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Usability Evaluation of Web Mapping Sites

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To identify the potential usability problems of Web mapping sites, four different sites were evaluated: Google Maps, MSN Maps & Directions, MapQuest, and Multimap. The experiment comprised a series of expert evaluations and user tests. During the expert evaluations, eight usability engineers and eight cartographers examined the Web mapping sites by paying attention to their features and functionality. Additionally, eight user tests were carried out by ordinary users in a usability laboratory. In all, 403 usability problems were identified during the trial and were grouped according to their severity. A qualitative description is given of these usability problems, many of which were related to search operations that the users performed at the Web mapping sites. There were also several problems relating to the user interface, map visualisation, and map tools. We suggest some design guidelines for Web mapping sites based on the problems we identified and close the paper with a discussion of the findings and some conclusions.

Keywords: usability evaluation, Web mapping site, Web map, user-centred design, cartography

INTRODUCTION

Recent technological developments have provided new tools and techniques for designing interfaces and interacting with Websites. Web mapping sites, or simply Web maps, are interactive maps that are accessed through Web pages (Mitchell, 2005). Consequently, many people use these sites for locating places and businesses, and for planning visits to unfamiliar places. Figures gathered from Web mapping sites' own Web pages give an indication of their popularity; one site states that it has over 40 million unique visitors each month (MapQuest, 2007), while another maintains a unique user base of over 10 million, ranking consistently in the top 10 Websites by traffic in the UK (Multimap, 2007). Web maps are often freely available and not only provide the map, but different map tools and map-related services.

However, the use of Web maps is not always straightforward. One reason for this may be that Web maps are used by a large number and variety of people, and the sites may not always fulfil all of the users' needs. Another reason may be changes in information and communication technology, leading to new methods for visualising geospatial data. Due to this, traditional map design and evaluation methods may no longer always be valid. Koua and Kraak (2004) crystallised this problem by stating that map use studies that have long been carried out in the field of cartography are not fully compatible with new interactive visualisations, which can have new representational spaces and user interfaces. So how can it be guaranteed that today's maps using different (new) technologies will fulfil user requirements?

Usability engineering – a term used to describe methods for analyzing and enhancing the usability of software – is an approach to help design products that take into account the new technical environments and user requirements (Nielsen, 1993). Usability is defined in the ISO 9241 standard as 'the effectiveness, efficiency, and satisfaction with which specified users achieve specified goals in particular environments' (ISO, 1997). The ISO 13407 standard gives instructions to achieve user needs by utilising the User-Centred Design (UCD) approach throughout the entire life cycle of a system (ISO, 1999). Making systems more usable may have noticeable benefits for users by guaranteeing easy-to-use systems, which are less stressful for the user and therefore more acceptable. A user-centred design can provide financial benefits for the system developer in reduced production costs, reduced support costs, reduced costs in use, and improved product quality (Earthy, 1996).

Several researchers have observed the lack of thorough usability engineering in cartographic visualisation and geovisualisation, for instance, MacEachren and Kraak (2001), Fuhrmann *et al.* (2005), van Elzakker (2005) and Nivala *et al.* (2007). The aim of the present study was to identify potential usability problems of Web mapping sites in order to provide guidance for the future design of such services.

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Previous usability evaluations of on-screen maps

Previous research on the usability of Web mapping sites seems to be rare. However, several usability evaluations have been carried out in relation to other on-screen maps. Beverley (1997) studied the benefit of a dynamic display of spatial data-reliability from the user's point of view with a test using map data for decision-making that included both novices and experts. Harrower *et al.* (1997) evaluated the design elements and communication quality of Internet maps for tourism and travel in a user survey. Studies have also been conducted on map animation and interactive tools (e.g. MacEachren *et al.*, 1998), learnability, memorability, and user satisfaction with specific geovisualisation tools (Andrienko *et al.*, 2002), and on the usability of zoomable maps with and without an overview map (Hornbaek *et al.*, 2002).

Arleth (1999) studied the problems of screen map design and listed a few of them, for example, the map area was too small and both the legend and instructions too dominating on the screen. Leitner and Buttenfield (2000) investigated the effect of embedding attribute certainty information in map displays for spatial decision-support systems by having test users perform specific tasks with test maps. Harrower *et al.* (2000) adopted a focus group method with structured user-testing to find out how novices understood and used the geovisualisation tool that had been designed to support learning about global weather. Ahonen-Rainio and Kraak (2005) described a study that included iterative design testing with map prototypes for visualising geospatial metadata.

