User-Centred Design and Development of a Mobile Map Service

Nivala, A.-M., Sarjakoski, L.T. and T. Sarjakoski

Department of Geoinformatics and Cartography, Finnish Geodetic Institute,
P.O. Box 15, FIN-02431 Masala, Finland
Annu-Maaria.Nivala@fgi.fi - Tiina.Sarjakoski@fgi.fi - Tapani.Sarjakoski@fgi.fi

Abstract. User-centred design (UCD) is being taken into account increasingly in product design. This also applies to Information Society Technologies (IST) EU projects, which emphasise a usability approach throughout the whole life span of the projects. The research presented here was carried out over three years in the EU-funded project called 'GiMoDig'. The practical outcome of the project was a prototype of a spatial data service for mobile users, which provides access to the primary national geo-databases. The need to consider usability issues during product design was one of the main concerns in the project. The evaluations started from the beginning of the project and lasted until the end. In this paper the iterative UCD approach is explained through the experiences with the project. Finally, a discussion is held on how to integrate usability issues into map applications, especially in a mobile map context.

1 Introduction

The aim of user-centred design (UCD) is to support the entire product development process with user-centred activities. This is done in order to create applications that are easy to use and fulfil the needs of the intended user groups. User-centred design is considered to be important especially when new applications are created. This applies to cartographic products, too. Today, developments in hardware and software have led to new innovative methods for visualising geospatial data and there has been a change from view-only to highly interactive map applications. However, Slocum et al [24] pointed out that these novel methods will be of little use if they are not developed within a theoretical cognitive framework and iteratively tested using usability engineering principles.

MacEachren and Kraak listed research challenges in geovisualisation, and one of the main topics included in their work was cognitive and usability issues [10]. According to them, there is a lack of established paradigms for conducting cognitive or usability studies with highly interactive visual environments, and therefore one of the crosscutting challenges included the need to develop a human-centred approach to geovisualisation. Fairbairn et al. also stressed that since modelling techniques are developing rapidly, there is a need to advance ways of transforming information about the world into models suited to digital and cartographic representations that lead to effective visualisation [3]. According to them, such models "should draw on research

into the cognitive issues that surround increasingly personalized and flexible possibilities for map use with an expanded range of map forms" [3, p.14].

Our literature review revealed that cartography has a long history of perceptual-cognitive research on the use of maps, and that there have been usability evaluations and remarkable amount of a user testing done in cartographic research. However, on the whole the research seemed to be occasional and only dealt with one specific problem under investigation. Systematic usability engineering throughout the lifecycle of map applications (including user requirements, design and iterative evaluation) seems to be rare.

One reason for this may be that the required knowledge for integrating usability issues into the product development does not exist in the cartographic research community. Bringing the UCD concept into such a specific research area as geoinformatics raises many questions. When usability methods are incorporated into applied sciences, some adaptation to the methods used may have to be carried out. Due to the novelty of geovisualisation and the difficulty of defining the nature of users and their tasks, applying usability engineering might be problematic [24]. Therefore, in many situations an outside evaluator on usability engineering would be needed.

Second, it was also observed that current map applications were being evaluated by two different groups of researchers: 1) cartographers and GIS specialists or 2) HCI engineers (especially in the case of mobile maps). However, it was observed that studies in general either included studies related to the map visualisation or to the GUI of map applications – but not both. The overall usability of screen maps was therefore not completely investigated, or was not at least reported in academic research.

The aim of this paper is to give a short outline of user-centred design and describe the methods that were used in the development of a mobile map service. The study emphasises the relevance of user-centredness in the development of map applications, and gives guidelines on how to put these methods into practice in mobile map design. The research was conducted as part of the GiMoDig project (Geospatial info-mobility service by real-time data-integration and generalisation) [4]. The project was funded by the European Union's Information Society Technologies (IST) programme, which strongly emphasises the concept of user-centredness [6]. Therefore a user-friendly interface and the UCD approach also formed a significant part of the GiMoDig project [19]. The main goal of the project was to deliver maps in real time to the mobile users. The project resulted in an XML-based prototype for a seamless, cross-border mobile map service, based on open system architecture. The topographic data from national mapping agencies (NMAs) is used to provide a vector-formatted, high quality SVG (scalable vector graphics) map displayed on a mobile device [20,21].

