



Blekinge Institute of Technology  
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# Usability concerns in GIS development for a wider user-base - A qualitative usability research in Swedish municipal infrastructure

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## Abstract

We now live in a society where communicating is done mostly through computer-technology based mediums. In Swedish municipal infrastructure a lot of the communication-data consists of geospatial data-collections. This data is generated with Geographical Information Systems (GIS) which usage in Sweden has increased rapidly. This has led to a competition between developers in designing their systems for a wider user-base. A transition between designs that has its focus on a small target group and designs intended for a wide range of different users puts the developers in a challenge where usability is one of the big concerns. In this thesis we, have adopted a qualitative research approach with contextual observations and usability testing, in order to identify the crucial usability concerns when designing GIS for a wider user-base. Results show that the most crucial usability concerns are related to system feedback and the GIS not being compatible with other GIS data formats. The research has been concentrated within municipalities in Sweden and results presented in this thesis are rough, but true indications. More research is needed to get detailed accuracy of the usability concerns. We hope that this thesis will aid developers of GIS in their design-phase and to be part of a foundation to future GIS-standards.

**Keywords:** *GIS, usability acceptance level, expanding user-base, Swedish municipal infrastructure*

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## Introduction

### Background

We now live in a society where communicating is part of our daily work routine and is done mostly through mediums based on computer-technology. A lot of this communication-content consists of data-collections or data-flows. In Swedish municipal infrastructure a lot of this data (ESRI S-GROUP, 2008) between different sections consists of geospatial data-collections to represent the real world. The data is generated with Geographical Information Systems (GIS). GIS is used for collecting, analyzing and storing data that can be represented in a real world location. GIS is not only roads, lakes and buildings drawn on a map, it's a way of packaging almost any data that has a spatial connection so that it can be managed and represented in a more accessible and easy way. This is the power of GIS and just as important is the usability of the tools used to manage the data. It must be easy to handle, have a user friendly Graphical User Interface (GUI), be visually advantageous and be able to handle both spatial and thematic analyzes (Eklund Hylin, J., 2003).

### Problem

GIS-application development has increased in Sweden for the last few years and to the groups understanding the competition between developers has made an impact on how GIS today is developed. Because of this increase in competition the developers are trying to design their systems to get a wider user-base instead of the tailored systems for a small user group (Göthammer, M., 2008). This transition between a design that has its focus on a small target group and a design that is intended for a wide range of different users should put the developers in a challenge where usability is one of the big concerns. The goal of this thesis is to identify the crucial usability concerns when designing GIS for a wider user-base, if there are any. This leads to the questions that the group will try to answer and the hypothesis that will be tried.

- What is a crucial usability concern in GIS?
- What crucial usability concerns are there when designing for a wider user-base?
- Are the general usability concerns different to the GIS-users' perception of usability?
- What usability issues are prioritized by the GIS-user?

## Hypothesis

### *Null hypothesis*

*There are crucial usability concerns when designing GIS for a wider user-base that has to be dealt with in order to retain an acceptable level of usability.*

### *Alternative hypothesis #1*

*There are no crucial usability concerns when designing GIS for a wider user-base.*

### *Alternative hypothesis #2*

*There are usability concerns when designing GIS for a wider user-base but not that has to be dealt with in order to retain an acceptable level of usability.*

The term *crucial usability concerns* refer to issues that prevent the user from fully utilizing the tools of the system, without being related to functionality. Designing for a wider user-base refers to when an application is designed with the goal to expand the original target audience with the aim to meet the needs of other user groups. An acceptable level of usability is reached if the users of the system in a satisfactory manner, experiences minor errors, easily recovered from, not preventing the user from reaching the intended goals.

To get a wide understanding on GIS-application usage, thoughts of and how satisfactory they are in the municipalities of Sweden, a survey will be made and sent out to end-users. The survey will have some free form-questions that will target key issues with specific uses of GIS. The group will also conduct some contextual observations and case studies with experienced GIS-users at one municipality in Sweden where a change to a new GIS will be made in a near future.

The group believes that the outcome of these methods will show that there are crucial usability concerns that need to be taken care of if the users are to be satisfied to an acceptable extent with the product.

## Delimitation

Delimitations will be done because of GIS being a wide area. The research will be concentrated to Swedish municipal infrastructure with a case-study focusing on one municipality in southern Sweden and the GIS-application that is in use there and the one that will be used in a near future, where the latter is of a wider user-base design. Two users are chosen as participants of tests and observations during this work. They are chosen based on their frequent GIS usage and previous contact with a research group at Blekinge Institute of Technology (Blekinge Tekniska Högskola, BTH).

## Theoretical background

### Usability

Usability, from the perspective of a system developer, is a quality attribute that describes how well a GUI meet the requirements of the end-users in terms of *satisfaction*, *efficiency* and *effectiveness*. We all share the common knowledge that a tool is useless if you can't use it properly to achieve intended goals and that a tool is less attractive to use if it lacks an efficient way of reaching intended goals. A product with a low level of usability will likely be altered by a competing product that is bundled with a higher level of usability which better suits the user and context - why use a product that is less efficient and less satisfactory than a competing product? These facts tell us something about the importance of usability in software development.

Several definitions of the term usability have evolved through the years. The definitions are however closely related, some of them even share the same core components. The following definition of usability is provided by the International Standards Organization (ISO) in ISO 9241: Part 11 "Guidance on usability":

"Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use."

The term usability is furthermore divided into measurable components to strengthen its definition, make it easier to understand and apply. The keywords in the definition provided by ISO that each make up an individual component are:

- **Effectiveness**  
To which extent the intended goals are achieved.
- **Efficiency**  
Steps taken to reach the goals are as few as possible.
- **Satisfaction**  
Level of satisfaction and to which extent user expectations are met.

These components vary between definitions but there are similarities worth mentioning. An analysis of the different usability definitions (Tajakka, S., 2003) points out four frequent components in the definitions available. These components are:

- **Efficiency**  
The system should be efficient to use. This means that a system should provide a way for the user to perform a certain task quickly with as few steps as possible.
- **Learnability**  
The system should be easy to learn and use so that the user quickly can get work done.

- **Attitude**  
The user's feelings, thoughts and attitude towards the system need to be positive in order to ensure continuous use.
- **Satisfaction**  
The user should experience that the system is pleasant to use.

Since these four components make up a mixture of frequent components in the available usability definitions they should be thought of as a general, rather than an exact, description of the term usability.

## Geographical Information Systems (GIS)

The acronym GIS is generally used for computer-based systems that has the capability to manipulate geographical data (Bernhardsen, T., 2002). By rendering the possibility of manipulation and analyze of individual layers of geospatial data and also allow for analyzing and modeling the relations between the layers, GIS has made a strong impact in different areas of application (Bonham-Carter, G., 1997). These application areas in a global scope can include studies for environment, logistics and tourism potential, hydrology and water resources management, geo-demographics studies and flood control monitoring (Datta, M.M., 2003).

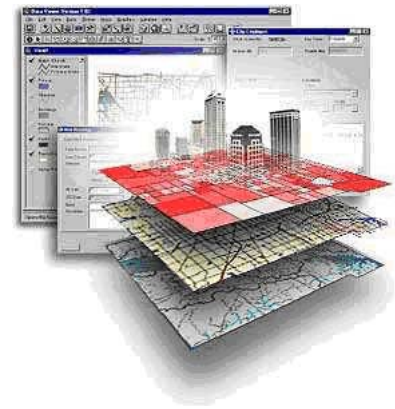


Figure 1 – GIS and layers  
[ image source: <http://www.uflib.ufl.edu> ]

These advanced operations are made possible with GIS mainly because of the map in the GUI that serves as a tool for accessing information in several databases. By using a map as the main tool, users of the GIS are able to manage, analyze and present geographical information in a way that may support important decision-making. For instance, users can perform analyses such as calculating the number of children between five and ten years of age, in a radius of four blocks from where a new playground is being planned.

The group found limited relevant literature that handle usability and GIS though Koua and Kraak (Koua, E.L. & Kraak, M.J., 2004) states that usability of GIS and geovisualization products has received considerable attention in recent years and development of GIS-technology has been rapid (Göthammer, M., 2008). One paper explained only that GUI's should be user friendly and functional (Eklund Hylin, J., 2003). Another paper pointed out that the screen resolution had an interest on the systems usability and that lack of a standardized storage format was an impediment to GIS usability (Saghir, S., 2005).



## Methods

This section describes methods used in this study, decisions and adjustments made to properly fit the situation. The research work is divided into one quantitative part and one qualitative part in order to answer the questions *how* and *why*.

“Survey research tells you what people feel and think about themselves, their behavior, and your product, but it's too limited a technique to say much about *why* they feel that way. For that, you need to follow up with qualitative research” (Kuniavsky, M., 2003).

