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# Usability methods' familiarity among map application developers

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**Abstract**

Developments in hardware and software have led to new innovative methods for visualising geospatial data. At the same time user-centred design (UCD) and usability engineering methods have a fundamental role in designing applications for new technical environments, which involve entirely new ways of interacting. However, applying methods from other research disciplines may not always be straightforward, as the product developers have to operate in a challenging interdisciplinary field. The aim of this study was to find out how usability engineering is currently included in the development of map services. Seven companies developing different types of map applications in Finland were interviewed. The results support the suitability of usability engineering for map application design, since by including the usability approach into the product design, while simultaneously taking into account the individuality and diversity of users and their tasks together with the characteristics of the maps, application developers are more likely to design products that have a higher quality of use. This study identifies the main occasions when the usability approach could be most beneficial. Furthermore, the benefits and challenges of including usability approaches in map application design are discussed. Preliminary ideas on what usability means in the context of map applications are also given. Finally, the importance for providing a basis for the further development of application-specific guidelines and techniques is addressed.


*Keywords:* Usability engineering; User-centred design (UCD); Usability methods; User requirements; Geographic information system (GIS); Map application; Map service; Cartography; Geovisualisation; Product design; Product development process

## 1. Introduction

The need to consider usability approaches during product design is widely accepted. The ISO 13407 standard—human-centred design processes for interactive systems—gives instructions to achieve user needs by utilising a *user-centred design* (UCD) approach throughout the entire life cycle of a system (ISO, 1999). However, it is not always straightforward to apply methods originating from different research fields to all application areas. This type of interdisciplinary task, in which usability evaluation methods adopted from software engineering are used for the development of applications in other areas, is challenging. One reason for this may be that the required knowledge for integrating usability engineering into specific product development does not exist. When usability methods are incorporated into applied disciplines, some adaptation to the methods may also be necessary.

In the present paper the focus is on usability evaluation methods used among map application developers. Due to the interdisciplinary nature of the study, a definition of *cartography* is required at the outset: "cartography is the art, science and technology of making maps together with their study as scientific documents and works of art" (ICA, 1973, p. 1). A *map* can be described as "a symbolised image of geographical reality, representing selected features or characteristics, resulting from the creative effort of its author's execution of choices, and is designed for use when spatial relationships are of primary relevance" (ICA, 2006). The term *geovisualisation* is sometimes preferred over the term cartographic visualisation, because it integrates approaches from visualisation in scientific computing, cartography, image analysis, information visualisation,

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exploratory data analysis and GISs to provide theory, methods, and tools for visual exploration, analysis, synthesis and presentation of geospatial data (MacEachren and Kraak, 2001). *Geographic information systems* (GIS) can be defined as a set of tools for collecting, storing, retrieving, transforming and displaying spatial data from the real world (Burrough, 1986).

Computer-based map production technology changed the output and plotting of maps into an automatic process. Clarke (2001) divided the influence of the computer on cartography into different phases. Firstly, large mainframe computers were used as analytical engines for problem-solving using an algorithmic approach. Smaller desktop computers and workstations followed, allowing personal interaction with computer-based processes. In the third phase, Internet solutions also allowed non-cartographers to receive maps via the Internet.

The fourth era, *mobile computing*, includes location-based services (LBS), from which map data can be delivered to a user's mobile device, such as a cell phone or Personal Digital Assistant (PDA) according to the location of the user—or to a specific requested location. Recent technological developments have also provided a vast number of tools and techniques of interest to geovisualisation, especially for interface and interaction design. As a result, research has emerged relating to augmented reality (AR), virtual reality (VR), and ubiquitous computing within the field of cartographic visualisation.

Due to technological advances, traditional user requirement techniques and design methods may not be valid from all perspectives. Designers have to understand varying devices and system properties, such as the different sizes of the screens, placement of hardware buttons, input methods, screen colours, and processing power and memory capabilities, in order to be able to design user-friendly applications. Tolcher (2000) emphasised the need to understand the tasks that users carry out from the point of view of activity, instead of using conventional approaches that concentrate on abstractions like processes and tasks. In addition, given that the intelligence in UIs could be described as a way to make the system more adaptive and flexible for each situation and user (Lieberman and Selker, 2000), understanding the different user groups and use situations, especially the while-on-the-move usage with mobile computing, also introduces new requirements for design.

This applies to map application design, too. Koua and Kraak (2004) stated that the map use studies that have been carried out over a long time in the field of cartography are not fully applicable in new interactive visualisations, which may have new representational spaces and user interfaces. Cartwright et al. (2001) concluded that the technological developments involving both cartography and computer graphics have made modern cartographic representation different: a wider range of maps can be made more quickly and less expensively and interaction with visual displays in almost real-time is now possible. This results in moving the emphasis from static to dynamic map use and in new requirements for the design and interfaces of representations. But how can today's map applications using new technologies be guaranteed to fulfil user requirements? What assurance can be given that the applications are easy to use and that user acceptance and interest in investment can be achieved?