2 The User-Centred Design Cycle

ISO 13407, 'Human-centred design processes for interactive systems' gives instructions to achieve user needs by utilising a UCD approach throughout the whole life cycle of a system [5]. The study starts with planning the project, at which point a

decision must be taken on what kind of information is needed with regard to the usability of the product: information about the usability of an existing product, ideas for developing a new product, or information for comparing products already on the market. The factors affecting the project planning process are strongly related to the amount of resources: money, time, people, etc. In addition, it is preferable to decide during the early stages of the project by whom, how, and when the usability evaluation will be carried out, i.e. usability experts or users, with usability tests or questionnaires, and at which stage of the project.

The three-step design is an iterative process, see **Fig. 1**. The first step is to ascertain the user requirements. These can be analysed by studying potential users and the context in which the application will be used. A decision must also be taken on which usability criteria are to be emphasised in the study: effectiveness, efficiency, satisfaction, memorability, and/or minimal errors?

The first design solutions and preliminary mock-ups can be designed on the basis of the user requirements. The following stage must analyse whether the defined user requirements have been met. Evaluation can be carried out using various usability methods, and if the results indicate that the user requirements have not been achieved, the iterative process goes back to redefining the user requirements. New solutions must be designed and evaluated. If the requirements are met the design comes out from the iterative cycle and can be considered ready for the market.

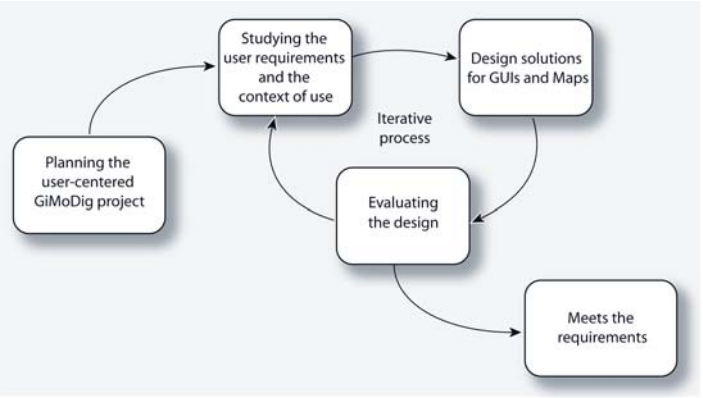

Fig. 1. A user-centred design (UCD) cycle in the GiMoDig project (adapted from the ISO 13407 standard [5]).

User studies should not end there either, since the market situation may change quickly. Therefore, evaluations on existing products should be carried out accordingly, to obtain information e.g. for future versions, and for making sure the product still satisfies user needs.

2.1 UCD in the GiMoDig project

In the GiMoDig project the need to consider usability issues during product design was one of the main concerns. Evaluations started at the beginning of the project and

continued throughout the whole lifespan of the project. Recently also other EU projects related to Geoinformatics and Location Based Services (LBSs) have been carried out. Most of them have followed the UCD approach in their research; e.g. the PARAMOUNT [16], LoVEUS [9], WebPark [2] and CRUMPET [22] projects.

The practical outcome of the GiMoDig research project was a working prototype (but not a complete end-user application) for a mobile map service. During the project some inconsistency was encountered with regards to developing a research prototype and its evaluation by users. This was due to the fact that both parties had requirements that did not correspond to each other. Scientific goals cannot be validated by user evaluation; and therefore different methods for evaluation were needed. This paper emphasises the user's point of view. The implementation and success of other research objectives are not discussed here.

At the beginning of the project there was a lack of experience on how to perform and utilise modern usability testing methods. The project gained practical help by attending the workshop for the VNET5 project in 2002, and by using the material offered for different tasks considering user-centred product development [25].

3 User Requirements

The UCD process often starts by identifying all the primary and secondary users and classifying them in a meaningful way according to project's objectives. The preliminary requirements for the system can be decided by identifying the user requirements for these groups and the real context of use. This is an important stage of the study, since the first mock-ups will be based on these results.

There are many methods for collecting such information: surveys, interviews, contextual inquiries or observations of users in a field study, user participations in a context of use analysis, focus groups or brainstorming, or even evaluating an existing system. Questionnaires or user surveys are often used since they are relatively easy and inexpensive to compile and analyse. This was done e.g. in the PARAMOUNT [16], LoVEUS [9] and WebPark [2] projects. Less common methods have also been used: in the PALIO project [15] the user requirements study was based on a combination of brainstorming and emphatic modelling.

The first usability goals can be created from the user requirements, against which future designs can be evaluated and tested. The acquired information can be structured e.g. by a compiling use scenarios, i.e. use cases, which specify how users perform their tasks in specified contexts [8]. They should include information about which activities should be performed by the user and which by the computer when the user is performing a certain task with the system. After compiling the scenarios they can be validated according to their relevance and importance. Usability goals can be established from the results.