In the quantitative part there was a large focus on usability aspects in municipal GIS usage with the purpose of discovering the needs and expectations of the target audience and to make assumptions based on the collected data about usability issues in future GIS development. In the qualitative part there was more focus on the user experience and observation of the user behavior during usability testing of two different versions of software within the same family where one aim of the latter was an expansion of its user-base. A set of metrics were used for the measurement process to get comparable data of the two systems. The backbone of this study has been gradually built up through an ongoing literature study.

## Literature study

The initial part of the study covered GIS and its application areas. This part resulted in the foundation to the discussions that led the group to take the chosen approach to investigate usability concerns in GIS. Remaining study mainly covered practical usage of different methods within usability and research.

## Survey

There are few reports on the municipal GIS usage in Sweden apart from the escalation in number of GIS users. A research of GIS usage in Sweden made by Utvecklingsrådet för Landskapsinformation (ULI) shows a raise of nearly 40% in GIS usage during the years 1997-2000 (Ny Teknik., 2001). There is a large piece of information missing about usability aspects.

Survey is the obvious tool of choice to outline users' goals and valuations in their GIS usage. In this study the choice has been made to collect this missing piece of information using a web survey as a fast and cheap alternative to paper copies. Using the web as medium for a survey has some advantages over using paper copies including the possibility to check whether mandatory fields are filled in or not upon submission and the offering of a powerful way of putting data together by direct-manipulation of the underlying database.

## Usability Testing

Usability testing is a straightforward way of capturing the behavioral aspects in usability, and the process is ideally seen as a part of software engineering. One of the common critiques towards usability testing is that it is expensive and time consuming to schedule tests with all participants that are needed in order to get valuable data. Some studies states that the majority of usability issues will be observed with the first five participants (Lewis, J. R., 1994; Nielsen, J. & Landauer, T., 1993; Virzi, R., 1992) whilst other studies state that five participants are not enough (Molich, R., et al., 1998; Spool, J., & Schroeder, W., 2001; Woolrych, A., & Cockton, G., 2001). However, it is acceptable to say that five participants per significantly different class of users usually is enough (Tullis, T., et al., 2008).

Usability testing is well suited in this study in the pursuit of uncovering usability concerns in GIS where the aim is an expansion of the user-base. The case-study will focus on a specific user class and therefore a few participants would be enough to identify key issues. The measurement of usability in the different versions of the system is done through the use of some well-approved usability metrics. As a result of the efficiency measurement the group is forced to adopt a retrospective probing technique in which the participants is asked to hold their comments until after the task is performed. Using a thinking-aloud protocol is almost certainly going to have an impact on the time taken to perform a task (Tullis, T., et al., 2008) and the idea in this case is that the user should perform the task just as if it was a regular day at work. The data concerning user thoughts and behavior is not totally lost when testing without a thinking-aloud protocol, instead notes are taken by the observer and is immediately followed-up after the test case while the participant's memory is still fresh.

## Metrics

“A metric is a way of measuring or evaluating a particular phenomenon or thing” (Tullis, T. et al., 2008).

Usability metrics reveals something about a system during use, depending on which metrics are used in the usability study it may involve the user experience or interaction between system and user. By using metrics in the same way each time something is measured, powerful analyses and conclusions can be the results of the comparable outcome.

As proposed in the book *measuring the user experience* (Tullis, T. et al., 2008) the most appropriate metrics for the usability study scenario “comparing alternative designs” is: *task success, task time, issue-based metrics, self-reported metrics* and also *combined and comparative metrics*. Task success reveals difficulties in reaching the goal when the participants are performing certain tasks. If the participants are unable to complete a task

there's obviously something wrong that needs further investigation. Task time is the time taken for a participant to complete a task. This is an excellent way to measure efficiency and it says a lot about the usability of a product (Tullis, T. et al., 2008). Issue-based metrics are associated with identification of usability issues and finding design solutions to them which most usability professionals probably consider as the most important part of their job (Tullis, T. et al., 2008). Usability issue in this case could be such things as confusion with navigation or terminology used which could result in an increase in error rate and thereby a less efficient system. Self-reported metrics are metrics associated with the participants experience with the system that are carried out by the participant filling out forms, list of attributes, rating scales and answering questions regarding their perception of the system. Combined and comparative metrics is the term used for new metrics built up on a combination of more than one metric making it unique in the sense of exploring aspects of usability.

The metrics used in this study are task time, issue-based metrics and self-reported metrics.

### **After-Scenario Questionnaire (ASQ)**

After-Scenario Questionnaire (ASQ) is a post-task rating technique designed to be used in usability testing after the user completes a scenario. The main goal of post-task rating techniques is to give the observer insight into which tasks the participant thought were the most difficult (Tullis, T. et al., 2008). This information is then used to point out parts of the system that needs improvement. ASQ covers three fundamental aspects of usability; effectiveness, efficiency and satisfaction.

### **System Usability Scale (SUS)**

A quick and easy way of getting an overall usability score of a system is to use the System Usability Scale (SUS). The SUS was originally developed by John Brooke at Digital Equipment Corporation as a "quick and dirty" tool to be used in usability engineering (Brooke, J., 1996). The SUS is used to make comparisons across different systems and to obtain a global view of subjective assessments of usability. The SUS consists of ten statements to which participants rate their level of agreement on a five-point (or seven-point) Likert scale. The statements with odd numbering are positively worded and the statements with even numbering are negatively worded in order to prevent unconsidered responses. To calculate a SUS score to begin with, one simply sums up all score contributions from each statement where each odd numbered statement score contribution will be the scale position minus 1 and each even numbered statement score contribution will be 5 minus the scale position. This sum of scores is then multiplied by 2.5 to obtain the overall SUS score. The overall SUS score will range from 0 to 100. It is important to know that the score for individual items are not meaningful at all (Brooke, J., 1996) and cannot be used to justify a single usability aspect. The statements in the SUS

covers a large set of usability aspects (learnability, satisfaction, efficiency, effectiveness and consistency) but since measurement results from some of these components is context specific the statements are taken to a higher level of abstraction in order to enable comparisons to be made across different systems.

The SUS was used in the case-study (see Appendix C) during the usability testing sessions after the completion of all the tasks. The main goal of using the SUS was to obtain comparable data for the current version of the GIS and a prototype of the upcoming GIS in which one of the aims is an expansion of the user-base. The result of this comparison would indicate whether there are usability concerns associated with this system transition or not.

## Phase 1: Background study and problem definition

When the subject of the research project was set, the group discussed from what angle and how to approach this. At this point the group got an invitation to attend at an acceptance test as spectators. The test was for another research project on user experience and quality of mapping services (Eriksén, S. et al, 2007). At the test the group came in contact with a web-based GIS and one of the GIS-users at the municipality of Karlskrona. Observations at the test were interesting to the group but later delimitations made the results irrelevant. Through the research group at the test site, the group got access to the web-based GIS that were used during the test. Besides the literature study the group did a practical study of the GIS to get a more accurate feel of the usage.

This particular GIS was designed as a light-weight version of a bigger more complex client. Functionality in the GIS was limited to a few small tools; zooming in and out, measuring area and length, view object attributes, print and send maps by e-mail. When analyzing the GUI, the group looked for design patterns and principles that might violate usability in field work. Results from this analysis showed that some details in the design, buttons, language flag icons and such might not be exemplary for usage in field work. Because of this being assumptions, the group wanted to test the web-based GIS in the context of field work. At the initial test that the group attended, a contact was established with the test user. This contact was established so that the group could arrange a meeting at the user's place of work later on in the project to get a more conclusive observation of GIS usage.

Observations were made with two users at the municipality of Karlskrona. Results showed that the GIS-application that is in use in the municipality of Karlskrona is very complex and takes a long time to learn, compared to the web-based GIS. The group also noticed that the GUI of the GIS was very consistent with a lot of the screenshots seen in the literature study. During the analysis of the observation notes the group realized that research time didn't allow for a user test in the field, which led the group to shift focus from researching usability in the field, to usability when designing GIS-applications.

A meeting was arranged with some developers of the GIS-client studied and the group was informed that there was a "next generation" GIS under development (Göthammer, M., 2008). With this GIS the developers wanted to reach out to a wider user group and had focus on this during design. The group seized the opportunity and changed focus again, slightly. To identify usability issues when designing for a wider user-base the group had to explore the usage of GIS. From the observations at the municipality of Karlskrona the group learned that municipalities in Sweden are a large user group and that this would be a good area to investigate GIS usage.

## Phase 2: Exploring user needs, expectations and contexts of use

This section describes the quantitative part of the research in which a survey was used to discover the needs and expectations of the target audience.

### Target audience

The target audience for this quantitative research was users working in different sections within the municipalities of Sweden that to some extent uses GIS in their work. The decision was made to target the 50 largest municipalities (Statistiska Centralbyrån, 2007) which to the group's assumptions were more likely well-established with the usage of GIS. A higher rate of replies was expected as a result of choosing this targeted group.