### 1.1. Map as a GUI and usability methods

As with graphical user interfaces (GUIs) in software engineering, maps can also be regarded as user interfaces (UIs); Peterson (1995) suggested that the word interface can be related to maps in two ways: maps are, firstly, interfaces to the world and, secondly, composed of UI elements. The layout of the map, its legend, colours, folding and other design, are all aspects of the map's UI allowing the user to interact with the map. Kraak and Brown (2001) stated that due to the multimedia nature of the Internet, maps can be seen as interfaces, or also as indices to additional information. If we consider a map on a computer screen as another type of GUI, the design principles for maps should follow the same standard design methods as used in other GUI design.

*Usability engineering* is a term used to describe methods for analysing and enhancing the usability of software (Nielsen, 1993; Mayhew, 1999). *Usability* is defined in the ISO 9241 standard—ergonomic requirements for office work with visual display terminals—as "the effectiveness, efficiency, and satisfaction with which specified users achieve specified goals in particular environments" (ISO, 1997). Another definition outlined in the ISO 9126-1 standard (ISO, 2000) uses the term "quality in use", which means the capability of the software product to enable specified users to achieve specified goals with effectiveness, productivity, safety and satisfaction within specified contexts of use.

The purpose of usability engineering methods is to collect information in order to gain greater understanding of the users, and their tasks and environments and apply this to the product design. There are several methods for collecting this information: surveys, interviews, contextual inquiry or observation of users in a field study, user participation in the context of use analysis, focus groups, brainstorming, evaluation of an existing system, etc. Different ways of finding out user requirements and understanding what usability means in a new technological, multimodal, mobile, ubiquitous or in distributed computing settings, may provide essential knowledge for designers.

Cartography has a long history of perceptual-cognitive research into the use of maps, and several usability evaluations and a remarkable amount of user testing has also been carried out in cartographic research (Nivala, 2005). Montello (2002) concludes that map design research includes much of what has variously been called

'perceptual cartography', 'the human factors of maps', 'evaluation research', 'usability research', 'communication research' or 'experimental cartography'. However, systematic usability engineering throughout the lifecycle of map applications (including user requirements, design and iterative evaluation) seems to be rare (Nivala et al., 2005).

### 1.2. Related literature

Several researchers have noticed the lack of thorough usability engineering in map application design. MacEachren and Kraak (2001) stated that there is a lack of established paradigms for conducting cognitive or usability studies with highly interactive visual environments. Fairbairn et al. (2001) also emphasised the need to advance ways of transforming information about the world into models suited to digital and cartographic representations that will lead to effective visualisation.

Slocum et al. (2001) listed six areas in geovisualisation in which cognitive and usability issues should be considered: geospatial virtual environments, dynamic representations (including animated and interactive maps), metaphors and schemata in UI design, individual and group differences, collaborative geovisualisation, and evaluating the effectiveness of geovisualisation methods. The authors also argued that the traditional cognitive theory for static two-dimensional maps may not be applicable for interactive 3D and other dynamic representations. Hedley (2001) pointed out the importance of understanding new technologies and how they relate to people in order to maximise the potential of these new technologies within spatial visualisation. In addition, Cartwright et al. (2001) emphasised that the main challenge is to find out: in what ways geospatial interfaces should be different from other interfaces; how geovisualisation interfaces should be adapted or created for new and emerging devices; what the most appropriate interaction methods for different users and applications are; and how users with different expertise interact with interface tools.

Koua and Kraak (2004) proposed a usability framework for designing and evaluating exploratory geovisualisation environments that combines visual and computational methods with knowledge discovery. van Elzakker (2005) listed the usability research agenda for maps under main headings: user profiles and requirements, usability testing, UCD and research methods and techniques. MacEachren et al. (2005) stated that the development of more natural interfaces for computer systems has been part of HCI research for a while, and that this approach should also be incorporated into GIS applications in order to improve their usability.

Slocum et al. (2001) pointed out that the focus of geovisualisation on facilitating work related to ill-structured problems may make it difficult to apply standard usability engineering principles. Fuhrmann et al. (2005) stated that it is sometimes difficult to make out the difference between usable and useful when applying HCI methods, because in geovisualisation data exploration and knowledge discovery tasks are not straightforward enough to say what the goal is and how well it is achieved. They emphasised the need to assess additional, and mostly qualitative, information, in addition to discussing more formal guidelines in the design process to make geovisualisation useful and usable. According to Fuhrmann et al. (2005) this "geovisualisation theory" could be constructed from different disciplines, such as perceptual science, cognitive science or HCI science, the role of geovisualisation researchers would be to extend and refine it in ways that would make it specific to geovisualisation.

Despite the fact that the trend appears to suggest that an increasing number of usability evaluation methods are being used, Meng (2004) noticed that map usability tests have so far only concentrated on testing the effectiveness and efficiency of the map's use, whereas the map may still not fulfil user requirements, because the individual requirements of the user may not have been considered. In fact, there is currently insufficient understanding about user requirements (Meng, 2005). Nivala et al. (2005) observed that current usability studies concentrated either on evaluating GUIs (of GIS applications or mobile guides) or evaluating different types of map visualisations. The studies in general did not include both aspects, and because of this the user friendliness of the whole application was not always considered. This may be related to the fact that current map applications were evaluated by two different groups of researchers: cartographers/GIS specialists or HCI engineers, and their results have also been reported in different conferences and journals (Nivala, 2005).

