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TESTING-SDI: E-GOVERNMENT PROSPECTIVE, REQUIREMENTS, AND CHALLENGES

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Abstract

Spatial Data Infrastructure denotes the collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial information. During the last few years the development of spatial data infrastructure in Sweden has been influenced by two actions. The first was the European Directive in spatial data infrastructure namely Infrastructure for Spatial Information in Europe (INSPIRE), and the second action was the Swedish parliament's directive early in 2008 on e-Government. In a modern society, spatial data play major roles and have different applications such as information support during disaster prevention and management.
These two milestones involving Geodata development have created huge demands and represent great challenges for researchers in the area of spatial data infrastructure. One of these challenges concerned the methodologies involved for testing proposed data specifications from INSPIRE. This paper addresses the above challenge and introduces a framework for testing Geodata. The testing of Geodata includes, the testing of the data specifications for different geographical themes and data structure, the performance testing of Opengeospatial Web Services (OWS) and the usability of Geoportals and services. The proposed methods were evaluated during a pilot test for a regional geoportal in Sweden, and the reported results in this paper show the feasibility and applicability of the methods used. The methods used assisted in the identification of the performance related defects and the bottleneck involved in relation to the response time, stress and load. The methods support the detection of different types of errors that occur during the testing time such as http error, timeout error, and socket error. During the pilot test of a geoportal, it was discovered that the response time was 30 seconds which is 6 times higher than the INSPIRE required time (Maximum 5 second), with 500 virtual users accessing the system and performing a specific task. A usability test was conducted which focused on the users' acceptance and the "think aloud" methods. The usability testing enabled the identification of user-interface related problems and the results were quantified to enable comparisons to be made with current results and those from the new test.
Keywords: INSPIRE, Performance testing, SDI, Geoweb services, Usability testing.

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1. Introduction

Spatial Data Infrastructure (SDI) as defined by (Spatial Data Infrastructure Cookbook, 2009) is often used to ‘’denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data’’. The scope of SDI is wider and covers both geographic and attributes databases, which are typically documented with well organized metadata to provide efficient utilization of their content.

During the last two years, the development of SDI in Sweden has been influenced by two actions. The first was the European Directive in spatial data infrastructure namely the Infrastructure for Spatial Information in Europe (INSPIRE) [Directive 2007/2/EC of the European Parliament and of the Council of 14th March 2007]. INSPIRE will now become the European platform for sharing geospatial data sets among EU member states by means of web services.

The second action was the Swedish parliament's directive early in 2008 on e-Government [Axelsson and Lindblad-Gidlund, 2009]; the main aim of this directive is to transform public services within the country to ICT based services. Part of this initiative was the establishment of the Geodata strategy and the Geodata board at the national level.

The main purpose of the Swedish Geodata Strategy was stated in [National Geodata Strategy, 2008] and ‘’ is to encourage increased co-operation within the geodata sector by providing increased and clearer information as well as guidance to producers and users. Key principles for the Geodata strategy are that it should contribute to the development of Swedish e-governance, support the development of the private sector and facilitate adaptation to new pre-conditions’’. One of the main results of this strategy was the development of the Swedish Geodata portal (http://www.geodata.se).

These two milestones for Geodata development created huge demands and represent great challenges to all those involved within the area of SDI. One of these challenges was the requirement for testing methods in order to test the proposed data specifications from INSPIRE and to ensure that the chain of web services through the Swedish Geodata portal conformed to the required INSPIR standards and to provide assurances that the service is delivered according to the performance criteria specified in the INSPIRE implementation rules [INSPIRE, 2007].

This paper introduces a framework for testing Geodata which includes, but is not limited to, the testing of the data specifications for different geographical themes and data structure, the performance testing of Opengeospatial Web Services (OWS) the usability of Geoportals and services, and the testing of spatial metadata and data quality.

The position of Geodata development and its implementation in Sweden is represented in Figure 1. The main actors in this diagram are the EU commission and the Swedish parliament and Government, see [Swedish National Geodata Strategy, 2008].

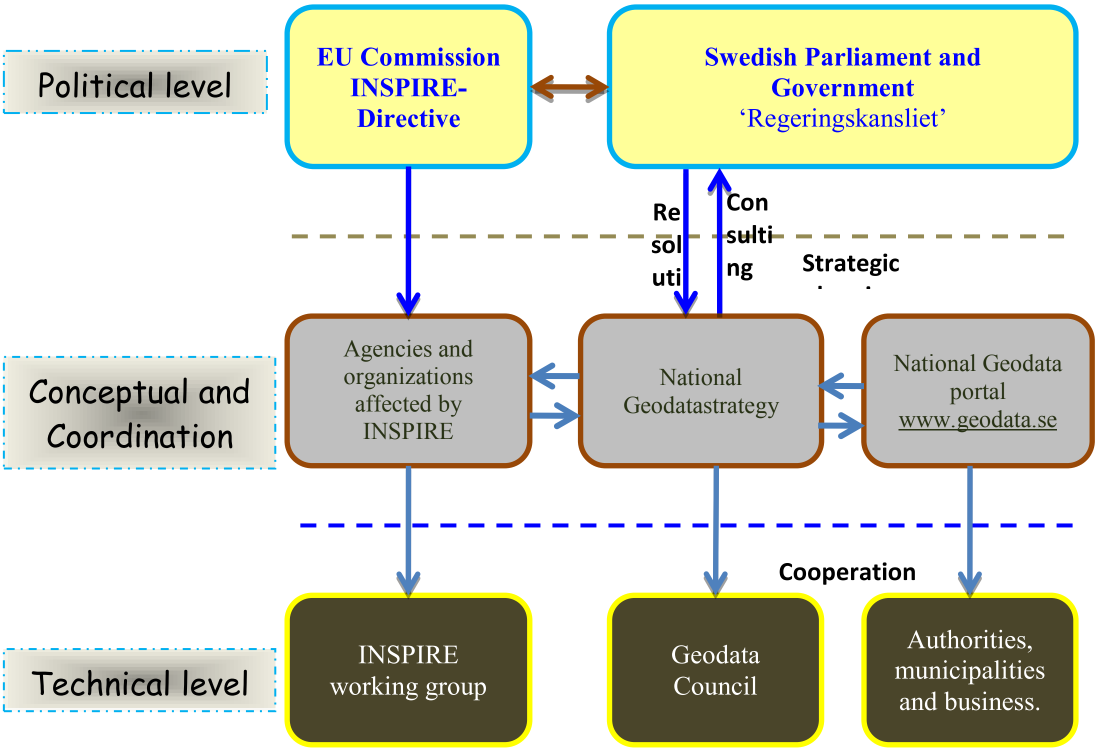


Figure 1. Geodata within the context of EU commission and Swedish Government. Source: [Swedish National Geodata Strategy, 2008]

2. Implementation challenges

The main challenges facing the e-Government action plan in general and the implementation of INSPIRE Directive in particular are the transformation of the current services from traditional delivery mechanisms to the ICT based services build on the mandatory implementation rules and EU Directives [CEN 2006]. INSPIRE services should allow the users to identify and access spatial information from a wide range of sources, from the local level up to the global level. The main condition in this case is to ensure that the services and the data work in an inter-operable way for a variety of uses all over Europe [Masser, 2006].

Data set providers (member states) must comply with the INSPIRE data specification and the technical guidelines. The Swedish Standard Institute (SIS)[2] has already developed national standards in relation to geodata and this standard is also supposed to be considered in the future development of geodata. An adoption of the entire national standards from SIS and also the INSPIRE standards is very challenging. This is particularly true in relation to INSPIRE, which has very wide and comprehensive specifications in order to accommodate the different requirements for all the EU member states. In order to achieve this interoperability and openness, the INSPIRE portal will be based on open standards such as the Geography Markup Language (GML)[3] which makes the platform vendor independent. However, such a requirement demands great efforts in relation to the main capacity and the in-house

2 www.sis.se
3 GML is an XML based mark-up language

experience required in order to carry out and implement the technical implementation work.

2.1. Delivery mechanism

The ISNPIRE portal will offer the user access to a national portal for each member state based on the Service Oriented Architecture (SOA), see [Josuttis, 2007]. SOA has become an accepted architectural style for building business applications. Services offered through SOA are based on loosely coupled software components, with functionality offered in a platform-independent and network-accessible manner [Baresi and Nitto, 2007]. The INSPIRE portal and the member states' geoportals (the national node for INSPIRE) are designed so as not to be dependent on any particular technology. The SOA triangle and different services offered via the INSPIRE portal are depicted in Figure 2 [Pulier and Taylor, 2005]. A description of the SOA and its different protocols is beyond the scope of this paper.

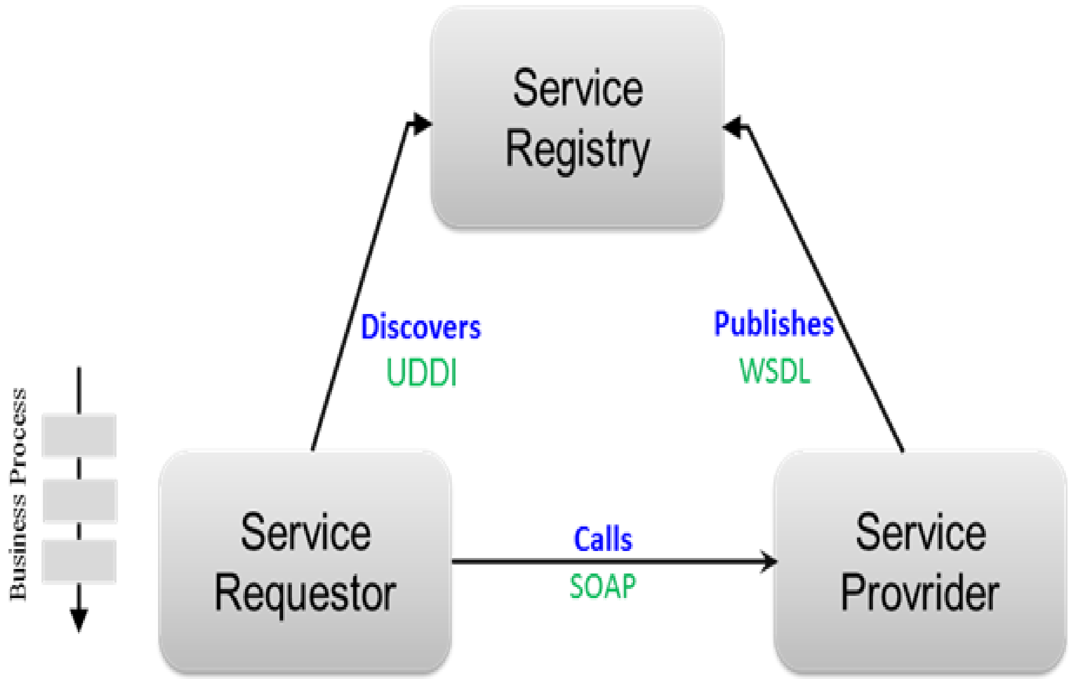


Figure 2. Service Oriented Architecture triangle.

2.2. INSPIRE services

INSPIRE will offer a number of services defined in the 2007 Directive to the user community and the information flow and users' interaction with the portals are represented in Figure 3.

During 2008 and 2009 a number of technical guidelines have been issued for INSPIRE Network services, which represent a key part of the Directive. The services as stated in the technical guidelines should be accessible to the public according to Directive on the re-use of public sector information [EU, 2003].

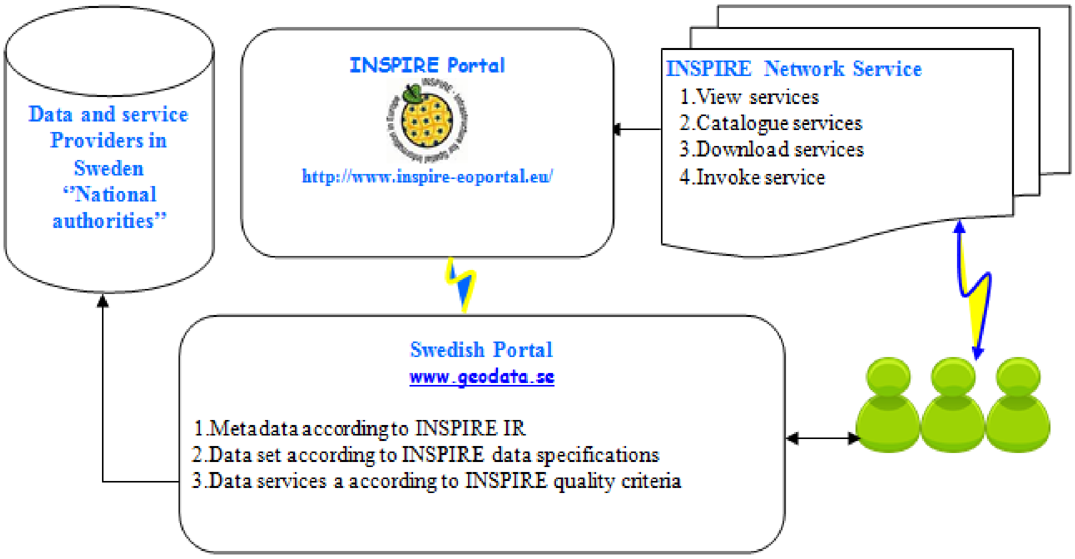


Figure 3. Geodata portal and INSPIRE portals. Source: [Abugessaisa, 2010]

The following are the main network services:

2.2.1. Catalog services

The catalog services is an open standard, developed by Open Geospatial Consortium [Nebert et al., 2007], and is a web service supporting the storage and retrieval of metadata that describes the geospatial data sets and services. The catalog service/ registry is a key component of the SOA and the Web Services Description Language WSDL is used by service providers to describe the services to be offered to the end users. The metadata, supposed to be published in the INSPIRE catalog service, is based on the INSPIRE Implementation rule regarding Metadata.

On the 4th of December 2008 the implementation rules (IR) for Metadata were published in the official journal of the European Union. The INSPIRE implementation rule for metadata has been developed and published through defined procedures as stated in the commission's regulation (EC) No 1205/2008 of the aforementioned date. Among others, The advantages associated with INSPIRE IR in relation to metadata includes the facts that it supports the sharing of spatial data and increases the usability of the spatial data for different applications and uses.

It proved to be very challenging to provide all the required mandatory elements in the IR and the result from the INSPIRE transformation testing at the Swedish Land Survey during the early part of 2009 shows the current gap and the availability of the elements, see Figure 4.

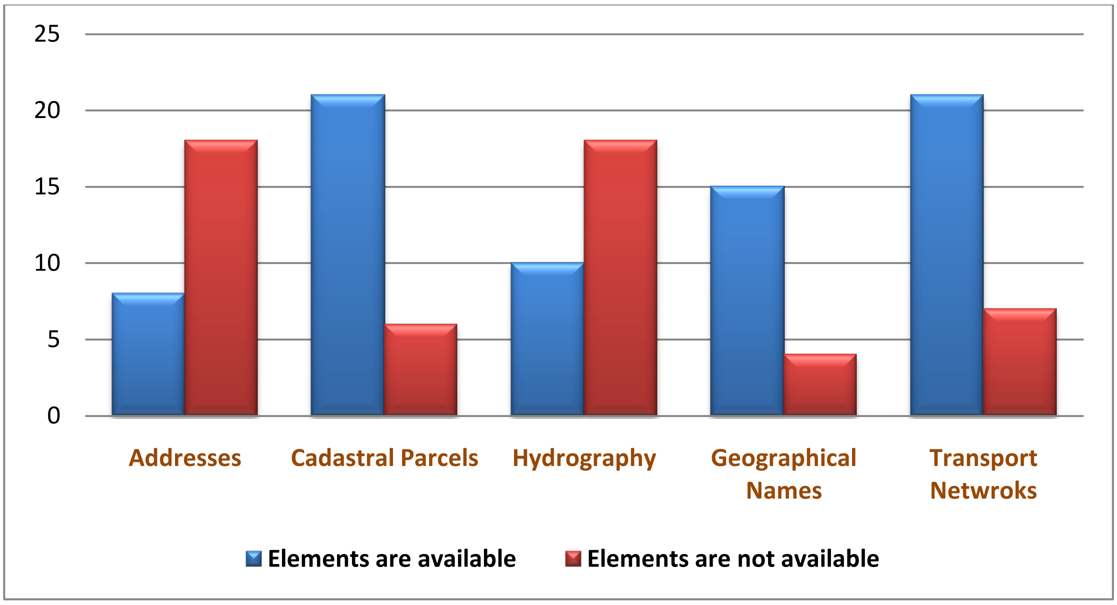


Figure 4. Gap in dataset-level metadata. Source: [Östman et al., 2009]

2.2.2. Network services

As specified in article 17 of the INSPIRE Directive, the network services of the INSPIRE portal are necessary in order to share spatial data between the various levels of user groups and authorities in a member state. From the implementation point of view, the network services are a type of web services that serve Geodata on the same technical basis as is the case for web services [Sarang et al., 2007]. These services can provide access to the Geodata stored in the databases, can have the ability to perform different kinds of geometric and spatial computations that can either be a simple task such as route calculation or an advanced task such as geostatistic computation and can also rerun messages that could be numeric or a geographical feature [Lake et al., 2006].

