Use and Users of Maps on the Web

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Accessibility and actuality are presented here as the real benefits of the WWW medium for the dissemination of geospatial information through maps. In addition, the Web allows different modes of using web maps that address different map use goals. An argument is made that a great deal of web map use research will be required to develop more effective cartographic tools to better serve the needs of the users. Part of this research will have to be directed towards the characteristics of the web map users and the nature of their questions. Currently, we are witnessing a significant diversification of the user profile combined with an exponential growth of the total number of Internet users worldwide. The global distribution of the Internet is still very uneven, but there are now signs that the geographical anomalies will be somewhat reduced in the years to come. There are a number of other problems and limitations with which users are confronted in their use of maps on the web. However, the Web already is the major medium for the dissemination of maps and it has a great potential for further growth. But, this growth will have to be accompanied by cartographic research.

INTRODUCTION

In our discussions about maps, there is sometimes confusion about the designations *use* and *user.* In some cases, we refer to the producers who use maps to disseminate geospatial data, for instance through the World Wide Web (WWW). In a similar way, website designers may *use* a clickable map as an interface to the information residing on the site, be it geospatial or not (*URL 1*). When reference is made to the user, cartographers normally have in mind the person who is actually using the maps (including, perhaps, maps as interfaces) to find answers to the essentially geographical questions they have. This is also the perspective from which this paper has been written, concentrating on web map use in a rather broad sense.

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What is considered here is the entire process of using the Web to retrieve geographic information that is, or can be, transmitted by cartographic means. The geographic data may already come in the form of ready-made cartographic displays or the maps may still need to be constructed based on user input. Thereafter, the users may actually use the maps thus generated to obtain the information required.

While looking for answers to their geographical questions, WWW users may not be searching for a particular map, but may be offered a map display as a possible answer to a more general question like: "Where can I find a Chinese restaurant?" The Dutch version of the Yellow Pages (*URL 2*) offers the users, in addition to the address and other textual information and perhaps fully unexpectedly for the user, a map ("Toon Kaart" = show map) with the locations of all Chinese restaurants in the region specified; or a map showing the location of the selected restaurant; or even (if the business was willing to pay for it) a map (next to a textual description) showing the route to the restaurant selected from the place where the user is staying. In this case, the user was only looking for a place to eat and was not specifically asking for a map.

Based on these initial observations, the purpose of this paper is to shed more light on some aspects of map-use processes on the Web, as well as on the users themselves. It starts with presenting the real benefits to the user of the WWW medium for the dissemination of geospatial data by means of maps. The next section provides examples of different modes of using web maps in relation to different map use goals. Here, map use research is suggested that would help to develop more effective cartographic tools to better serve the needs of the users. The section on *user profiles* deals with the questions: "Who are they?"; "How many are there?"; and "What is their global distribution?" Some quantitative data on the use of maps on the Web are presented next. The last paragraph before the conclusion summarizes some of the problems and limitations web map users are confronted with in practice.

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WHY HAVE WEB MAPS?

Compared to a medium like CD-ROM, the real advantages of the new WWW medium for the dissemination of geographic and cartographic information may be summarised under two main headings: *accessibility* and *actuality*.

A user with access to the WWW has, in principle, access to an enormous wealth of information from his or her PC. Information, including web maps, is easily accessible through user-friendly web browsers, 24 hours a day and not hindered by political and geographical boundaries. Through the hyperlinking interface, users also have limitless access to much more information than could ever be carried on a single CD-ROM. The Web can provide a quick answer to many geographical questions. Users also do not have to buy a CD-ROM, nor do they have to worry about installing the CD-ROM on their computer. Through the WWW, scanned copies of rare historical maps may be made accessible to users. The originals of these maps may only be available in one or a few map libraries in the world with perhaps very restricted access because of their fragile condition (*URL 3*). The accessibility of the medium also creates possibilities for public participation and collaborative cartographic visualization, for instance, in physical planning procedures (Krygier, 1999). Another aspect of accessibility, and a big advantage to the user, is that much of the information on the WWW is still available free of charge, given suitable hardware, software and an Internet connection.

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One of the most serious problems of traditional cartography was to keep maps up-to-date. Due to the lengthy production process, sometimes a paper map was only made available to the users years after the initial data collection. By that time some of these outdated maps were already of limited use. With the introduction of electronic mapping, the production process could be speeded up somewhat, but the problem of actuality remained. A new edition of a route planner on CD-ROM will not be published every month, and even if it were, users would not be willing to buy a new version that often. The WWW, however, makes it possible to supply the users with up-to-date geographic and cartographic information. Good examples of this are web sites that include up-to-date weather maps (*URL 4*) or web maps showing real-time traffic information related to road construction work and traffic congestion (*URL 5*). Ultimately, the limit to the speed of revision is the speed of the data transfer through the Internet. A step further is to make real-time predictions of traffic conditions available to the user. The University of Duisburg in Germany, for instance, has created a computer simulation model by which traffic flows are predicted on the basis of measurements of current traffic intensities (*URL 6*). A next step would be to incorporate this kind of up-to-date information in the route planners that are available on the Web. A last example of the unprec-

edented potential of the WWW to provide really up-to-date information by means of web maps is presented by sites that keep users informed of recent developments in news and sports, such as websites that inform people at home about the actual position of boats participating in sailing races. The positions of the boats are recorded by means of GPS techniques and are continuously plotted on sea charts that can be consulted on the Web. During the first ten days of the Route du Rhum 98 sailing race, more than 5 million maps of the race were distributed through the web in this way (Baumann, 1999).