### 1.3. Research questions and objectives of the study

Slocum et al. (2001) stated that due to the novelty of geovisualisation and the difficulty in defining the nature of users and their tasks, applying usability engineering may be problematic. However, **because** of this novelty and diversity, the research presented here presumes that the user-centred approach should be considered **compulsory** in the successful implementation of usable map applications.

The related literature review showed that many studies emphasise the need for usability engineering methods in map application design. However, previous research on this issue has not been conclusive, because it has been based on data describing academic research projects, when evidence on the use of usability methods with real application developers would needed. The topic has not yet been studied from that perspective.

The motivation of the present study was to find out whether the results reported in academic research papers correspond to the current real-life situation of map application developers. The main research question was: Are the methods of usability engineering widely known and

used among current map application developers? And if not, why not?

To find the answer to this question, the study aimed at gathering information about the design process and the ways map applications are tested and evaluated during product design. Knowledge was also gathered regarding the extent to which, and in which ways, end-users are involved in the current product design. After acquiring this type of information, conclusions could be drawn about the current use and the appropriateness of usability engineering methods in the map application design from the product developers' perspective. The objective was for this information to specify the type of situations in which the usability methods would be the most suitable, needed, and/or beneficial. Furthermore, the necessity for usability engineering methods in a map application design could also be defined.

## 2. Method

The companies involved in the research were among the largest map application developers in Finland. Seven out of eight companies agreed to join the research proposed. One company thought that taking part in the study would compromise their trade secrets.

### 2.1. Procedure

The research was carried out as semi-structured interviews with companies that develop different types of maps, map applications and GISs. A set of questions was prepared relating to the research questions, see Table 1. Interviews were carried out with one usability specialist and one spokesperson for the company, usually a person responsible for the product design process or a usability specialist (in one case). The interviews were recorded on audiotape and a qualitative analysis of the informants' responses was later carried out.

Table 1
The structure and the questions of the interviews

1. What type of map applications or services are you developing?
2. How do you identify the end-user's requirements for the application?
3. How do you ensure that the design meets the end-user requirements?
4. To which extent are the end-users involved in the design and the evaluation of the application?
   →In what way?
   →At which stage?
5. Are usability evaluation methods and user-centred design approaches utilised in the current application design? If not, why not?
6. If the answer was yes to the previous question, what are the usability engineering methods used?
7. Do you plan to use the usability engineering methods in future projects?
8. How is the application evaluated after the release?

### 2.2. Description of the companies

The general business model with the **companies** was to develop map applications for their **customers**, who provide systems for **end-users** (Fig. 1). Some of the products were also directly designed for end-users, for example, some paper maps. The map applications varied from general consumer products to highly specific GI applications. Some map products were small and simple while others were large software packages that not only included the map application, but also the database and application software. A few products were designed for single use only, whereas others were used for core functions and customised for different customers.

### 2.3. Description of the map products

The most traditional end-user products were different types of paper maps (topographic maps, road atlases, travel books, outdoor and cycling maps) and also digital map atlases and CD-ROM maps on roads and sea routes. Some companies were dealing in and sharing the map data and map products developed by other organisations or companies. A few GI applications were designed as online services for different directory companies and Internet organisations, such as the route guidance and information systems (for public transportation etc.).

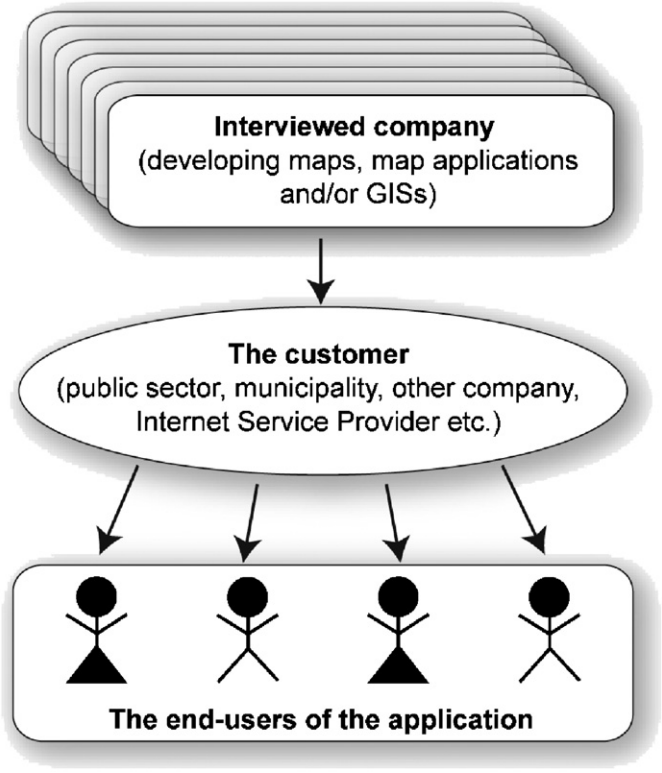


Fig. 1. The general business model for companies developing map applications. The interviews were carried out with company representatives.