Network services as listed in the Directive are 1. Discovery services; this is to discover the available data sets described in the catalog with the metadata, 2. View services; this service will assist the user to view the content of the dataset and to perform different types of cartographic operations. This service will be based on OGC Web Map Services [Foerster et al., 2009], 3. Download services; to download a data set from a particular database. 4. Transformation services; this service aims to support the interoperability of geodata throughout the member states, and 5. Invoke service; this is a type of service which is required in order to run and execute a chain of services. The services are normally orchestrated using a language such as Business Process Execution Language (BPEL) [Stollberg and Zipf, 2007].

3. Requirements of the testing methodology

The above mentioned services and the INSPIRE implementation rules 'IR' meant that there was a requirement for a testing methodology that was able to meet the implementation challenges of the Directive [Craglia and Annoni, 2006]. This section of the paper will provide an example of the different requirements which was the main motivation behind this research and which supported the development of the framework. Three elements must be taken into consideration when designing a testing framework. These are data specification, quality of service testing, and usability testing.

3.1. Data specification testing

The content of the spatial portal, based on GML and SOA technology, can hold the following different types of GML schemas see Figure 5 [Lake et al., 2006]:

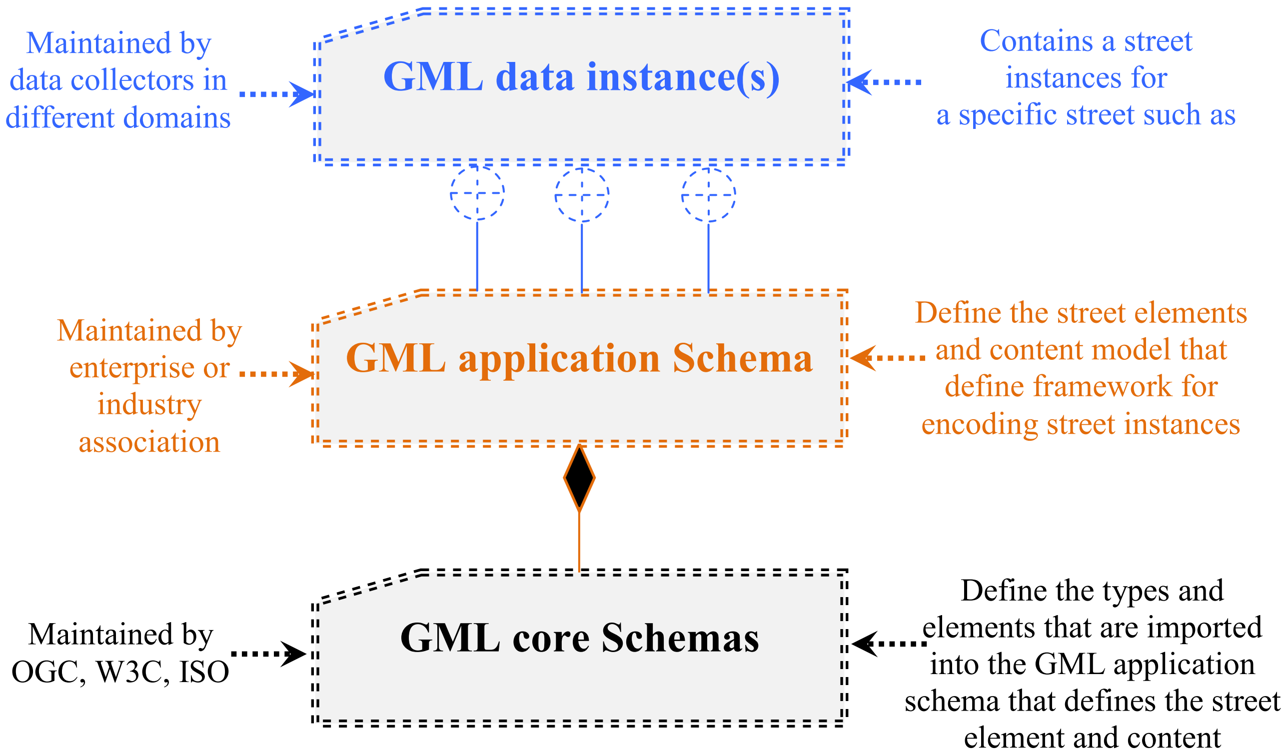


Figure 5. GML different schemas.

In Figure 5, both the GML instance and application schema should be tested for a number of properties and should maintain specific quality criteria. The criteria will be discussed in this section:

3.1.1. Conformance

Conformance is a type of testing in which a specific product is to be tested in order to determine the extent to which the product conforms to its implementation [SDI-cook book, 2008]. The GML data instance is normally built according to the application schema for a specific domain and the instance must conform to the specifications embedded in the application schema. Thus, all the coded features (classes) and their properties and property values should use the GML object-property model defined by the OGC core schema. The INSPIRE data specification is divided into three annexes, each of which contains the specifications for one or more geographical themes, for example Annex I contains nine themes (Protected Sites, Transport Networks, etc.). For each specific theme, the spatial data sets relating to the theme will be provided using the spatial object types and the data types specified in the application schema for the specified theme. Each spatial object must comply with all the constraints specified for its spatial object type or data types used in the values of its properties, respectively. At the class level, the feature types in the application schema are classified into three levels which are either mandatory, optional, or recommended.

During the testing of the GML instance, the mandatory elements are to be tested so as to ensure that they exist according to the specifications. In addition to the INSPIRE data specifications, the OGC, W3C, and ISO standard on GML schema are to be tested and verified. The following provides some of the rules which are covered by the data specifications:

i. All required Name spaces should be declared at the beginning of the schema as a header. The following is a small segment from the GML schema with a number of name spaces:

```
<schema targetNamespace="http://www.opengis.net/gml"
xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xlink="http://www.w3.org/1999/xlink"
```

ii. Core schemas are maintained by the OGC, ISO, and W3C and are accessible on-line via URL. The application schema must import the appropriate core schema(s). The GML segment below imports two core schemas. Gml.xsd from Opengis.net and BaseTypes.xsd from the INSPIRE specifications.

```
<import namespace="http://www.opengis.net/gml"
schemaLocation="../gml/3.1.1/gml.xsd"/>
<import namespace="urn:x-inspire:specification:gmlas-
v31:BaseTypes:3.1" schemaLocation="../GCM/BaseTypes.xsd"/>
```

iii. All GML objects must drive directly or indirectly from a corresponding abstract collection type.

iv. Properties can be declared as global elements or as local elements within an object's content model.

v. Objects defined in an application schema must conform to the rules with respect to the base types from which these objects derive.

3.2. Testing quality of services

Testing the QoS is one of the main requirements for the testing framework. The quality of service (QoS) will be the key issue in obtaining an efficient means of sharing and exchanging spatial information.

Recently Geoweb services and Geoportals appeared as one of available Internet services delivered through the Internet protocols [Zhang et al, 2007]. The INSPIRE architecture reflects the requirements for specific network connection quality and other constraints on the server and client configurations and capabilities.

A very broad definition of the concept of Quality of Services given by [ISO 95 QoS Framework], (QoS) is "A set of qualities related to the collective behaviour of one or more objects". The definition deals with QoS as a collection of objects that have specific behaviour. The basic objectives of these technologies are to provide continuous transmission which is capable of granting the delivery of services provided by the server.

A more detailed and descriptive definition in relation to QoS research is given by [Wang, 2001] "A new research direction for the next generation of the Internet and focuses on the new technologies and standards to provide resource assurance and services differentiation for various Internet applications".

The QoS for a geoportal such as INSPIRE are:

3.2.1. Performance qualities

Considered as the top qualities required by INSPIRE's network services,in which performance qualities are measured in terms of the system's ability to respond to the user's operations and queries and, in addition, to the reliability of the service over time. The performance of the Geoweb services are related to three components; namely, the client, server and network [Foster et al., 2004]. Throughput and response times are used as measurable performance indicators [Shan and Earle, 1998].Throughput is measured as the unit of time required to perform operations (generation of maps in Web Map Services 'WMS') and hence this is a server side quality, whereas the response time was measured as the total time as perceived by the user from sending a particular request to the obtaining of a response or the result of the query or any services (download services).

Performance can be measured against the standards or can be compared (Benchmark) with other systems. Benchmarking of a system is concerned with identifying and measuring best practice processes that work elsewhere and then attempting to emulate them [Kelly, 2006]. The benchmarking of a system can assist in understanding weaknesses and can be used as a comparison with peers (system, platform).

The proposed testing framework aims to identify the weakest components which will assist in enhancing the overall system performance.

3.2.2. System reliability

The IEEE reliability society describes reliability as ("product performance over time") (http://www.ieee.org/portal/site/relsoc/menuitem.e3d19081e6eb2578fb2275875bac26c8/index.jsp?&pName=relsoc_level1&path=relsoc/Reliability_Engineering&file=index.xml&xsl=generic.xsl).

With respect to Geoweb services, a reliable system should function as required as an unreliable system means that the system will fail to function from time to time. Reliability is based on measurable indicators and this requires statistical data which can be obtained from a user or a system log book. System faults can be caused by [Peng and Tsou, 2003]: human error, component faults, or product defects. A system which is unavailable for user access is considered to be unreliable, and thus the system reliability could be measured in term of availability. Thus the system availability (A) is taken as a function of the Mean Time Between Failure (MTBF) and the Mean Time to Restore the Services (MTTR)[4] [Peng and Tsou, 2003] and :

$$A = \frac{MTBF}{MTBF + MTTR}$$

Here are examples of the obligatory quality criteria for the network services' architecture which are to be maintained by the data and service providers at the member state as described in the Commission Regulation (EC) No 976/2009 of 19 October 2009 [Official Journal of the European Union, 2009]:

Download data set or metadata services

- Get metadata: Not more than 3 seconds
- Get vector data: a maximum of 30 seconds + 2 s / Mb

4 It includes time to respond + time to isolate to failure + time to correct the failure + time to verify faults.

- Get item description: Maximum of 10 seconds + 2 s / Mb
- At least 10 concurrent requests
- Availability of the service 99%.

Web Map Services 'WMS'

- Maximum 5 second response time for an image of 470 Kb
- At least 20 concurrent requests in a normal situation (Normal situation represents periods out of peak load. It is set at 90 % of the time).

Capacity of the discovery service

This requirement represents the discovery service capacity which is described as the minimum number of served simultaneous requests according to the performance quality of service and which the implementation rules specified as 30 requests per second.

Availability

The probability of a download service, view service and discovery service being available should be 99 % of the time. This represents a high demand on the service providers in each member state.

3.2.3. Testing orchestrated services

The most challenging part of the INSPIRE network services is the ‘’ invoke” services. This type of service allows multiple services to be invoked and to offer a single composite service to the end users. Through a chain of services both the data inputs and data outputs expected by the spatial service are defined as a work-flow ‘’ business logic” [Martens, 2003]. The chaining process is technically implemented through the orchestration engine of the web services. The following example will simplify the idea of chaining and the orchestration of services.

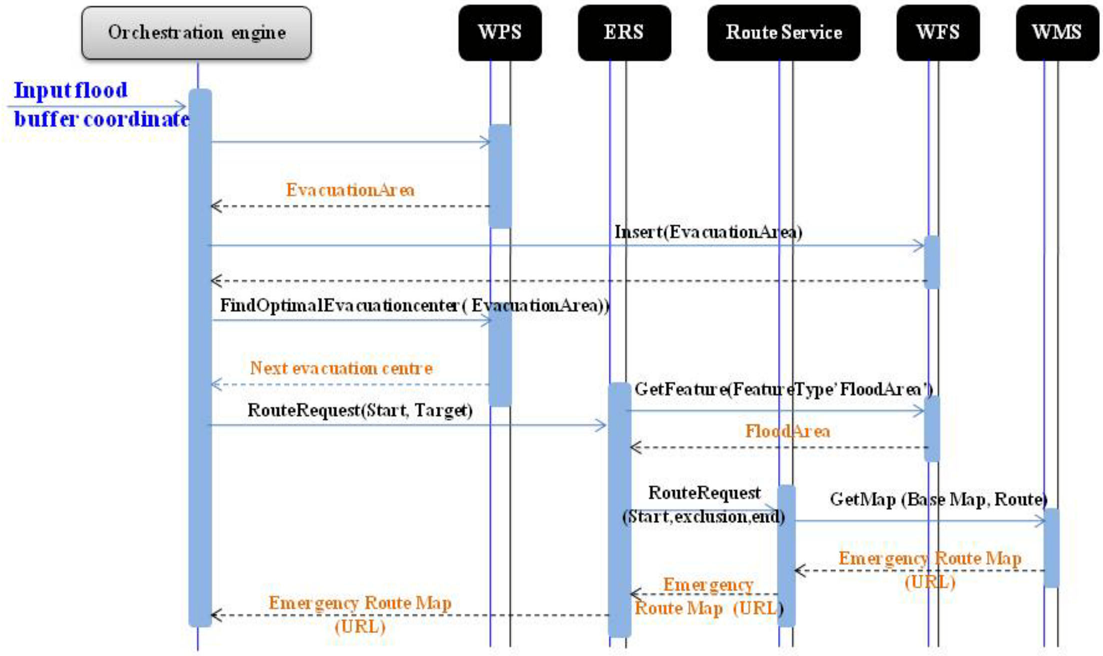


Figure 6. Orchestration of Geoweb services. Source: [Stollberg and Zipf, 2007].

The above example of a user case or scenario in which it is necessary for the user to send a single input and then as a result to receive an emergency route map to an evacuation center(s). Figure 6 is an example of scenario from crisis management. The figure shows how an orchestration engine orchestrates a chain for a single service (atomic service) with a work-flow as the input and output from and to the user. In the work-flow a number of web services are used, the services are:

- **WPS**: Web Processing Services.
- **ERS**: Emergency route services.
- **WFS**: Web Feature services
- **WMS**: Web Map Services

The services are composed using a language such as BPEL which is to be executed as a complex work-flow. The above services are supposed to be available at the service registry and be executed on user demand. This type of composition and changing of web services is subject to the same software problem [Peltz, 2003]. Services are required to be tested before their deployment into the server; the pre-deployment testing will secure the services and increase their performance.

4. Usability and acceptance testing

Usability and acceptance tests assist in measuring the extent to which the system complies with the usability design procedures [Nielsen, 2000] and also gives the system developer and owner feedback that can help them to maintain a usable and acceptable system — in this case, to test the system and its acceptance by the users [Abugessaisa, 2006]. The approach adopted in this case was to test usability according to three dimensions of usability proposed by [Wachowicz, 2006], which are the content of the system, user satisfaction, and ease of interaction. The evaluation of users' satisfaction should not only be based on user interface design and influence, but should also consider the content testing and functional capability of any kind of spatial information portal [Benyon et al., 2004] The usability testing dimensions of the spatial data and services are depicted in Figure 7.