Agrawala and Stolte (2001) studied how route maps are used, analyzing the generalisation commonly found in hand-drawn route maps. Climate forecast maps were evaluated by Ishikawa *et al.* (2005), who concluded that in many cases, qualified and motivated test users failed to interpret maps in the way that the designer had intended. Richmond and Keller (2003) carried out an online user survey to assess whether maps on tourism Websites met the expectations of users. Van Elzakker (2004) carried out user tests in order to investigate how maps were selected and utilised by users exploring geographic data. Similarly, Koua *et al.* (2006) studied test subjects' ability to perform visual tasks in the data-exploration domain, and emphasised that use and usability assessment is an important part of understanding visual methods and tools for data exploration and knowledge construction. The UCD approach also played a central role in the development of the Atlas of Canada Website (Kramers, 2007) and considered as the factor responsible for increased user satisfaction and growth in its overall use.

The usability evaluation of Web maps, similar to the study presented here, was carried out by Skarlatidou and Haklay (2006), who arranged workshops for assessing the usability of seven public Web mapping sites. In their method, users carried out six to seven tasks with the sites. Qualitative data was gathered through the 'thinking aloud protocol' and questionnaires and quantitative data by measuring the total time each user was performing each task, as well as the total number of clicks. Through measuring the users' performance, Skarlatidou and Haklay drew conclusions on which sites were the most and least usable and discussed the qualitative findings of their evaluation.

METHOD

The aim of this study was to identify potential usability problems with Web mapping sites and gather qualitative information to suggest guidelines for the design of future sites. Four different Web mapping sites were evaluated in this study: Google Maps (abbreviated in this paper as GM, available at http://maps.google.com/), MSN Maps & Directions (MD, http://maps.msn.com/), MapQuest (MQ, http://www.mapquest.com/) and Multimap (MM, http://www.multimap.com/). These well-known sites were chosen because they all consisted of an interactive 2D map application with zooming and panning options. Additionally, users were able to search for different locations and directions for routes.

Procedure

Several experiments were carried out in order to identify as many potential usability problems with the chosen Web maps as possible. First, a typical scenario for using these types of sites was drawn up: 'A tourist is planning to visit London and uses a Web mapping site for planning the trip beforehand'. Part of the evaluation was conducted as a series of user tests (with eight 'general' users), with the other part involving the evaluation of the maps by experts (eight cartographers plus eight usability engineers). Altogether, 24 participants were involved and 32 different evaluations were carried out. Thus, each of the four Web maps was evaluated by eight separate participants (four test users and four experts). The experiments were run in a Windows environment using either desktop or laptop PCs. Evaluations were carried out from August–September 2006 and the results presented here are based on the content of the Web mapping sites at that time.

User tests

Before the test, users completed a background information questionnaire. Eight test users were involved in the evaluation (five males, three females), with ages ranging from 19 to 35. With the exception of one person, all users had previous experience of using several different types of maps (topographic maps, road maps, city maps, Web maps). All of the users regarded their map-reading skills to be fairly good or excellent.

The use scenario was described to the users at the beginning of the test. Following this, the test instructor gave the users one pre-defined task at a time, which they would try to complete by using the Web map (Table 1). The participants were given a Web map site that they had not used before. The users were then encouraged to 'think aloud' and describe the reasoning behind their actions. During the tests, the computer screens were recorded with a video camera to support subsequent data analysis.

Expert evaluations

Sixteen experts (eight cartographers and eight usability engineers) were involved in the evaluation (eight males,

eight females), with ages ranging from 23 to 45. The term 'expert' here means a postgraduate student in cartography or usability engineering or a person who has already worked as a cartographer or usability specialist. The expert evaluators were given the use scenario and a list of typical user tasks (Table 1) and asked to go through the Web maps carefully, and, by using their own expertise, write down all the problems they encounter with when performing the same tasks as the users in the user tests. The experts were asked to list all the usability problems found and send them to the conductors of the experiment as a text document.

Analysis

The video data from the user tests were analyzed by writing down everything that the users had problems with and/or commented as a problem in some way. The same was done with the expert evaluations and all the negative findings were picked up from the evaluation reports. In the following, the term 'usability problem' means an individual problem, which was identified either from the user test or from the expert evaluation.