3.1 GiMoDig User Groups

The GiMoDig project started with study on user requirements [7] and market analysis of mobile map services [17]. The potential usage areas of the GiMoDig service

included: information services, safety, emergency, restrictions on use or movement, guidance or navigation, logistics and military services. Potential users of the GiMoDig service could be divided into two user groups: a) end-users, and b) technology users.

End-users are the potential users of the service and they can be further divided into professional users and consumers. The preliminary expectation of the GiMoDig project was that it would result in a working prototype for the end-users. Jakobsson [7] classified the different goals which end-users may have for the use of LBSs: locating your position, and being located, locating other people, locating objects, obtaining guidance, obtaining information and obtaining help. 12 different use scenarios in which the user could benefit from using the service were compiled using the information on user goals and usage areas.

Technology users are those organisations providing value-added services for LBSs. These include, for instance, yellow page services etc., as well as tourism and leisure activity organisations. Technology users considered a critical success factor for the project as being the ability to exploit the results from GiMoDig and provide their own datasets above the topographic datasets for users with mobile devices.

3.2 Context of Use

The context of use was studied by arranging a field test in a national park [12]. The purpose of the tests was to obtain basic information on user requirements related to the use context, and also to find out how usable existing topographic maps in mobile devices were. This information was used in creating preliminary design principles for the GiMoDig service. At this point the project did not have any real prototypes to test. Therefore, it was decided that existing maps with existing hardware and software should be tested. The aim was not to test the software or the hardware, but to use them only as a means of utilising mobile maps.

3.3 GiMoDig Usability Goals

Both the main user groups (the end-users and technology users) had distinctively different tasks and requirements, and therefore the usability evaluation in the GiMoDig project also followed a similar division during the evaluation procedure. In other words, different evaluation methods for the both user groups were used.

End-users

The usability evaluation criteria were established and first mock-ups designed on the basis of the field tests and end-user requirements ascertained during the study. The usability goals were divided into four main categories each of which also included more specific requirements:

a) *Easy-to-use user interface (UI):* users had problems during the test tasks with the commercial navigation software; therefore the goal of this study was to make the UI easy to use. This was carried out using two different adjectives: simple and

intuitive UI. The main focus was to highlight the difference between the terms used among system developers and the terms of end user's use context.

b) *Suitable cartographic presentation:* users had quite a lot of problems with the current map symbols during the field tests. The goal was, therefore, to create a cartographic design suitable for two different environments; maps designed for a portable laptop PC and maps designed for a Personal Digital Assistant (PDA). Special emphasis was put on the intuitivity of the Point of Interest (PoI) pictograms, and the aim was to make them so intuitive that users could understand them without a legend.

c) *Integration of different data sets:* as separate topographic datasets were not enough from the users' point of view, one of the goals was to integrate additional information from different databases. This included the integration of value-added services information presented over the topographic map data. When the different datasets were being integrated the most important goal was the compatibility of the diverse datasets, i.e. how to present them seamlessly and in a way that users would like them to be presented.

d) *Context-aware maps:* During the tests it was observed, that users need meaningful map entities adapted according to their context of use [13,18]. Adapting the presentation and content of maps according to the usage context would greatly improve the usability of mobile topographic maps. The implementations for aiming to fulfil this requirement were considered to be one of the main goals.

Technology Users
User requirements for technology users were gathered in meetings with the organisations providing value-added services for LBSs, which were arranged during the project and at varying scientific conferences. Service quality goals were established on the basis of these contacts: a) functionality of service layers in the GiMoDig in the prototype environment, b) conformance to the Web Feature Service (WFS) interface for value-added service providers, c) conformance to the Web Map Service (WMS) interface, d) conformance to the Presentation Service interface, e) effectiveness of real-time transformation of coordinates, f) quality of real-time generalisation of data, g) quality of real-time integration of data and h) availability of the service.

4 Design

After the user requirements and usability goals for the system have been studied, the next stage is to make the first design implementations. At this point it is important that the design meets the user needs in specific tasks. Sometimes the preliminary design ideas can be very rudimentary (even paper prototypes or mock-ups that 'look real', but which do not have real functionality behind them can be used). The purpose

is to improve the design step by step in an iterative UCD cycle. By visualising the design ideas at an early stage in the process, evaluations can be presented to users quickly and cheaply. The feedback from users can be gathered, and implementing changes at the early stage of the design may reduce the design costs.

5 Evaluation

After the design phase, and often concurring with it, an iterative UCD cycle approach continues to evaluate and test the mock-ups, to find out whether the design fulfils the user requirements and usability goals established earlier during. The motivation for testing and evaluating is also to find out whether there are usability problems in the design that may negatively affect the real use of the system. Valuable information and feedback for further developing the UI can be gained from the testing.