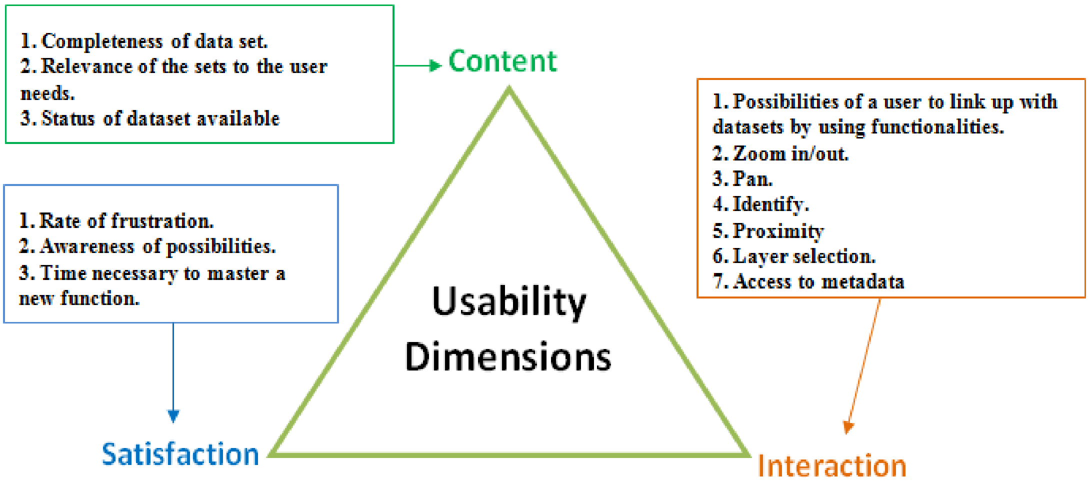


Figure 7. Dimensions of the usability of SDI.

The main focus of the testing is with reference to the 'user' of the system and it has been possible to identify and test using three types of user, namely the individual user, a target group, and a focus group. In collaboration with the system owner different testing scenarios and Use-Case(s) have been developed. A scenario consists of groups of tasks that should be performed by the user within a specified time [Beyer and Macleod, 1994].

4.1. Results from pilot test of regional geoportal:

GIS- Arena is a regional geoportal in three counties of Sweden. GIS-Arena aims to promote the implementation and application of Geographical information System in the region. The current operating version of GIS-Arena offers a common platform so that information and Geoweb services are available to public authorities and citizens.

We tested and evaluated our proposed methodology on GIS-Arena, in particular usability and performance testing. We proposed and conducted the testing procedures as depicted in Figure 8. The testing procedures was a modified version of [Dumas and Redish, 1999] approach. The users are divided into three sessions and each session of five users. The option for the five users per session was based on (Nielsen, 2000), where testing with 5 users will help to identify 85% of the usability problems and testing with 15 will make it possible to identify 100 of the problems. Appendix (1, 1 Participants in the usability testing session) describe the different demographical attributes of the participants in the usability test.

A software solution called Morae was used for usability testing the software enhances data collection and speeds up analysis and reporting procedures after testing with the users[5]

[5] http://www.techsmith.com/morae.asp

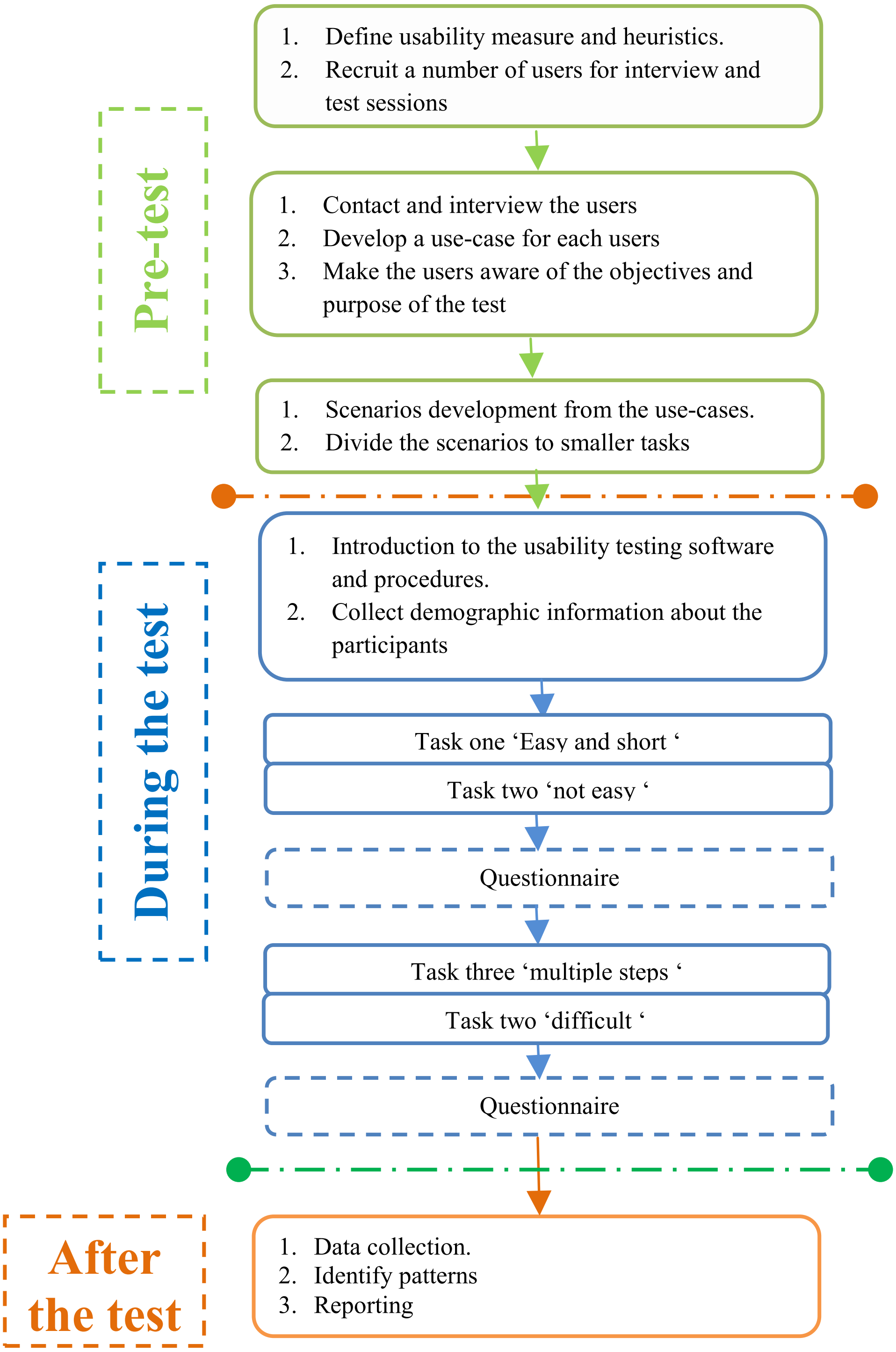


Figure 8. Usability testing procedures and steps.

4.2. Scenarios development

At this point examples of scenarios (use-cases) developed for usability testing of GIS-Arena are presented. A number of potential users were selected from the three regions in the middle of Sweden and they were interviewed, with the main purpose being to: (1) Prepare users for usability testing, (2) To obtain the users' expectations from the GIS-Arena, (3) Description of the user's roles and tasks in their organizations. The flowcharts in Figure 9 represent two use-cases.

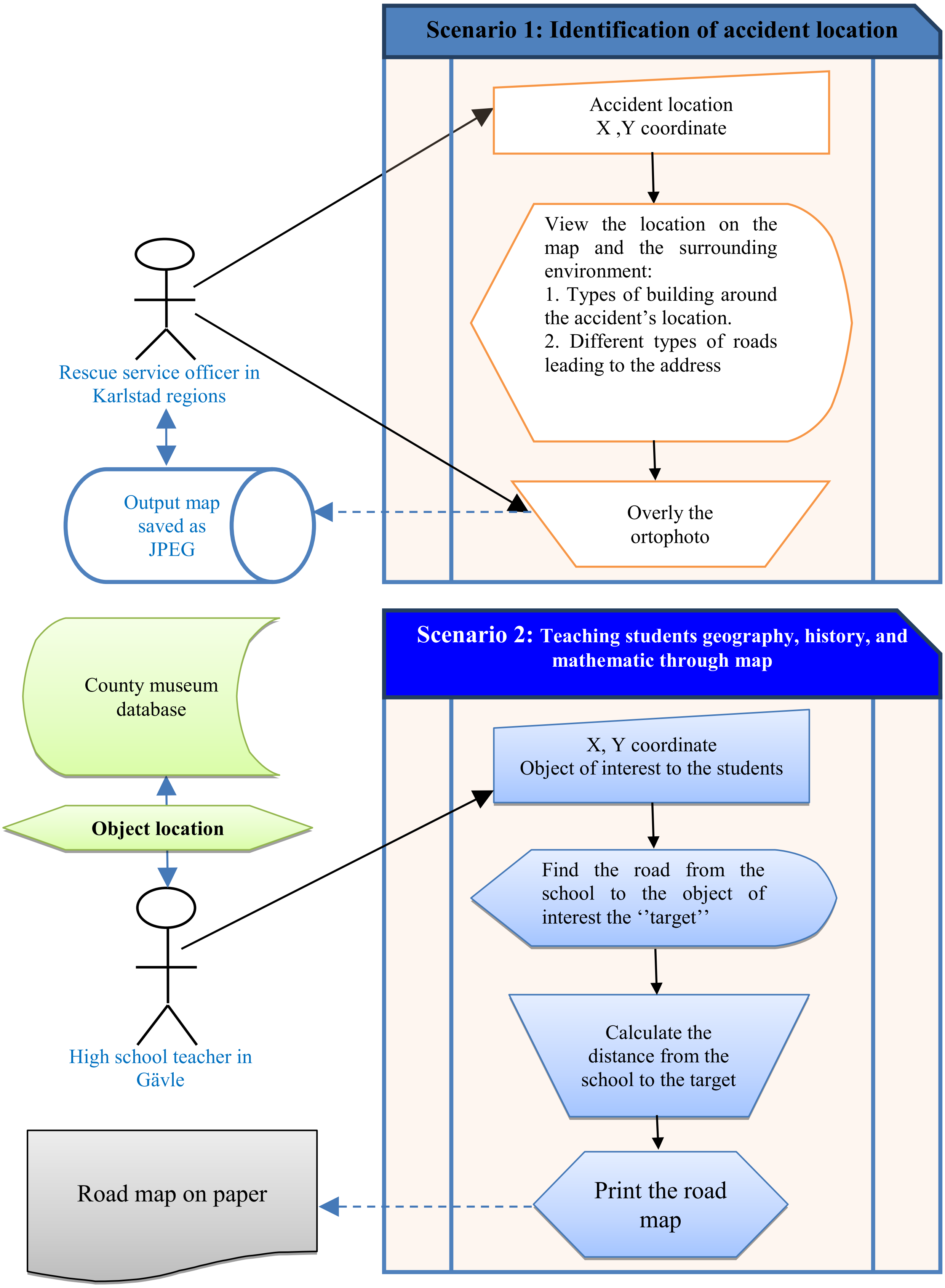


Figure 9. Use cases for usability testing.

During the usability sessions, the users were asked to perform a number of tasks, which were offered in Swedish and the user interaction and all mouse events are recorded by Mora. The tasks in Swedish are as follow:

Pan and Zoom operation

1. Select from the tools bar the pan tool and pan to Värmland area
2. Zoom in to Karlstad
3. Zoom out.
4. Pan to Gävleborg
5. Zoom in to Gävle

Scale

1. Change scale to 1:2 000.
2. Change the scale to full
3. Change the scale to 1: 5 000 using a different method than the scale bar

Activation of different layers

1. Pan to central Karlstad, zoom to 1:2 000.
2. You are going to use the left menu .
3. Activate the layer under name "Fastighetsgränser"
4. Activate the layer under name "Fastighetsgränser"
5. Activate the layer under name "Flygfoto Värmland"
6. Activate the layer under name "Flygfoto Värmland"

Search address

1. Zoom out to max.
2. Search the address Fryxellsgatan 4, Karlstad.
3. Mark the address as a place of interest by using " point tool 10).
4. Find the nearest primary school to the address Fryxellsgatan 4, Karlstad .
5. Print the current view to the printer

4.3. Testing sessions

User testing is an empirical method which involves observing users while they are interacting with the system during the execution of different task scenarios [Kalen, 1997]. Usability testing provided direct information with regards to how GIS-Arena works for each user and many usability problems can be detected when the system is actually being used by the end-user. The participants in the usability test have different backgrounds and education levels. The majority were middle-aged women and men but also included two students from secondary school who had a technical background. The heuristics below summarize the guidelines to follow when designing a user interface and the usability evaluation was performed by analyzing each of them, a) Layout, visual clarity, overall impression, b) Consistency, c) Navigating in the system, d) Terminology and compatibility, e) Feedback, user control and help, f) Functionality, g) Error handling.

In order to analyze the results, the general model for qualitative data analysis by [Lantz, 1993] was used, see Figure 10. The data collection in this case consists of the questions asked of the participants after the completion of each task. The data reduction is an on-going process, closely linked to the critical inspection of the results and the reduction process was applied in order to reduce the users' feedback to those who answered the usability questions. The questionnaires have resulted in a large amount of information and it is important to remain focused on the main patterns.

The patterns found in the participants' answers have been summarized in diagrammatic form in the results section.

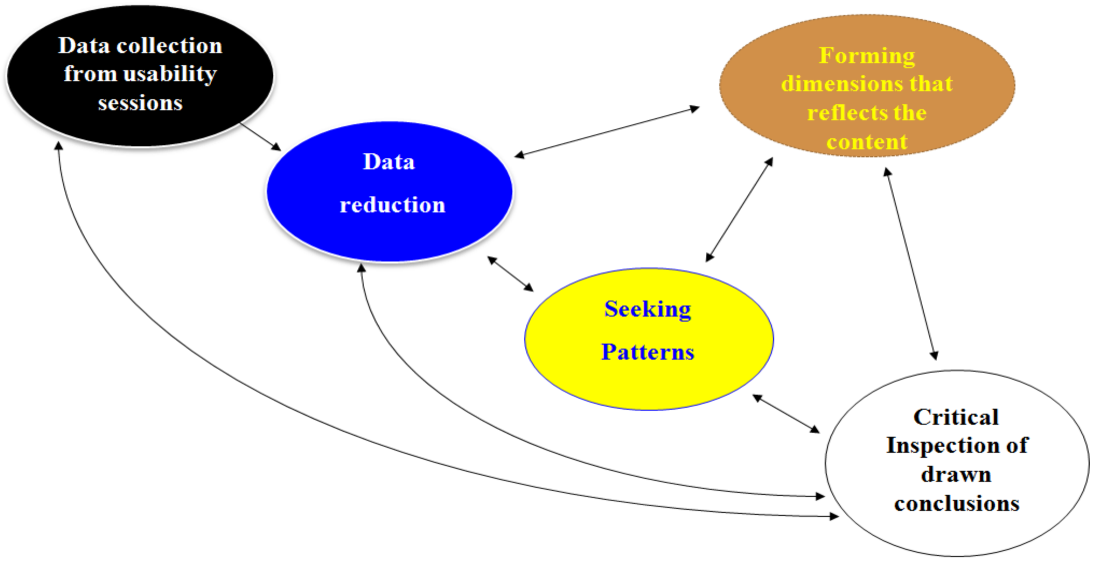


Figure 10. General model for qualitative data analysis. Source: [Lantz, 1993].