### Purpose and goals

The underlying purpose for this quantitative research was to get an insight in the GIS usage today; how and where GIS is used to accomplish tasks and support everyday work depending on the section in which the user is stationed; GIS products currently in use, satisfaction levels and general attitudes. This information would help to clarify the needs and expectations in the current market of GIS users within municipalities of Sweden that needs consideration when designing GIS for a wider user-base; the goal is not to change user-base, the goal is to expand the current user-base and to fit the needs of the larger market.

In this explorative research the group wanted to capture data concerning:

- The overall level of satisfaction and attitudes towards GIS usage.
- The contexts of use.
- Environmental preferences.
- The tasks performed and user goals.

Level of satisfaction and attitudes towards GIS usage is interesting because in a combination with GIS software of choice in a quantified form – further investigation may outline strengths and weaknesses in a GIS that indicate requirements for a specific class of users. Context of use refers to in which environment the GIS is used, this is of importance when it comes to designing flexible GIS solutions that suits the user in the field as well as in the office. Platform and functionality of choice is a part of the environmental preferences which is one of the many concerns when aiming for an expanded user-base. Tasks performed and user goals refer to the goals of each individual user in their GIS usage and usual tasks performed in order to reach their goals.

## Conducting the survey

The survey was conducted online during two weeks in April 2008. A request of e-mail addresses to three GIS representatives in different sections was sent out to 50 municipalities of which 31 responded to the request. The survey website address was thereafter sent out to the 93 contacts and generated a total of 73 answered survey replies. The survey can be found in Appendix A.

## Responses

The 73 responses to the survey showed that 54 persons use GIS every day in their work, 16 persons a few times a week, 2 persons a few times a month and 1 person less than one time a month. The results shows that it's not uncommon that the respondents use multiple applications within the same GIS-platform to reach their goals, the results also shows the need to use applications across different GIS-platforms in some cases. The question about which GIS that's currently in use was answered with names of applications as well as complete GIS-platforms where 46 persons use only one application to support their work, 15 persons use 2 applications, 4 persons use 3 applications and 7 persons use 4 or more applications. The respondents GIS is running solely under the Windows operating system and only a few preferred to use another platform – 61 persons preferred to use Windows, 1 person preferred MacOS, 1 person preferred Linux and 10 persons left a blank answer. Although these survey results were dominated by Windows users it still outlines a small market of users using different operating systems than Windows which indicates a small need for GIS running on multiple platforms.

In question 7 of the survey, the respondents were asked to rate their level of agreement in a total of 6 statements on a Likert scale ranging from 0 to 5. The statements in this question are presented in the diagram below, starting with "I think the GIS I'm using today...":

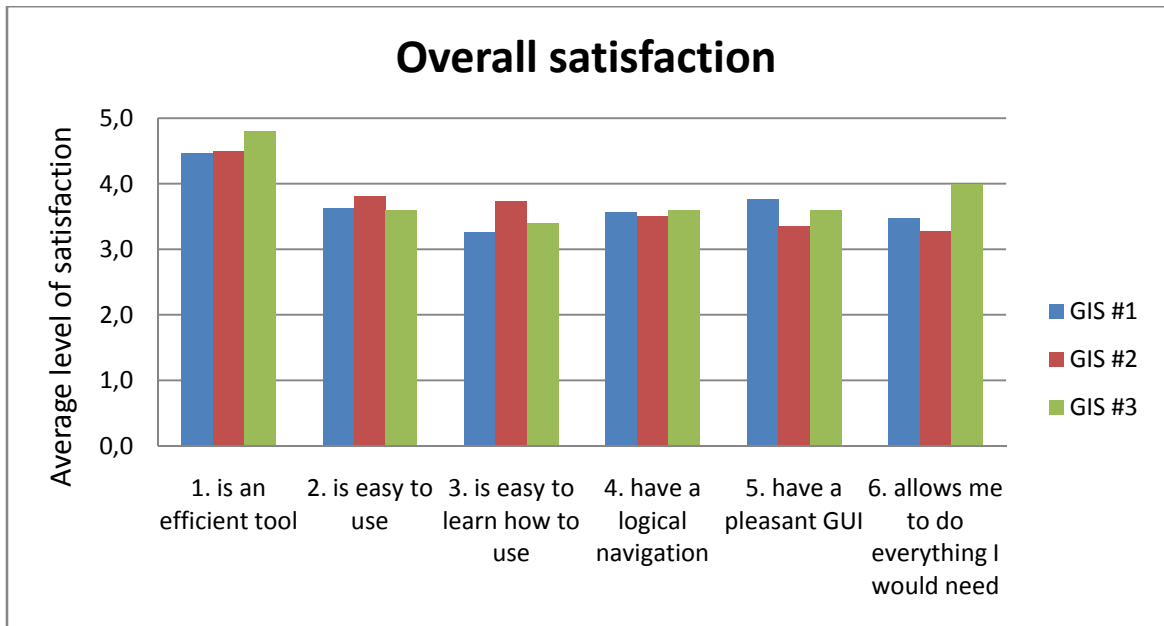


Figure 2 - Overall satisfaction in GIS usage within the 50 largest municipalities of Sweden

The average level of each statement from all respondents makes up the overall level of satisfaction of GIS usage within the municipality of Sweden. Only the results of the most frequent GIS are presented in order to get a fair comparison.

The overall level of satisfaction is quite high. The results of statement number 1 indicate that the tools used by the respondents today are as close to irreplaceable as they can get and are highly valuable in their work, in fact, their work is almost impossible to accomplish without the use of a GIS. According to the respondents, the level of satisfaction in statement 2 and 3 is slightly higher in GIS #2 indicating a higher rate of learnability which according to Nielsen is in some sense the most fundamental usability attribute (Nielsen, J., 1993). Level of satisfaction regarding the navigation style (statement 4) is almost identical across the three GIS, presumably as a result of these GIS having a similar map-based navigation. Users of GIS #1 are the most satisfied with the look of the GUI and users of GIS #3 are the most satisfied with the functionality and possibilities in the use of that particular GIS.

All respondents of the survey are using GIS in an office environment on a desktop computer or laptop. 28 of 73 persons states that they accomplish tasks that require work out in the field. 17 of these persons use GIS during fieldwork while the remaining 11 persons accomplish their fieldwork tasks without the use of GIS. The use of GIS in the field seems to increase within the municipalities of Sweden as some of the respondents stated that they were in the middle of a change after which they would have the possibility of using GIS during fieldwork. Answers to the question about which devices that was preferred during fieldwork are presented below.



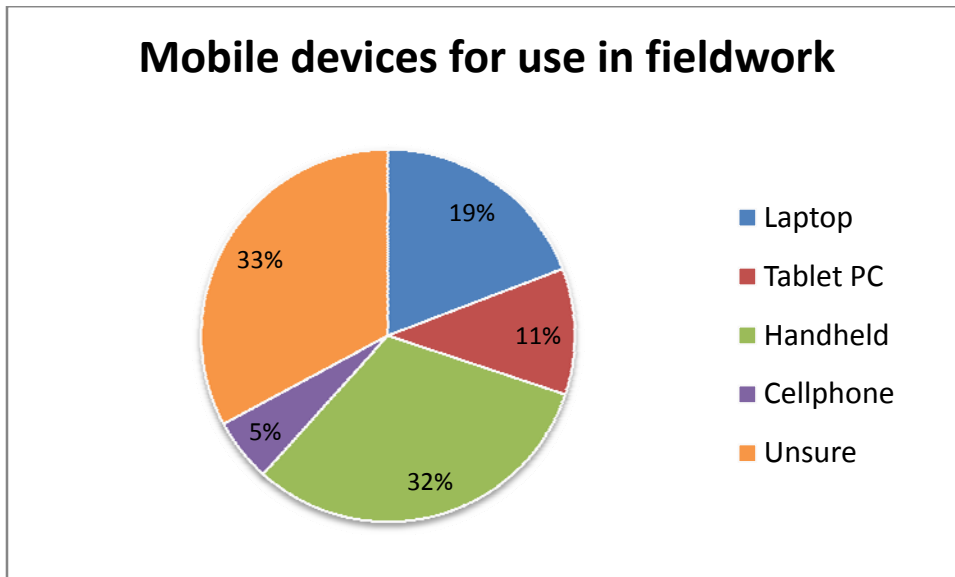


Figure 3 –Preferred mobile devices for use in fieldwork

*Unsure* includes the respondents who thought that the choice was task dependent and the respondents who had no need for GIS during fieldwork. Because of the relatively low number of respondents who use GIS during fieldwork today – the number of unsure respondents is the highest, as seen in figure 3 above. Respondents who chose handheld devices were in need of a portable device with a clear, contrast-rich, screen and stated that battery life was of high importance - it had to last an eight-hour shift without the need of recharging the batteries. Respondents choosing laptop and tablet PC preferred screen size and performance. A few respondents mentioned that they used the same software in the field as in the office and that they needed a device with high performance to be able to properly use the GIS. Respondents choosing cell phone preferred portability but stated that they would only perform minor tasks with the use of a cell phone.