Usability problems were grouped under four different categories (1–4) according to the severity of the problem (categories modified from Nielsen, 1993) (Table 2). To make the rating more objective, a conductor of the experiment judged the severity of each problem together with one cartographer and one usability expert.

RESULTS

Altogether, 403 usability problems were found with different evaluation methods (Table 3). The number of problems here means the number of all the problems found with different methods. However, some were found with different methods, so the number of unique usability problems with each Web map is less than the total number of problems. In total, 343 unique problems were identified: 69 in Google Maps, 83 in MSN Maps & Directions, 92 in MapQuest and 99 in Multimap (Table 3).

Severity of the problems

Although the total number of usability problems gives an indication of the usability of the site, the severity of the problem also plays an important role. In total, 33 catastrophic problems were identified (severity category 1), in addition to 138 other major problems (category 2), 127 minor problems (category 3) and 44 cosmetic problems (category 4). From GM only one catastrophic problem was found, whereas MD and MM generated the same number of the most serious problems (13). GM also had the smallest amount of major problems (21) (Figure 1).

USABILITY PROBLEMS AND DESIGN GUIDELINE SUGGESTIONS

The usability problems were grouped under four different categories according to which part of the site they belonged to: 1) user interface; 2) map; 3) search operations; and 4) help and guidance provided to the users in an error situation. The following paragraphs give examples of the most typical problems, followed by a reference to the Web mapping site(s) in which the problem was encountered.

Table 1. Usability evaluation tasks

	Task Description
1	You are planning to visit London during a weekend. Identify the most ideal location for a hotel by using the map site. Describe the reasons behind your choice.
2	Show the same place you chose during the previous task (the screen view returned back to the start page).
3	Find Roupell Street in London and point it out on the map to the test instructor.
4	Find the most northerly street in London with 'smith' included in its name.
5	What is the distance between Buckingham Palace and Piccadilly Circus?
6	Show the route that you would use if you were to walk from Sumner Road to Gresham Street.
7	Find London Bridge.

Table 2. Usability problem classification according to its severity to the use situation

Rating	Description	Effect on map usability
1	A catastrophic usability problem	May even prevent the use of the application.
2	A major usability problem	Makes the use of the application significantly difficult.
3	A minor usability problem	Makes the use of the application somewhat difficult.
4	A cosmetic usability problem	Prevents the feeling of a finished design.

Table 3. The number of usability problems found from different evaluation methods

	User tests	Cartographic experts	Usability experts	No. of problems	No. of unique problems
Google Maps (GM)	38	17	25	80	69
MSN Maps and Directions (MD)	57	21	18	96	83
MapQuest (MQ)	50	26	32	108	92
Multimap (MM)	71	32	16	119	99
Total	216	96	91	403	343

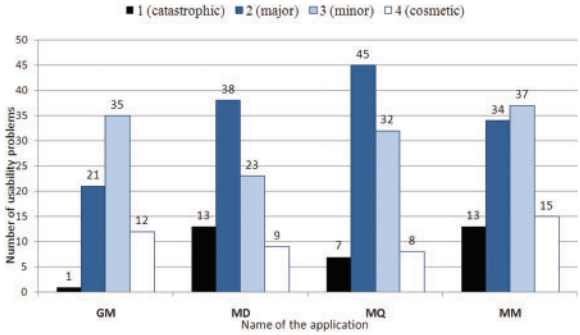

Figure 1. Distribution of the severity of usability problems in each Web mapping site

However, the discussion in the following does not take into account how many users experienced each of the usability problems, as it is not the focus of this paper. Preliminary suggestions for design guidelines are given at the end of each category. While some of the guidelines may be 'self-evident' among map designers, the fact that problems emerged during this evaluation suggests that some aspects were not as evident for the designers of these specific Web mapping sites. The words 'participant' and 'user' in the following mean either test users or expert evaluators who participated in the study.

The user interface

First impressions are important when entering Web mapping sites. Despite this, there were a lot of problems relating to 'start pages' and user interfaces (UIs).

Layout

In many cases, the home pages of the Web maps appeared to be overloaded with different types of information (advertisements, links, images), and the users commented that these looked messy and prevented them from finding relevant information (MD, MQ, MM). Some of the links (e.g. school and insurance sites) were considered irrelevant for ordinary tourist users (MQ, MM). Users were also confused about inactive image links that did not seem to have any purpose (MD). Distractive animations were considered very annoying (MM). Some home pages were criticised for not indicating that they actually were about maps at all, i.e., there was no image or preview of a map (MD, MQ). It was also remarked that some of these sites seemed to be more interested in drawing user attention to different advertisements than actually helping them to find locations (MQ, MM).