4.4. Results from usability testing

Example of testing tasks

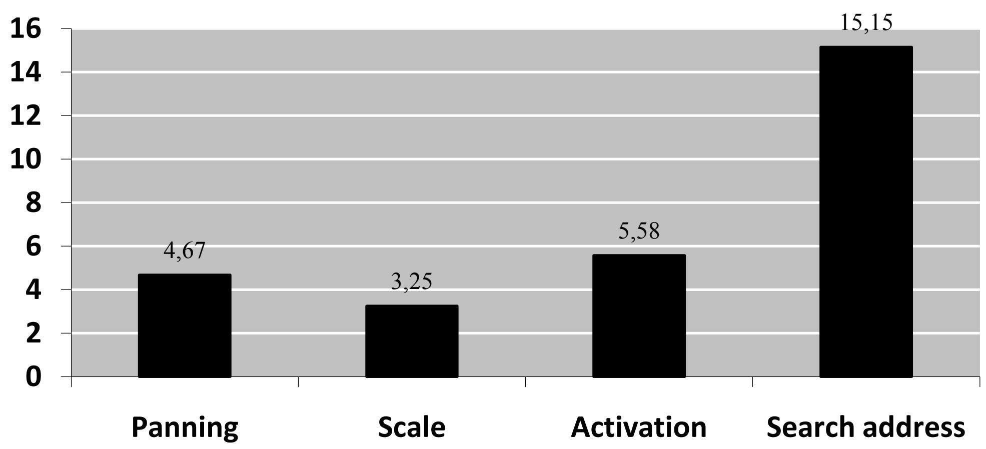
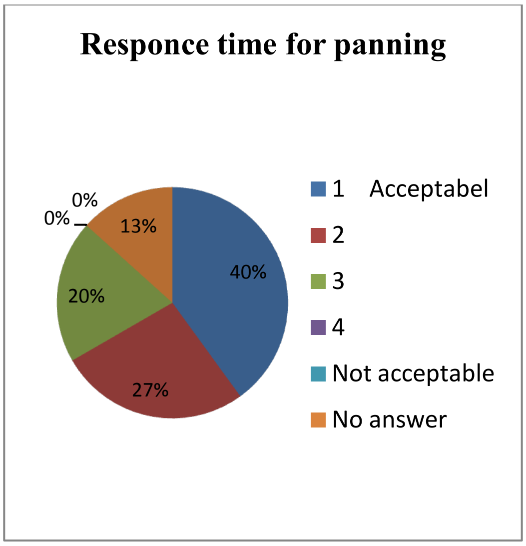


Figure 11-a. Average time on task, the results showing that all uses spent their time on the search function. Users stated that searching for an address is the painful task to do.



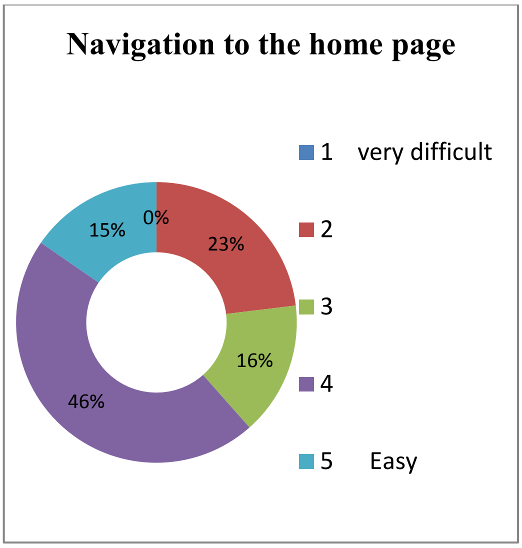


Figure 11-b. User' answer on response time to panning function.

Figure 11-c. User' answer on response navigation on pages.

5. Performance testing

The main objectives of the performance testing were to (1) To identify and evaluate a method for performance testing on the (client-side), (2) Identify an evaluation matrix for this type of test, and (3) Test different web services of the GIS-Arena. The testing methodology for this type of testing is illustrated in Figure 12:

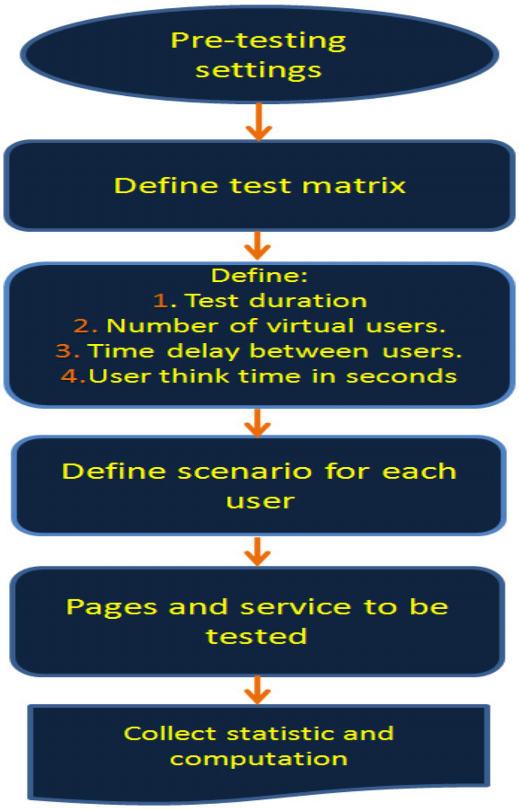


Figure 12. Services performance testing methodology.

5.1. Performance test methodology in detail

The load and stress testing run to observe system's behaviour is performed by:

- Increases the number of concurrent virtual users and monitors the reaction of the service to the increased load.
- Test duration: 64 hours
- Number of virtual users: 1 to 500 (can be increased more)

– With step of 5 users each 10 sec (5 users each 50 sec)

– User think time: 1-15 sec (The time specified to simulate the time taken by a real user to take action before clicking to the next)

- Connection speed (Broadband)

5.2. Applied matrix and performance results

- Response time: This is to measure the elapsed time between the end of an inquiry or demand on a computer system and the beginning of a response (e.g. selection of new map layer)
    - Average response time (during 64 hours) see Figure 13-a
    - Maximum response time, see Figure 13-a
- Percentage of errors (during 64 hours): this is to identify the occurrence of any type of errors such as http errors (server OR client), Timeout errors, and socket errors, see Figure 13-b
- Test scenario: The user wants to view a specific bus line in Karlstad city and then download the bus time table in PDF.

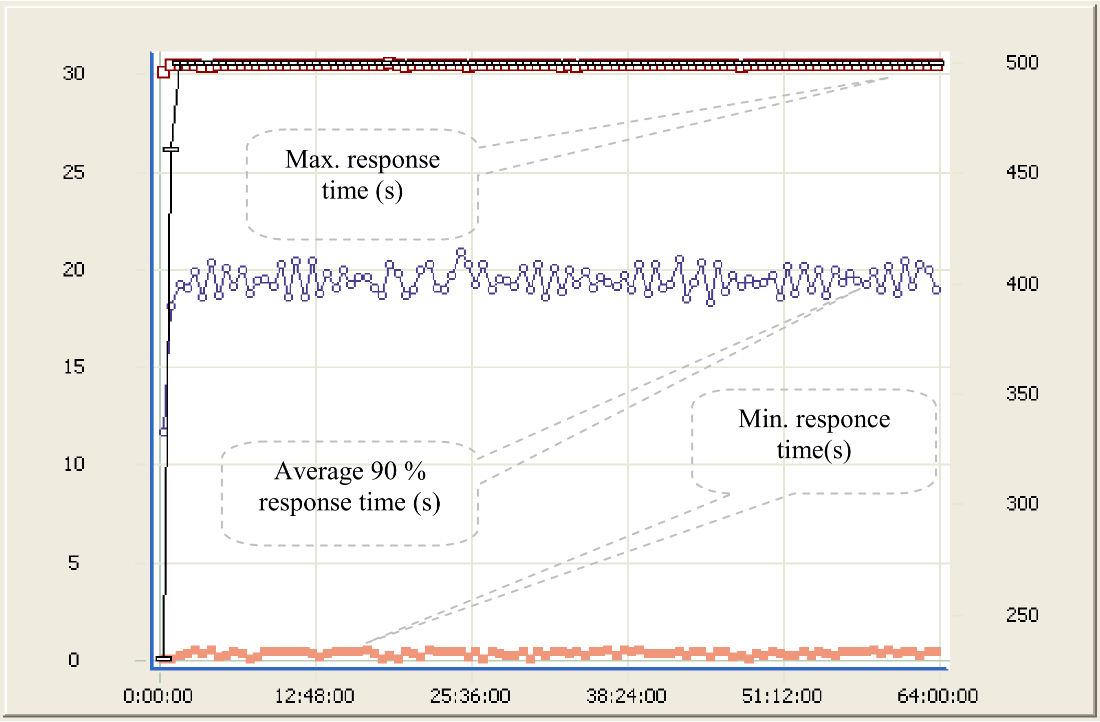


Figure 13-a. response time measured w.r.t number of users 0-500 users, Max time is 30 seconds when total number of users reach 500. Test run for 64 hours.

- **HTTP errors %**

Profile time	0:00:00-6:24:00	6:24:00-12:48:00	12:48:00-19:12:00	19:12:00-25:36:00	25:36:00-32:00:00	32:00:00-38:24:00	38:24:00-44:48:00	44:48:00-51:12:00	51:12:00-57:36:00	57:36:00-64:00:00
KarlstadBuslines	0	0,03	0	0,02	0,03	0	0,02	0	0,02	0

- **Socket errors %**

Profiletime	0:00:00-6:24:00	6:24:00-12:48:00	12:48:00-19:12:00	19:12:00-25:36:00	25:36:00-32:00:00	32:00:00-38:24:00	38:24:00-44:48:00	44:48:00-51:12:00	51:12:00-57:36:00	57:36:00-64:00:00
KarlstadBuslines	15,4	17,0	16,9	16,9	17,6	16,8	16,8	16,9	16,9	16,6

- **Timeouts %**

Profiletime	0:00:00-6:24:00	6:24:00-12:48:00	12:48:00-19:12:00	19:12:00-25:36:00	25:36:00-32:00:00	32:00:00-38:24:00	38:24:00-44:48:00	44:48:00-51:12:00	51:12:00-57:36:00	57:36:00-64:00:00
KarlstadBuslines	13,7	14,9	15,1	14,9	14,9	14,9	15,1	15,1	15,0	15,1

Figure 13-b. All types of network errors (server-side) are detected and reported.

6. Summary of the results

Table 1 summarizes the results obtained from the usability test and the performance test. During the usability test the users participated in three groups, with each group consisting of five users who spend one full day performing the test tasks. The test sessions run for 3 days. The results show the usability problems that must be resolved in the new version. The users were not satisfied with the visual appearance and layout of the interface. Navigation through the different sub menu proved not to be an easy task and the video recording of the users' interactions highlighted this limitation. The general opinion was that the system was neither sufficiently friendly nor easy to use. Table 1 summarizes the results with respect to the heuristics mentioned in section 4.3, the detailed results of the usability testing are illustrated in Appendix (1) 1-3. With regards to the performance testing, a comparison of the results with the INSPIRE technical requirements showed that the response time in GIS-Arena is higher than INPSIRE demands. It was also observed that timeout errors are very common error especially when the number of virtual users is increased to 250 and more. Detailed results from the performance test are illustrated in appendix (1), section 6.

Usability	Usability study
Layout, visual clarity	unsatisfactory
Consistency	Several inconsistencies
Navigating in the system	Not easy to navigate
Terminology	Appropriate
Feedback, user control and help	Poor feed back
Functionality	Not easy , e.g. search
Error handling	Poor error handling
General opinion	GIS-Arena is not easy to use
Performacne	
Responce time	> 5 sec with more than 250 user
Errors	All types of error are exist

Table 1. Summary of the usability and performance test.

The proposed testing approach, when compared to the existing approaches, has the advantage of being focused both on the use of the geoportal services (user-centered) and also on the testing of the contents with regards to the INPSIRE specification and QoS.

7. Lessons learned and conclusion

The simultaneous combination of a number of tests has proved to be of significant value and has assisted in covering different aspects of the product (data set + data service). It is usual for researchers to focus on one particular testing area within SDI and the authors of this study feel that this will influence the final results and that greater efforts will be required in order to integrate all the results into a coherent set.
The usability method does not question the users and is not only collecting their answers, but is also measuring all their interactions with the interface, including the mouse clicks and inputs from the keyboard. The video recording system can assist in the use of talk-loud methods as it has the ability to observe the users' reactions and their mode during the testing sessions. Many features and different parts of the system were tested during these scenarios and the pilot test showed the applicability of the methods and testing procedures.

The performance and QoS method has proved to be of great value in detecting a system bottleneck in the server side. As there were long and steady periods involved in the testing, it was possible to define and accurately measure different types of times. The results from the testing were compared against the INSPIRE network of services performance specifications. The methods also appeared to suggest that it was possible to detect server errors such as an http 40X error and timeout errors which are hardly detected by system developers without the system been used by significant numbers of users. The generation of virtual users (virtual session) enabled the possibility to specify the entry time between each user and the time each user requires thinking before taking action (event). In this case the virtual users (500) in the pilot study performed the same scenario.

Currently a usability lab with five user terminals is available and running at the testing facility of the Swedish Land Survey. This is a significant advantage as compared to the traditional testing run by software developers. The methodology will support the development and implementation of the INSPIRE Directive and the Swedish Geodata strategy.

The testing methodology presented in this paper has been discussed and verified and has proved its usefulness with respect to the current development of SDI. The methodology is balanced in terms of its services; users are at the heart of the methodology. The risk involved in ignoring the users' experiences may lead to the situation in which the system will not be used, and hence the huge investment involved in the SDI and geoportals implementation will be lost. The piloting of the methodology with its different parts has provided increased confidence and has encouraged the authors to apply it to a large scale testing for a similar environment.
Geoweb services based on Service-Oriented-Architecture (SOA) will demand more efforts to maintain the life of the services and to stabilize such activities as service monitoring and analysis and these will be additional tasks for the SDI providers.

Acknowledgement

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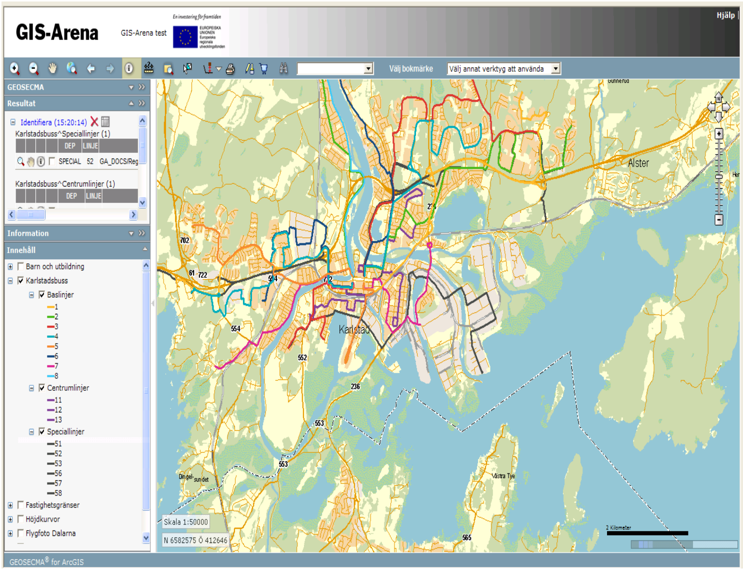
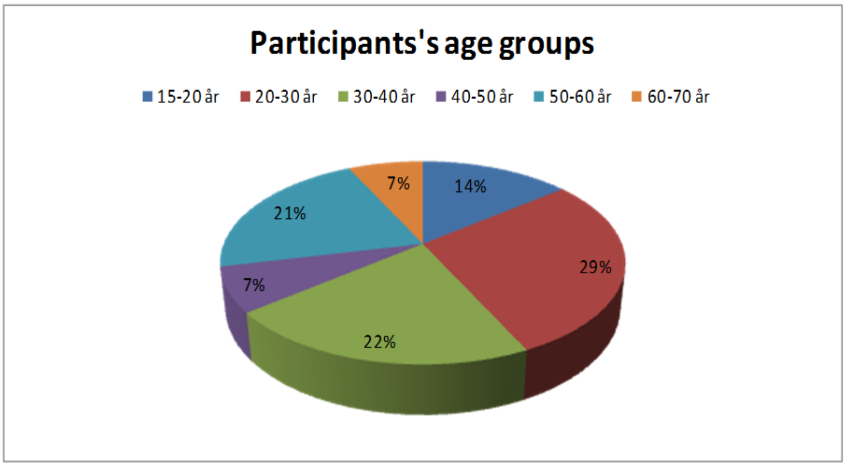
Appendix

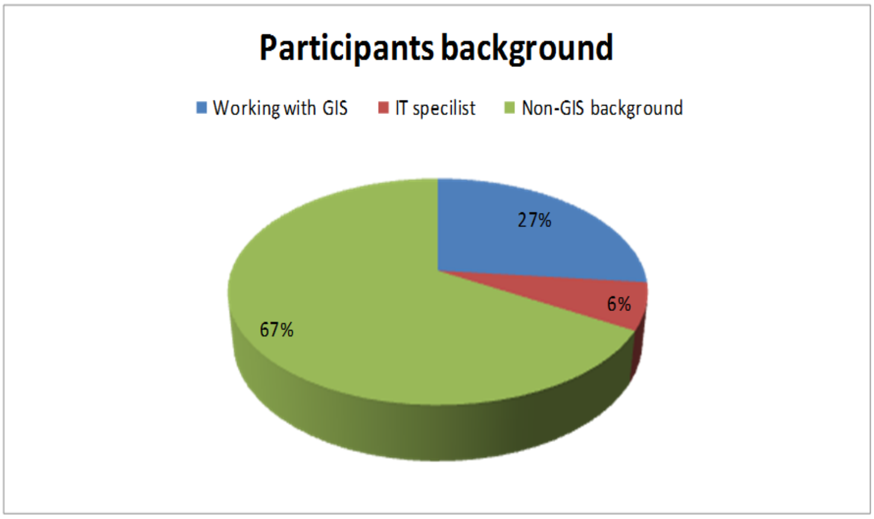
This appendix summarizes the results of the usability test, user satisfaction survey, and performance test results. The figure below shows the GIS-Arena portal.