There are several different usability evaluation methods that can be used when testing the design. The evaluation can be done either by using experts (usability inspections) or the users of the system (user tests) [23]. The term expert refers to an evaluation either by a usability engineer, interface designer, or person who is familiar with the application area, etc. Involving the users is often more time and money consuming than usability experts, but also provides real-usage information, which is sometimes difficult for the developers of the system to perceive. The choice of the appropriate method may also depend on the project's financial and time recourses, as well as what needs to be evaluated. These may differ between systems and the stage of the current design.

Usability problems ascertained during the evaluation can be used immediately for improving the UI. In other instances the findings can be used to redefine the user requirements established earlier. If no usability problems are discovered, then there is no need for another iterative round. However, if the user requirements are not fulfilled, the design, implementation, and the evaluation continues until the objectives are reached.

5.1 Usability Evaluation in the GiMoDig project

To evaluate the GiMoDig UI from the end-users' point of view, the evaluation started immediately after the first prototype became available. The mock-ups were evaluated and new user requirements were established, followed by new design implementations. The iterative process continued until the prototype met the user needs, while also taking into account the limits of the project's research goals.

The usability evaluations in the GiMoDig project were carried out using four different methods: heuristic evaluations, expert evaluations, usability tests and intuitivity tests.

Heuristic Evaluations of the GUI

As the aim of the project was to develop a UI as easy as possible to use, the first evaluations were done in order to find out the possible problems of the GUI at an

early stage of the prototype in the development and design. The preliminary results were needed quickly, which was also one criterion for choosing the method.

In heuristic evaluation the usability of the UI is studied using simple heuristics, i.e. guidelines. The procedure primarily consists of an evaluator who examines the interface and tries to find out what is good and what is bad about it by comparing it with the predefined heuristics [11]. The heuristics used in this study were compiled by Nielsen [11] and are listed as the following: 1) Simple and natural dialogue, 2) Speak the user's language, 3) Minimise the user's memory load, 4) Consistency, 5) Feedback, 6) Clearly marked exits, 7) Shortcuts, 8) Good error messages, 9) Prevent errors, and 10) Help and documentation.

A usability expert following Nielsen's 10 heuristics carried out the heuristic evaluations for the GiMoDig project. The evaluator went through all the menus in the UI and considered each step against the heuristics. Some of the problems found were related to the fact that the evaluation was carried out on a prototype still under development, and therefore its properties had not been completely designed. In the following **Table 1**, a few examples of the problems found are listed. The first column describes the problem and the second column lists the heuristics that the problem violated. In the third column the problems are classified according to their seriousness in terms of the use of the application, and in the last column, the possible improvement is proposed.

Table 1. Examples of usability problems discovered during heuristic evaluations of the GUI, see text for details.

Description of the problem	Which heuristic does it violate?	Criticality of the problem? (1-4)	Improvement proposal
Possibility to go back to the start page is missing from some views.	4,6	3	All the views should have an icon for going back to the start page, and always at the same place of the UI.
Tools do not have any indication of being 'active' when selected.	1,2,4	3	Active tool could be enhanced with different colour.
There is no short way to receive a default map.	7,9	2	Shortcut should be added.
When loading a map, there is no indication that the application is processing something.	5	1	User should be informed that the process is still going on, e.g. with the text 'Loading the data'.

After the evaluation, a meeting was arranged between the usability evaluator and the UI designers and programmers. The meeting covered all the problems and at the same time discussions were held on possible improvements to the problems. Heuristic evaluations were repeated several times during the project, and improvements were made at each stage of the design, based on the results.

Expert Evaluations of the GUI

Heuristic evaluations were used at the early stage of the project, but once the design became more sophisticated, experts working in the area of cartography or geoinformatics evaluated the GiMoDig GUI. The experts examined the GUI and at

the same time performed predefined test tasks presented to them in a questionnaire. A total of 13 persons filled out the test questionnaire: nine project members (not directly involved in the GUI design) and four users from outside the project.

The main aim of the evaluation was to find out, how users managed to get different types of maps from the service, how they liked the visual design of the GUI, and what they thought about the parameters and preferences that were used and the different types of maps available. Research was also carried out into whether users recognised the different GUI buttons, i.e. how intuitive they were, as well as functions of them.