The GI applications were also used in combination with timber logistics and process management, with work planning and the checking of mobile field-workers (power line repairers, maintenance men etc.), for military applications, emergency, rescuing and public safety services. Some systems were designed to aid the navigation of boats, for railway infrastructure planning purposes, and for planning and observing the power or pipe line networks. The others were built for municipal purposes, and used for construction and land-use and real estate planning.

Most of the companies did not produce their own spatial data, but were profiled as content refiners who either bought data or used free public data sources. Customer tended to have their own thematic data, which was relevant for their business, and usually something very different to normal map data. This was combined with a basic map, which was typically used as a background map. Some of the companies produced their own maps and some made their own definitions for the visualisations of the data for, for instance, multiple resolution databases. Both vector and raster data were used.

## 3. Results

The interviews showed that the process of map application design varied a lot according to the extent of customer knowledge about the system to be developed, and the type of the project. If the project was carried out as a *waterfall project*, it started with customer-defined requirements. This was followed by redefinition, technical description, implementation, testing and installation. Some of the projects were carried out as *iterative projects*. Design was mainly carried out by software engineers and GIS professionals, but cartographers, graphic designers, usability specialists or informaticians were sometimes also involved.

### 3.1. Product idea

Product design was set in motion for different reasons. In general, it was the customer who had the idea for a new system. They would often need to cut down their expenses, improve their service, for instance, and would therefore need a new application. In addition, the existing system was sometimes too difficult to use, and a simpler and easier product was needed.

Another driving force was when a company had an idea about a new technical application area. Either the technology had advanced to create a new possibility for a product, or then there was a potential market area for a new product. Monitoring the market situation was considered relevant for this reason. New product ideas were refined also as a result of companies' own research and development groups.

Most of the companies already had their own specific customers and projects, through which a strong understanding of customer needs was built. Based on this, new product development could also start on the companies' behalf. The various customer projects often had much in common, and therefore the product itself could be the same and only had to be customised to a specific customer.

### 3.2. User requirements

Identifying the end-user requirements varied according to the type of application being developed. The requirements were sometimes known beforehand in cases where the companies had been giving user support for the previous versions and already knew about the problems. A few companies carried out questionnaires with the end-users regarding the prior-version of the application.

A few companies met the end-users in order to define user requirements, either through their product development group, or through the usability group, if they had one. However, with some projects the end-users were only involved in the design at the very end of the project for evaluation purposes.

Some of the companies did not meet the end-users at all. One reason for this was that the companies had been developing map applications for a long time, and they said they already knew what to do, and how, so that the application would serve the end-users and that they would like it. In these situations, the product development was based on the expert knowledge and 'know-how' of the companies.

Sometimes the companies did not meet the end-users because of their business model (business to business type, see Fig. 1). In this situation the information on the end-user requirements was specified through the customer company. Occasionally, end-user feedback was also considered irrelevant, if the product was already on the market. It was also commented that as today's UIs are built in the form of separate modules, it is relatively easy to change them anyway if problems are encountered after the product release.

### 3.3. Testing

Testing was carried out from three different aspects. The most common approach was to test the **functionality**, trying to find the program bugs and other functionality-related problems with the system. This was mostly based on the professional knowledge of the product developers. The product was developed up to a certain point and then evaluated by the same people. Some functionality testing, as was the case with CD-ROM map products, was carried out by external testing companies, which looked at how the products worked, tried to make them fail and reported all the problems found.

One reason for **usability testing** methods was to gain end-users' commitment to the new system. Experience shows that when users know what they are going to get, and that they can actually influence the design, they are more willing to adopt the new system. It has also been pointed out that the best feedback was gained from the people who were not

involved with the product design and development process. If they could not understand something, it was most likely that the end-users would not be able to do that either. The usability testing in the interviewed companies did not always follow the usability methods that are familiar from literature, but were more like arranged simulations with different layouts for the UIs and discussions with the customers or end-users in informal ways. It was also said that the user groups were not always representative enough of the real end-users, because there were not enough resources (time, money etc.) to use more than one to three people for an evaluation. Furthermore, the test users involved may not always be the best representatives of the real users, since people who are involved in an evaluation phase are usually more interested in the new system and new technologies. Therefore, having non-motivated people involved in the evaluation was considered relevant when gauging the level of acceptance of the product.

The third testing approach, **cartographic evaluation**, was only carried out occasionally and mainly on traditional paper maps. The evaluation was mostly timed for the end of the lifecycle of a certain product, when information was needed about the requirements for a new product. End-user questionnaires were sometimes used at reseller stores. Questions were related to whether the information and the functionality included in the product were suitable, and what would be an appropriate price for that product.