1. Participants in the usability testing session

The participants in the usability test had different backgrounds and education levels. The majority was middle-aged women and men but it also included two students from secondary school who had a technical background. Some of the participants had been working as GIS engineers within the municipalities for several years, and some had been working in the field of IT in general, but with very limited experience on GIS. The remainder of the participants had been working with web mapping application for day to day use only.





2. Session 1:

Task 1.Pan and zoom (PANORERA)

1. Select from the tools bar the pan tool and pan to Värmland area
2. Zoom in Karlstad
3. Zoom out.
4. Pan to Gävleborg
5. Zoom in Gävle

Task 2.Map scale (SKALAN)

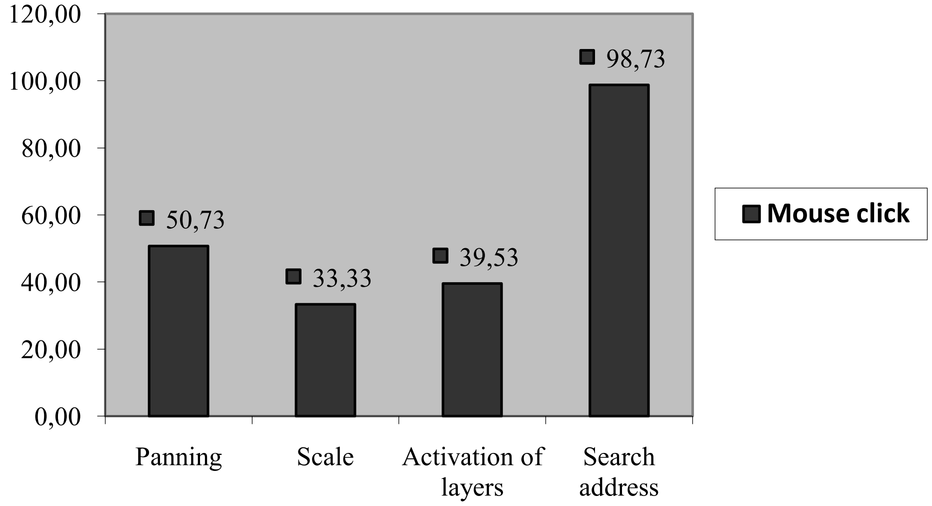
1. Change scale to 1:2 000.
2. Change the scale to full
3. Change the scale to 1: 5 000 using a different method than the scale bar

Task 3. Activation of different layers (AKTIVERING)

1.Pan to central Karlstad, zooma to 1:2 000.
2. You are going to use the lefe menu .
3. Activate the layer under name "Fastighetsgränser"
4. Activate the layer under name "Fastighetsgränser"
5. Activate the layer under name "Flygfoto Värmland"
6. Activate the layer under name "Flygfoto Värmland"

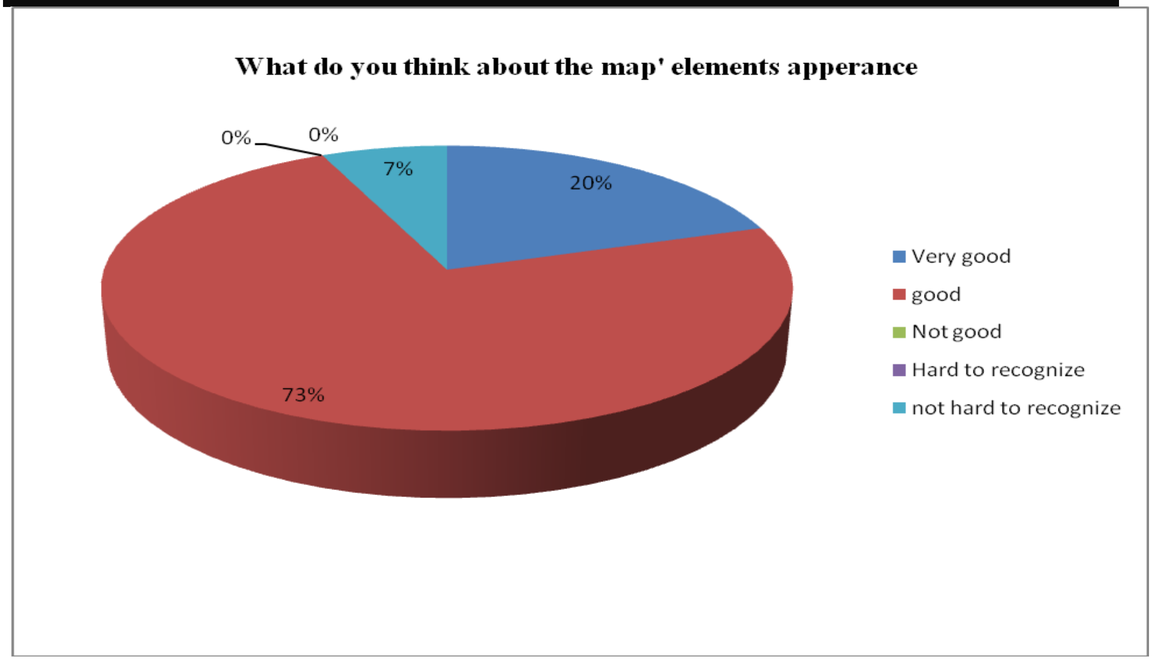
Task 4. Search address (SÖK ADRE)

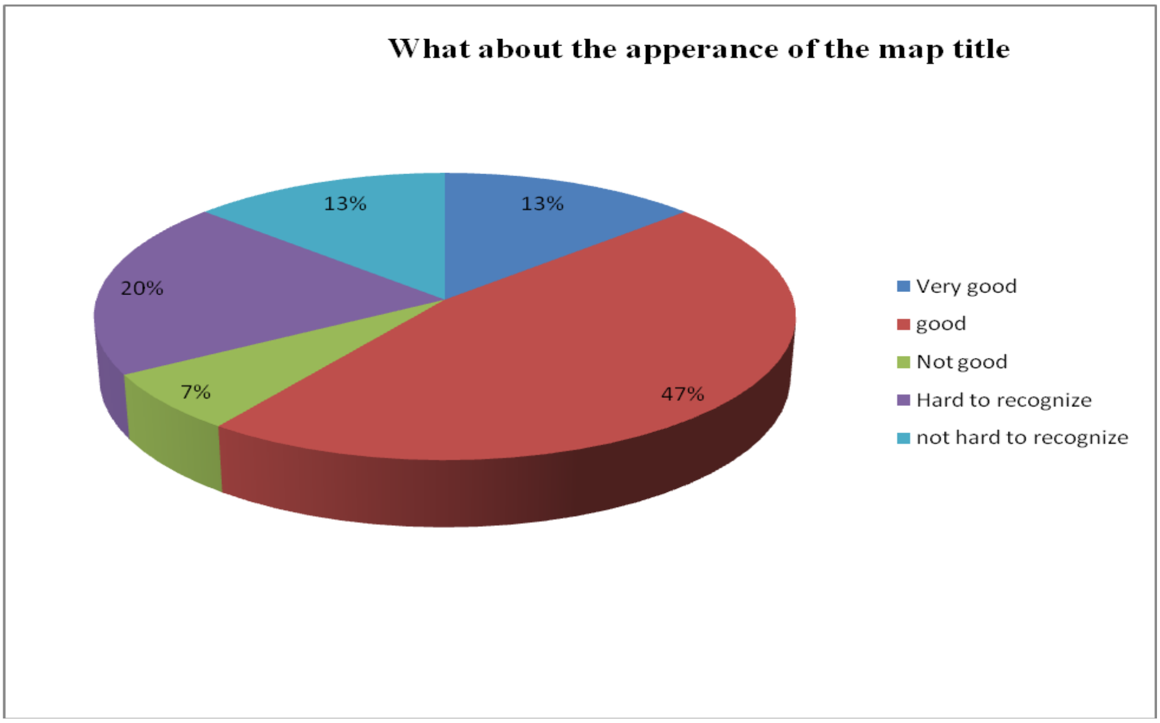
1. Zoom out to max.
2. Search the address Fryxellsgatan 4, Karlstad.
3. Mark the address as place of interest by using " point tool 10).
4. Find nearest ground school to the address Fryxellsgatan 4, Karlstad .
5. Print the current view to the printer

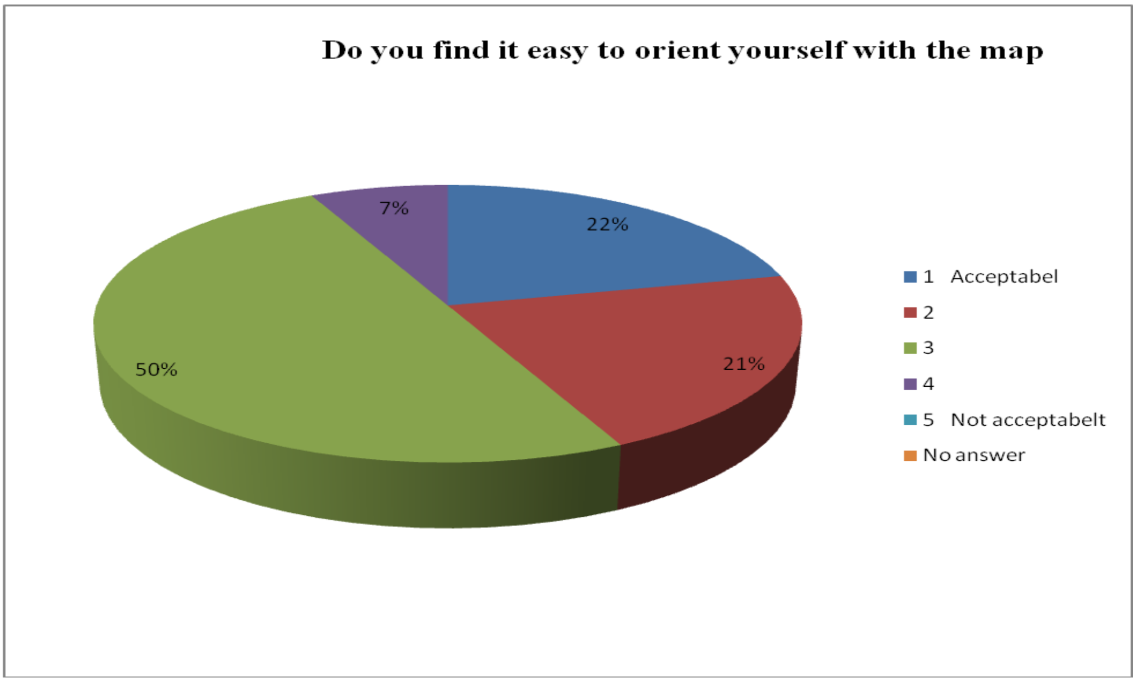


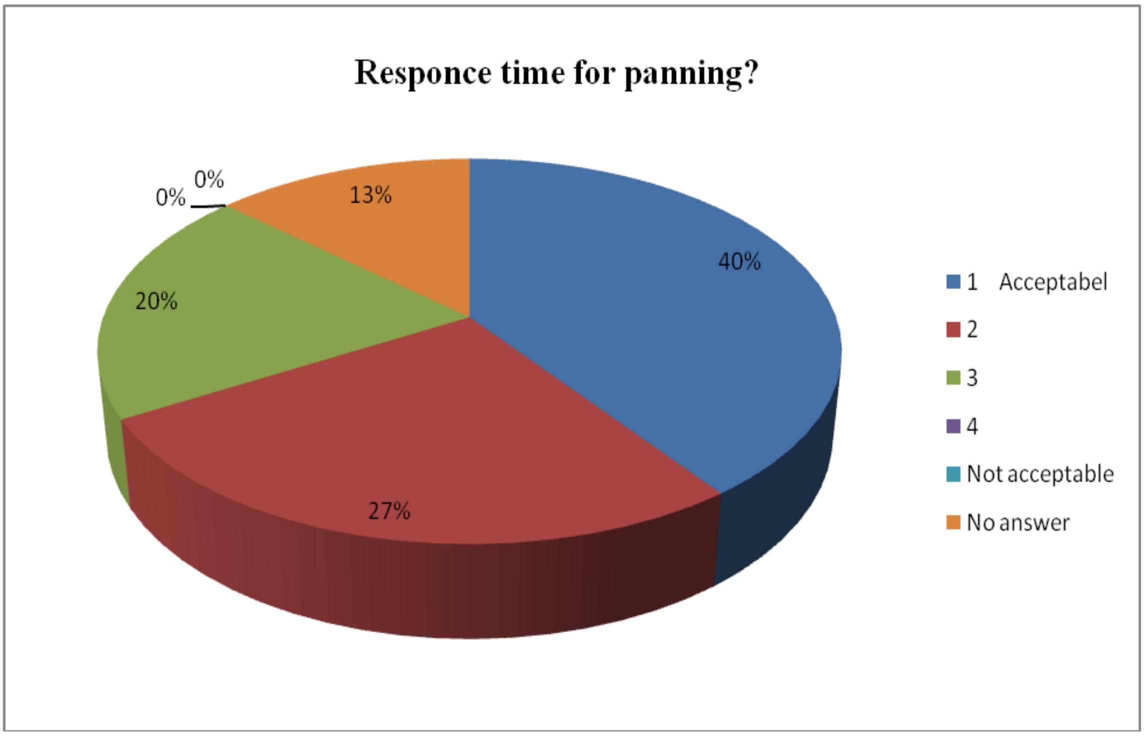
This section summarizes the results of the questions answered by the individual users after each task.