The results from the questionnaire were analysed and grouped under different divisions. As with the heuristic evaluations, it was observed that many of the problems the experts came across were mainly due to the prototype and the research nature of the application. The users, for example, missed some functions that they were used to having in other map applications (like opening the map from a selected area, because in the GiMoDig prototype they could only choose from four different test areas). Critical errors were also found in the GUI, which needed to be fixed in the first instance. It was discovered, for example, that some of the buttons did not function at the same time, which was critical from the users' perspective.

Usability Tests for the GUI

A usability test is one of the most fundamental methods in usability evaluation, because real test users are asked to use the product. The moderator of the test gives predetermined test tasks one at a time to the test user, who in turn performs the tasks with the UI [11]. The test users are usually asked to think aloud while doing the test tasks. Interviews and questionnaires are also often used in order to gain more insight into the user's actions with the interface.

The usability test method was also used for the GiMoDig GUI evaluation, in order to get more detailed information about the real use of the map application. The tests were arranged so that the user used the GUI to carry out certain test tasks, which were provided by the moderator. The users were encouraged to think aloud when using the application. The PC screen and users' comments were recorded on film during the tests. The usability test resulted in a list of usability problems that the users came upon during the test situation, and also a list of positive comments relating to the product.

One of the major problems to be discovered was the zooming function, with which the users had conceptual problems. The 'level of detail' property in the GiMoDig project was a new concept, and the way the zooming was executed in the current application was surprising and caused irritation among users.

Intuitivity Test for Cartographic Design

A set of PoI pictograms was designed in the project and a special intuitivity test was arranged to measure their usability [14]. The test was based on a study reported by Bewley et al. [1], who tested the intuitivity of some icons by showing them to users and asking them to describe, "what they think it is". In an intuitivity test it is not necessary to use the symbols and terms of the final UI; paper pictures of the symbols and terms can be used as well.

The intuitivity of the symbols was tested with a test form, which was sent to several users by email. Users were asked to look at each of the pictograms one by one and write down beside it, what they thought the meaning was. Information about the aesthetical validity of the symbols was also gathered on the form. A total of 19 users answered the intuitivity test. Their ages varied from 14 to 47, and they represented four different nationalities.

Quantitative data on how many users recognised the symbols was gathered from the intuitivity test. Qualitative data was also gathered from the user comments.

Expert Evaluation for Cartographic Design

Since GiMoDig maps were provided for two different media (for PDA and portable laptop PC), the cartographic design was also especially designed separately for both environments. Therefore the maps were evaluated in two different environments; maps designed for PC and maps designed for PDA.

The idea of the expert cartographic evaluation was to go through different kinds of GiMoDig map designs and gather information about the map usability to improve the design. There was a specific form created for this purpose. For each map the evaluator had to consider each cartographic object according to its: 1) area fill colour, 2) line or outline colour, and 3) contrast compared to other map symbols. Also the over-all layout of the maps was considered according to following questions: Is the map harmonic? Are the symbol colours harmonic? Are the symbol colours associative? Are the symbols self-evident? Is the map easily understandable without a legend? What is the overall legibility of the map?

Several cartographic experts carried out the evaluation of the cartographic design using the evaluation form. When evaluating PDA maps, the evaluators went outdoors in order to examine the real use context with differing light conditions, whereas the laptop maps were evaluated indoors. The evaluations took place four times and each of them took a couple of hours. During the evaluations, the cartographic experts found problems with the cartographic design that were listed and taken into account during the next design phase.

5.2 A Focus Group Meeting with the Technology Users

The most important objective of the GiMoDig service from the technology users' (value-added service providers and/or the NMAs) point of view was their desire to exploit the GiMoDig results and use the service for providing their own datasets above the topographic datasets for users with mobile devices. This objective was taken into account by arranging several discussions during the project. The feedback provided by technology users was used for updating input data for the design and service.

The final validation of the service prototype was carried out with the end users. The method chosen for the validation (focus group) is described by Nielsen [11, p. 214]: "In a focus group, about six to nine users are brought together to discuss new concepts and identify issues over a period of about two hours. The group is run by a moderator who is responsible for maintaining the focus of the group on the issues of interest. The moderator has to follow a preplanned script for what issues to bring up.

Focus groups often bring out users' spontaneous reactions and ideas through the interaction between the participants."

A total of 6 user group meetings were arranged within the GiMoDig project. The attendees were private companies with private marketing interests. The main topics of the discussion were 1) System and its interfaces, 2) Adapting maps to the usage situation, 3) Datasets, 4) Mobile technologies and there development, 5) The most promising/potential applications. The following aspects were considered in discussion considering each topic: usefulness, usability, functionality, necessity, implementation possibilities, needs for development (why and how), rationality and feasibility.

