I

Laakso, M., Sarjakoski, T. and L. T. Sarjakoski, 2011. Improving Accessibility Information in Pedestrian Maps and Databases. Cartographica, 46(2): 101–108. DOI:10.3138/carto.46.2.10.

INTERNET MAPPING

Improving Accessibility Information in Pedestrian Maps and Databases

Mari Laakso, Tapani Sarjakoski, and L. Tiina Sarjakoski
Department of Geoinformatics and Cartography / Finnish Geodetic Institute / Masala / Finland

Abstract

As populations age, more and more people have some kind of restrictions on their mobility. In order to increase the potential of mobility-impaired persons to move around and navigate independently, information on the accessibility of the environment should be supported by map services and delivered together with spatial information to their devices for personal navigation. Spatial databases for pedestrian route planning should contain more detailed information on accessibility, such as pavement surfaces, slopes, and stairs. This study examines a wide range of examples of map services in Finland in terms of the extent to which they support accessibility. The authors then provide and discuss a proposal for the information content of a geospatial database to fulfil the requirements of users with impairments. With guidelines for data content, data classification, and functionality, map information can be developed so that it is also more useful for special user groups and makes the environment more accessible for everyone.

Keywords: geospatial information, accessibility, pedestrian, route

Résumé

Avec le vieillissement de la population, de plus en plus de gens ont des contraintes physiques réduisant leurs mouvements. Afin d'accroître la capacité des personnes à mobilité réduite à se déplacer et à s'orienter par elles-mêmes, les renseignements sur l'accessibilité devraient être contenus dans les services cartographiques et inclus avec les renseignements spatiaux dans les outils personnels de navigation. Les bases de données spatiales pour la planification des routes pédestres devraient contenir des renseignements plus détaillés sur l'accessibilité, comme les surfaces pavées, les pentes et les escaliers. L'étude examine un large éventail d'exemples de services cartographiques en Finlande pour savoir jusqu'à quel point ils tiennent compte de l'accessibilité. Les auteurs suggèrent des idées quant à l'information que devrait contenir une base de données géospatiale afin de satisfaire les besoins des utilisateurs à mobilité réduite. Grâce aux recommandations sur le contenu des données, la classification des données et la fonctionnalité, on pourra créer des cartes informatives qui seront plus utiles aux groupes d'usagers ayant des besoins particuliers et on pourra rendre l'environnement plus accessible à tous.

Mots clés : information géospatiale, accessibilité, piéton, route

1. Introduction

Digital maps, Web-based map services, and navigation and route-planning services have become commonplace tools for an increasing number of users. The map is becoming an interactive platform for different types of activities. Digital maps are no longer just a passive source of information; they are a data source that can be adapted for different user needs and for many kinds of user groups with individual user requirements (Sarjakoski and Sarjakoski 2008). The ideal situation would be for the same geospatial data content to respond to the majority of requirements of different map users. People have different motivations, personal preferences, or restrictions, such as visual impairments or mobility restrictions, that affect how they choose the route they need to take. In order to satisfy the various needs of different users, geospatial databases for pedestrian route planning should also contain detailed information on accessibility, such as pavement surfaces, steep slopes, and stairs. A comprehensive spatial database for pedestrians with special needs would increase their spatial awareness and help them to orient themselves more easily and to find their way in unfamiliar environments.

Persons whose ability to move and act independently is permanently or temporarily hindered by illness, injury, ageing, or some other reason are called *functionally disabled* or *mobility-impaired persons*. The disability may relate to their senses, their ability to move, their ability to understand and learn, or other restricting aspects. As noted for example in Wikipedia (2010), "accessibility is a general term used to describe the degree to which a product, device, service, or environment is available to as many people as possible." By "accessibility" here we mean the availability of access to the physical environment, to transportation, to information and communications, and to other public facilities and services. The main emphasis in the present study is on the extent to which the content of spatial information meets the requirements of mobility-impaired pedestrians.