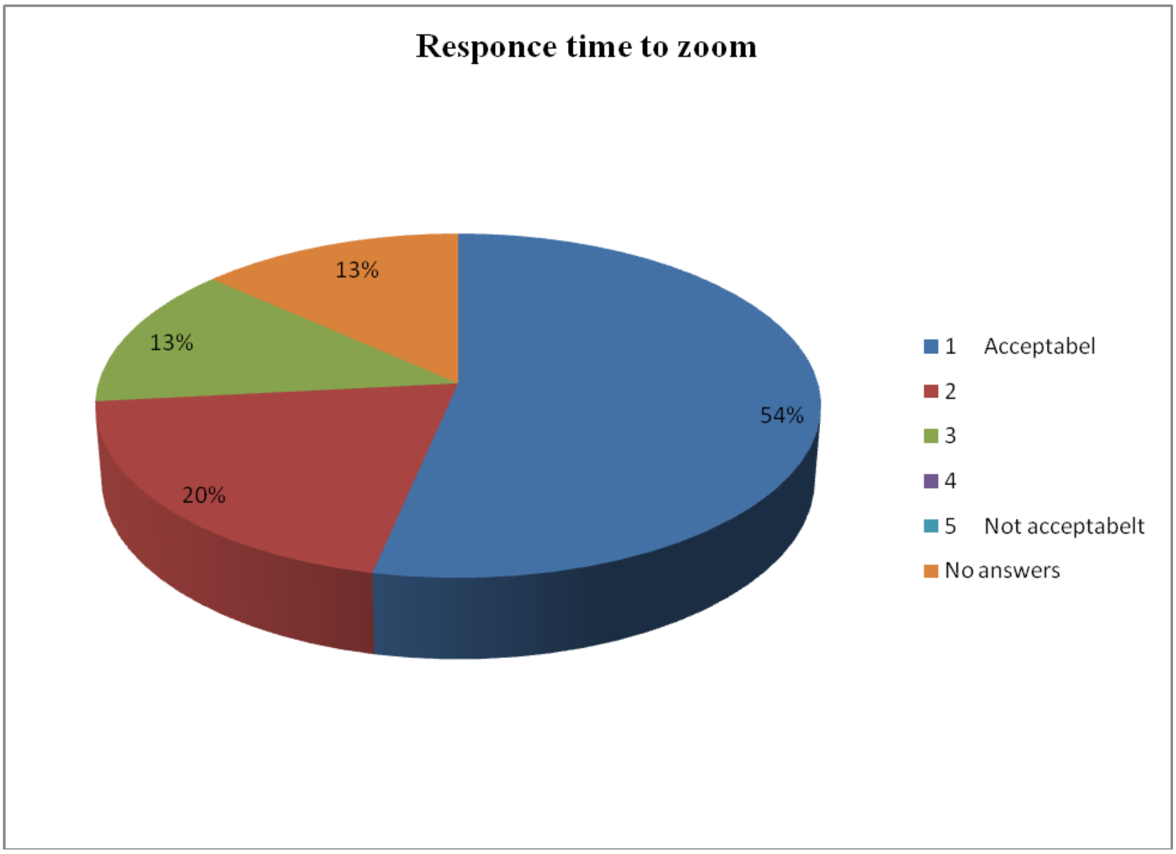
Task 1: Pan and zoom



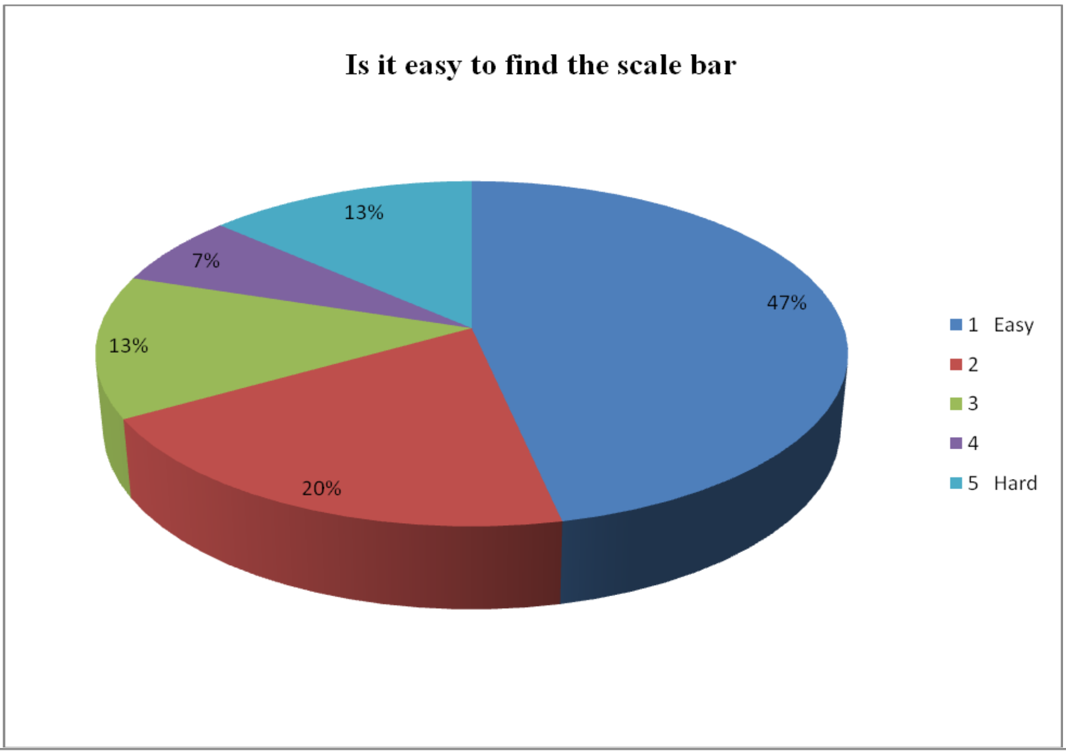

What about the apperance of the map title
13%
13%
20%
7%
47%
Very good
good
Not good
Hard to recognize
not hard to recognize

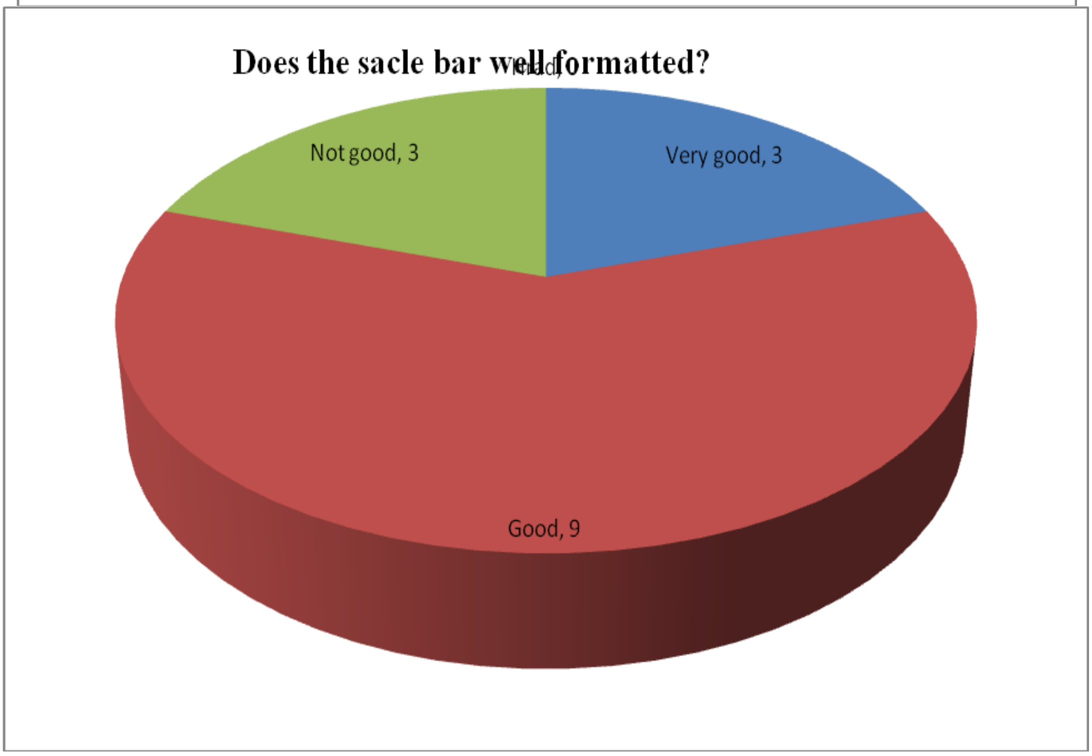

Do you find it easy to orient yourself with the map
7%
22%
50%
21%
1 Acceptabel
2
3
4
5 Not acceptabelt
No answer


Responce time for panning?
0%
0%
13%
40%
20%
27%
1 Acceptabel
2
3
4
Not acceptable
No answer

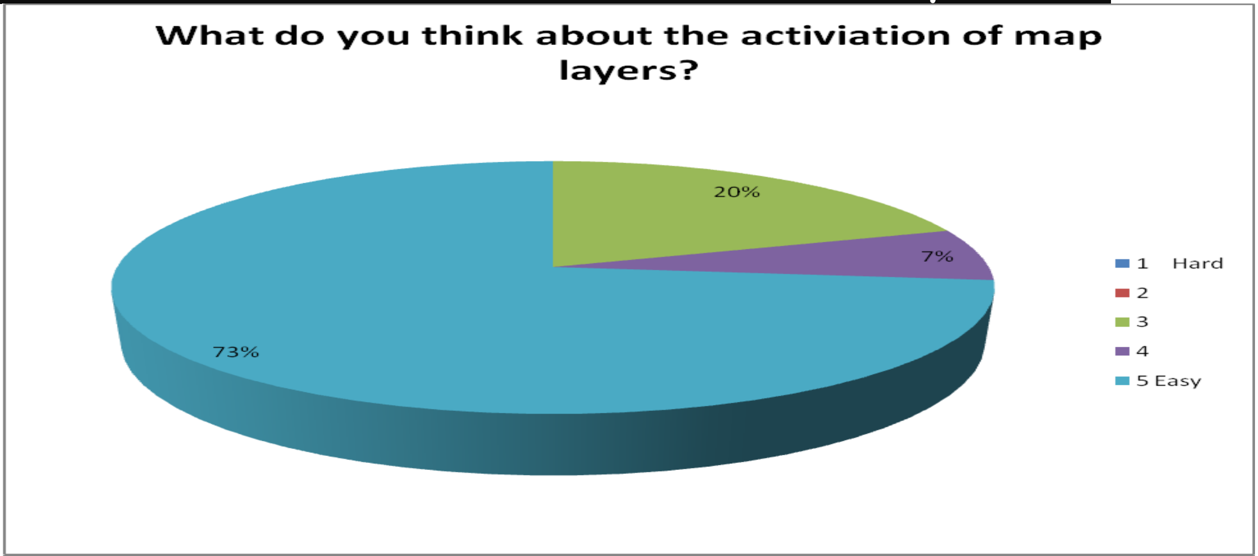

Responce time to zoom
13%
13%
54%
20%
1 Acceptabel
2
3
4
5 Not acceptabelt
No answers