These are all examples of new possibilities for a new medium to supply (almost) real-time geographic information by means of web maps. But, geographic information that is somewhat less dynamic (e.g. tourist maps or topographic base maps) may now also be supplied to the user in a more up-to-date form than ever before. It may be expected that users will become more discriminating in this respect and that they will lose their confidence in websites that are not kept up-to-date.

MODES OF USING WEB MAPS

Figure 1 shows the classification of web maps that has been undertaken for the book by Kraak & Brown (2001). The subdivision made at the lowest hierarchical level of this classification (view-only versus interactive interface and/or contents) is made from the perspective of the web- map user.

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Another way of looking at the various ways of using web maps is to consider map use goals as positioned in the so-called "map-use cube," originally conceived by MacEachren (1994) (see Figure 2). Maps, including the maps generated in WWW sessions, may occupy any position in the three-dimensional space defined by the cube's axes, depending upon what a user does with the map and for what purpose. MacEachren and Kraak (1997) recognized four map use goals that are positioned in the cube: to explore, to analyze, to synthesize and to present information. However, in principle, web maps may also occupy other positions in the cube, depending on the typical use characteristics.

The static view-only scans of existing paper maps occupy a position close to the *present* ball in the cube. Many of these maps can still be retrieved through the Perry-Castañeda Library Map Collection site (*URL 7*). Typically, they were designed for a wide group of users and for a general purpose. Dynamic equivalents of these view-only maps are also available through the Web (*URL 8*). They may occupy the same position in the map-use cube, depending on their use.

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As the Web typically is a medium for private use, many cartographic sites can be found near the base of the cube. Through these sites, maps may actually be created by an individual user to suit his or her private needs. When these possibilities for online map creation are limited to the selection of an area, a projection method, switching layers of map details on and off, and the design of the symbols representing these details, including the selection of colors, we are dealing with medium interactivity and the presentation of known geographical data relations (*URL 9*). This implies a position near the middle of the bottom side at the back of the

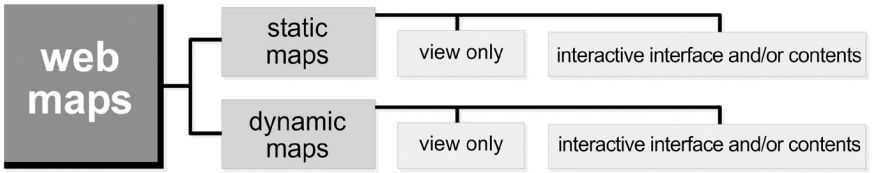

Figure 1. Classification of web maps (source: Kraak & Brown, 2001).

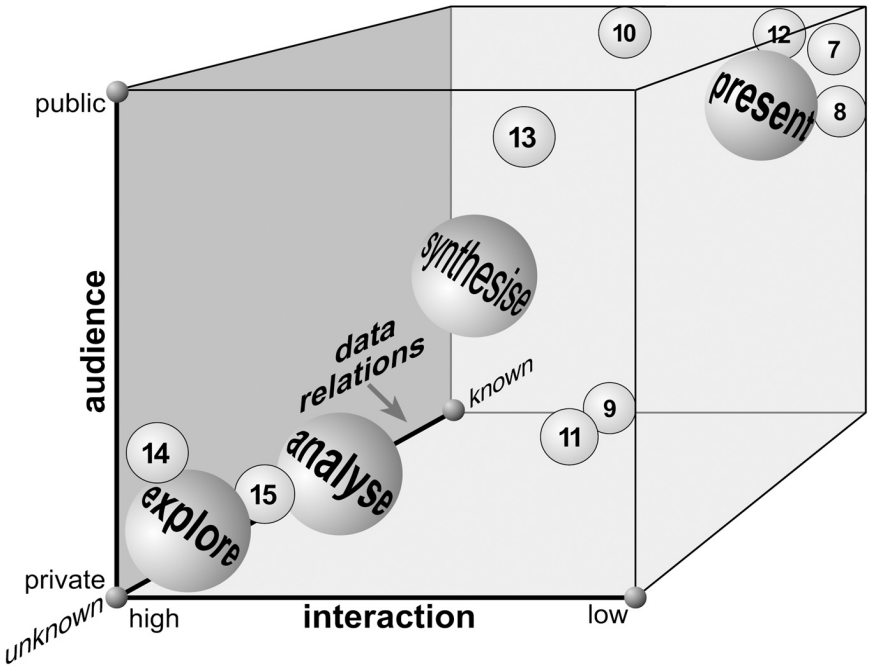

Figure 2. Goals of map use arrayed in the map use cube (source: MacEachren & Kraak, 1997). For illustration purposes, some of the examples (URLs) that are mentioned in the text have been positioned in the cube as well.

cube. In a sense, clickable maps or hypermaps for public use may also be regarded as a kind of moderate interactive map, occupying a high position near the back of the cube (*URL 10*). In other interactive maps on the Web, users may change the area portrayed through panning, or the scale through zooming (*URL 11*), and some user-friendly sites even allow the user to change the orientation of the map display (e.g. North or destination at the top of a route map).

The *presenting knowns* to *revealing unknowns* axis of the map use cube also reflects different conditions of map use through the Web. On the *presenting knowns* end, users know exactly what geographical information they want and often what map on which website supplies that information to them. For example, the site of the Dutch High-Speed Line Project (*URL 12*) contains maps showing the routes of the railway line. These maps may also be positioned close to the *present* ball in the map use cube. On the front side of the cube, we may find the Web surfers who may not know exactly what they are looking for and browse, for example, through one of the atlases on the Web. For instance, the Lycos World Atlas (*URL 13*) may be positioned somewhere near the middle/right of the top of the front side of the cube.