The overall layout of the UI was also criticised. For instance, the search box was considered too small and its location wrong because it was not in the centre of the screen (MQ). Some users did not notice the search box during the first 5–10 minutes of trying to find something on the map (GM, MM). The grouping of the map tools, search boxes, and general UI tools was also criticised because function buttons were distributed all over the screen (MM) and advertisements placed disturbingly between some of the function buttons and the map window (MM).

Functionality

Where links in the UI opened in the same browser window as the map (MM), which was then easily lost, this was considered to be a problem. In the home page of one Web map there were three different maps that looked like links, but when the user clicked on the UI nothing happened, and there was no clear feedback as to why not (MM). In some cases there was no quick way back to the home page; the user had to click the back-button many times to get to the main menu (MD). With one Web mapping site, taking the bigger map view caused all the other functions to be pushed away from the screen, forcing the user to scroll the window to use them (MD).

From the analysis of feedback from this part of the experiment, several design guidelines are recommended. These are provided in the following section.

Design guideline 1: the user interface

Layout

- The home page should be clear and simple.
- Intuition is important; the user should be able to start using the map immediately when entering the page.
- There should be a modest number of adverts and animations and these should be located in such a way that they do not disturb the user.
- Information presented on the UIs should be placed logically; attention should be paid to the grouping of the various tools.
- The search box should be given a principal role in the layout.

Functionality

- Links in the UI should not be opened in the same browser window as the map.
- There should always be a short cut back to the home page.

The map

The map was naturally the main focus of these sites. However, in sites where the actual map took quite a small amount of the space on the Web page (MD, MM), this was criticised, as it made it difficult to get an overall picture of a location. There were also many problems related to map visualisation and tools.

Map visualisation

Maps were criticised for looking like they were designed to appear as paper maps instead of Web maps, because their visualisation was messy, confusing, restless and awful to look at on a computer screen (MD, MM). Some maps were regarded as being quite sketch-like (MM), old fashioned (MD), or the map projection looked weird to the participants (MM).

The use of colours was also criticised. For instance, the background colour of built-up areas was considered unreadable and the text was not optimal in contrast (MD); similar colours made it difficult to distinguish between shopping areas and hospitals (MQ); and some

colours were considered to be unintuitive (MQ: built-up area). Colours were also criticised in general (MM: scale 1:50 000) and in specific cases (MM: a motorway illustrated with a blue line – 'Looks like a river').

Some maps were overloaded with information and/or colours at certain scales (GM: overview map of London; MM), while others just looked unpleasant 'As if there were no cartographers involved!' (MQ). The categorisation of streets for different scales was also thought inappropriate in some cases (MQ). On the other end of the scale were comments that the map was too general (MD, MQ) and, for instance, that the information on the overview map was not sufficient to support decision-making because street names, etc., would be needed (MM, MD: on the fifth-closest zoom, only the names of biggest sites and on the second-closest level, only a few street names were visible).

There were also problems with the text on the maps; the placement of the text was poor (GM, MD), the text was not legible (GM: hybrid map; MD), or the font size was too small for a Web map (MM). Some street and district names were also messy at the biggest scale, so the user could not read them (MD).

Some symbols caused problems because they 'stood out' in relation to the other symbols, especially if it was not clear what they were and why they were emphasised (MD, MQ, MM). Sometimes the users tried to click or point at the symbols to get information about them (MD). On a small-scale map, the names of towns, etc., looked like links from users' point of view, but did not work as such (GM, MM). Many symbols were also misinterpreted (red squares on MM; train tracks on MD).

Some maps also generated problems at different zoom levels. For instance, some symbols (MD) or text (MQ) appeared and disappeared randomly with different scales; the step between map scales was too large (MQ); and in many cases, the visualisation between different scales was distinctively different (MD, MQ, MM) (Figure 2). This made it difficult to keep track of a specific location and to make a connection between different scales.