Some of the companies provided support and maintenance of their products. This provided them with information about the problems and suggestions on how to improve the product. In general, information was not gathered systematically after the product lease unless there was a clear need for improvement of the product in a certain aspect. In one case the company's own usability group was in close contact with the support and maintenance group, and monitored user training in order to see what properties caused problems for the novice users. This information provided them with guidelines for the next versions.

### 3.4. Types of prototypes tested

The prototypes used during the design stages can be divided into two different types. With *functional prototypes* the visual design had not been decided yet. They were used because customers sometimes had systems (e.g. databases) where the functionality already existed and which had to be maintained and integrated into the new system. When the compatibility of these was tested, the functionality already existed, but not necessarily the design.

The design of *visual prototypes* was already very advanced. The advantage of using these types of prototypes is that because the layout of the buttons etc. is easily altered, during testing there is no need to discuss these factors with the users. For example, when a map application was designed for use during driving with gloves on, the design was tested very early on to see whether its visual appearance supported the tasks of the user in real usage situations.

### 3.5. Usability testing

Usability testing was seldom included in the companies' offers to customers. One reason for this may be that only well-known testing aspects are included. If companies do not know what the usability methods, or the potential benefits of including them in the product design, are then they will not invest in them. Today, most of the product development work was based on know-how on how map applications have been developed in the past, and according to the companies, the most obvious usability problems at least can be avoided through this. Another reason for not undertaking usability testing was that applications are sometimes designed for a limited number of users, whereas the usability aspects are only considered important when the system is designed to be used frequently by a large number of people.

However, systematic usability evaluations were also used: *observations, interviews*, and *heuristic evaluations* of the UIs, and in some cases *usability tests*. The main objective was to gain assistance in locating the buttons, and to choose between different layouts and the navigation paths between different views. A few companies, the larger ones for whom map application development process was only a part of their software development, had their own specialist usability groups. Others carried out co-projects with usability research groups at universities or similar. Nevertheless, careful consideration was always used to decide whether the end-user opinion of a product was critical or not, and whether resources needed to be used for usability evaluation. Despite this, all the companies emphasised the need to start the project with a thorough understanding of user requirements. At the same time the general opinion was that defining the user requirements was not a trivial task.

Five main reasons for including usability aspects in the map application development process were given by the interviewees: (1) user requirements were more specific than normal, (2) the application was used in a demanding usage situation, (3) the system was developed for experts and the product developers were unfamiliar with the user tasks, (4) the system was to be used in a situation unfamiliar to the designers, and (5) the system was intended for large user groups, who all had to adopt it. Table 2 gives examples of each type of situation described by the interviewed companies.

The experience of bringing usability approaches into a project revealed, inter alia, the need to change the layout of the user interface, to reorganise the menu of an application, to relocate buttons and to change the functionality behind them. The suggestions for improvement that were found during evaluations varied between the type of the system and their degree of development. If the changes were about to be made for an existing system, then not all the

Table 2
Five main reasons to include usability aspects in the map application development process with real-life examples

| Description | | An example |
|---|---|---|
| (1) | User requirements especially demanding | A usability test was carried out in a laboratory to simulate a web-based emergency information centre experiencing an alarm situation caused by power lines crashing down because of bad weather conditions. The user requirements in this situation were that the application should be easy to use and remember and quick to use in a sudden emergency situation. |
| (2) | Usage situation especially demanding | Usability testing and simulation were carried out when an application was being designed for a critical usage situation (managing a fire rescue vehicle). The user requirements were especially demanding because the user had to drive at 100 km/h and use the UI at the same time. The usability aspects were considered relevant, as the system should not make the situation even more demanding. |
| (3) | User tasks unfamiliar to the designers | A company designed an application to be used for land-use planning, property formation and control of building construction in municipalities. End-users were interviewed and observed in situ in order to understand their tasks before any implementations were made. |
| (4) | Usage situation unfamiliar to the designers | For the design of one mobile application the usability specialists went into the field with maintenance men who were repairing and checking electricity power lines in order to observe the latter's tasks and use situations. This helped them understand the requirements for a mobile map usage situation. |
| (5) | Application targeted for a large number of users | A company developed electronic maps to be used together with Yellow Pages services. Altogether 500 users tested the user interface and different cartographic variations of the maps (varying in colour, information density, etc.) over 2 weeks. The feedback for different visualisations was gathered. |

suggestions for improvement could be taken into account, because they would require too many resources at that point.

### 3.6. Evaluation of the maps

Maps are often considered to be a work of art on their own. Despite this, they do contain many mistakes (e.g. texts can overlap, the data is not correct). Sometimes this does not bother the users, as long as they can still use the map as required, for example, to navigate with a screen map application. It was pointed out that since the users are able to zoom in on screen maps while requiring more information, they are more tolerant of mistakes or bad design. Printed maps are considered to be different: if they contain a lot of mistakes, the map producer might get bad publicity.