Currently, in web cartography, as in cartography in general, lots of interesting developments are taking place in the left hand bottom front corner of the map-use cube. This is the position of exploratory cartography: map use in the private (revealing unknowns) and high human-map interaction corner of the cube. Because of further developments in the client-server architecture, it becomes ever more possible for users of web maps to explore and really interact with certain geospatial datasets, while making use of modern cartographic visualization techniques in order to gain insight into these unknown datasets. In such cases, it may be possible to manipulate (e.g. classify) the data, choose different cartographic representation methods and visually compare the resulting map displays.

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As such, online visual exploration may be followed by downloading the geospatial data for analysis locally. In this respect, there are some interesting examples on the Web relating to the exploration of census data. The CIESIN DDViewer can be used to calculate statistics and explore the 220 demographic variables from the 1990 US Census (*URL 14*). In the United Kingdom, the KINDS Service Pages (*URL 15*) provide various search and visualization tools for national spatial data sets. The Cartographic Data Visualiser (CDV) (Dykes, 1998) and Descartes (Andrienko *et. al.*, 1999) are examples of the software used for online interactive cartographic visualization. Further developments may be expected at this side of the map-use cube, as the WWW environment is well-suited for interactive visual exploration.

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THE NEED FOR RESEARCH

With all these map use goals, the extremely important question is whether the maps that appear on the display screens during or after a WWW-session really are as efficient and effective as they could be. That is, do the users always get an appropriate answer to the geographical questions they have posed?

As cartographers have always done, web map designers must also take into account the purpose of the map and the needs and characteristics of its users. And, in view of the current potential for users to produce their own maps, this requirement also holds for the design of the cartographic tools offered to the users, as well as for the design of the web site's user interface.

One problem is that we hardly know anything about how people use web maps, or more generally, how people use the WWW to retrieve geographical information. In addition, we also do not know enough about who is using web maps. The user profile is becoming more and more diverse (see next section) and we need to know more about the different needs and different characteristics of the different user groups. In any case, the users themselves would certainly be helped if it could be made clearer which websites meet their requirements.

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To some extent, the required web-map use research is not different from map-use research that has already been (and still has to be) executed in other map-use environments (van Elzakker & Koussoulakou, 1997). For example, the answers to questions like when, why and how people are using maps in the exploration of geographical data are as much needed with stand-alone GIS as with WWW user environments. Likewise, the results of research into the perception properties of visual variables (including the new 'derived' and 'dynamic' ones) as applied to cartographic symbols are relevant in all circumstances in which maps are displayed on monitor screens. Knowing more about the specific backgrounds and characteristics of users, and which affect their ability to perceive and/or to comprehend the geographical information inherent in the map (e.g. age, previous education, existing knowledge and experience), would also be relevant for the design and development of cartographic tools for the Web.

Some aspects of map use may, however, be very specific to the WWW-environment and will have to be investigated separately. For example: What are the typical characteristics of the web search and surf process in which answers are sought to various geographical questions that are provided through maps? What is the role of the user interface in this process? What are the consequences of the volatility of the medium that is used by rather impatient users? And do the web maps generated by the users themselves actually provide the information required, or do they give

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cause for misinterpretations? Finally, what is the quality and reliability of the geographical information transferred through cartographic displays on the WWW?

In view of the very recent rise of the new medium, it is not surprising that, so far, hardly any web map use research has been executed. As usual, technical developments precede usability questions. However, a start has been made with investigating how maps are being used on the Internet. Examples are the work of Harrower *et al.* (1997) and the extensive customer survey and online user feedback option on the website of the National Atlas of the United States (*URL 16*, click the "Atlas Feedback" button) (also see Wright, 1999). Peterson (1997) also mentions the web map-use research associated with the development of the Alexandria Digital Library (*URL 17*). At this site, map use is being studied by examining the log files of web sessions. These files contain information on the types of maps that are accessed, how long they are viewed, what map is viewed before and after, and where the user clicks on the map. This kind of work should be followed by many more investigations of the use and the users of maps on the Web, so as to be able to develop more effective cartographic tools to better serve the needs of the users.

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USER PROFILES

There is a need to know more about who is using which maps on the Web and for what purpose. This need is becoming more and more pressing as the population of users is expanding and map-use goals are diverging. In 1997, we also did not know much about the use and users of web maps. However, we did know that the group of people who actually made use of the Internet was not very diverse at that time. Therefore, three years ago it was possible to state (van Elzakker & Koussoulakou, 1997) that the group of users of maps on the WWW could be defined as relatively young (15 to 40 years of age) males in Western countries with a high level of education, with an interest in science, technology and/or computers and with access to the Internet. Also, in view of the specific characteristics of the WWW medium, they were sometimes considered as a completely new generation of map users who were interacting with map displays in entirely different ways than 'traditional' map users. But still, because of the rather limited group of people actually connected to the Internet, it was not so difficult, in theory, to identify web map purposes and to adjust the cartographic web tools to the needs and characteristics of its potential users.

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There has been a significant change in the web user profile since 1997. User data are made available (not always free of charge) through several websites (e.g. *URLs 18*, *19* and *20*). These data show that the Internet now plays a role in all levels of education and is becoming more and more common in every home and business. In the United States, most users now access the Web from home, whereas they primarily did it from work in the early days (Kehoe *et al.*, 1999). Peterson (1999) reports on an investigation of people planning to get Internet access: almost half of them have only a high school education or less; and 58% of them make less than US$50,000 a year. The use of the Internet is democratizing, although significant segments of society still have not made it onto the information highway. International Data Corp. (IDC) expects that 62% of all adults in the United States will have Internet access by 2003 (CyberAtlas, 1999a). In the first quarter of 2000 in the US, the number of women online surpassed that of men (CyberAtlas, 2000a). At the same time, adults 55 and older represent the fastest-

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growing group of US Internet users (CyberAtlas, 2000b). For older people, the advantage of accessibility (as discussed above) is perhaps even more important than for younger people.