6 Guidelines for Incorporating UCD into Map Projects

In this paper the user-centred design process was explained not only at a general level but also from a mobile map project point of view. Based on the experiences gained, a set of guidelines can be drawn up for creating a UCD map application. The approach given here is not a conclusive statement of the issue, but more a recommendation based on the experiences gained during the 3 years of the UCD project.

Cartographic systems are specific in a way that the usability of the system is composed of different system elements. First, mobile map usage may vary a lot (outdoors/indoors, PDA/PC, navigation in the forest/tourist navigation in the urban area). The *context of use* should be studied beforehand to compile realistic user requirements, and during the design process to ensure that it is suitable for the use context. Second, the mobile *map* has to be user-friendly and usable in the context. Third, the *graphical UI* must also fulfil the needs of the user. Therefore we enhance a three-headed approach for the evaluation, see **Fig. 2**:

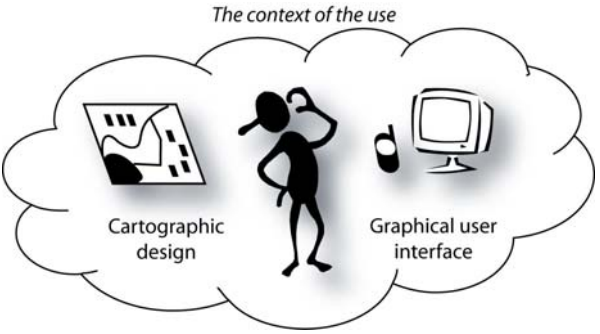

Fig. 2. The design of a map application should take usability issues into account in two different areas: *the usability of the GUI* and *the cartographic design*. These are affected by the *context of the use*, which should also be taken into account at every stage of the process.

Find Out the Context of the Use

Everything is based on good knowledge of the potential users of the mobile map service and the situation in which the map is going to be used. Therefore, evaluating

the mobile context of use is critical. Based on the experience gained, we recommend arranging field tests for the purpose. The most important element is to meet the real users at the beginning of the project. Expert evaluations (such as market studies etc.) can be used for gaining information from secondary sources.

Evaluate the Cartographic Design

According to our experience, the best way to evaluate the cartographic design is by using cartographic experts. They possess knowledge about the visualisation possibilities and restrictions, as well as the spatial cognition of map users. Thus, these experts have a realistic insight into the design. When an expert cartographic evaluation is carried out, the context of the use should be taken into account as well, e.g. maps in mobile devices have to be evaluated outdoors in varying light conditions.

Involving users is necessary for finding answers to questions such as the aesthetic quality or intuitivity of the map design. But it must be kept in mind that asking users on the design's aesthetic appearance is always such a subjective matter that valid results will not be gained unless there are sufficient amount of users involved in the evaluation. It should also be borne in mind when involving users in the map evaluation that in many cases the use of a map is strongly related to getting used to something: if the user expects a traditional map, the differing visualisation may be an irritating factor.

Evaluate the GUI

When the UI evaluation has to be done quickly and/or at the early stage of the design, the most suitable method may be the heuristic principles described earlier. But if the design is more sophisticated or even nearly 'finished', involvement of the users in the evaluation process is necessary, and e.g. usability tests should be arranged. Since heuristics are not designed for map GUIs in particular, a set of instructions was created based on the experience gained during the project. The guidelines described here are based on general usability heuristics [11] and give a preliminary idea on how to practice usability engineering in map services. Still, the methods have to be further developed and adapted to suit the multi-disciplinary nature of mobile map projects.

Simple and natural dialogue: every additional feature on a screen makes the use of any application more complicated for the user, by increasing what has to be learnt, the opportunities for misunderstanding and the number of searches that have to be carried out when looking for a specific element [11]. Therefore, one of the main usability goals in map application design should be to provide the user with as simple a UI as possible.

Speak the user's language: to make the UI intuitive for the user, the terminology used should be equal to the user's natural language. The main focus is to bridge the gap between terms used by system developers and the terms used by end-users. In addition to the verbal language used in the interface, this also includes other elements of the interface; e.g. the graphic design of the icons. By having an intuitive UI, the use experience of the application can be made more pleasant. The intuitivity of a UI makes it easier for the user to figure out how to proceed with the application, which is especially important when the user starts to use the application for the first time. The interface should match the user's task in as natural a way as possible. Since different

map applications may have different types of users, the interface should be adapted to for different user groups. If a map application is being designed for sailing purposes, the appropriate expert terminology for that context should be used, whereas for tourist city guides, totally different and more general terms are needed. This puts the focus on natural dialogue suitable for each user.