The different contexts in which GIS is used and the varying preferences of the users indicate the need of a flexible, efficient and portable GIS which is hard, if not impossible, to design as one single application without usability trade-offs.

## Phase 3: Measuring the user experience

In order to identify the crucial differences between the GIS in use at the municipality of Karlskrona and the GIS the developers call “next generation”-GIS, the group wanted to measure the user experience of the two systems and compare these. A new meeting at the municipality of Karlskrona was arranged with the two users the group met earlier in the project. This meeting was divided in three parts that overlapped; first the group did a usability test with the participants, one at a time then a small interview and discussion about the tests. The tests were designed so that the group could measure experience and satisfaction of the participants. The group created a set of tasks designed similar to the tasks the participants would encounter in their daily work. These tasks had an ascending level of complexity.

### **Task 1:** Plot boundaries

*Instructions: Look up the street address (1) “Ängvägen 9, 371 45 Karlskrona”, (2) “Släntgatan 4, 371 38 Karlskrona”, and print a map over the plot area.*

Notes: This task is to see how the user locates objects in the GUI with what function(s).

(1) refers to the address used in the first test and (2) refers to the address used in the second test.

### **Task 2:** Outline road

*Instructions: Outline the road between Karlskrona Central station and “Östra Hamngatan 7B, 371 83, Karlskrona”. Make an overview map so that the way from “Karlskrona C” to “Östra Hamngatan” is easy to see and ready to be printed.*

Notes: This task is designed to discover what tools are needed by the user to find the road and addresses, what tools and methods are used to outline the road and displaying a good road map.

### **Task 3:** Several objects outlined and marked

*Instructions: Outline the roads connected to “Campus Gräsvik” that are serviced during the winter. Mark them so it is easy to see the difference between big and small roads. Mark the street lights connected to the roads so it is easy to see the difference in effect.*

Notes: This task is designed to show all the functionality that is required in a bigger task.

### **Task 4:** Traffic

*Instructions: Find the road from “Bergåsa Train Station” to “Campus Gräsvik”. Look up the traffic regulations and statistics for that road.*

Notes: This task will show how different attributes are fetched and viewed.

## System 1

### Participant 1

The first participant thought of himself as an experienced GIS-user and had been using different GIS-applications in several years. Before the first task was presented the participant opened a clean workspace without any opened maps.

#### **Task 1:** Plot boundaries

After the first task was presented to the participant he directly wrote the address on a piece of paper in front of him, "So I don't have to remember it". Then he opened a map over the district of Karlskrona. The only data on the map at this point was the road web within the municipality, a "fast map" as the participant commented. This map gave him an easy way of navigating in the map and fast access without unnecessary data.

To find the address the participant started to navigate in areas of the map where he recalled seeing the street name in earlier projects. After some time the participant decided to stop looking for the street name this way and opened an overlay option that included real estate information. With the mouse he then selected an area in which the address might be found and the area was filled with real estate objects. From the menu option "Tools" the participant selected "Search". After the participant had selected to search for an address and had made the input of the search criteria he turned to the group and said that this was the first time he's done this. This comment surprised the group that until now assumed that searching an address in a map was one of the most commonly used functions within GIS. This assumption was justified through the structure of the "Tools" menu in the GUI, the search option was placed amongst the top options.

The search dialog showed the participant that no results were found which lead the participant to question if the address was correct and asked the group for the real estate designation, which the group didn't have. After some hard thinking on how to solve this problem the participant opened a web browser with the comment; "I use this in my daily work routine so this is surely allowed". He directed the web browser to a Swedish website designed for users to find telephone numbers and people's addresses ([www.hitta.se](http://www.hitta.se)). When the search resulted in no findings the group observed a slight frustration from the participant who asked his colleague for some pointers to where the address could be found on the map. Unfortunately the colleague had no further information to give. The participant then realized that he was given the zip code and directed the web browser to Sweden's mail service ([www.posten.se](http://www.posten.se)) where he from a search, got a list of all the street names in that zip code area.

Then a mistake from the group's side was discovered - the street name was not actually "*Ängvägen*" but "*Ängsvägen*". The participant, not knowing that this mistake was unintentional, opened the search dialog yet again and entered the new address and got a

better result. He directed the map to the first address in the list of results and opened another overlay option with more detailed objects so that the rest of the task could be completed. To get a better view of the area the participant zoomed in on the plot and positioned it in the right way so that a map could be printed.

Though the mistake drastically impacted on the time it took for the participant to complete the task it was not a complete disaster. After the task the group explained that this was not intentional but the participant replied that this sort of mistakes could happen in a real situation. The participant thought that the task presented was realistic and surely common for some GIS-users but not that related to his particular employment. The task made the participant use functions in the GIS that he had never before needed to use which he said was interesting and exciting.

The first search that the participant made with “*Ängvägen*” as input returned no result which indicates that the search function is quite simple in its implementation. This might be why the developers have chosen to put the search option in a menu structure instead of giving it its own icon in the main toolbar.

### **Task 2:** Outline road

The participant located the area immediately which shows that the participant has great knowledge of the district. When the locations are identified, the participant opened another more detailed overlay option and marked the area so it displayed the right details and objects. After marking the area, the participant disabled some unnecessary objects, altitude markings, the sea color and such. From a newly opened toolbar (sketching) the participant chose a tool that stuck to the road as he clicked at one point and then moved the mouse over and along it. He then marked the line and altered its properties so that it became thicker and bright red, this made it easier to see. To make it more understandable, the participant wrote “*Station*” at the starting point of the route with a text-drawing tool and made a big dot at the end of the route. After this the participant commented that this should be enough but he showed the group that he could alter the map to make it even more understandable. He chose a new drawing tool that let him put an arrow on the map at the right side and pointed it towards north. Then the text tool was chosen again and he wrote “N” and “S” at the arrow and “ca 1 km” by the dot that marked the end of the route.

This task showed the research group that the participant is truly experienced with the tools and functionality of the GIS. To the groups understanding the tools chosen by the participant to complete the task was ideal in the sense of efficiency.

### **Task 3:** Several objects outlined and marked

Like the previous task the participant found the area directly because of his knowledge of the district. Over the “fast map” he opened a new detailed overlay option and closed

altitude and other unnecessary objects so that the area was easily viewed and recognizable with all the buildings and roads. The participant now opened a theme with all the roads that are serviced during the winter clearly marked. As a bonus, the bigger roads were marked with a thicker line than the small ones. Satisfied with the roads the participant moved on and opened another overlay that showed all the street lights in the area. The lights were displayed as small dots. To make the lights more visually comparable the participant changed the properties for the different lighting attributes. The way he did this was to open a dialog box where he searched for the “light identity” and changed it. The participant commented that it would be easier if a list of all the lights was presented and sorted by effect. Red, yellow and green was applied to the different effects and the lights on the map changed color. Now all the criteria’s for the task had been met.

#### **Task 4: Traffic**

The participant did not have to search for this location either he simply panned and zoomed to the location. The next step was to open the database for local traffic regulations where the user pointed out that the only regulation noted was that the road is a primary road. The participant said that if this task was done on behalf of a client, he would give them this information and if they wanted more detailed information on regulations on a primary road, they would have to look it up themselves. The next step was to get information on traffic statistics and the participant looked for a self-constructed attribute connected to the road. This was not found and the user pointed out that he had to make one if it was necessary but for now the district stores all the traffic statistics in a binder.

#### **Participant 2**

This participant was not as experienced as the first, and fairly new to the world of GIS.

#### **Task 1: Plot boundaries**

The participant recognized that the address street was “*Ängsvägen*” and started looking for it on the map. He orientated around the map for a long time without finding the right location. This suggests that he does not know that there is a search option for real estates. At one point the participant hovered over a help button with the mouse pointer and clearly thought of ways how to solve the problem. Without clicking the help button he instead opened a web browser and directed it to a website that has addresses to people in Sweden ([www.eniro.se](http://www.eniro.se)). From there he navigated through some pages without any luck of finding a clue to the whereabouts of the address and continued to look for the street in the map. The participant used the scrolling wheel very effectively when going through the map. The mouse he used made it possible to scroll horizontally and vertically by tilting the scrolling wheel to the left or right. After a long period of scrolling the participant returned to the same website as before and searched for locations on the post

code. He found a location and returned to the map and found it there by panning. Then he zoomed in on the address as if he would print the map.

