the geodata and finally to Web publishers with special thematic concerns. Such a community would help to exploit the constantly increasing techni-

cal opportunities for the diffusion of cartographic products and ideas (p. 129).

Neumann and Winter (2003) describe the advantages of a vector format called SVG. Andrienko, et.al. (2003) relate the experience of developing and evaluating an open source GIS program. Zazlavsky (2003) looks at the cartographic potential of XML, a new mark-up language for the Web.

Elzakker, et.al, (2003) review worldwide progress in the dissemination of census data in the form of maps. Elzakker, et.al, (2003) state that the advantages of web mapping "may be summarized under the headings of accessibility and actuality. Accessibility means convenience in accessing data anytime and from anywhere (as long as there is Internet access). Actuality refers to the potential of making the data available to the user immediately after their collection" (p. 58). In their review, 126 national statistical organizations (NSO's) were identified and analyzed. They point out that if "NSOs (National Statistical Organisations) wish to enable further possibilities to interact with maps, some kind of *mapping application* is needed that dynamically constructs maps out of the available data according to the user's specifications" (Elzakker, et.al, 2003, p. 74). Many possibilities are available, some open source, that would make this possible.

Cartwright (2003) "addresses the new area of Web mapping and covers why maps delivered through the Web are different, what constitutes effective Web map design, and the criteria by which they should be evaluated." (p. 35). He concludes that: "Proper design and evaluation procedures are essential if usable Web-delivered geovisualizations are to be provided and effectively exploited" (Cartwright 2003, p. 55).

Andrienko, et al. (2003) develop and test a general purpose GIS program called CommonGIS. The objective is to incorporate exploratory data analysis with online maps. CommonGIS is implemented in the Java language and can be used in two ways: as an applet running in a standard Java-enabled Web browser and as a local application, after being installed on a user's computer.

Jiang (2003) examines the potential of developing an analytical online cartography. He argues that "more and more users would like to query maps or geographic information for various purposes" (p. 147). Seeing limitations in the server-client model, he sees the potential of P2P for developing and distributing Geographic Information Services (GIServices).

Li (2003) examines point-to-point protocols (P2P) that are used for the exchange of music files and movies. He shows how a "node-hub P2P system enables individual users to form a cartographic data network where

cartographic data are packaged, published, registered, searched, and transported over the Internet" (p. 159).

Zazlavsky (2003) introduces XML and outlines its potential for online cartography. Through an application called AxioMap, he shows how data and instructions can be downloaded and processed on a local computer. He concludes by pointing out that XML makes it possible to perform many spatial data integration and dynamic mapping tasks that could not be addressed before (p. 194).

Newmann and Winter (2003) describe the advantages of Scalable Vector Graphics (SVG), a vector graphics standard based on XML. They describe it as the first "vendor neutral vector graphics standard that integrates vector graphics, raster graphics, text, scripting, interactivity and animation while also being fully extensible, open to metadata and internationalization" (p. 217). They argue that SVG will reach its full potential when it is fully integrated with other XML standards (p. 218).

Lehto (2003) views the Web as a new publishing platform, similar to traditional print media. The challenge is to publish maps in multiple formats. He describes a mechanism for transforming XML-encoded data, the Extensible Stylesheet Language Transformation (XSLT) specification, and explains its use as a tool to provide multi-purpose publishing functionality for the Web and the Mobile Internet-based spatial services (p. 221).

Tsou (2003) envisions software agents that reside on the Internet and handle map related functions, such as map design. He argues that: "Software agent-based communication mechanisms can facilitate the dynamic integration of geospatial data, GIS programs, and cartographic rules and knowledge bases in distributed network environments (p. 242).

Torguson & Blinnikov (2003) show that an online atlas can be made by combining the efforts of students and Internet data sources. The project brought students from several different classes together to work in a team-building work experience (p. 312).

3.6.3 Internet multimedia mapping

A particular form of map delivery research attempts to exploit the potential of the Internet for combining multimedia content with maps. For example, Hu (2003) describes the creation of a web-based multimedia GIS. According to Hu, "web-based multimedia GIS is based upon interactions between three components: 1) a web-based GIS application developed to manipulate digital maps; 2) a web-based interactive multimedia application designed to manipulate multimedia information including hypertext, hyperlinks, graphics, photographs, digital video and sound; and 3) a mechanism

linking the web-based GIS application and the interactive multimedia application" (p. 336). He argues that the "integrated multimedia-GIS approach provides a multi-sensory learning environment" (p. 341)

Caquard (2003) evaluates the potential of Internet maps to serve a role in a public participation decision-making setting. He argues that the dynamic maps that he studied are better suited to improve public participationby reducing the influence of the mapmaker and supporting the user's participation in the map-making process (p. 355).