At least part of the world will undoubtedly follow the American example and demonstrate similar changes in user profile in the years to come. For instance, many European countries are catching up rapidly. As a consequence, there will be more and more different users of web maps with different needs and requirements. Some of these potential web map users may be regarded as 'new' users in the sense that maps now are much more accessible to them, and before they would normally not have considered buying GIS software. The Internet will make it possible for them to really interact with maps for the first time, so that all kinds of individual geographical problems may be solved much more efficiently and effectively than ever before. All this means that more and more attention should now be paid to adjusting the cartographic websites to specific user groups. For instance, the nature of the user interface and the possibilities for interaction cannot be the same for primary school children as for geoscientists exploring a geospatial dataset.

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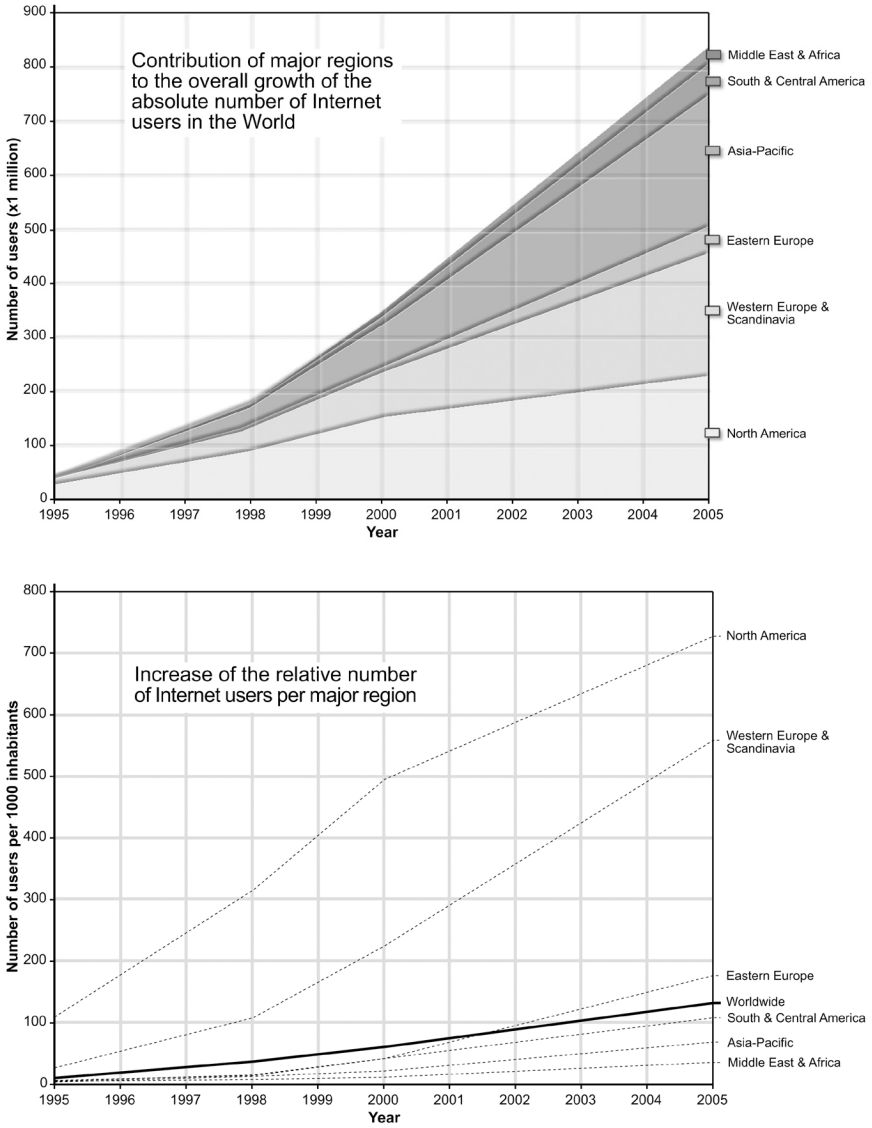

Figure 3. Worldwide Internet users 1995-2005 (sources: URL 21 & 22, *December 1999 & May 2000).*

It is not only a matter of a user profile that is becoming more and more diversified; the number of users of the Internet and people with access to the WWW is also still growing exponentially. A November 1999 estimate arrived at 259 million Internet users for year-end 1999 (CyberAtlas, 1999b), while a September 2000 estimate put the number at 374.9 million Internet users for the entire world for year-end 2000 (CyberAtlas, 2000c). Internet users are defined here as individual adults over 16 years old with weekly usage in their business and homes. The numbers are said to be 15-30% higher when occasional Internet users are included. Supposedly, the numbers would also increase if the use at schools and, for instance, in public libraries and cybercafés would be included. In any case, the number of users will grow rapidly in the years to come, particularly in regions with current low penetration levels (see Figure 3). At the same time, it should be realized that the number of Internet users expressed as a percentage of the total population of the world (see Figure 4) will still be rather low, even five years hence (*URL 22*: 13% in 2005). This is mainly a matter of the global diffusion of the Internet. By year-end 1999, for instance, 40% of the total world Internet users still lived in the United States. This figure will decline to 25% by the end of 2005 (*URL 22*).