Minimise the user's memory load: the UI should be designed so that it is immediately 'ready to be used' for each user. The users should not have to remember what kind of settings or parameters have to be given in order to achieve certain maps; instead the use should be supported by the application. The designers should avoid long and complicated command-sets that the user should remember in order to get something done with the map application. Instead attention should be paid to design easily recognisable and intuitive icons and buttons.

Consistency, feedback and clearly marked exits: the map application should have logical function buttons, which are consistent through the whole interface. For example, the exit button for the application should always be in the same place, and the zoom in-and-out function should work all the time with the same logic. The user should also know what she/he did, is doing at the time, and will have to do in the future when using the application. This is very important e.g. when large map files are being loaded, which takes a long time before they can be shown on the screen. The users should know that 'something' is happening in order to prevent frustration and the idea that the application is not working. The application buttons should be designed in a way that the user knows what is currently selected. The user should know all the time how to quit or proceed with the application.

Shortcuts: if the map application has both novice users and experienced map users, the different demands of both users should be supported. Novices should be offered help and wizards, whereas experienced users should be provided with shortcuts to make the experience quicker and easier, e.g. getting a default map, changing the map parameters and selecting different tools.

Prevent errors, good error messages, help and documentation: the best situation would be to totally prevent any mistakes being made with the application. This is difficult and often a too optimistic approach, and therefore good error messages have to be implemented. It is not informative to read: "Error code 122423", but more specific error messages help the user in a much more gentle way. Obviously, a 'help' functionality is always an important part of the UI and the map application.

7 Discussion

In the paper a user-centred design for developing a mobile map service was described. During the process it was discovered that users need various types of maps in different situations, and in order to create useful products users should be involved in the development cycle from the beginning of the project until the final product is launched onto the market.

Our literature review revealed that although cartography has a long history of perceptual-cognitive research on the use of maps, systematic usability engineering throughout the lifecycle of map applications (including user requirements, design and

iterative evaluation) seems to be rare. Nevertheless, several researchers have emphasised the need to develop a human-centred approach to geovisualisation and iterative testing by using usability-engineering principles, as shown in the introduction.

It was also discovered that current map applications were being evaluated by two different groups of researchers, namely cartographers/GIS specialists or HCI engineers. However, it was observed that studies in general either included studies related to the map visualisation or to the GUI of map applications, but not both. This indicates, that the overall usability of map applications was therefore not completely investigated.

Consequently, we enhanced a three-headed approach for the evaluation based on the experience gained during the project: The *context of use* should be studied beforehand to compile realistic user requirements, and during the design process to ensure that it is suitable for the use context. Second, the mobile *map* has to be user-friendly and usable in the context. Third, the *graphical UI* must also fulfil the needs of the user.

Experiences were gained during the project to implement usability evaluation methods and UCD successfully into the map project. Based on our experience, a set of instructions was created. The guidelines described here are based on general usability heuristics, and give a preliminary idea on how to practice usability engineering in map services, but the methods still need to be developed and adapted to suit the multi-disciplinary nature of mobile map projects.

Furthermore, it may be that knowledge on incorporating usability issues in product development is not available in the cartography research community. Hence, we also emphasise the need for increasing the human computer engineering knowledge among cartographers and GIS specialists.

References

1. Bewley, W.L., Roberts, T.L., Schroit, D. and W.L. Verplank. Human factors testing in the design of Xerox's 8010 'Star' office workstation. *Proc. CHI'83 Conf., ACM Press*, 72-77, 1983.
2. Edwardes, A., Burghardt, D. and R. Weibel. WebPark – Location Based Services for Species Search in Recreation Area. *Proc. of the 21st International Cartographic Conference*, Cartographic Renaissance, Durban, South Africa, 1012-1021, CD-ROM, 2003.
3. Fairbairn, D., Andrienko, G., Andrienko, N., Buziek, G. and J. Dykes. Representation with Cartographic Visualization. *Cartography and Geographic Information Science*, Vol. 28, No. 1, 13-28, 2001.
4. GiMoDig. Geospatial info-mobility service by real-time data-integration and generalisation. At <http://gimodig.fgi.fi/>, accessed 5/ 2005.
5. ISO 13407. Human Centered Design for Interactive Systems. International Organization for Standardization, Geneva, Switzerland, 1999.
6. IST, Information Society Technologies. At <http://www.cordis.lu/ist/>, accessed 5/2005.
7. Jakobsson, A. User Requirements for Mobile Topographic Maps. GiMoDig-project, IST-2000-30090, Deliverable D2.1.1., 2002. At <http://gimodig.fgi.fi/deliverables>, accessed 5/2005.