Cammack (2003) uses a sense of virtual reality immersion with a map so the map-reader can experience the complexity of the virtual reality scene and abstraction of the map at the same time. He explains that spatial information can be represented in an extremely abstract or nearly realistic way (p. 361) and that there is a relationship between the level of abstraction and map use. "One aspect of this relationship is that spatial representations at different levels of abstraction can have the same map use" (p. 361). He proceeds to develop a multimedia-map environment using QuickTime VR that helps users understand water quality issues in a particular drainage basin.

Schwertley (2003) also uses QuickTime VR to create an online virtual landscape of a small city in Iowa. The individual virtual reality scenes are linked to a map and to each other. He concludes that "QuickTime VR can enhance spatial understanding and provide a better sense of place by combining virtual realitywith geographical information in the form of maps" (p. 381).

Giordano (2003) describes an application to distribute historical maps through the Internet with a GIS. As he states, the study "exemplifies the difficulties of using geographic information technologies with historical data (p. 321). His study showed that it is possible to integrate the traditional tools of GIS with computer cartography and multimedia. Together, "they provide a formidable suite of tools. The geographic query capabilities of the GIS, coupled with cartographic animations, images, pictures, and videos that can help a researcher gain additional insights into the study of historical databases. On a negative note, however, the integration must be done totally from scratch. Today's GIS is too immature to integrate multimedia applications" (p. 331).

Fuhrmann (2003) examines use of a geovirtual environment to support wayfinding. The research looks at how an egocentric frame of reference is best extended for navigation purposes with an exocentric map view and whether adding such a frame of reference significantly reduces navigation and wayfinding problems within the virtual environment.

Ottoson (2003) looks at the use of the Internet for three dimensional visualization, mostly in reference to the Virtual Reality Modeling Lan-

guage (VRML). The advantage of VRML files is that they can be downloaded and executed on a standalone computer but the format has suffered from a lack of a widely available plug-in. He concludes that there are a large number of 3-D map applications particularly with small mobile devices.

3.6.4 Internet mobile mapping

Gartner (2003) defines mobile mapping as an extension of Internet mapping through the distribution of cartographic presentation forms via wireless air data transfer interfaces and mobile devices. One potential application of this technology is Location Based Services (LBS) in which the location of the map user is identified. He sees the use of multimedia as both a "necessity in the context of small displays and special usage conditions of mobile users and a benefit for the cartographic information transmission (p. 392).

Wintges (2003) tackles map design issues on a PDA display. The purpose of this his research is to design a "satisfactory user interface and a method for navigation and interaction with a personal digital assistant" (p. 397). In the PDA user interface that he proposes, to "compensate for the absence of scrolling and to guarantee the largest display area possible, pop-up menus and information frames which fall back on a structured layer-model were integrated" (p. 402).

Interest in mobile mapping has led to a series of conferences held at the Technical University o Vienna in Austria. These meetings, entitled *LBS and Telecartography* have helped define this new area of study.

3.6.5 Theoretical development

Taylor (2003) argues that the increasing use of maps and the Internet requires a new paradigm for cartography. He proposes the concept of Cybercartography which he defines as: "The organization, presentation, analysis and communication of spatially referenced information on a wide variety of topics of interest and use to society in an interactive, dynamic, multimedia, multisensory and multidisciplinary format" (p. 406).

Brodersen (2003) attempts modeling the visualization of Internet maps. He argues that despite "the changes in the process of geo-communication through Internet maps, communication is still the purpose" (p. 434). The "content of a communication is media-independent" and the ultimate aim

is that the map affords the user the possibility of *quickly* and *safely* getting *correct* answers to *relevant questions*.

Peterson (2003) identifies the four paradigms that have guided cartography over the past half-century that have had an influence on the development of cartographic research related to the Internet. These four paradigms include cartographic communication, analytical cartography, cartographic visualization, and maps as power. For example, the latter paradigm argues that "the technological dimension of cartography has managed to overwhelmingly dominate the discourse in the field" (p. 443). It was pointed out by Harley "that under the influence of the computer, cartographers are more interested in technological questions rather than in the social consequences of what they represent" (p. 443).

3.7 Summary and suggestions

Cartography has always been subject to changes in technology. The particular change in the way maps are delivered to map user that began about a decade ago can be seen as a revolution. We are still adjusting to this rapid change. The research that is summarized here reflects this adaptation to a new medium. Clearly, there is much research yet to accomplish before the use of the Internet can be mastered by cartographers.

The *Maps and the Internet* commission of ICA has taken a leading role in spurring discussion and research about this new medium. Additional international efforts need to be focused on encouraging individual map suppliers and government agencies to take a greater role in improving the creation and use of maps through the Internet.

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