Understanding the consumers was considered to be important in order to be able to provide the end-users with a map visualisation suitable for the task the map is aimed to. But, in general, the end-users were not included in the evaluation; instead, it was the customer who approved the map visualisation. Customers did not usually have specific requirements for the maps, but for them it was more important that the data was up-to-date, accurate and could be delivered to users easily. Their comments mainly concerned showing the thematic data on top of the background map distinctively enough. The background maps were often overloaded with information, although a sufficient amount of information would be only the most important features needed for orientation. It was pointed out that even though this was such a basic need, it was still mostly ignored within map design. The other comments received from customers were more functionality related, such as, why specific operations were not included, or why the system was working slowly or why a system was working in a specific way instead of another. However, these aspects were seen as mainly cost-related. The cheaper the product, the less functionality it had.

Evaluation of the visualisation by end-users was more common for printed maps, especially if the product was aimed for the market over several years. In these cases the company sent a draft of the map visualisation to users and asked for their opinion about it. Comments received were often very specific and related to the level of detail for road networks, place names, etc. Users also commented on the colours used on the maps; i.e. they were too dark or too light, some theme was not shown well enough, some road types dominated the visualisation, etc. Comments on the maps were occasionally emotionally based, for example, the unjustified exclusion of a building name from a map, although it had some historical or similar relevance. These types of comments were not often made regarding screen maps, because they are considered to be more like technical devices to aid navigation. Printed maps are looked upon as a work of art, and people also judge whether they are beautiful or not. Therefore, even when users' opinions were asked, not all their comments were included in the final design, because these opinions were too personal. It was also pointed out that the question of "How the map should look?" does not have a single right answer, so at some point the cartographic evaluation just has to be stopped.

In one case, a request to test a map came from a customer who had entered a competition situation and wanted to win (Table 2, Example 5). The experience gained from testing the map visualisation with users was that the company had succeeded well with the project and the product got high acceptance from the users.

Because the map visualisation is an essential part of the GI application, some of the companies also considered the fact that they did not have their own data a problem. However, the maps used were produced by professional

map producers, so this was not considered a great problem. Using raster data, however, was not considered to be the optimal solution from the end-users' point of view. To provide a zoom function one must have several different raster data sets, and because the change between these steps is not continuous, zooming may cause problems. Although the customers often commented the granularity or the unreliability of the raster data, it has, up to now, been easier to handle than vector data.

One of the major user requirements for maps was that the availability of the data should be flexible. One of the interviewees said that the best way to provide users with different types of maps would be to arrange a web-based catalogue, where the users could go through the different possible visualisations and choose the one that best suits their purposes. In some cases they could also design their own maps. This is especially important with small displays, which have new requirements for map visualisation.

## 4. The necessity of usability engineering methods

In general, there was no doubt about the benefits of including usability evaluation methods in the design of every map application product. Some companies had used usability methods in their product design and some even had their own usability specialists. A few said that in the future they would get usability knowledge through subcontractors.

### *4.1. Benefits of the usability approach*

It was stated that emphasising the usability aspects may give the company credibility and portray a positive image to the customer, because it shows that this knowledge is included in the product design to create successful products. The benefits of an iterative design were also emphasised as it means that the product development project does not have to go into so many side-tracks during the design stage, because information about the user requirements is constantly updated. Sometimes the direction of the design was not well known during the first implementations, but became clear when showing the design to the users and asking for their feedback.

Map applications are often large and complicated systems with a lot of different functions using large databases. Therefore they can be difficult to modify once they have been designed. In addition to this, they are generally integrated into other applications, for example, operational systems for an emergency system, management of different types of networks etc. If one of these systems has to be modified, it usually means that the map application also has to be modified accordingly. For this reason, understanding the user requirements from the beginning of the project is essential, since changes at the later stage require expensive resources.

One of the biggest challenges in designing map applications is that the users and their level of knowledge on GISs can vary significantly. Originally, GIS was used by specialised professionals who were not only visualising but also collecting, managing and analysing the data. However, map applications are now used by a larger number of people who are often less experienced in processing the geospatial data. With web applications the user group is even much wider and, in principle, anyone should be able to use them. If the requirements of all the user groups are to be fulfilled with the same application, designing a user-friendly application is especially challenging. Different types of users do not all need to be provided with the same properties of the system if they are using it for different purposes. Instead, they should be offered a variety of choices in the main menu for different types of use situations.

Usability aspects were seen to be most beneficial when designing products to be used by large numbers of users, such as internet-based services. When a large amount of people uses the service, it must be easy to use and attractive to explore. It was also observed that usability aspects are becoming more popular now as geospatial data is shown on the screen of mobile devices. The generic system solutions may not work the way they did within the desktop environment. The varying technical properties of the devices place emphasis on going through things with real end-users during the product design stage. Furthermore, the use of mobile applications while-on-the-move sets different types of requirements compared with static desk-top applications. It is difficult to imagine all the situations which the user may face, for example, when checking power lines in winter and using a mobile map application at the same time as travelling on a snowmobile. The usability aspects for mobile devices were also considered important when finding out which purpose the map is supposed to be used for, for instance, route planning cannot be efficiently carried out using a mobile device.