The information included in the maps was criticised as being insufficient, especially regarding public transportation (railway stations, airports, timetables, etc.) and different types of tourist attraction, points of interest, and landmarks (GM, MD, MQ, MM). In terms of completeness, the data were considered to be inconsistent; some airports and hotels were shown on the map from a specific location, while others were not (GM, MM). This gave rise to questions such as 'Who decides what is included or not in the map?'; 'Is it based on who is paying, e.g. their hotels to be listed for user queries?' Some participants commented that because of this, they did not know whether the data was valid. Data accuracy seemed to be insufficient also when one participant commented that the 'hotel search' gave the same distance to several hotels, which in real life were not close to each other (MM). Sometimes it was impossible to find information about where the map data was from and when was it gathered (MQ).

Map Tools

There was either no legend for the maps, or the participants were not able to find it (GM, MQ, MM, MD). Some users had problems realising that they could actually perform searches on the map (GM, MM). Estimating distances was also difficult, mainly because some of the users did not realise that there was a scale bar (MD, MM). One scale bar only showed miles, while some of the users only understood the metric system (MM). It was also criticised that the scale bar could only be used for a rough estimation of distance (MD, MM). Some users wanted a grid in the map for comparing different locations and estimating the distances between them (GM, MQ).

Figure 2. Four different visualisations from the same location when zooming-in from zoom level 5 to level 2 in Multimap (maps from top to bottom; accessed April, 2007). Reproduced by permission of Multimap, Tele Atlas NV, HarperCollins, and Ordnance Survey. Based on Ordnance Survey mapping © Crown copyright. AM 53/08

Mistakes in design were also observed. For example, the map-size buttons did not work if a route was shown on the screen, although they appeared to be active buttons (MD). At times, parts of the map were covered by zoom buttons and scale bars (GM). The scale bar was also considered to disappear on the map window because it was so tiny (MQ, MM) and/or poorly designed (MM). Some participants criticised the lack of an option to customise the map by checking 'boxes' to show or hide different data layers or symbols on the map (GM, MD), especially because some of the maps were overloaded with so many different objects (MM). An option to highlight various classes of object (e.g. tourist attractions, hotels, restaurants) was also called for (MQ).

In addition, a link to print the map was missing (MQ, MM), as was an option to save a search or system state and thus return to it easily (MQ). A route direction tool 'from here to' was also required (MM), as was an indication of north (MM). Users also wanted to add markers to the map in order to make re-finding a certain location easier (MQ). Some sites provided an option to change the map area, but either users did not realise this or did not understand how it

worked (MD). It was also annoying for the participants that the setting for the map size was not retained for the next query (MD).

Panning was sometimes considered problematic and too slow when there was a discrete click to scroll the map (MQ, MM). If there was no feedback, users often thought that they had missed the button the first time and so they clicked it again. Participants were also confused about the different types of zoom setting and their relationship with each other (MM). One user did not realise that there was a zoom function at all (GM). Sometimes the zoom function was criticised as being old fashioned (with scale numbers) and confusing for ordinary users (MD, MM). Zooming was also considered problematic when there were neither steps nor animation when switching between different zoom scales (MD, MQ), because users lost the location that they were looking at earlier. With one site, zooming moved the search result out of the map window because the search result was not centred on the map when starting off (MM).

Some participants would have liked to point at the area into which they were interested in zooming (MD). It was found confusing that the map could be zoomed by clicking on it, as the cursor did not change when it was pointed at the map (MD). It was also considered annoying that clicking on the map did not just centre the view, because it always also zoomed in (MM). It was surprising to the users that clicking on the map re-focused and re-centred it, when they only wanted to point on it (GM). Accidental zooming also occurred when participants used the scroll wheel of the mouse when they wanted instead to scroll down the search results window (GM).

From these results, a series of design guidelines were developed that relate to the map. These are provided in the following section.

Design guideline 2: the map

Visualisation

- The map should be visualised according to the properties of the computer screen.
- The map should be optimised for viewing on a computer screen.
- Maps should be simple and intuitive and pleasant to use. Colours should be in harmony.
- Each map scale should be considered separately: what information should be included and how it should be visualised at each of the scales.
- Information about data accuracy and validity should be provided.

Map Tools

- Map tools should be distinctive, but not obscure too much information on the map.
- A route-measuring tool would be beneficial (in addition to a scale bar).
- New tools would be beneficial for users: an option to add markers on the map; to click on different objects in order to get more information about them; to customise the map by checking 'boxes' to show or hide different data layers or symbols on the map (e.g. tourist attractions, hotels, restaurants); and incorporate an easy way to print and email the map.
- The scale bar (and other) units should be customisable.
- A continuous click-and-drag option would be best for panning.
- Scale increments should not be too great, allowing users to follow a specific location while zooming in and out.
- Scale numbers (ratios or representative fractions) should not be used. Instead, scale should be indicated by more commonly used terms (such as street level, city level, country level, etc.).