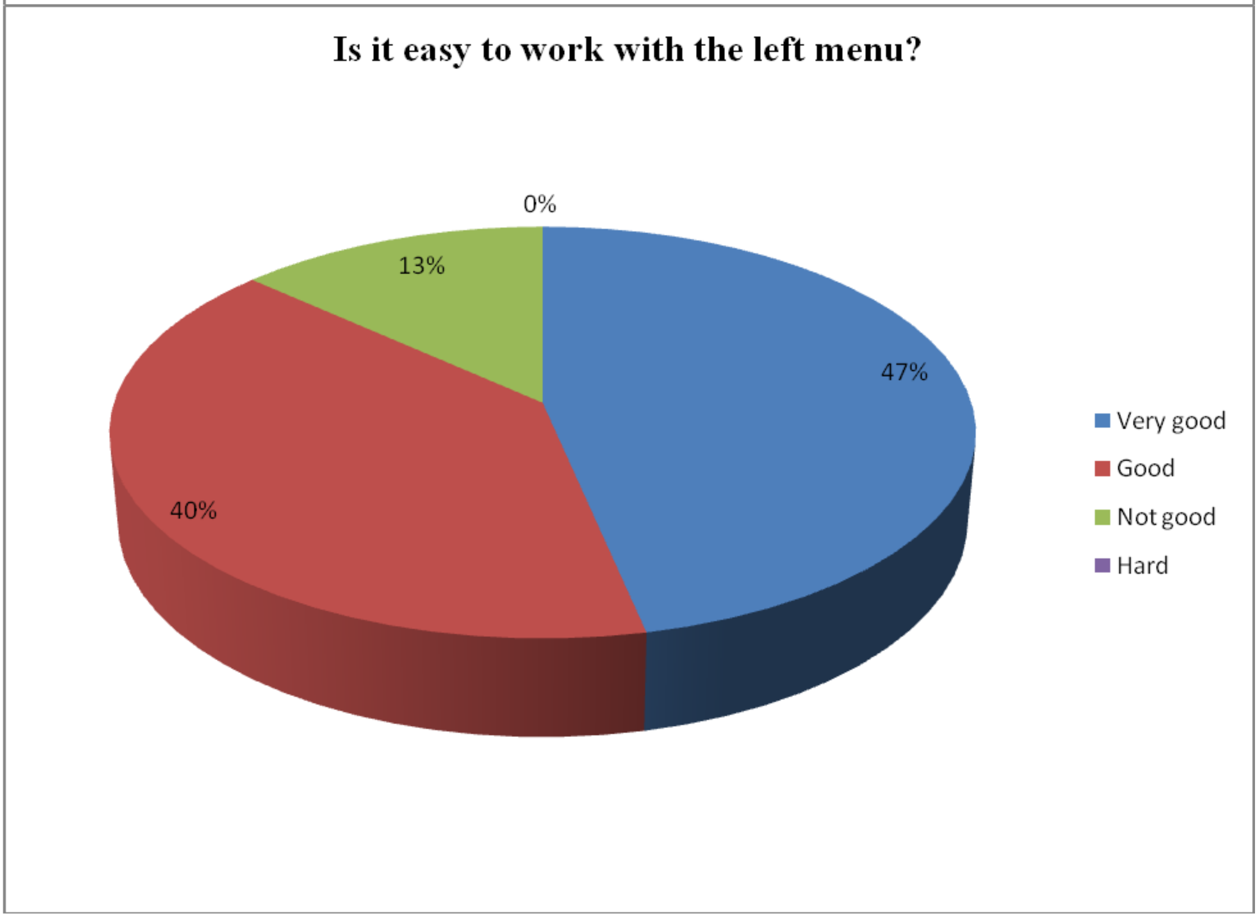
Task 2:Scale

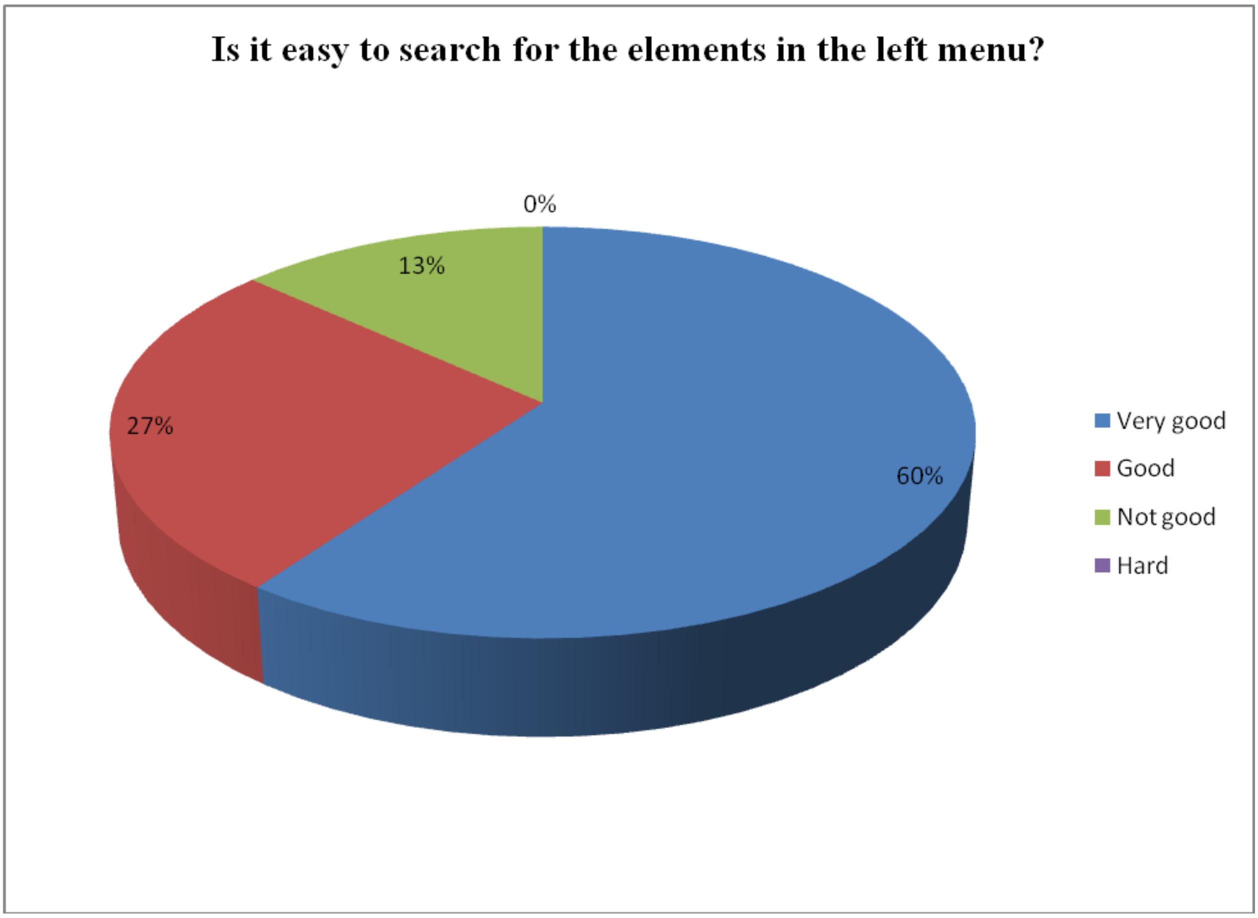

Is it easy to find the scale bar
13%
7%
13%
47%
20%
1 Easy
2
3
4
5 Hard


Does the sacle bar well formatted?
Not good, 3
Very good, 3
Good, 9

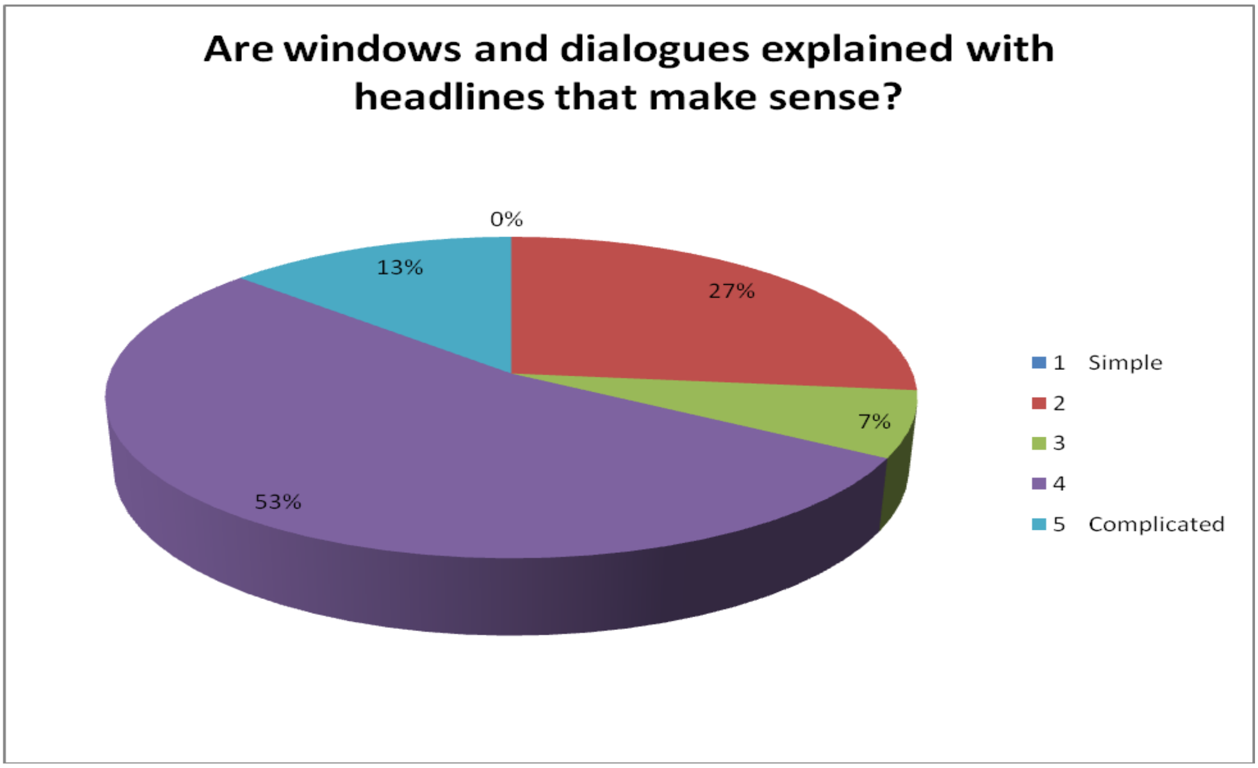
Task 3: Activation of different layers

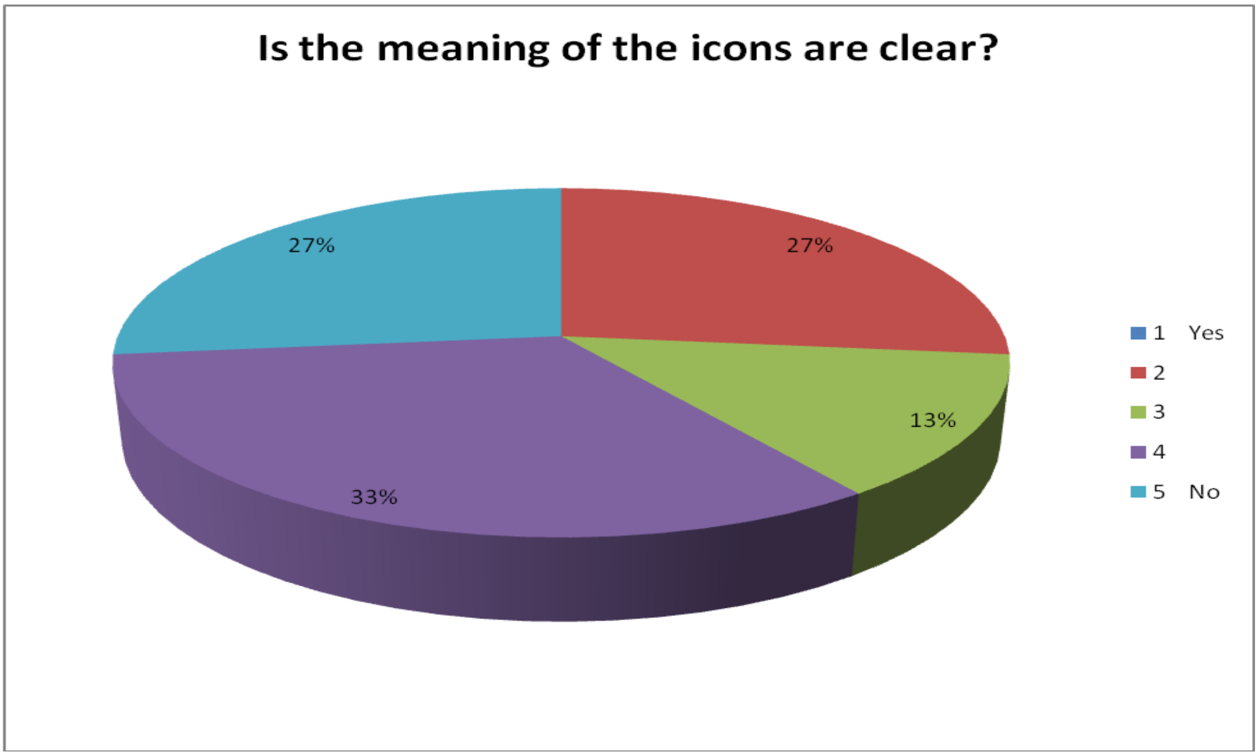


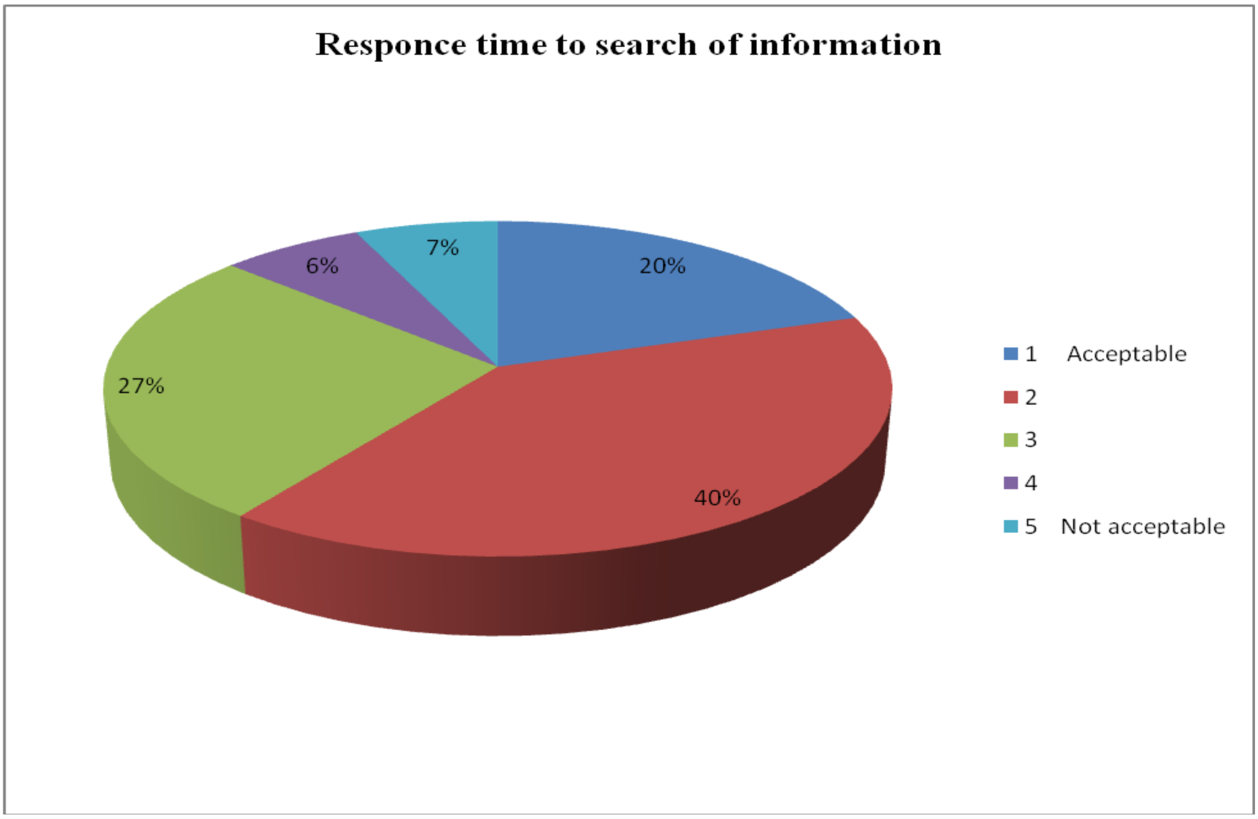



Is it easy to search for the elements in the left menu?
0%
13%
27%
60%
Very good
Good
Not good
Hard

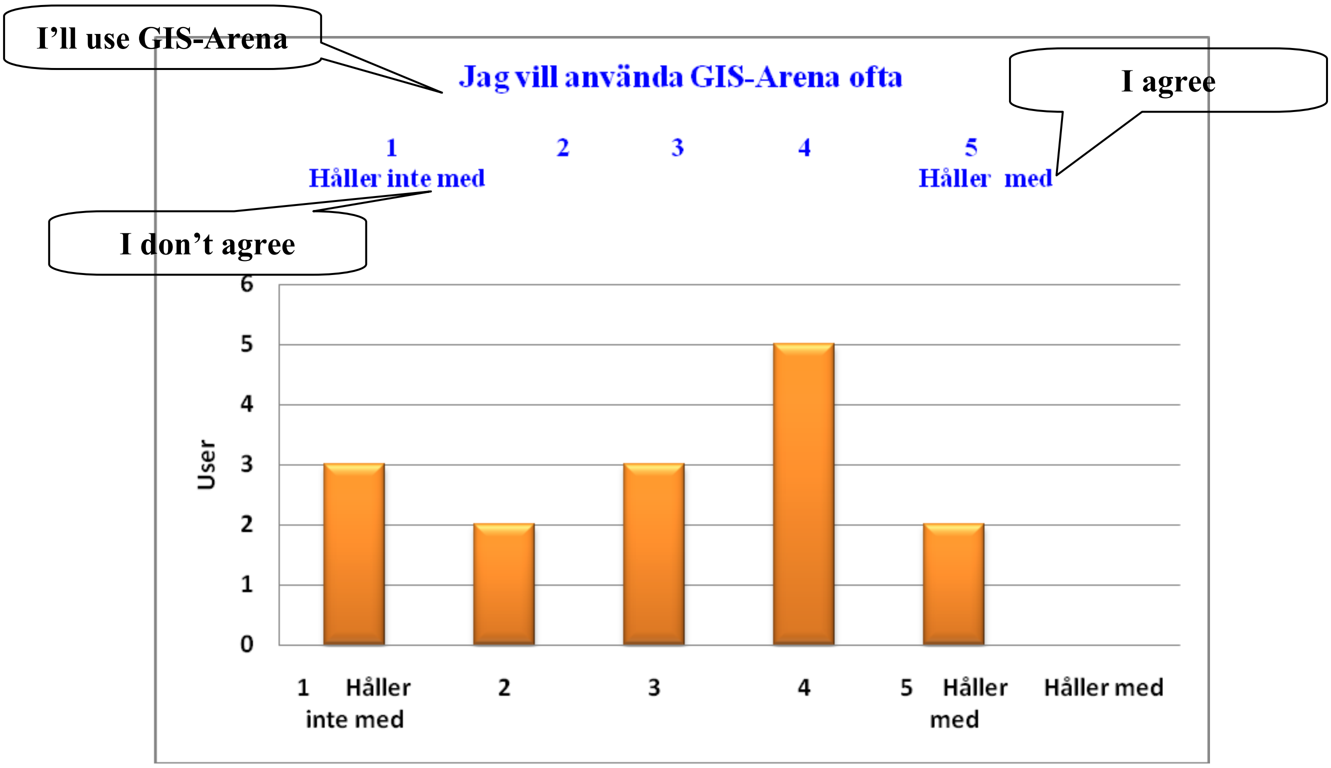
Task 4: Search address.