It was also pointed out that at the beginning the developers of the map applications were doubtful about the benefits of usability methods, but changed their minds, as the customers stated that due to the usability aspects in a project, and the understanding of the user requirements through them, the product was successful on the market. One example was also that when a web map application was redesigned with usability aspects in mind, it increased the amount of users. Previously large numbers of people had found it too difficult to use. It was also pointed out that when there are a lot of different companies providing applications with same technology, the one who can design the most usable application may win the battle for market dominance.

### *4.2. Challenges*

The problems encountered in making map applications are that there is extensive know-how on how things have been carried out in the past, and it is a challenge to think

how things could be done differently (for instance the visualisation). The lack of resources for carrying out usability evaluations is also a concrete concern because, for example, in a small country such as Finland the applications are not normally designed for large numbers of potential users. Another problem is that the methods are not always widely known among map application developers and their customers. It may also be that when usability methods are incorporated into applied disciplines, some adaptation to the methods may be necessary.

A relevant question is also who will pay for including usability aspects in a project? In the end it is always the customer who decides what is emphasised in the design. One very revealing comment was that sometimes it does not actually matter what the end-user of the product thinks because competition is so strong. It was also pointed out that users are often satisfied anyway when they are provided with a new technology because new systems are generally better than previous versions. Furthermore, involving users in the product development of applications for consumers was not seen as important as it is with systems that are being designed for professionals. The reason for this is that it may be more difficult to understand the tasks in professional use than those for ordinary mobile application consumer needs. In addition, the professional users often have higher status at the organisational level, and they are in the position to draw conclusions, and therefore their acceptance of the product is more important. It was stated that the more professional the system the more important it is to include the end-users in the design.

If a usability group existed in a company they had to do a lot of work at the beginning to convince the others of the benefit of including usability methods in the design and the cost benefits of using them as early as possible in the project. One of the interviewees said that heuristic evaluation was the first method that could easily be included into a project plan, because it is relatively cheap and fast to arrange. However, when a usability group pointed out all the mistakes found during an evaluation and stated that these could have been avoided by including usability aspects in the early stages of the design of the project, the usefulness of the usability aspects also proved to be cost effective. One of the usability group's primary targets was to emphasise that in order to save money, it is not worth developing high level implementations for a customer/end-user to choose between, but to use very primitive prototypes instead. An additional challenge posed by using usability experts is the question, where does the usability expertise fit in from the organisational point of view. Should they work through the system developers or should they have direct contact with the end-users?

### 4.3. What is the usability of a map application?

The need for user-friendly map applications was seen relevant because there has been a change from professional GIS users to consumers using the map applications. The easy-to-use approach is critical especially with the online map applications because the user is typically a private, non-professional, map user. This must be reflected in the terminology used within the applications, for example, the use of map-specific terms like 'topology', 'coordinates', 'level of detail', etc. is not straightforward. Consequently, the application providers should be able to respond to the different levels of user needs and provide the users with flexible systems. In many cases the GI software packages are complicated and difficult to use, and without user training they can often be left on the shelf without being used, because the users get frustrated with trying to use them without any help. Partly because of this, some of the emerging applications provide more guidance and are mainly designed to be used by non-professionals. They look more like standard 'office' style applications, which most people are familiar with.

One of the interviewees said that the main user requirement for an application used by field workers in a mobile situation is that there must be as few buttons as possible in the UI (maximum 3–5), and the users must be able to use the application while wearing gloves. Another concrete usability demand is that users must be able to rely on that the editing they perform in the field, using a web-based application, will be stored into the database with 100% certainty, regardless of the instability of the systems' Internet connectivity. It is also important that the device carried in the field is not only a note tool, where the actual tasks have to be finished back at the office. Users must be able to finish their tasks while in the field. One of the critical things is also that a new application may sometimes even complicate the tasks executed, instead of aiding the user as required.

From a usability point of view, a GI application also includes specific features, which may be difficult to understand by an ordinary user. For instance, the coordinate data is not always easily understood. Furthermore, zooming operations performed on the map, and how they relate to the map scale, require a lot from a user. One of the interviewees demonstrated this by showing problems with an existing web map application: there was no index map provided, some text fonts were too small, and the route guidance did not follow the actual routes, but took nasty-looking shortcuts. These usability aspects should be carefully considered by product developers.

Cartographic design is a key issue in the development of map applications. The choice of colours, symbols, map content, and a level of detail should be wholly reconsidered for new technical environments to guarantee usability. The disadvantages and advantages of mobile devices bring new aspects to the design, in addition to which there are more advanced visualisations such as 3D, VR and animations to be utilised. Psychology and cognitive sciences are also relevant aspects to be considered in map application design: how the users behave and how they interpret maps.

Additionally, more information about the diversity of users and usage situations will be needed for providing users with *adaptive maps*, which could provide the users with context-related information and assist in use in a given situation. An example of this is a field worker, who has to write a message on his mobile device to inform his headquarters about a completed task. Writing a message in the field may be frustrating, and a better solution could be to provide him with a context-aware drag-and-drop menu, from which he could choose between the words relevant for that situation and that specific message.