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In our understanding of web maps and the dissemination of geo-spatial data, we not only want to know who the users are and how many there are, but also where they are. Figures 3 and 4 already give an indication of the number of users in the major regions of the world. In absolute terms, North America will remain the leading region for Internet users in the years to come, but the other regions are growing at a faster rate. Very interesting developments are taking place in some of these other regions, like the Cyberjaya project in Malaysia, stimulated by Prime Minister Mahathir. Cyberjaya is a digital city with a so-called e-government that uses no paper and exchanges all information through the Internet (*URL 23*).

Figure 5 shows the percentage of the population with access to the Internet by country. In this map, the different surface areas of the territorial units (in this case countries) have an unwanted effect on the perception of the global diffusion of the use of the Internet (larger countries tend

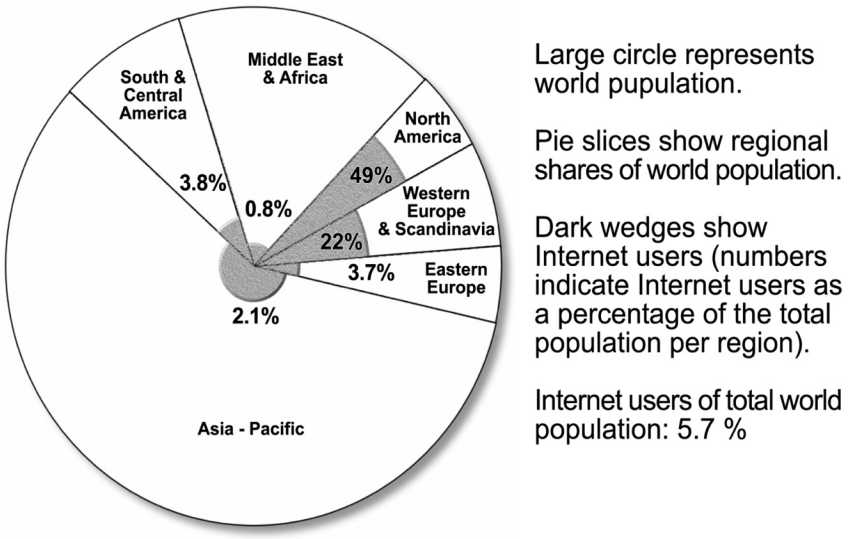

Figure 4. The portion of the world's population that uses the Internet, forecast for year-end 2000 (source: URL 21, *December 1999) (diagram conceptualised by UNDP, 1999).*

Figure 5. Number of Internet users as a percentage of the total population by country, 2000 (source: URL 24 *and CyberAtlas, 2000c).*

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to dominate, although their surface areas are not related to population numbers).

Therefore, Figure 6 is included here to show the absolute numbers of Internet users by country (using the same data sources as for Figure 5). The top 15 nations with the most Internet users at the end of 2000 are represented by means of separate proportional circles. All other countries (with less than 5 million Internet users) are put into classes. Together, the Top 15 nations account for about 82% of the worldwide Internet users. While all nations are now connected, the uneven distribution of Internet users (see Figure 6) and, consequently, web map users is striking. Factors that are mentioned (e.g. by Hargittai, 1999) to explain this uneven distribution are: economic wealth, level of education, English language proficiency, government policies (e.g. political or religious freedom, freedom of competition leading to differences in Internet access pricing) and existing telecommunication, computing and power facilities. In looking at Africa as a whole, for example, the low number of Internet users is not very surprising, if only because of the low literacy rates and the low number of fixed telecommunication (telephone) connections. And, it should also be realized that the Internet connectivity is often limited to one or two large cities within the countries (Press *et. al.*, 1999). It is sometimes argued, therefore, that the globalization that is partly brought about by the Internet is elite-based and at the same time leads to increasing global – and social – inequality (UNDP, 1999).

On the other hand, every country in Africa is now connected to the Internet (*URL 26*). Technical progress, in particular a rapid introduction of less vulnerable wireless means of telecommunication, may mean that the dissemination of maps and geospatial data through the WWW could contribute to the further development of this part of the world as well. In some African countries there are already more mobile telephones than