#### **Task 2: Outlined road**

With the same ease as the first participant, he found the two places without the need to search. To outline the road a drawing tool is needed and the participant tried to open the toolbox with all the drawing tools. Instead of the toolbox, a new application window was loaded. The participant closed it and succeeded with the opening of the toolbox. The drawing tool chosen by this participant was different from the choice of the first participant. The tool connects dots that you mark on the map, but not visually connecting them with a line except for the two dots marked last. So when the participant had marked more than three spots, there was just a line visual between the last two.

When the participant had marked the way to the location and double clicked the last marking, the line became red which color he had chosen before start.

#### **Task 3: Several objects outlined and marked**

The location of "*Campus Gräsvik*" was easily found by panning the map. To make the overlay option with roads serviced during the winter visual - the participant had to get some pointers from his colleague. For the lights, instead of making a theme, he opened the lighting overlay and altered the name of each lamp so that it would change color. The way he did this was by right-clicking each lamp then choosing the properties option in the menu and assigning a new identity to the lamp in the properties dialog window. Because of the large number of lights in the area the participant settled with changing just a few of them and explained that this was the way he would do it.

From this task the group understood that this GIS is very complex and that some education is required to fully make use of all the functions available.

#### **Task 4: Traffic**

The participant pans to the road and right-clicks it to get the properties. He then turns to the group and explains that he has insufficient rights to get information on traffic regulations. To gather the statistics needed to complete the task he opened his e-mail client and searched for an e-mail received several days earlier from his colleague that had a document attached with the correct statistics for a lot of roads, including the one in the task.

## System 2

This test was performed at the developer's office because it was the only place where the test could be conducted. Before the first task was presented to the participants they were allowed a few minutes to get familiar with the system.

The system tested in this part is a prototype of a next generation GIS which is under development. The system is client-server based with the client entirely web-based. This means that in order to run the application one must use a web browser.

### Participant 1

#### Task 1: Plot boundaries

The participant directly made use of the search icon located to the right in the toolbar in the upper part of the interface. The icon looked like a pair of binoculars which is consistent with some other well known applications search functions (e.g. Microsoft Office 2007 and Adobe Acrobat). He chose the option "Address" from a drop down menu in the search dialog window and entered "släntgatan". The two results were listed in the "Results" dialog to the left and were not clearly visible due to the participant customizing the dialog windows when familiarizing with the system before the task. When the overlaying window was moved out of the way, the participant looked at the icons listed next to the result "Släntgatan 4". There were three icons and a checkbox. The first option that he hovered over was a checkbox and the tooltip-text "Mark on the map" appeared next to the mouse pointer. The participant checked the box and waited a few seconds for something to happen. Nothing happened so he hovered with the mouse pointer over a magnifying glass also located near the search result, and the tooltip-text "Zoom to" appeared. After the participant clicked this icon the map zoomed to the location and marked the real estate weight point with a green dot. One of the other icons was the "Pan to"-icon that if clicked pans to the location without zooming. This icon had the same design as the *Pan tool* in the toolbar. The participant commented that the map was zoomed in too much and he zoomed out so that the neighborhood was visible and then clicked the *print* icon in the toolbar. From the different options presented in the print dialog he clicked a check box to add an arrow that points to north on the map. Then he chose that the map should be printed on an A4 paper and changed the scale to fit the purpose. Then he opened the map for preview and put the mouse pointer at the "Print" button which concluded the task.

After the task was completed the participant wanted to try some other functions related to the task. He tried to search for another address in the same manner as before. There were no results and the participant made the conclusion that there were a limited amount of addresses in the database. He then tried to search for "Släntgatan" again and the results dialog indicated that the search was being conducted by showing a "busy-animation" within the result dialog. While the result dialog was still busy the participant

tried to do a new search, this time adding the street address number to the search. An error was displayed in the search dialog just under the search text field; "Cannot find column Created date" in red text. The participant did not understand what this error message meant. Then he discovered a way of stopping the result dialog from being busy, he did this by searching for another street address so that the result dialog showed "No results". After the test he pointed out that maybe there should be a way of stopping or pausing a search or analysis while it is busy. The errors and problems with the results dialog were later discovered to be the client losing connection with the server. Unfortunately this was not discovered until all the tasks were completed which indicates that there should be a better design principle that tells the user what and when something goes wrong, e.g. losing connection with the server.

### **Task 2: Outline road**

The participant panned and zoomed to the right location and opened the sketching tool dialog from the toolbar. He hovered over the different options to see the description so he could select the appropriate tool for the occasion. The line tool was chosen, size and color were set. The participant clicked and held at the starting point then tried to draw a line along the road, but did soon realize that the tool was used by clicking at different points connecting the line between them. The reason why he first tried to draw with the tool is not clear, the group did not ask but assumes that because this being a new system maybe the participant thought that the function of the tool was new and that this way of marking a road suited the participant better. When the road was marked correctly he selected another sketch tool, the text tool. He put "Station" at the train station and "Goal" at the correct address to finish the task. After closing the sketch dialog window the zoom out icon was marked and the participant clicked the map to zoom out but instead of zooming out - a new "Goal" was inserted in the map. Obviously confused by this the participant wanted to erase the last "Goal" and looked for an eraser tool. The only eraser tool found erased all the sketching leaving a blank map without the marked road or texts.

Note that the connection with the server was still lost and that this task was still solvable.

### **Task 3: Several objects outlined and marked**

During this task there were some troubles because of the connection to the server was lost. The participant panned and zoomed to "Campus Gräsvik" and found that the right layers were lit for the task. He still wanted to try to change the visibility of those layers to "off" and changing them back to "on" again. In the left side of the GUI a dialog window named "Content" presented a list of all the layers with the options to change their visibility on/off. Because of the connection problem, only the underlying map was presented in the list. A plus sign next to the map name suggested that there were additional layers whose visibility could be turned on/off. When the participant tried to expand this tree of layers there were no additional layers there. The participant closed



the map and the area of the GUI displaying the map turned white. When opening it he realized that there were no indications that the system was busy - he did not see if the action of opening the map really opened the map until it appeared almost one minute later. The timer was stopped because of this being the right way of completing the task.

#### **Task 4: Traffic**

As before the participant panned and zoomed to the road and discovered that it was already outlined, the layer was lit. To get the attributes the participant selected a tool from the toolbox that looked like an information speech-bubble. Unfortunately because of the connection loss, this tool did not work as intended. The participant did not give up and tried different approaches in order to get the information required to complete the task. In the last attempt he used a tool with an icon that looked like a shopping cart (but was called basket). This tool is used to make different “baskets” with selections of objects that can be stored for later maintenance or analyzes. By selecting the road with a polygon lasso and adding it to a basket - saving it to the hard drive and then opening it again - actually presented the correct traffic statistic numbers, nevertheless they were not associated with a road and therefore not usable.

### **Participant 2**

#### **Task 1: Plot boundaries**

As soon as the participant was given the task instructions he started to look around the GUI for a search function by hovering over items in the global menu with the mouse from left to right. It is obvious that the participant recalls the search action from the first test as he spend more time on locating the search function instead of panning back and forth on the map. As he's hovering over the items he's not paying so much attention to the tooltip-text of each icon, he seems to focus more on the icon itself and the word “*address*” rather than “*search*”. The group recognizes this behavior from the test of System 1 where he first chose the registry in which he wanted to search and then accessed the search tool for that registry, instead of as in this case first choosing the search function and then in which register to search. Next, the tool for sending out mails was clicked which opened another dialog in which the participant scrolled through the listbox alternatives looking for the word “*address*” but left the dialog as soon as he realized that it lacked a search function. This mail sending tool has nothing to do with the given task but is accessed presumably because of the participant being attached to the word “*address*” and associates the mail icon with it. The participant continued looking around the GUI and showed a slight sign of confusion as he located the dialog for real estates pinned to the left side of the screen, he right-clicked the caption which opened the standard right-click menu of the web browser and explained that he expected a menu that would allow him to make a search in the registry of real estates just like the one system 1 would show. This is where a context-specific right-click menu would come in

handy to compensate the differences in consistency between the two systems that hopefully would shorten the learning curve for users familiar with the previous version of the system – by providing several ways of achieving a certain goal. As he hovered over the dialog for real estates he discovered a function for searching neighbors, he then scrolled through the listbox looking for the word “*address*” but didn’t seem to find any functions of relevance for the current task nor seem to know how this tool was supposed to be used. Only the first half of the listbox was showing, which made the participant suspicious and encouraged him to explore the dragging functionality of the left side menu. As he extended the left side menu area he discovered more options in this dialog and also the search button of this dialog which was previously hidden as a result of the low screen resolution set. The participant made the decision that this function was of no use in this task and moved on.