In modern legislation, regulations directing the building of environments that suit the needs of disabled people are well established. Different acts and regulations with various guidelines, such as the European Concept for Accessibility (ECA 2003), are directing the building of environments that are equally accessible to all people. There also exist specially constructed accessible paths where accessibility has been the main design consideration. However, pedestrians with mobility restrictions still face obstacles and difficulties while moving around in their everyday lives. In order to increase the potential for mobility-impaired persons to move around, the accessibility aspect of various routes and paths should be integrated with the mainstream map services (Magnusson and others 2009), so that users can get comprehensive information on routes and paths and their characteristics for the entire route that they intend to take. With comprehensive route information, users can plan the most suitable route for their current needs and judge for themselves whether they can manage to walk the route alone or whether they will need assistance.

1.1 PREVIOUS STUDIES

There are several studies which include geographical information requirements of mobility- impaired persons (Beale and others 2006; Pressl, Mader, and Wiesel 2010; Sobek and Miller 2006; Svensson, 2009; Völkel, Kühn, and Weber 2008; Völkel and Weber 2007). Two studies (Pressl and others 2010; Beale and others 2006) identified from user questionnaires the most important obstacles faced by mobility-impaired persons and other preferences for the content of geographical data for visually impaired and wheelchair users. Thorsten Völkel and colleagues (Völkel and Weber 2007; Völkel and others 2008) gathered the information requirements of mobility-impaired persons from a survey that included visually impaired respondents. Their study shows that many environmental features that are important and even crucial to some special user groups are not included in currently available map data. They conclude by presenting a technique for the multimodal annotation of geographical data, including spatial, temporal, and subject-group relations. The idea of user-generated data annotation is also presented by Harald Holone and Gunnar Misund (2008). In their study, Adam Sobek and Harvey Miller (2006) describe a routing tool called U-Access that guides users in avoiding obstacles according to their ability levels. Sobek and Miller classify users into three ability levels and attribute the data using mobility indexes. They also note that acquiring and creating the data is the most critical step in the development of a successful application. None of these prior studies, however, attempts to ameliorate the information in existing mainstream applications, even though integrating such information would benefit all kinds of users, including cyclists and parents or caregivers pushing prams/strollers.

1.2 BACKGROUND OF THE STUDY

This research is part of the project Haptic, Audio and Visual Interfaces for Maps and Location Based Services (HaptiMap), which is supported by the European Commission. The HaptiMap project aims to develop multimodal location-based services (LBS) that are also accessible by special user groups, such as elderly and visually impaired people, and that support their use of spatial information (Magnusson and others 2009). The project's assumption is that with better perceptualizations (making perceivable by the senses, including senses other than visual) and interface designs, one could greatly increase both the usability and the accessibility of navigational systems, especially for special user groups (HaptiMap 2008). The project focuses on the following research questions: (1) Which information is relevant for the user in different situations? (2) How should this information be accessed and represented multimodally? (3) How can design practices within the industry be supported and modified to ensure that the applications developed make use of the knowledge gained in the project?

1.3 OBJECTIVES OF THE STUDY

With the objectives of the HaptiMap project as a starting point, our goal in this paper is to study what spatial information and map data content is appropriate for different kinds of user groups and their special needs. The aim was to collect knowledge about what kinds of geographic information currently exist and what are the information content requirements to enable mobility-impaired users to resolve whether or not they can take a particular route. The final goal of this ongoing research project is to create a set of guidelines for developing geospatial databases in terms of accessibility and Design for All (DfA 2009).

2. Accessibility in Different Types of Web Maps, Map Services, and Guidelines in Finland

When one needs to find one's way in an unknown environment, maps, current navigation aids, and route-planning services on the Web are helpful. In this study, we examined different kinds of maps, map services, and guidelines on the Web for pedestrian use in Finland. We scrutinized a wide range of map services, geospatial databases, different kinds of hiking and outdoor route services, city maps, and journey planners. In all, we examined approximately 25 map sites and services, some of them covering broad areas. We also included Web maps and map services of special accessible paths and routes in the survey, as well as available guidelines for considering pedestrian accessibility. Map services that do not support pedestrian navigation were not included in the survey.

2.1 WEB MAPS AND MAP SERVICES

As described in this section and summarized in Table 1, we studied the data content of the different types of map services, especially from the point of view of accessibility. Our findings are detailed below.