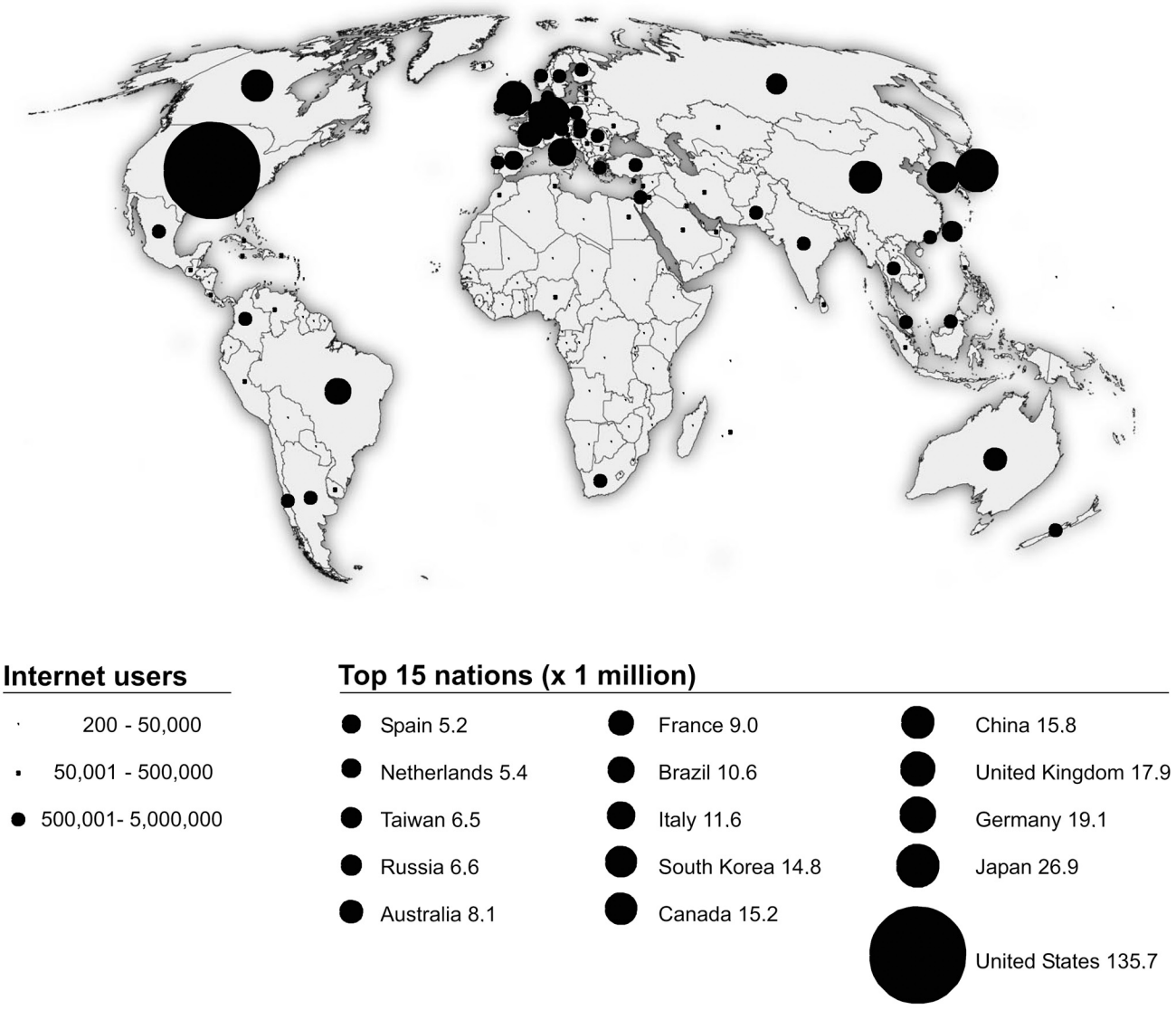

Figure 6. Number of Internet users by country, 2000 (source: URL 24 *and CyberAtlas, 2000c).*

fixed telephone connections, and soon it will be possible to have access to the Web through a mobile Internet (Stähler, 1999). In Europe, as in Africa, the penetration of the Internet is very unequal at the moment. The contrast between Western and Eastern Europe (see Figure 3) may not be surprising. There is also, however, a contrast between Northern Europe, where Sweden, Norway, Denmark, Finland, Iceland, The Netherlands and the United Kingdom all have more than 30% of the population with access to the Internet, and Southern Europe, where some Mediterranean countries (Greece, Spain and Portugal) have less than 15% of the population using the Internet (see Figure 5). In the Asia-Pacific region, Japan, China, South Korea, Australia and Taiwan already belong to the Top 15 nations in Internet use (Figure 6), and this will become the largest Internet region by 2005 (Figure 3). The growth in the number of people with Internet access in a country like China is exponential. Depending on the Internet policy of the government, and in view of the enormous number of people living in this country (1.25 billion), China may rise in the Top 15 rapidly. And this will also have consequences for the number of maps generated through the WWW.

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WEB MAP USAGE

In the past decades the need for maps has increased enormously in all parts of the world, as a consequence of, among other things, the growing number of geospatial relationships, greater human mobility, and more physical planning problems brought about by a more intensive use of land and water. It still remains to be seen what influence the exponential growth of the Internet, the corresponding increase in the time people will and may spend at their network stations, and the resulting globalization will have on the intensity of geospatial relationships and the related need for maps and geodata. In any case, there will be a need for maps of cyberspace. And, because of a better accessibility and actuality of web maps, the medium may also generate a greater interest in maps of all kinds (even paper maps!). It should be noted that with the introduction of the Internet and the WWW, we have witnessed an enormous increase in the number of maps that are actually produced and used. In quantitative terms, the Web now has become the major medium for the dissemination of maps.

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In the previous section, estimates were provided on total numbers of Internet users. Much data are also collected on the numbers of 'hits' on websites, for these data are used to attract advertisers or to assess how much a website can charge for advertising banners. The only problem is that these data are not made readily available because of the competition between commercial websites and because the data have now become a property, handled by separate and independent companies (Peterson, 1999). At the same time, there are many web-map sites that do not advertise and do not keep a record of the number of people that access their site, or use their maps (Peterson, 1997).

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MediaMetrix keeps up some rankings of websites that are hit by most users (*URL 26*). The rankings show the actual number of total users who visited the website once in a given month, whereby all unique visitors are unduplicated (only counted once). In the rankings, search engines, Microsoft sites and Amazon.com are at the top of the list. The highest specific web-map site, MapQuest (*URL 27*), is listed as number 38 on the March 2000 ranking with 5,572,000 different users (compared to rank 49 in November 1999 with 3,754,000 users). However, rankings like these do not give an indication of the total number of web map-users nor of the total number of web maps actually retrieved, generated or downloaded. For instance, maps are also an important means of information dissemination for sites like The Weather Channel (*URL 28*), listing as number 27 on the MediaMetrix ranking with 7,598,000 different users in March 2000 (November 1999: rank 39 with 4,677,000 users). But, we do not know how many of these users actually used maps to get information on the weather, how often they came back to the site, how many maps they used each time, nor how effective the maps were in providing the wanted information.