The screen resolution issue is not uncommon – that different settings in screen resolution have consequences such as the design being deformed, objects are hidden and that text is overlapping objects and therefore hard to read - this is a major design concern in web development. The countermeasures taken in system 2 are conventional ways of dealing with such problems; by using small icons to indicate customizable areas of the GUI - it provides much guidance for the user.

The participant continued hovering over the items in the global menu, this time carefully reading the description of each icon, until he reached the last icon - the search icon - which was omitted. The reason for this is presumably because 1. He recognized the icon but associates it with another search action which was of no use in this task or 2. The dark colors of the search icon on the pastel colored background made it look less important, maybe even deactivated, and attention is drawn to the other more colorful icons. The participant showed clear frustration and stated that it is surely tricky to use a new system when you’re used to behavior of the old one. When the participant explained that he was unable to find the search function on its regular location he was given a hint – “*Have you checked all the global menu items?*” – after that, he immediately found the search icon and clicked it which brought another dialog up on screen.

In the search dialog, the participant chose to search for addresses in a listbox and as soon as the participant clicked an option in the listbox two additional input fields appeared below it. This information hiding was appreciated by the participant. It suddenly seemed very straightforward, the participant didn’t hesitate to enter “*släntgatan4*” into the address-field and press the search button. The results dialog on the left side was updated with an animated image indicating that the search was in progress, the participant waited for a few seconds until the search had finished, presenting the results “*No results found*”. The participant almost immediately noticed that he had accidentally entered “*släntgatan4*” instead of “*släntgatan 4*”, he corrected this mistake and pressed the search button once again, this time the search results came back with one match.

The participant had some trouble at first showing the location on the map. A checkbox with the caption “Mark on the map” was clicked a few times but nothing seemed to happen. The three icons next to the checkbox weren’t at first recognized as clickable buttons but after some time moving the mouse pointer back and forth he unintentionally hovered over one of the icons and a tooltip-text with the caption “*pan to location*” appeared. Directly after the button was pressed the map went blank for a few seconds while the system loaded the new map area and as soon as the area was loaded, a good overview of the neighborhood was shown on the right side of the screen and the sought street address was clearly marked with a distinctive color. The participant used the zoom function to get a better view of the plot by clicking multiple times on the map. The goals for this task had been reached and the timer was stopped.

Not knowing how to view the sought address from the results dialog on the map, the participant is experiencing an affordance issue with the icons representing the zoom and pan functions. Because the participant didn’t recognize the icons as clickable buttons he simply didn’t click them until he got an indication (the tooltip-text) that they were clickable. This is an issue not so easy to deal with when striving for a compact and efficient design. The most obvious negative impact on the user experience in this task was caused by the delay between map updates when the main map area turned blank for some seconds. Unknowing of how long this duration would last – the participant was eager to click on the main map area a few times that resulted in a series of actions to be placed in a queue and executed once the system was finished loading the map.

### **Task 2: Outline road**

The participant started out by smoothly panning to the central station using the compass in the upper right corner and then zoomed in on the location so that the sidewalk was clearly visible. The participant knew exactly which tool to use when outlining roads and selected the sketch tool from the global menu straight away. This action opened up another dialog in which the participant selected the color red for the line color and made adjustments to the line height in order to make it clearly visible from an overview map. The sketch dialog was dragged away so it wouldn’t overlap any part of the visible map area. Notice how quickly the participant is becoming familiar with the routines in the system. The main tool used in this task is consistent with the one from system 1 which certainly is one of the reasons the participant is learning so quickly.

When the participant clicked out the first point, he expected a red line to appear but instead the map is zoomed in once more and he didn’t seem to know what he did wrong. The sketch tool had not yet been activated and since the last action was zooming in on location this was still the active function. The participant zoomed out one level and started over by selecting the line tool from the sketch dialog (which activated the tool) and thoroughly clicked out a few points on the map along the sidewalk. When he tried to pan using the compass again - the tool became deactivated and the lines that previously

were visible as a trail from the first point to the last were all removed from the workspace without any confirmation. The participant let out a slight sigh and started zooming out so that both the central station and “Östra Hamngatan” were clearly visible and then started the sketch procedure again. After some discussion, the participant agreed that it would be easier to see which tool that was the active one if the mouse cursor changed to something suitable when hovering over the main map.

The participant outlined one of the roads that led to the destination without flaws until he was about to finish the line when he moved the mouse pointer away from the destination point and clicked on the right mouse button which brought up the right-click menu of the web browser. Right after he made the popup menu disappear using the left mouse button - one more point was unintentionally added to the route and the line was finished with a double click on the left mouse button.

### **Task 3:** Several objects outlined and marked

At first, the sketch tool was still active so that an additional red line was added when the participant tried to zoom out. The participant was a bit confused but did soon realize that he hadn't activated the zoom tool after the previous task. After zooming out to a level showing a good overview of the district of Karlskrona he zoomed in on the campus and noticed that the layer containing the streetlights as well as the layer containing the roads serviced during wintertime (whose visibility were supposed to be switched off) were already lit up. The goals for this task were met very quickly due to a mistake the group did when saving the test map leaving the visibility of the layers switched on.

### **Task 4:** Traffic

The participant tried his luck in right-clicking the road but just like in earlier tasks this action brought up the right-click menu of the web browser. It is likely that he expected to have the option to view the properties of the object from this popup menu just like in system 1. He proceeded by looking closely on the left side of the screen at the different pinned dialogs, examining each and every listbox looking for something related to traffic. After some searching he found an option in one of the listboxes containing a word similar to “traffic amount”, he selected this option and clicked the search tool in the global menu which brought up the search tool dialog. In this dialog, he clicked the listbox for *search type* and discovered that the only option in the list was meant for real estates and no option for traffic amount as he expected. The participant thought that the search tool was integrated in a way so that the input field *search type* in the search dialog was automatically updated as he selected different options in listboxes in any part of the GUI. As soon as he realized that the search tool wouldn't help him to get information about traffic amount he continued searching along the left side menu for other alternatives. He then saw the pinned dialog entitled *content* which held a tree of brief information about the layers and whether the visibility of the layers were set to on or off. As he clicked the

plus sign next to the layer entitled *traffic amount* - additional information about traffic amount was displayed in a list with a small colored square next to each row matching the colors of the different roads shown on the map. Even though this wasn't the way of getting this information the group had expected it was still an acceptable way of assigning an amount of traffic to a certain road.

The timer was stopped when the participant turned and said that he was unable to find any traffic regulations for that specific road.

## Phase 4: Data Comparison

### After-Scenario Questionnaire

The results from the ASQ's are compared to point out parts of the system which the participants found the most troublesome. The average of all scale positions in each ASQ is presented in the tables below. These results are affected by the participants' familiarity with the system and should be seen as indications on parts of the system, which the participants experienced more troublesome, and not as a system comparison – which one's better than the other.

<b>Task 1: Plot boundaries</b>	<i>System 1</i>	<i>System 2</i>
<i>Participant 1</i>	3.4	1.8
<i>Participant 2</i>	3.2	3

Participant 1's overall satisfaction in task 1 is significantly higher in system 1 than in system 2. The main difference lies in the satisfaction with support information and system functionality which was rated higher in the ASQ for system 1. These two statements were rated lower in system 2 presumably because of the participant experiencing problems due to a database connection loss and the lack of feedback from the system indicating on connection problems. Participant 2's satisfaction with system functionality is slightly lower in system 2 than in system 1 probably of unfamiliarity of the system.

<b>Task 2: Outline road</b>	<i>System 1</i>	<i>System 2</i>
<i>Participant 1</i>	4.4	2.4
<i>Participant 2</i>	4.2	3.6

Both participants are more satisfied with system 1 in this task. Participant 1 is not satisfied with the time taken to complete the task in system 2 and thought that the task was not as easy to complete as in system 1. Though participant 1 completed the task in system 2 in nearly half the time taken in system 1 the satisfaction is not as high as in system 1 probably because of the participant thinking that the goal was not met as thorough as in system 1 in the same amount of time. Participant 2 was not as satisfied with the time taken to complete the task in system 2 as in system 1 and reported that the number of errors experienced in system 2 were more than in system 1.

<b>Task 3: Several objects outlined and marked</b>	<i>System 1</i>	<i>System 2</i>
<i>Participant 1</i>	3.6	3
<i>Participant 2</i>	4.4	4

The difference between system 1 and system 2 is minimal. Both participants completed

this task without any flaws related to usability.

<b>Task 4: Traffic</b>	<i>System 1</i>	<i>System 2</i>
<i>Participant 1</i>	4.2	1
<i>Participant 2</i>	4.4	2.4

Participant 1's disastrous score for system 2 has little to do with the usability of the system; the score is set because of an unfortunate database connection loss which prevented the user from fully completing the task. It's the differing consistency between the two systems that keeps participant 2 from completing this task in system 2 as quickly as in system 1.