2.1.1. National Databases

There are two national databases related to the road network in Finland: the Topographic Database, maintained by the National Land Survey (NLS), and Digiroad, maintained by the Finnish Road Administration. The former covers several natural and built themes, while the latter deals with roads only. The majority of road information in the Topographic Database is included in Digiroad. In addition to name, number, width, and other basic attribute information on roads included in the Topographic Database, Digiroad also includes information on public transportation stops and stations, underpasses and overpasses, street lights, traffic lights, and pedestrian crossings, as well as services and their entrances and exits, including hospitals and taxi stands. The main emphasis in the Digiroad database is on vehicle navigation; it needs additional data in order to reach the level of detail required by pedestrians.

2.1.2. OpenStreetMap

The amount of data in OpenStreetMap (OSM) is rapidly increasing in many regions. OSM data are stored by the user community and originate from various sources, including satellite images, aerial photos, digitized maps, and data collected via GPS. There are areas with high information density, but areas of lower data density still exist as well. At best, a wide range of accessibility information is available, including information on streets (type, surface, smoothness, tactile paving); steps (number of steps, handrails); bridges and tunnels (height, width); crossings (traffic lights, pedestrian islands); public transportation stops and stations; wheelchair accessibility; and landmarks such as towers, fountains, and benches. Information is also available on other points of interest, such as libraries, pharmacies, post boxes, vending machines, public buildings, picnic sites, and sport venues.

2.1.3. City Maps

For our overview, we analyzed maps from 16 Finnish cities: Tuusula, Lahti, Vantaa, Tampere, Oulu, Jyväskylä, Kouvola, Etelä-Kymenlaakso (Kotka), Vaasa, Rauma, Pori, Savonlinna, Seinäjoki, Tornio-Haparanda, Espoo, and Kuopio. Information on accessibility is limited to the data generated with traditional mapping methods, such as route surface material and information on separate/integrated pedestrian and cycle lanes. Some attribute information is included, but city maps do not include detailed information on accessibility.

2.1.4. Hiking/Outdoor Maps

For hiking and outdoor activities, there is a central site for Finnish national parks and different map services for other regional hiking areas. Information on accessibility is not explicitly offered to map users, but destinations classified as barrier-free can be found. No uniform classification system is currently in use. Trail descriptions include verbal explanations of the degree of difficulty, such as "The trail is quite steep in the beginning, so it is not suitable for the disabled." For some routes, more specific information concerning accessibility is given.

2.1.5. Accessible Paths/Routes

Accessible paths have been designed and planned especially for disabled users. While the available information on accessibility is extensive, it is given in narrative form; the data are not included in geospatial databases, and the maps are just static pictures.

2.1.6. Journey Planners

Map use is becoming more interactive, and route maps for current need are common. As stated in the European Concept for Accessibility (ECA 2003) and in other studies (Harder and Michel 2002), a route planner and route-oriented map are indispensable to improve the mobility of functionally disabled persons. Good practices for route-planning tools are developing as new services

Table 1. Types of map services and their properties

Map Service Type	Example(s) + URL(s)	Main Source(s) of Content	Attribute Information	Accessibility Information	Person-alization
National Database	• Topographic DB, National Land Survey of Finland (NLS), http://mapsite.fi	NLS	✓	–	–
OpenStreetMap (OSM)	• http://www.openstreetmap.org/c	OSM community + other sources	✓	some	✓
City Maps	• Espoo, http://kartat.espoo.fi • Helsinki, http://kartta.hel.fi/opas/ • Tampere, http://www.tampere.fi/ytoteto/kartta/map.php	NLS + cities' own production	✓	some	some
Hiking/Outdoor Maps	• Metsähallitus, e.g., Finnish National Parks, http://excursionmap.fi • http://www.elamysliikunta.fi/	Metsähallitus + NLS + private companies	some	some	–
Accessible Paths/Routes	• The Accessibility Project, http://www.esteeton.fi/portal/fi/tieto-osio/luontoliikunta/ • Parts of different hiking sites	On top of topographic (e.g., NLS) or city maps + own production	✓	✓	–
Journey Planners	• Helsinki Regional Transport, http://reittiopas.fi	Helsinki region cities' own production + private companies	✓	some	some