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In October 1998, only 10.4% of the 3291 respondents of a WWW user survey (Kehoe *et al.*, 1999) said that they never looked for a web map; 41.4% accessed maps less than once a month; 32.2% monthly; 14.7% weekly and only 1.3% accessed maps daily. Assessing the total absolute number of web maps that is produced and used is a very difficult task for reasons mentioned above. However, use data are available for some specific websites. And these data are sometimes very impressive. For example, as already mentioned above, in 1998 over 5 million web maps were interactively and dynamically created during 10 days of the Route du Rhum sailing race (Baumann, 1999). On average, there were 200,000 hits per day on the race's website. So, on average 2.5 maps were generated during each WWW session. MapQuest (*URL 27*) is consis-

tently mentioned as the number one web map-site in the world, or, as Crampton (1998) states, the biggest mapmaker in history. According to a MapQuest employee, there were 75.4 million maps drawn on the MapQuest site in November 1999 (Gebb, 1999). This would translate to 2.5 million maps a day or 1,750 maps a minute on average (and it would be much higher during peak hours). In November 1999, the MapQuest site had 16.6 million user sessions (cf. the figure of 3.7 million *different* users counted by MediaMetrix, as mentioned above). And this means that, on average, some 4.5 maps were generated during a user session. MapQuest is a very popular site, offering various functionalities and a lot of useful geographic information. However, perhaps the speed and ease of information retrieval are at the expense of the quality of the cartographic design. As a consequence, we may doubt their effectiveness. Web map designs that are better adjusted to the needs and characteristics of their users may lead to even higher hit rates, and stimulate growth in the overall popularity of maps as carriers of geographic information over the Web.

". . . there were 75.4 million maps drawn on the MapQuest site in November 1999 . . . This would translate to 2.5 million maps a day or 1,750 maps a minute . . ."

On the basis of information derived from selected sample sites like these, Peterson (1999) estimated that approximately 40 million web maps in total are used per day world-wide. This is a four-fold increase of the estimate he made in 1997. An even more dramatic growth of web map usage may be expected as a consequence of the predicted exponential growth of the overall number of Internet users.

PROBLEMS AND LIMITATIONS

For users, some limitations of web maps are not directly related to the WWW, but are a consequence of the computer nature of the medium (as opposed to traditional paper maps), such as limited portability, difficulty in manipulating the map (folding, turning, drawing or measuring on it), and limited display size, resulting in fewer possibilities for overview. In addition, screen and color resolution usually limits the amount of detail present on a monitor screen map. In these respects, paper media such as atlases still have some inherent advantages.

"For users, some limitations of web maps are not directly related to the WWW, but are a consequence of the computer nature of the medium (as opposed to traditional paper maps) . . ."

Another problem is that the creators of web maps do not have full control over the final appearance of these maps. Although they are stored in platform-independent formats (e.g. GIF, JPEG or PDF), they do not appear exactly the same for every user. The effects of the cartographic designs may differ greatly depending on the various output configurations used. Even when considering only PCs (and not the new Internet appliances like set-top boxes for online digital TV), there will be differences in the users' browsers and operating systems (which handle colors in different ways, for instance) and in the quality (e.g. resolution) of their graphic cards and display screens (e.g. LCD or CRT in different sizes). In addition, users are able to personally adjust their displays for resolution, contrast, brightness and color balance.

"Another problem is that the creators of web maps do not have full control over the final appearance of these maps."

A further problem is that some websites are not kept up-to-date regularly, causing users to lose confidence in these sites. What may be even more important is that, in practice, there are considerable limitations to accessibility. These limitations may be listed under the following headings:

"A further problem is that some websites are not kept up-to-date regularly . . ."

- Finding web maps and geodata
- Language
- Accessibility for everyone?
- Web maps and geodata for free
- Internet access, and
- Speed of data transfer

Many users of the web will have problems analogous to "drinking from the fire hose" (van Elzakker & Koussoulakou, 1997), i.e., finding the maps or geodata they need on the information-rich, but disorganised, WWW. A related problem is the volatility or continuity of the information: what appears in a site today might be gone tomorrow.

"Many users of the web will have problems . . . finding the maps or geodata they need on the information-rich, but disorganised, WWW."

Language also plays an important role in accessibility. Misspelling (e.g. of geographical names) may cause difficulties in finding the required web maps or geodata. And, although the Web is not limited by political boundaries, the worldwide dissemination of maps and geodata may be hindered by language. English is the dominant language on the WWW (*URL 29:* 86.55% of the web pages are in English), while only around 10% of the world's population understands this language. Besides, it should be remembered that some 22% of the world's adult population is still illiterate (UNDP, 1999).

". . . the worldwide dissemination of maps and geodata may be hindered by language."

Indeed, the WWW is not yet accessible to everyone. Even in societies with a literacy rate of (almost) 100%, certain social classes do not have access to the Internet. Figures 3, 4, 5 and 6 show that there are substantial geographical anomalies too. It seems that access is currently limited to people or areas with a certain economic wealth, a certain level of education and computer skills, (English) language proficiency, a favorable government policy, and the necessary equipment. Economic factors alone are perhaps the most important explanation for limitations in web access. An important point to remember, however, is that access to maps through the web is far greater than access to maps on paper, even for people who have limited access to the Internet.

". . . the WWW is not yet accessible to everyone."

Accessibility is fostered by the web through the availability of free geodata and web maps, although this may lead to problems with quality. However, pay web sites are proliferating, and getting web maps and geodata for free is actually an illusion. A web-map/geodata user must have access, and this now means having a powered computer with a modem connected to a telecommunications network. In addition to this hardware (and some software), the user, or his or her organization, has to pay for the telephone costs and/or an Internet provider. In some places, e.g. in developing countries, these costs are relatively high, but in other countries these costs are lower in order to attract as many new Internet users as possible. It also means that Internet access is still limited to places with a connection to a properly functioning, fixed telecommunications network, i.e. at home or at work. Therefore, obtaining maps and geodata through the WWW while away from one's base is not currently widespread. However, technology is developing rapidly, and it may be expected that the mobile (wireless) Internet will be commonplace within a few years.