### System efficiency

The system efficiency was measured using a stopwatch as the time taken for the participant to complete a task. The results from the time-on-task measurement in the two systems are presented in figure 4 below where each column represents the average time of both participants.

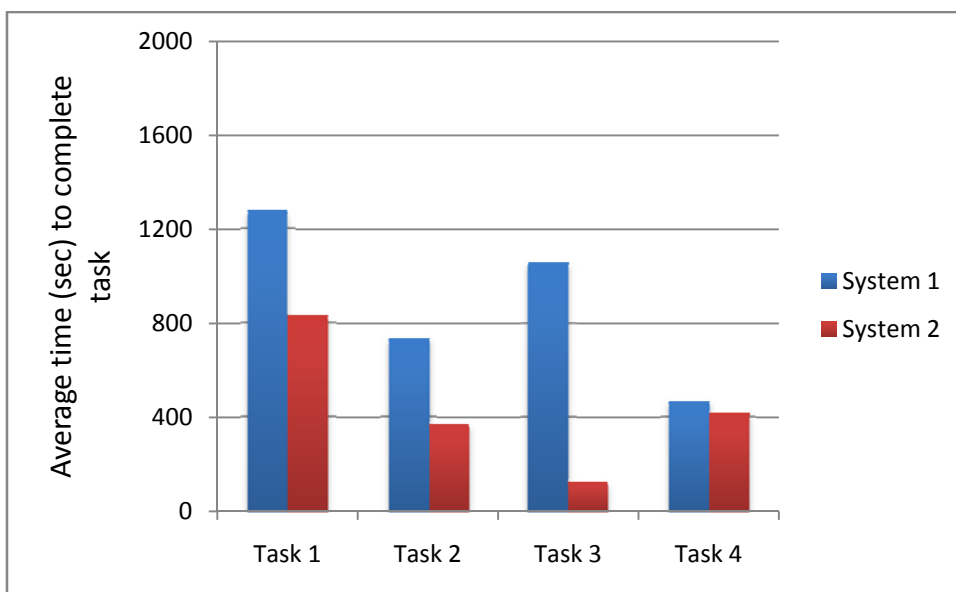


Figure 4 – Time-on-task data

The results show that system 2 is more efficient than system 1. Worth mentioning is that the average time for system 2 in task 3 is a bit misleading due to a mistake the group did during the preparation of the task which resulted in a vast difference on the time taken for the participants to complete this task, but not to an extent that would affect the results as a whole. The results are unexpected but interesting. Since the participants were familiar with system 1 the group expected the results to show that system 1 was more efficient than system 2. To the groups assumptions this increase in efficiency of system 2

is because of closeness of the standard tools - often are accessed with just one mouse click, and the use of information hiding - not revealing more information than necessary.

In contrary to Tullis, T., et al. (Tullis, T., et al., 2008) which states that in almost every situation the faster a participant can complete a task, the better user experience – the results from the efficiency measurement combined with the results from the ASQ in this study shows the opposite. Even though the participants completed quickly in system 2, the user experience reported in the ASQ's of system 2 is significantly lower than in the ASQ's of system 1. The main preference is not swiftness but confidence - in this case, the quality of the user experience is founded in the user's confidence with the system.

### **System Usability Scale**

The SUS score for system 1 was calculated to 67.5 and the score for system 2 was calculated to 42.5. This doesn't mean that system 1 is better than system 2. What it does mean is that the two participants scheduled for the tests in this study found system 1 more usable than system 2. It is not fair to compare these results in the purpose of identifying good design solutions because the participants are experienced with system 1 and has gradually built up an acceptance level whilst they have never used or seen system 2. Moreover, system 1 was tested in the participants' office on their own computers, with their own settings and peripherals whilst system 2 was tested in a lab environment on a laptop with default settings. For these reasons the results from the SUS should be thought of as two separate scores, both representing systems with an acceptable level of usability. The purpose of the SUS comparison is not to point out one design better than the other – in fact, the results presented cannot be used in that purpose – the purpose of this comparison is to show indications whether there are usability concerns associated with an expansion in the user-base or not.

The results from the SUS shows that system 1 score is above average and system 2 is below average in relation to one review of a large number of usability studies which shows the average SUS score of 66 percent (Tullis, T., et al., 2008). Even though the results from the SUS and observation notes show that an acceptable level of usability is reached in both systems, the vastly lower score of system 2 emphasizes the theory that there are usability concerns related to a wider user-base design that needs attention in order to retain an acceptable level of usability.



## Results

Because of the vastly lower SUS score of the second system compared to the first, the conclusion can be drawn that there are crucial usability concerns that needs attention in order to retain an acceptable level of usability.

The usability concerns discovered in this thesis are the following, which are further discussed in the *Discussion* section of this report.

### **No standardized data format, crucial**

First discovered in (Saghir, S., 2005) and supported by respondents to the survey. It is a crucial usability concern when a GIS designed for a large targeted user-group don't have the support of reading and storing geospatial data in a well known and frequently used data-format. This is a concern associated with the effectiveness of the system.

### **Lack of feedback, crucial**

The group discovered through the usability testing that the lack of feedback from the system is a usability concern, crucial and not always obvious for the developers. In this study, the lack of feedback had a large negative impact on the users' satisfaction with a system.

### **Consistency**

The consistency of a system, and between systems within the same family, is of high importance when aiming for an expansion of the user-base. The lack of consistency between systems may not be an issue for new users of the system - as they're facing a new logical system with superior functionality - but will have an impact on the time taken for experienced users to learn the new system, as a result of some functions being replaced or altered in ways of interaction. Consistency problems between the two systems was discovered during the usability testing in this study and are identified as the main cause of the users' time consuming actions.

### **Information hiding**

The technique of hiding information irrelevant to the action the user of the system is currently performing. By only displaying information of relevance - the users' of the system are able to find the sought functions with less effort. As seen in the results of the time-on-task measurement, this technique of hiding irrelevant information have a remarkable impact on the system efficiency.

### **The use of several monitors**

Observed at the work place of two GIS-users, and supported by their comments, two or more monitors made their work more efficient by making the main map more visible. This concern is related to user satisfaction as it is a user preference and the use of several monitors is not really needed in order to achieve main goals in GIS.

### **Web-based solutions**

Using a web-based GIS allows for a wider user range in many different ways. The system is independent regarding operative system or platform and no software has to be installed.

## Discussion

### Standardized data format

As stated in the introduction - the municipalities in Sweden use spatial data in their communication between different sections and departments. Spatial data exchange can occur between the municipalities as well. When exchanging information and co-organizing GIS-projects it can get very problematic if the data format don't match, as one of the survey respondents pointed out. Another respondent commented that this wasn't a problem for smaller municipalities as they don't exchange spatial data to the same extent as the larger ones. A third respondent wanted the solution with an open database that all the GIS-applications could have access to, store and retrieve data from. This is surely a good theoretical solution and might be possible in a small scale, but will likely take years to develop.

To overcome this usability concern and at the same time reach out to more users, one solution is to design a system that is compatible with other GIS data formats. A company or organization might choose not to use a new GIS because of it not being able to read their spatial data, even if the new GIS have superior functionality.

### Feedback

To the groups understanding GIS has a very complex implementation with many sophisticated algorithms and calculations which may have an impact on response time. If the user isn't told by the system when a time consuming action occur the user may get impatient and feel a loss of control. The group discovered through the usability testing that the lack of feedback from the system is a concern, not always obvious for the developers. The group came to the conclusion that this was one of the main issues why the second system got a much lower score on the ASQ of the first participant, compared to the second participant (that had no connection problems).

Feedback with error messages in both systems was observed and when asked, the participants had no clue of what they meant. Cryptic error messages are misleading and may lead to unnecessary, time consuming and costly support phone calls. Most of the error messages observed by the group were minor technical problems not directly affecting the goal of the user's action. But the presentation of some of those error messages gave the impression that the system had crashed. When designing error messages it may be a good idea to consider what implications this error oppose to the users work.

### Consistency

It is obvious that both participants experienced problems in consistency between the two systems as the group have observed attempts in interacting with system 2 the same way

as in system 1 (e.g. right-click to bring up a context-menu) that brought confusion to the participants as the outcome of some actions differed between the systems. As the learning curve of a system is affected by the consistency between software updates (Nielsen, J. 1993) the users that are familiar with the behavior of the old system would probably not learn the new system as quickly as if multiple interaction styles were used thus enabling users experienced with the old system to interact with the system the way they did before, as a complement to the new interaction style. In short - providing the users with alternative ways of approaching the same goal. Both systems tested in this study are conventional regarding icons and menu structures being consistent with the standard look most users are familiar with.