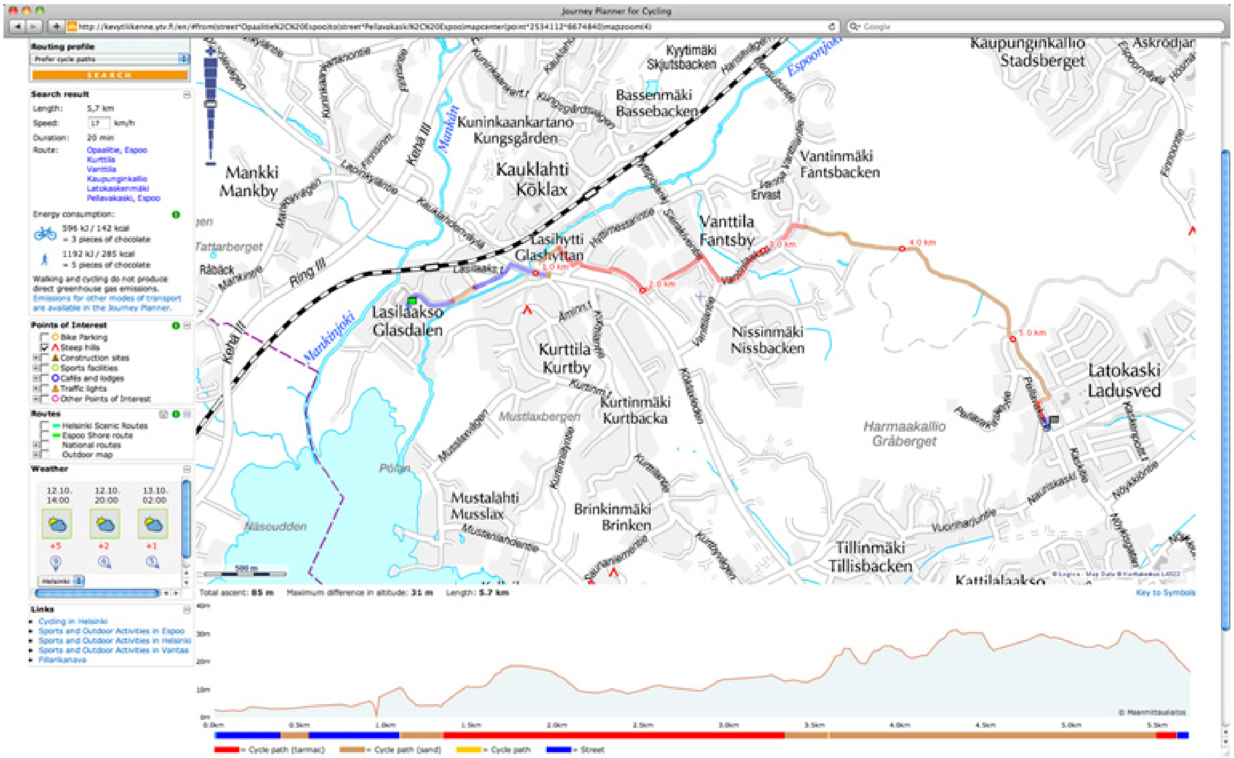

Figure 1. Helsinki Regional Transport's journey planner for cycling and walking. ©2009 HSL, reproduced by permission.

emerge. Some basic requirements for the service are specified here according to user needs.

The need for route planning arises from different situations. The requirements and criteria for route choices vary. The most obvious need for route planning might be when users want to know the route from their starting point to their ultimate destination. A route planner offers options for the criteria needed when choosing the route. An optimized route calculation is traditionally based on parameters such as shortest travelling time or shortest distance, which are the most important preferences for many users but not necessarily for mobility-impaired users. For example, mobility-impaired users may prefer a route with separate pedestrian walkways, or they may select a route according to its surface (such as asphalt or dirt roads) or walkways with aids for visually impaired persons. When the route planner shows the calculated route on a map, the user should be able to modify it according to his or her preferences—for example, in order to avoid known obstacles on the route. The user may also want to add intermediate points along the route. The user should be able to select various points of interest to be displayed on the map and click on them to see additional information related to these locations, such as accessibility information (e.g., steep slopes, stairs, traffic lights without audible pedestrian signals).