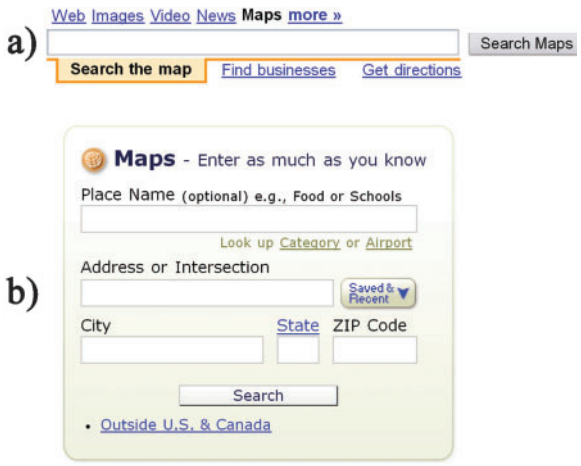

Figure 3. Different types of search possibilities with Web mapping sites (accessed April, 2007): a) Google Maps (© 2007 Google); b) MapQuest (© 2008 MapQuest, Inc. MapQuest and the MapQuest logo are registered trademarks of MapQuest, Inc). Used with permission

Search operations

A significant number of usability problems were found relating to queries and searches for different locations and objects on the maps.

Search Criteria/Logic

Of the four Web mapping sites used in this study, one site was different from the others in that it supported a 'free search', whereby the user could type their search criteria more liberally in one or two search boxes (GM) (Figure 3a). The other sites provided users with different search boxes, each requiring a certain kind of text, e.g. country, address, place name, etc. (Figure 3b).

Both search types had their positive and negative elements. The free search was liked because it is the way people normally find information when using search engines. However, it was also considered to be confusing: 'What can you really search? And how?'. For example, one user typed in the search box 'road1 to road2' and then pressed 'get directions', but got no results (GM). It was also commented upon that minimalist thinking is being taken somewhat too far; users may like to have access to at least some shortcut buttons (instead of always having to search).

The positive elements of the other search type (MD, MQ, MM) were that people are more used to having

separate search boxes for 'location', 'directions' and 'businesses' with Web maps, and most of the time people also know what to type in each search box. On the other hand, the boxes were not very flexible and often required the data to be typed exactly in the correct way. For example, a specific operation such as 'Find a place' can be misleading when asked ''what does 'a place' actually mean?'' (MD).

It was observed that the users wanted to make not only one search at a time, but also several separate searches simultaneously (multi-searches), so that the different objects would appear on the same map at the same time (GM, MD, MM). Moreover, people did not know whether or not the search they carried out was only going to include the area currently shown on the map (GM, MM).

Another criticism was that the only way to search for addresses or directions was via entering text, whereas it would be helpful to have the map as an interface as well, i.e., to be able to click on the map for start/end points of a route (MD). Searching for addresses was also not always easy; for example, if an address was entered street name first, house number second – as is the norm in central Europe – no results were found. Hence, the user needs to know that in the UK, the house number is placed first for an address (MD). Users were also frustrated by not being able to search for anything else other than addresses (i.e. places, MQ).

Default Settings

The severe usability problems encountered most often related to the default settings of the Web mapping sites, which, in the worst case, prevented some of the participants from using the sites. For example, if the user typed 'London Bridge', the site would only give results from the USA (GM), because the participant did not notice the USA default, or did not know how to change it (MD, MQ) (Figure 3b). It was considered especially frustrating that the search box always went back to the default settings – even though users had already changed the country to something else (MD, MQ). However, some steps were in fact sought after as default settings, for example, when choosing 'UK' as a 'start' for a direction search, the country at the 'end' should automatically change to UK too (MD, MQ).

Search Results

Often, the participants did not know how the search results matched their search criteria. On one site, the user typed in 'The London Bridge' and the search returned 'The Bridge', which was not the required result. The user had to accept this because if only one result matches the search criteria, the result is shown on the map without any explanation of how it matched the search (GM). On another occasion, the user got a list of 'Londons' in the USA and did not realise that these were not in the desired country (MQ). The participants also tried to use two or more search criteria at the same time and often got a map with the result displayed (MM). However, this was not always the correct result, since it sometimes returned only one search criterion. The users did not always realise this, because it was not pointed out to them where the result came from and/or how it had been deduced.