8. Kulak, D. and E. Guiney. *Use Cases – Requirements in Context.* Addison-Wesley, NY, 2000.
9. LoVEUS. Location Aware Visually Enhanced Ubiquitous Services. User requirements of the LoVEUS system, Deliverable D01, IST–2000-30155, 2002. At <http://loveus.intranet.gr/documentation.htm>, accessed 5/ 2005.
10. MacEachren, A.M. and M.-J. Kraak. Research Challenges in Geovisualization. *Cartography and Geographic Information Science*, Vol. 28, No. 1, 3-12, 2001.
11. Nielsen, J. *Usability Engineering*. Academic Press, San Diego, California, 1993.
12. Nivala, A-M., Sarjakoski, L.T., Jakobsson, A. and E. Kaasinen. Usability Evaluation of Topographic Maps in Mobile Devices. *Proc. of the 21st International Cartographic Conference*, Cartographic Renaissance, Durban, South Africa, 1903-1913, CD-ROM, 2003.
13. Nivala, A.-M. and L.T. Sarjakoski. Need for Context-Aware Topographic Maps in Mobile Devices. In Virrantaus, K. and H. Tveite (eds.), *ScanGIS'2003 –Proc. of the 9th Scandinavian Research Conference on Geographical Information Science*, Espoo, Finland, 15-29, 2003. At <http://www.scangis.org/scangis2003/papers/>, accessed 5/2005.
14. Nivala, A-M. and L.T. Sarjakoski. Adapting map symbols for mobile users. To be published in *Proc. of the 22nd International Cartographic Conference*, July 9-16, A Coruna, Spain, 2005.
15. PALIO, Personalised Access to Local Information and services for tourists. User needs and characteristics and contexts of use (D1) and Information and Service requirements specification (D2). European Commission/IST-Programme, IST-2000-20656 0, 2002. At <http://www.palio.dii.unisi.it/del/Del_01_02.pdf>, accessed 5/2005.
16. PARAMOUNT. Public Safety & Commercial Info-Mobility Applications and Services in the Mountains. User Requirements, Deliverable D1, IST-2000-30158, 2002. At <http://www.paramount-tours.com/>, accessed 5/ 2005.
17. Pekkinen, P. and A. Rainio. Market analysis of mobile map services. GiMoDig-project, IST-2000-30090, Deliverable D2.2.1, 2002. At <http://gimodig.fgi.fi/deliverables.php>, accessed 5/2005.
18. Sarjakoski, L.T. and A.-M. Nivala. Adaptation to Context - A Way to Improve the Usability of Mobile Maps. In Meng, L., Zipf, A. and T. Reichenbacher, (eds.), *Map-based Mobile Services, Theories, Methods and Implementations*, Springer Berlin Heidelberg New York, 107-123, 2005.
19. Sarjakoski, T., Nivala, A.-M. and L.T. Sarjakoski. Report on usability and validity. Geospatial Info-Mobility Service by Real-Time Data-Integration and Generalisation - project (GiMoDig), IST-2000-30090, Deliverable D9.1.2, Internal EC report, 2004.
20. Sarjakoski T. and L.T. Sarjakoski. The GiMoDig public final report. GiMoDig-project, IST-2000-30090, Deliverable D1.2.31,, 2005. At <http://gimodig.fgi.fi/deliverables.php>, accessed 5/2005.
21. Sarjakoski, T., Sarjakoski, L.T., Lehto, L., Sester, M., Illert, A., Nissen, F., Rystedt, B. and R. Ruotsalainen. Geospatial Info-Mobility Services - A Challenge for National Mapping Agencies. *Proc. of the Joint International Symposium on GeoSpatial Theory, Processing and Applications*, Ottawa, Canada, CD-ROM, 2002.
22. Schmidt-Belz, B. and S. Poslad. User Validation of a Mobile Tourism Service. In Schmidt-Belz, B. and K. Cheverst (eds.), Proc. of the Workshop W1 "HCI in Mobile Guides 2003", in conjunction with Mobile HCI'03, Udine, Italy, 57-62, 2003.
23. Shneiderman, B. *Designing the User Interface. Strategies for Effective Human-Computer Interaction*, 3rd edn., Addison-Wesley, 18-27, 1998.
24. Slocum, T.A., Block, C., Jiang, B., Koussoulakou, A., Montello, D.R., Fuhrmann, S. and N.R. Hedley. Cognitive and Usability Issues in Geovisualization. *Cartography and Geographic Information Science,* Vol. 28, No. 1, 61-75, 2001.
25. VNET5. At <http://www.vnet5.org/>, accessed 5/ 2005.