The total length of the route is essential information; for some users, the height profile of the route is also important. Helsinki Regional Transport's journey planner for cycling and walking (HSL 2009) provides a good example of this (see Figure 1). However, more accessibility information will still be required for users with special needs. With profiles or personal logins, it is possible to adapt route planners or map services to suit individual users' needs. Such adaptation could take place through a group-based user profile identification (e.g., a profile for wheelchair users or a profile for blind users) or through profiles based on individual profile identification (see Pressl and others 2010).

The properties of the different types of map services and Web maps are summarized in Table 1, which gives examples of the services studied.

2.2 CLASSIFICATION GUIDELINES FOR ROUTES

In addition to map services, we also studied different kinds of guidelines available on the Web. We made the following observations from the point of view of accessibility.

Suomen Latu, the Finnish Central Association for Recreational Sports and Outdoor Activities, has created accessibility classification guidelines for outdoor routes (Suomen Latu 2007). According to these guidelines, a trained classifier rates each route according to how demanding and passable it is and how it is marked in the field. Routes are rated as easy, moderate, or difficult, and a description of the route is also included. The guidelines also cover the classification of accessible paths for wheelchairs and for visually impaired persons. A number of routes have already been classified in national parks and other outdoor areas, and this work is ongoing. This is a good example of how a uniform categorization helps users to judge which routes are achievable and which are not.

There are many different types of impairments, which result in different kinds of accesibility requirements. Wheelchair users, people suffering from muscular weakness, blind or visually impaired people, and pedestrians with prams/strollers all have special requirements for their routes. In addition, people may have other preferences when deciding which route to take.

Additionally, for pedestrians, connections to public transportation are very important. Geospatial databases should also include detailed information on public transportation stops and stations. The Helsinki Regional Transport Authority has successfully defined guidelines for accessible city transport. These guidelines include the availability of information; low-floor buses, trains, and trams; raised and step-less stops; elevators or escalators at stations; suitable materials and colours at stops and stations; and continuous maintenance, including snow removal and sanding in winter (HSL 2010).

2.3 INFORMATION CONTENT FOR ACCESSIBILITY

In summary, based on the literature and Web searches conducted, the information content of geospatial databases needed to fulfil the requirements of users with impairments is as follows:

- Surface of the road and tactile paving
- Height profiles of roads, or at least indications where slopes are $>5\%$
- Lateral inclination of roads, if $>2\%$
- Width of walkways/gateways, if <2 m
- Stairs, escalators, and lifts/elevators
- Crossings and traffic lights with audible pedestrian signals
- Pedestrian subways and overpasses
- Squares and parks
- Public transportation stops and stations
- Landmarks: visible and sonic
- Benches and other places to rest
- Streetlights (or absence thereof)
- Obstacles, high curbs, construction sites
- Current information on maintenance, especially in winter

As the range of users is broad, the requirements for information are manifold as well; therefore, the list presented here is not exhaustive. However, the data content presented here would already be enough to ameliorate the existing situation considerably.

3. Discussion

Most of the information content for accessibility listed in section 2.3 above already exists in various databases and storage systems. It should be embedded within a geospatial database and presented to map users through the map interface. Integrating map services that deliver data from databases, including accessibility information, with location-based services for personal navigation would improve the possibilities for mobility-impaired users to move around independently. One example of this is an application by the Finnish Meteorological Institute (FMI) in which a service warns about slippery roads for a specific area during the winter. In addition, the use of photographs or Webcams is an effective way to communicate information.

The possibility of adding audio files to map services enables visually impaired users to exploit, for example, sonic landmarks. For visually impaired pedestrians, road signs are generally not accessible, which hinders their orientation; clearly visible or sonic landmarks, however, could be used to help these pedestrians orient themselves. For example, water fountains, basins, and natural creeks, ditches, and rivers with running water providing constant sound can all serve as sonic landmarks for visually impaired hikers in a park (Laakso and Sarjakoski 2010). The locations of notable visible and sonic landmarks should be included in the geospatial database and accessible through a route planner so that users can utilize the information when planning routes and while navigating those routes.