The participants remarked that the search results were sometimes 'weird' and that there was no help available to explain where they had come from. The users had to be sure about what they were looking for because some searches gave a number of incorrect results, even though the search was very well defined (e.g. 'Big Ben' gave results everywhere else except London) (MM). Search results were even more confusing when they were based on similar-sounding place names; 'London tower' gave the result 'Lake Teterower' (a lake in Germany) and 'Longbridge' in Birmingham (MD). One user got 25 results for a simple search, because everything that included the searched name or even sounded the same was included ('Tussaud' resulted in 'Tosside' and 'Thickwood'; 'train' resulted in all the names starting with 'tr' and 'th') (MM). It was difficult for users to figure out why such results appeared in the results of specific searches.

Performing route queries became problematic when users did not know which of the search results was the start or end points on a map of their route (GM). It was also criticised that users could not easily change the start or finish of a route already shown on the screen (GM, MD). For 'directions search' the participants would have liked to have all the possible choices (results) for the end and start to be shown on the map to help choose between them (MM).

The users did not always like, or realise, the fact that one site made the route suggestion automatically based on the previous road search (MQ). It was also confusing that when users searched for a route they got the result as a text description, not as a map as they had expected (MQ) (to see the route, users had to scroll the view). Some participants also wanted multi-stop route searches, enabling them to search for routes from A to C via B (MM, MQ). More choice for customising routes was also required: quickest, shortest, and with different transportation modes (GM, MD). It was also noted that it would be good to be able to search for businesses (e.g. restaurants) along a specific road or route (GM, MD).

Criticism of the visualisation of search results, for instance, when a street result was visualised with a pin (usually used for a single location) instead of linear highlighting (GM, MD) was also present. Comparing different search results was considered difficult, because they were not shown on the map at the same time (GM, MD) or because they were shown in different scales (MD, MM). Sometimes, the users had to open another map window to compare a distance between two locations (MD).

The search results were occasionally shown on the map on top of each other, so that the users were not able to see them all (GM, MM). One site centred the map according to the result without any visual emphasis of its location (MD). The users did not realise that this was a result, especially because not even its name was visible (five zoom-in operations would have been needed to see the text) (MD, MM). The same problem occurred when searching for routes (MD) and roads (MQ) where the results were presented at a scale where they could not be seen.

The search results were also easily lost on a map (GM, MM). The users commented that there should be an option

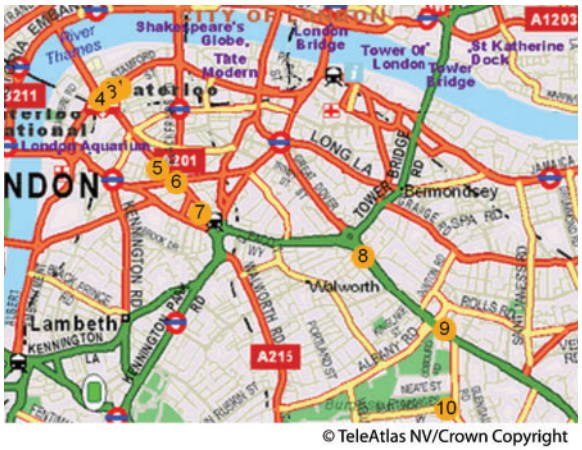

Figure 4. Route visualisation with turning points on top of each other in Multimap (accessed April, 2007). Reproduced by permission of Multimap and Tele Atlas NV. Based on Ordnance Survey mapping © Crown copyright. AM 53/08

allowing a quick return to the search result instead of constantly having to click back to the search page (MQ, MM). With one site, the zooming did not work when clicking the search result, but only when clicking around it, and the user thought that zooming was impossible (MM). With one Web mapping site there was no route shown after performing a directions search, only points indicating where to turn, and these were considered difficult to read (MM, Figure 4). More dramatically, the route visualisation changed between map scales (MM). Sometimes the search results were given on the same scale as the map preceding the search, therefore the whole route was not always shown on the map (MM). The lack of an option to print out the visualisation of the route was criticised (MM), as it was considered a common task.

A number of guidelines related to the search operations were proposed as an outcome of these evaluation results and are provided in the following section.