### **Information hiding**

Information hiding is the technique of only displaying the information of importance to the user's current action, and by hiding all other irrelevant information - provide the user with a clear, well-arranged GUI that is easily overviewed. The group found the first obvious use of this technique during the usability testing of system 2 when changing *search type* in the search tool displayed additional context specific input fields. This is a fairly small example but seemingly appreciated by the participants.

System 2 is customizable in a way that strengthens its usability - functions may be disabled/hidden for the users who have no need to use a certain function, making the system tailor-made for that user class. Since the user would never use the function it would in almost all cases be confusing and disturbing for the user to have the function clearly visible.

The group is convinced that the use of information hiding is a contributing factor, to the efficiency of a system, which shortens the time of all the small decisions the user makes when using different functions.

### **Monitors**

At the first observation during the research about GIS the group noticed, and was told that most GIS users at the municipality of Karlskrona had two monitors and used these when working with the GIS application. Dialog windows that were frequently used were placed to be viewed in the second monitor, otherwise blocking the view of the main map. They could also place other maps in the second monitor; these were then used as overview maps while the main map was zoomed in, for example. One of the participants said that if they had one additional monitor, three in total, they would all be used.

By using two or more monitors the users can get more of the main map visual and therefore use it in a more efficient way without having to move dialog windows out of way that restrains the work flow.

With the first system the group observed and tested, there was built in functionality that made the use of two monitors easily available. In the second system that is web-based, it was not as easy. To make use of two monitors the user had to stretch the web browser across the second screen, one of the developers said. This was not observed due to lack of time and equipment at the test site. The developer also said that there were tests being performed on an implementation that would allow the use of two web browsers communicating with each other and that this could be used with two screens, one browser in each. But because of the system being fully web-based the user could not move dialog windows away from the web browser. To the groups understanding an alternative to this had been implemented. The dialog windows were from the start pinned to an area in the GUI that could be closed to show more of the map. But hiding these limited the accessibility of the tools and the user had to open the area and the appropriate dialog window to get access to the desired tools, again restricting the visibility of the main map.

It is important to understand that some GIS users make use of two monitors in their work and to make support for this in a new system. But at the same time there are users that that don't have the map as their primary navigation of choice when working with GIS as confirmed from a few of the survey respondents, meaning that a GIS should not be designed only for two or more monitors.

The number of monitors was interesting to the group but not in the scope of the focus at the time the survey was made. Now afterwards the group realizes that a question about this should have been included in the survey.

### **Web browser**

When designing a system to be fully web-based, the test observations suggests that a system should be designed so that the user fully understands that the web browser is just a tool for accessing the system and not part of the actual GIS, as both participants during the last test at least once searched the context menus of the web browser for an aid in reaching their goal.

Using a web-based GIS allows for a wider user range in many different ways. The first positive outcome the group thought of was the systems independence regarding operative system or platform and that in most cases no software had to be installed. When designing a web-based system one has to take in consideration that there are several web browsers not compatible with each other and that may need different implementations of the system. It is not wise to make a system web-based in order to get a wider user-base and then limit the user to only one web browser.

As for the implementation concerning the map it is important to take in consideration if the map should be fully downloaded to the user computer or if every action altering the map (e.g. zooming) should download a new piece of the map. The first option will let the

user access different parts of the map faster even if the connection speed is slow but will have an overall higher work load on the computers processor. If the processor is slow the access time will be slower. In the second option the work load of the processor will be less but if the connection speed is slow - the access time will be slow as well. A solution to this would be a GIS in which the users' are able to choose if the map should be fully downloaded or directly streamed. In cases of fully downloading the map – a feature allowing the users to specify a region in which all the data is to be downloaded would have a vast impact on the download time and would optimize the work load on the computers processor. Such solution would be highly valuable for the users that don't have a persistent network connection during fieldwork – providing a way for the users' to make changes in the GIS during fieldwork and synchronize with the server at a later time when a network connection is re-established.

## Conclusion

It is easy to say that the higher level of usability the better the system is but it's not entirely true as one respondent to the survey pointed out. The respondent preferred GIS that had a lot of different utilities and possibilities with the disadvantage that it would take longer to learn, before a system that was easy to learn but was more limited in functionality.

As expected the results from the research conducted by the group for this thesis shows that there are crucial usability concerns that need attention in order to retain an acceptable level of usability when designing GIS for a wider user-base. This proves and supports the null hypothesis stated by the group, and the alternative hypotheses are thrown.

Far from all usability concerns are found in this study since the tests has been conducted with only two participants. The number of usability concerns found in this study can be viewed as proportional to the number of test participants. More research and studies needs to be done in order to get a more accurate identification of the usability concerns within the big field of GIS. If our selected approach to the problem is recognized, used and tried to get a more valuable result, more user tests are needed to get a more accurate and comparable SUS-score, positively with a wider range of different GIS-applications and user classes. At least five users per user class as stated in the section about Usability Testing. It is notable that the results generated in this thesis were discoverable though the tests were conducted with only two participants.

The survey needs to be overlooked as some questions may be irrelevant in future studies. New relevant questions need to be added e.g. "How many monitors do you usually use when working with your GIS?", "What would you like future GIS to have that they don't have today?" and "What are your expectations on future GIS-applications?".

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## Appendix

### Appendix A: Survey

1. Within which municipality do you work?

2. Within which section do you work?

3. Which GIS-application do you use today and which version is it?

4. Which operating system is used to run the GIS-application today?

Windows

Linux

MacOS

Other

5. Which operating system would you prefer to run the GIS-application on?

Windows

Linux

MacOS

Other

6. How frequent do you use GIS in your work?

Every day

A few times a week

A few times a month

Less than one time a month

**7. I think the GIS I'm using today...**

Statement:	<- Strongly disagree			Strongly agree ->	
	1	2	3	4	5
... is an efficient tool.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is easy to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is easy to learn how to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... have a logical navigation.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... have a pleasant GUI.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... allows me to do everything I would need.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**8a. In which context(s) do you use GIS?**

Check all that match.

In an office environment

In the field

Other. Please specify:

**8b. If you didn't check "In the field", what's the reason for this?**

There's no need to work in the field

The system doesn't support work in the field

I use another system during fieldwork

I use printed papers, maps etc. during fieldwork and synchronizes with the system afterwards

Other. please specify:

**9. If you were assigned for a work that required you to work in the field - which type of portable device would you prefer? Please motivate.**

Laptop

Tablet PC

Handheld

Cell phone

Unsure

Other. Please specify:

Motivation:

**10. Describe in short the tasks you perform with the use of GIS.**

**11a. Have you ever performed a task in which you thought that the map-navigation was cumbersome?**

That is, have you ever thought that the map-based navigation was an ineffective way of reaching the task goals?

Yes

No

I don't know

**11b. If you answered the last question with a "Yes" - Describe in short an example of such a task and how you went on solving it.**

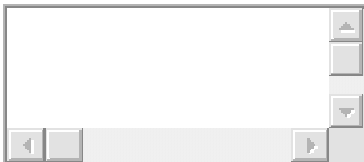
An empty rectangular text input box with a light gray border. It features a vertical scrollbar on the right side and a horizontal scrollbar at the bottom, both with standard arrow and track icons.

**11c. Do you have any suggestions on how the system could be improved to better support these situations mentioned in the last question?**

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**12. Comments**

If you have something to add, please write your comments below.

An empty rectangular text input box with a light gray border. It features a vertical scrollbar on the right side and a horizontal scrollbar at the bottom, both with standard arrow and track icons.

## Appendix B: After-Scenario Questionnaire (ASQ)

Name: \_\_\_\_\_ Municipality: \_\_\_\_\_

Section: \_\_\_\_\_ Date: \_\_\_\_\_

# After-Scenario Questionnaire

**Instructions:** For each of the following statements, mark one box that describes your level of agreement.

	Strongly disagree				Strongly agree
1. It was easy to complete this task.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. I am satisfied with the amount of time it took to complete this task.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I experienced no problems when completing this task.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. I am satisfied with the support information ( <i>online help, messages, documentation</i> ) when completing this task.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. I am satisfied with the system support and functionality when completing this task.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Comments:**

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## Appendix C: System Usability Scale (SUS)

Name: \_\_\_\_\_ Municipality: \_\_\_\_\_

Section: \_\_\_\_\_ Date: \_\_\_\_\_

# System Usability Scale

**Instructions:** For each of the following statements, mark one box that describes your level of agreement.

		Strongly disagree				Strongly agree
1.	I think that I would like to use this system frequently.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.	I found the system unnecessary complex.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.	I thought the system was easy to use.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.	I think that I would need the support of a technical person to be able to use this system.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5.	I found the various functions in this system were well integrated.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6.	I thought there was too much inconsistency in this system.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7.	I would imagine that most people would learn to use this system very quickly.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8.	I found the system very cumbersome to use.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9.	I felt very confident using the system.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.	I needed to learn a lot of things before I could get going with this system.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Comments:**

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