The quality of navigational data is a major issue for pedestrians. It can be argued that for mobility-impaired people, quality standards must be even more stringent, because such pedestrians have more difficulty in recovering from any mistakes made when planning the route. The standard ISO19113:2002 Geographic Information—Quality Principles (ISO 2002) lists five quality elements: completeness, logical consistency, positional accuracy, temporal accuracy, and thematic accuracy. Without going into too much detail here, all of these aspects seem to be extremely important, especially for disabled pedestrians.

It is a challenge to update the data content and the structure of city map databases to make them fully exploitable for navigational purposes and to create an accessible city. This is a challenge with which social media and voluntary mapping can offer assistance. We already have good examples of projects, such as OpenStreetMap, in which spatial information from users is collected and shared (OSM 2010). A wide range of users and the frequent use of map services increase the prospects for improvement and further development of map services. A large number and wide range of users is also invaluable when social networks are encouraged to create user-generated content. Therefore, map services that follow the principle of universal design would offer the best solution (DfA 2009) to benefit different types of users.

4. Conclusions and Future Plans

A considerable number of examples of geospatial databases and map services in Finland have been examined in our study, especially from the point of view of accessibility. While they do not represent the entire range of geospatial databases and map services, they do offer an extensive sample of what is available on the Web. Some good map applications already exist, but in order to fully serve a disabled pedestrian, they need to include more detailed information on accessibility.

The level of detail required in pedestrian applications is often so high that it cannot be achieved with traditional mapping methods. Social media and user-generated data could support the updating of geospatial databases and the improvement of data quality.

It is possible to achieve an accurate spatial database that includes usable and relevant information for most users by means of a change in attitude, more effort, and proper guidelines. Well-defined guidelines for data content, data classification, and functionality would ameliorate the present situation and make maps and map information more useful and, in particular, the environment more accessible for everyone.

Work on the HaptiMap project is ongoing, and guidelines on map content for pedestrian use will be prepared. The accessibility issue will also be covered in these guidelines, which will be published in 2012.

Acknowledgements

This survey is part of the European Commission–supported HaptiMap project (FP7-ICT-224675), coordinated by Lund University's Department of Design Sciences.

Author Information

Mari Laakso is Senior Research Scientist, Department of Geoinformatics and Cartography, Finnish Geodetic Institute, P.O. Box 15 Geodeetinrinne 2, FIN-02430 Masala, Finland. E-mail: mari.laakso@fgi.fi.

Tapani Sarjakoski is Professor and Head of the Department of Geoinformatics and Cartography, Finnish Geodetic Institute, Geodeetinrinne 2, FIN-02430 Masala, Finland. E-mail: tapani.sarjakoski@fgi.fi.

L. Tiina Sarjakoski is Docent, Chief Research Scientist in the Department of Geoinformatics and Cartography, Finnish Geodetic Institute, Geodeetinrinne 2, FIN-02430 Masala, Finland. E-mail: tiina.sarjakoski@fgi.fi.

References

Beale, L., K. Field, D. Briggs, P. Picton, and H. Matthews. 2006. "Mapping for Wheelchair Users: Route Navigation in Urban Spaces." *Cartographic Journal* 43/1: 66–81. doi:10.1179/000870406X93517

Design for All [DfA]. 2009. Finnish Design for All Network. Available at http://dfasuomi.stakes.fi/EN/index.htm

European Concept for Accessibility [ECA]. 2003. *Technical Assistance Manual.* Available at http://www.eca.lu/index.php?option=com_docman&task=cat_view&gid=13&dir=DESC&order=name&Itemid=26&limit=5&limitstart=5

HaptiMap. 2008. HaptiMap, Haptic, Audio and Visual Interfaces for Maps and Location Based Services. Available at http://www.haptimap.org/

Harder, A., and R. Michel. 2002. "The Target-Route Map: Evaluating Its Usability for Visually Impaired Persons." *Journal of Visual Impairment and Blindness* 96: 711–23.