It was also discussed that new technologies (e.g. animations) may bring a 'feeling of usability', but at the end the system may not even be as usable as the previous one. However, if downloading a map takes a long time, but the system is able to show it appearing gradually by animation, then this already makes the application more user-friendly. It does not matter that the data still comes as slowly as before, as long as the users do not feel frustrated and they can see that something is happening.

### *4.4. Future research topics on the usability of map applications*

Bringing the usability engineering concept into such a specific discipline as geovisualisation raises many questions. In order to support map application developers to adopt usability methods in their product development, further research is required on, at least, the following two topics:

1. To adapt HCI methods to suit the needs of map application designers.
   Not all the methods used in usability engineering are either suitable or useful for map applications. Therefore, research on how to apply these methods in map application design should be carried out. The usability methods should be further developed and adapted to suit the interdisciplinary nature of map application projects. A more systematic comparison of which methods should be used, and in which way, should also be carried out. Finally, guidelines for using usability methods which product developers could use to design map applications should be created.
2. Research on usability issues concerning interactive screen maps.
   One of the fundamental questions to be defined is the relationship between usability and map applications: what is a good map application? What are the elements and measures that define it? What is the conceptual structure for these elements? Where is usability situated in the hierarchy of map design? Acquiring this knowledge would create a combination of cartography and usability knowledge, and provide recommendations and definitions on usability aspects for map applications.

## 5. Discussion and conclusions

Developments in hardware and software have led to new, innovative methods of visualising geospatial data and there has been development from view-only to interactive map applications. Several researchers have pointed out that usability engineering methods have a fundamental role in the design of maps for new technical environments, which involve entirely new ways of interacting. Despite this, no research has been reported on how current map application developers' product design is carried out in real-life. Applying methods coming from other research disciplines may not always be straightforward, as the product developers have to operate in a challenging interdisciplinary field.

This paper presents an interdisciplinary view on usability engineering. The research question for this study was whether the usability engineering methods are widely known and used among current map application developers, or not. The objective was to use this information to specify the situations in which the usability methods would be the most suitable, needed, and beneficial, and in which situations this would not be the case. The research was carried out as interviews with seven companies that develop map applications.

The results showed that although usability engineering is slowly being incorporated into design of map applications, knowledge on how to execute the methods is still almost non-existent. Most companies would like to implement this approach, but the problem is the lack of resources, and knowledge on how to implement an approach, which has its origins in software engineering. However, there was good experience of bringing usability methods into the design. Including usability engineering approach in the design stage was thought to be an advantage in order to win the competition for the market dominance and to increase the saleability of a product.

Based on the interviews, the five main reasons for including the usability aspect at the design stage were: (1) the user requirements were especially demanding, (2) the system was used in a challenging situation, (3) the user tasks were unfamiliar to the designers, (4) the usage situation was unfamiliar to the designers, and (5) the application was targeted for a large number of users. Furthermore, the challenges and benefits of bringing such an approach into GI application design were listed and discussed in detail. By including a usability approach into the product design stage while simultaneously taking into account the novelty and diversity of users and their tasks, together with the characteristics of maps, application developers could design products that have a higher quality of use.

Although the study presented here gives a preliminary idea of how usability engineering is currently applied by map application developers, it must be noted that the approach was only discussed in a couple of Finnish

companies. The study should be repeated in another country to see whether the findings would support the ones presented in this paper. However, a literature review on international research revealed that usability methods were neither widely used elsewhere, nor reported in academic research papers. All the methods used in traditional usability engineering may not be suitable or useful for the evaluation of GI applications. Therefore, the methods need to be further developed to suit the interdisciplinary nature of mobile map application projects. Established map use research is still applicable to some extent; but it should be developed to suit the purposes of today's interactive, dynamic and location-aware map applications. Therefore, research on how to apply usability evaluation methods in map application design should be continued.

The importance of usability testing will be even greater in the future due to emerging mobile applications, which should be easy to access and use to achieve the acceptance of the users. The technical properties of the mobile devices combined with a use-while-on-move situation both require usability approaches in order to meet the user's needs. For example, people do not use PC applications while jogging or standing in a queue at the airport, whereas mobile devices can be used almost anywhere, and new design aspects are therefore needed. Another challenge is that it is not likely that users will be willing to pay for any services that they can use on the Internet, but map applications are seen more as part of some other application. A good example on this is google.earth.com, which provides a lot of free material for users.

Today, usability engineering is not often included in the map developing companies' offers to customers. However, if the customer sees that usability aspects are included in another company's offer then that may constitute a reason to choose that one. In the end it may be the product developer who can design the most usable application who wins the battle for market dominance. Although this study was a description of the current state of development of map applications, it is also a concrete example of the problems faced in product design when user-oriented approaches are applied to a specific research area. The interdisciplinary view of usability engineering is, however, a wide topic, and more research on how other application developers enhance the usability approaches to the product design is needed.

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