Design guideline 3: the search operations

Functionality

- Different types of searches should be supported.
- Users should know with what type of criteria the search is carried out.
- A list of users' previous searches should be saved and provided to them.
- It should be made clear to users what the search results are based on and how they relate to the query.

Visualisation

- The results should be centred on the map and distinctively visualised, taking into account the symbols that are already in use on the map.
- The result symbols should not cover the map too much and be on top of each other.
- The defaulting map scale should give enough information for the user to check whether or not the result is correct.
- It would be beneficial to show all the possible results on the map, so that the user can choose the correct option among them.
- Street and route search results should be visualised with a line.
- Route search results should be displayed on a tailored map scale so that the user sees the entire route.

Help and guidance in an error situation

Error situations are often inevitable with map sites because users may, for example, search something that does not exist in the database. It was observed that, in some situations there was no proper help available. Instructions on how to start using the Web map were missing from some sites, or the existing instructions were not considered useful (MQ, MM).

Some error messages did not look like a message and users did not notice them appearing on the screen (MM). If the error message was given clearly, it was not always informative (GM, MM). Some of the sites did not provide any help (or the users did not find it) for using the map (GM) or for looking for streets and directions (MQ). Some sites gave examples for help in using the searches, but they were also confusing: the help text 'in London' worked only for businesses (such as 'curry in London'), but not for street searches (GM). Sometimes the 'help' was not what the user expected; the user needed help for finding locations but only got a legend for tools (MM).

Design guideline 4: help and guidance

- The user should be provided with help in map use and in other functions in the site.
- Error messages should be clear, informative and distinctive.
- Users should be informed of current default settings and how they can be changed.

DISCUSSION AND CONCLUSIONS

By identifying pitfalls in existing Web maps, it is possible to offer recommendations on how to design Web mapping sites that are easier to use and attractive to different groups of users. A possible bias in this study, however, may be drawn from the fact that the Web maps included in the evaluation were well known and widely used. It might therefore be expected that such sites have fewer problems than more unfamiliar applications as a result of their popularity. The evaluation of the Web mapping sites nevertheless identified a considerable number of severe usability problems. If these were typical for Web maps that are in use every day and by large numbers of people, it would be interesting to investigate the usability of smaller, less familiar map applications. While this study did not seek to do so, the topic should nevertheless be investigated in future.

Even though many usability problems were identified, some of the problems may have been exacerbated by the

tasks chosen for this study. Different sites can have different objectives, and the use-scenario may not have corresponded exactly to that for which these sites were originally designed. In fact, some of these Web maps may not have been designed for use by tourists. This uncertainty should be kept in mind when considering the results of this study.

As map sites are unquestionably visual in their nature, distractive advertisements and messy user interfaces were criticised. A map that frustrates the user from the very beginning may cause very negative feelings towards it. Some of the users actually stated that in a real-life situation they would have given up trying to complete the tasks with some of these sites and tried another Web map. This is important, as it may be that the product developer who can design the most usable application, will win the battle for market dominance.

Some of the Web maps have been in existence longer than others, which may have biased the results of this study. Some users may have been attracted by newer ideas and these might have received more positive comments because of that. On the other hand, some of the users valued traditional types of services because they are used to them. This was especially obvious when the different search criteria of the sites were discussed. Some people have been used to making Web searches with search engines, and they also wanted to carry out map searches in the same 'free' manner. Others needed more structured or guided searches. The challenge remains to design sites that different types of people can use without getting frustrated or without facing a lot of problems in using them.

Another challenge is that some of the participants had hardly used any types of maps at all and, for them, the use of these sites was especially difficult; some of the users did not even realise that the map scale could be changed or that searches could be carried out for different objects. This is understandable, since Web maps deal with complicated spatial data and may allow a high degree of interactivity between the user and the site. How can we help ordinary Internet users to realise the variety of map sites and their functionality and benefit from their use? The observed lack of guidance within these sites does not help in this situation.

The Web maps often offer links to different additional services (such as hotels and tourist attractions), which either have their own map interface or no map at all. If a user wanted information on how to use the underground rail network to get from one tourist attraction to a hotel, at least three different maps and services had to be opened at the same time: an underground route map, a map with hotels on it, a map with tourist attractions on it, and perhaps even a base map for combining all this information. If all of these have their own maps with different scales and visualisations, users will find it difficult to combine the information. The best solution would be to have all these embedded within the same map service, or to have harmonised maps between different services, but it is clear that this requires further study.

BIOGRAPHICAL NOTES

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