Helsinki Regional Transport Authority [HSL]. 2009. Journey Planner. Online: http://www.reittiopas.fi/en/

—— 2010. Lähtökohdat suunnittelulle [Guidelines for Planning]. Available at http://www.hsl.fi/FI/suunnittelu/suunnittelunlahtokohdat/Sivut/default.aspx

Holone, H., and G. Misund. 2008. "People Helping Computers Helping People: Navigation for People with Mobility Problems by Sharing Accessibility Annotations." *International Conference on Computers for Handicapped Persons 2008* (*Lecture Notes in Computer Science* 5105), ed. K. Miesenberger and others, 1093–1100. Heidelberg: Springer. doi:10.1007/978-3-540-70540-6_164

International Organisation for Standardisation [ISO]. 2002. ISO 19113:2002: Geographic Information—Quality Principles. Geneva: ISO.

Laakso, M., and L.T. Sarjakoski. 2010. "Sonic Maps for Hiking: Use of Sound in Enhancing the Map Use Experience." *Cartographic Journal* 47: 300–307. doi:10.1179/000870410X12911298276237

Magnusson, C., S. Brewster, T. Sarjakoski, S. Roselier, L.T. Sarjakoski, and K. Tollmar. 2009. "Exploring Future Challenges for Haptic, Audio and Visual Interfaces for Mobile Maps and Location Based Services." *Proceedings of the 2nd International Workshop on Location and the Web (LOCWEB '09)*, 4–9 April, Boston, MA. New York: ACM. doi:10.1145/1507136.1507144

OpenStreetMap [OSM]. 2010. OpenStreetMap. Available at http://www.openstreetmap.org/

Pressl, B., C. Mader, and M. Wieser. 2010. "User-Specific Web-Based Route Planning." *International Conference on Computers for Handicapped Persons 2010, Part I* (*Lecture Notes in Computer Science* 6179), ed. K. Miesenberger and others, 280–87. Heidelberg: Springer. doi:10.1007/978-3-642-14097-6_45

Sarjakoski, L.T., and T. Sarjakoski. 2008. "User Interfaces and Adaptive Maps." In *Encyclopedia of GIS*, ed. S. Shekhar and H. Xiong, 1205–12. Heidelberg: Springer.

Sobek, A., and H. Miller. 2006. "U-Access: A Web-Based System for Routing Pedestrians of Differing Abilities." *Journal of Geographical Systems* 8: 269–87. doi:10.1007/s10109-006-0021-1

Suomen Latu. 2007. *Ulkoilureittien luokitus- ja kuvausohje [Guidelines for Classification and Description of Outdoor Routes].* Available at http://suomenlatu-fi-bin.directo.fi/@Bin/c64ddc4afdaf10e43e0d9246b7154148/1286276795/application/pdf/59327/ulkoilureittien_luokitus_1_07_netti.pdf

Svensson, J. 2009. "Accessibility in the Urban Environment for Citizens with Impairments: Using GIS to Map and Measure Accessibility in Swedish Cities." *Proceedings of the 24th International Cartographic Conference*, 15–21 November, 2009, Santiago, Chile [CD-ROM].

Völkel, T., R. Kühn, and G. Weber. 2008. "Mobility Impaired Pedestrians Are Not Cars: Requirements for the Annotation of Geographical Data." *International Conference on Computers for Handicapped Persons 2008* (*Lecture Notes in Computer Science* 5105), ed. K. Miesenberger, 1085–92. Heidelberg: Springer. doi:10.1007/978-3-540-70540-6_163

Völkel, T., and G. Weber. 2007. "A New Approach for Pedestrian Navigation for Mobility Impaired Users Based on Multimodal Annotation of Geographical Data." *Universal Access in Human Computer Interaction 2007 (Part II)* (*Lecture Notes in Computer Science* 4555), ed. C. Stephanidis, 575–84. Heidelberg: Springer. doi:10.1007/978-3-540-73281-5_61

Wikipedia. 2010. "Accessibility." Available at http://en.wikipedia.org/wiki/Accessibility

 Cartographica 46:2, 2011, pp. 101–108 doi:10.3138/carto.46.2.101