". . . getting web maps and geodata for free is actually an illusion."

Finally, a current limitation to accessibility is the speed (and reliability) of data transfer over the Internet. For users, speed is one of the biggest problems in using the Web (Kehoe *et. al.*, 1999) and often it is the very advantage of a medium like CD-ROM for the dissemination of atlases, route planners, maps and geodata. The Internet Weather Report™ (*URL 30*) shows the performance of the Internet by means of animated maps for various parts of the world. The animations are based on time sequences and they show that the speeds of data transfer vary throughout the day. For example, the Internet is fast in Europe during the morning hours while most Americans are still asleep. But, of course, the speed also strongly depends on the technology available to each user, not just his or her own PC and the speed of the modem, but, for instance, also the capacity of the local telephone, ISDN or cable networks. Web maps and geodata usually come in large files and it may take a long time to retrieve or down-

"For users, speed is one of the biggest problems in using the Web . . ."

load them from the Web. Therefore, they are prone to the World Wide *Wait* syndrome of the many users who are rather impatient and unwilling to wait for maps to download. If technology did not advance, the problem would become bigger and bigger, because of the exponentially increasing use of the WWW. The reliability and speed of the Internet are, however, constantly improving, and it may be expected that many new technological developments will further increase the bandwidth and the speed of data transfer. Indeed, some people argue that speed is not a technical but an economic problem: the solutions are there, as long as the user is willing to pay for them.

". . . some people argue that speed is not a technical but an economic problem: the solutions are there, as long as the user is willing to pay for them."

CONCLUSION

Despite all the problems and limitations, it may be postulated that there is great potential for the further growth in the use of maps on the Web. There will always be a need for maps and the success of a site like MapQuest promises to increase map use along with the exponential growth in the number of Internet users. This growth is in great part due to the advantages of acessibility and actuality. However, further growth of web map use also depends on improvements in the effectiveness of web maps and cartographic visualization tools on the Internet. And, for that, more research into web map use and web map users will be required.

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NOTES

This paper is based on research that accompanied the development of two chapters for a book on 'Web cartography: developments and prospects', edited by M.J. Kraak & A. Brown, and published in October 2000 by Taylor & Francis (London) (ISBN 074840869X). These chapters (on use and users of web maps, respectively) contain many more references to sample websites plus sections on how to find and retrieve maps and geodata on the Web, economic aspects and web maps in geospatial data infrastructures. The sample websites and illustrations are kept up-to-date on the site that accompanies the book (http://kartoweb.itc.nl/webcartography/webbook/).

URLs

URL 1 The website of ITC's Division of Geoinformatics, Cartography and Visualization <http://www.itc.nl/carto/>
URL 2 Dutch Yellow pages <http://www.goudengids.nl/>
URL 3 Historical maps Bremen University <http://gauss.suub.uni-bremen.de/>
URL 4 Radar simulation precipitation in the Netherlands <http://weerkamer.nl/radar>
URL 5 Real-time traffic congestion map of Athens <http://www.transport.ntua.gr/map/>
URL 6 Prediction of traffic flows <http://www.traffic.uni-duisburg.de/>
URL 7 PCL Map Collection <http://www.lib.utexas.edu/Libs/PCL/Map_collection/Map_collection.html>
URL 8 Deaths from cholera in London, 19th July to 2nd October 1866 <http://www.geog.qmw.ac.uk/gbhgis/gisruk98/index.html#cholera>
URL 9 Make your own map <http://www.aquarius.geomar.de/omc/make_map.html>
URL 10 Clickable maps <http://www.britannica.com/bcom/eb/article/single_image/0,5716,367+bin%5Fid,00.html>
URL 11 Limited interactivity <http://www.lonelyplanet.com/dest/>

URL 12 Dutch High-Speed Line Project <http://www.hslzuid.nl/hsl/uk/intro-uk.html>
URL 13 Lycos World Atlas <http://versaware.atlaszone.lycos.com/>
URL 14 CIESIN Demographic Data Viewer <http://plue.sedac.ciesin.org/plue/ddviewer/>
URL 15 KINDS (Knowledge Based Interfaces to National Data Sets) <http://www.kinds.ac.uk/kinds/>
URL 16 National Atlas of the USA <http://www.nationalatlas.gov/>
URL 17 Alexandria Digital Library <http://www.alexandria.ucsb.edu/>
URL 18 Matrix Information Directory Services <http://www.mids.org/>
URL 19 IDC <http://www.idc.com/>
URL 20 UK Internet User Monitor <http://www.fletch.co.uk/content/monitor/method.html>
URL 21 Computer Industry Almanac, Inc. Internet users by region <http://www.c-i-a.com/199908iu.htm>
URL 22 eTForecasts Internet user forecast by country <http://www.etforecasts.com/products/ES_intusers.htm>
URL 23 Cyberjaya project in Malaysia <http://www.cyberjaya-msc.com/>
URL 24 How many online <http://www.nua.ie/surveys/how_many_online/index.html>
URL 25 African Internet connectivity <http://www3.sn.apc.org/africa/>
URL 26 MediaMetrix Top 50 <http://www.mediametrix.com/usa/data/thetop.jsp>
URL 27 MapQuest <http://www.mapquest.com/>
URL 28 The Weather Channel <http://www.weather.com/>
URL 29 Inktomi WebMap <http://www.inktomi.com/webmap/>
URL 30 The Internet Weather Report™ <http://www.mids.org/weather/>

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