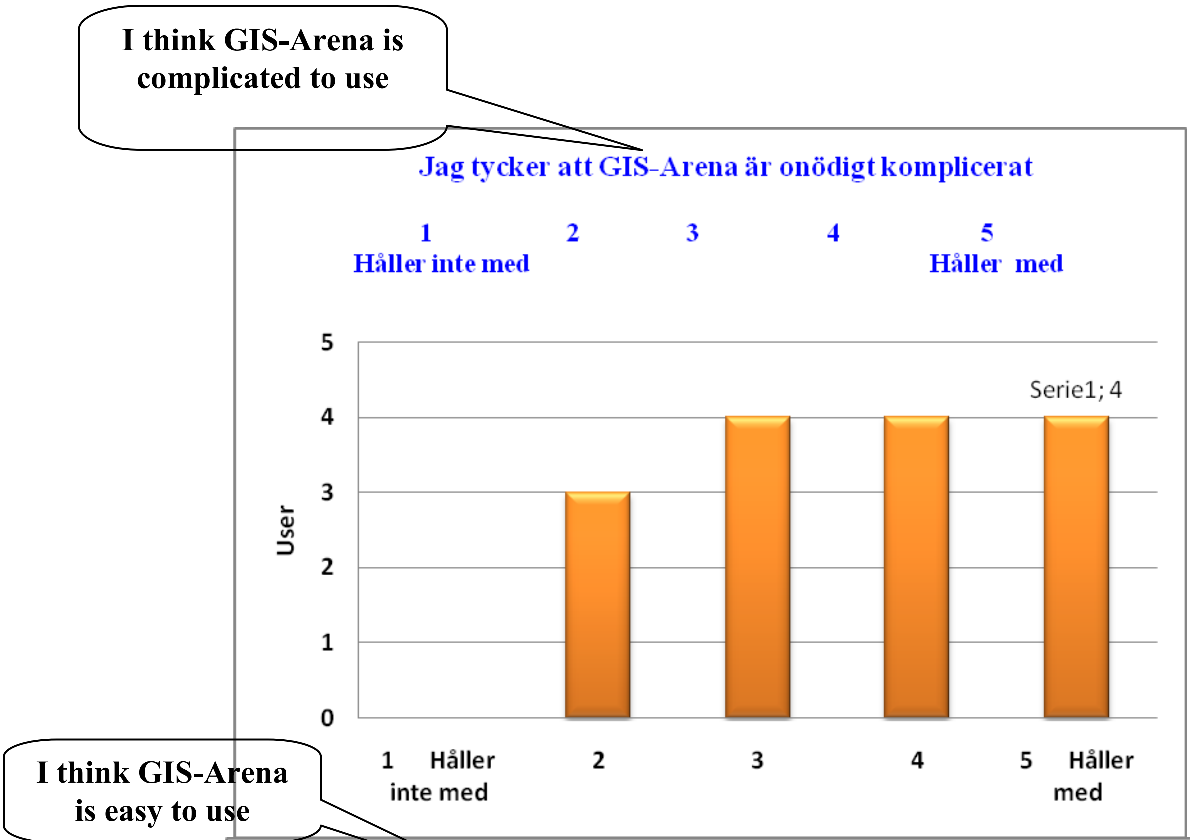


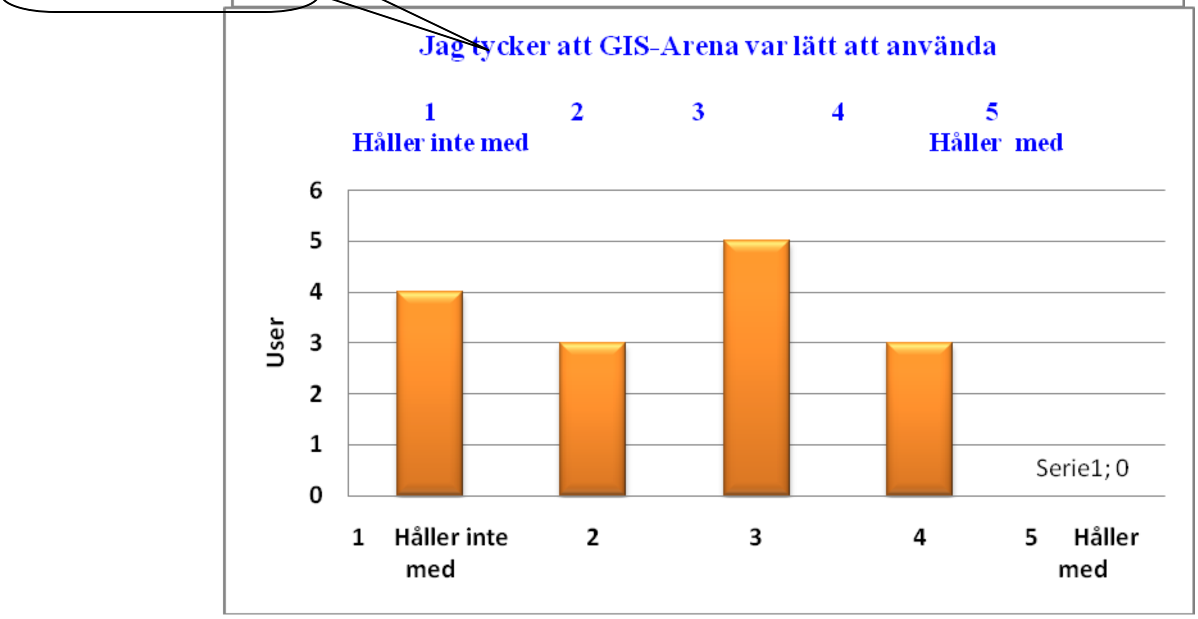


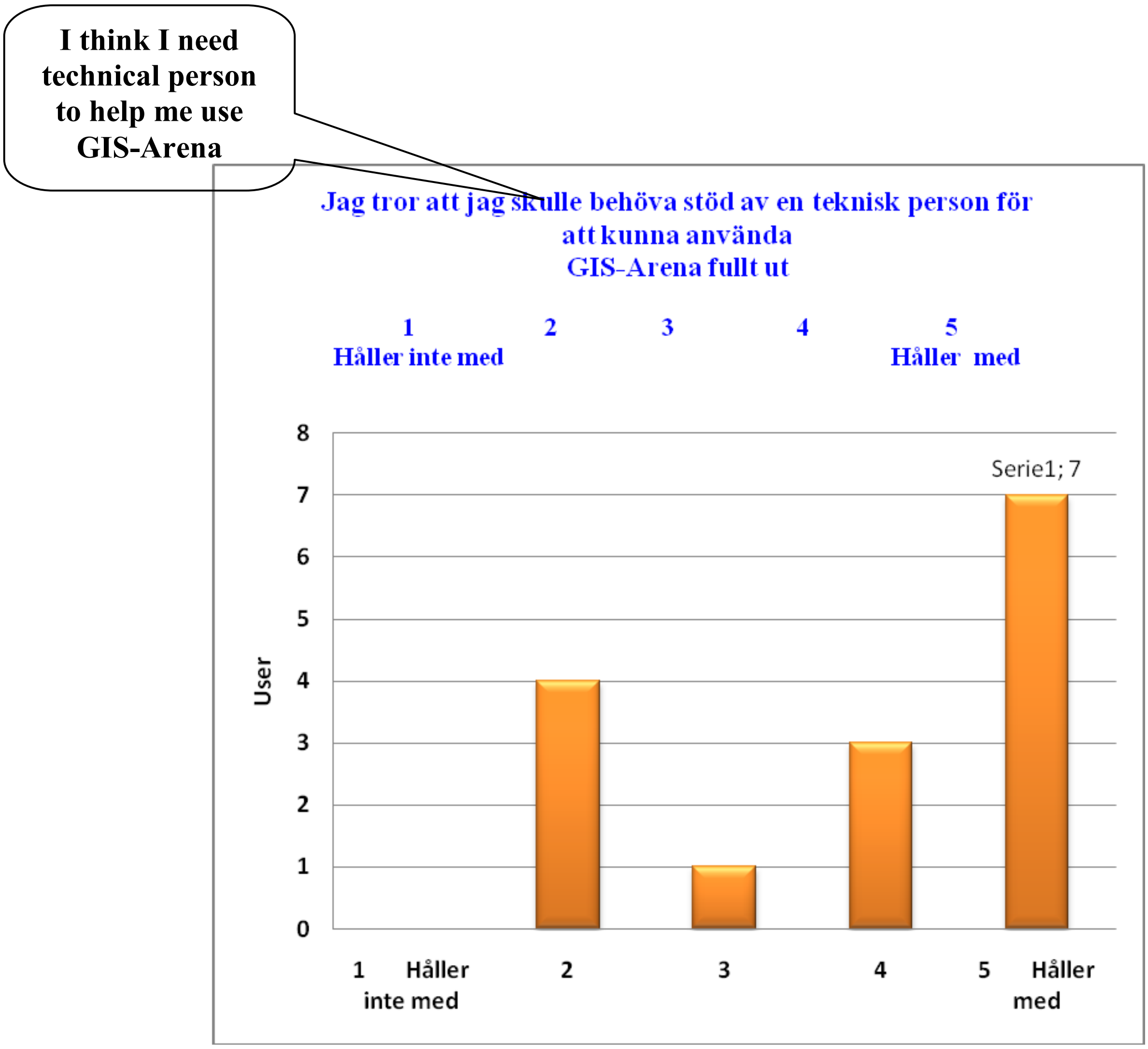


3. Survey of user satisfaction




I think GIS-Arena is complicated to use
Jag tycker att GIS-Arena är onödigt komplicerat
1 Håller inte med
2
3
4
5 Håller med
5
4
3
2
1
0
User
Serie1; 4
1 Håller inte med
2
3
4
5 Håller med


I think GIS-Arena is easy to use
Jag tycker att GIS-Arena var lätt att använda
1 Håller inte med
2
3
4
5 Håller med
6
5
4
3
2
1
0
User
Serie1; 0
1 Håller inte med
2
3
4
5 Håller med



4. Performance test result

Test execution parameters:

Test started at: 2010-02-12 17:00:32

Test finished at: 2010-02-15 09:00:32

Scenario name: Karlstad Bus lines

Test run comment:

Test duration: 64:00:00

Virtual users: 1 - 500

Summary

Profile	Sessions performed	Sessions with errors	Pages performed	Pages with errors	Hits performed	Hits with errors	Total KBytes sent	Total KBytes received
KarlstadBuslines	2 011 210	2 008 613	6 342 634	2 008 629	6 342 634	2 008 629	95 873 382	7 386 548
Total	2 011 210	2 008 613	6 342 634	2 008 629	6 342 634	2 008 629	95 873 382	7 386 548

HTTP errors %

Profile	0:00:00-6:24:00	6:24:00-12:48:00	12:48:00-19:12:00	19:12:00-25:36:00	25:36:00-32:00:00	32:00:00-38:24:00	38:24:00-44:48:00	44:48:00-51:12:00	51:12:00-57:36:00	57:36:00-64:00:00	Total
KarlstadBuslines	0	0,03	0	0,02	0,03	0	0,02	0	0,02	0	0,01

Total	0	0,03	0	0,02	0,03	0	0,02	0	0,02	0	0,01

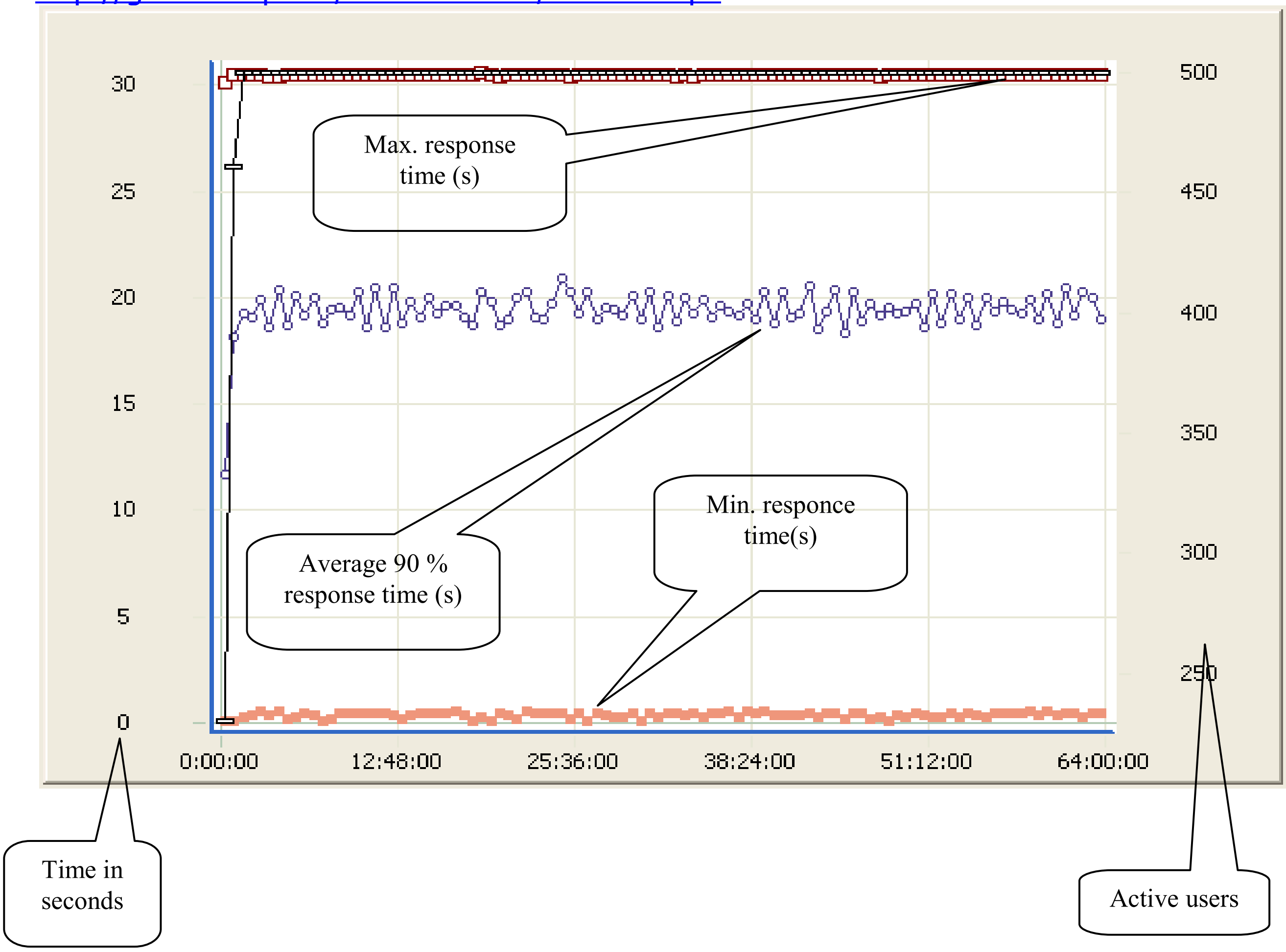
Socket errors %

Profile	0:00:00-6:24:00	6:24:00-12:48:00	12:48:00-19:12:00	19:12:00-25:36:00	25:36:00-32:00:00	32:00:00-38:24:00	38:24:00-44:48:00	44:48:00-51:12:00	51:12:00-57:36:00	57:36:00-64:00:00	Total
KarlstadBuslines	15,4	17,0	16,9	16,9	17,6	16,8	16,8	16,9	16,9	16,6	16,8
Total	15,4	17,0	16,9	16,9	17,6	16,8	16,8	16,9	16,9	16,6	16,8

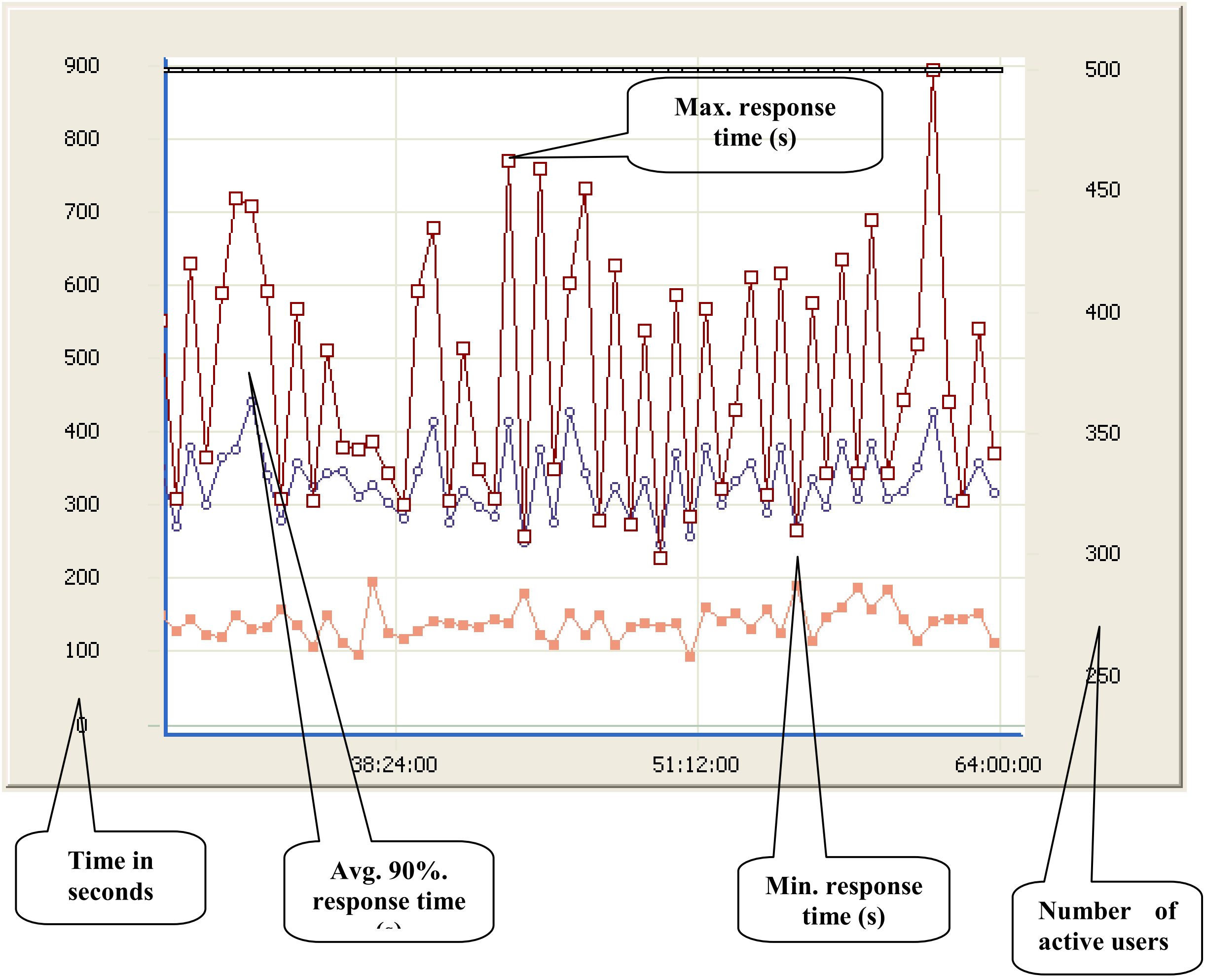
Timeouts %

Profile	0:00:00-6:24:00	6:24:00-12:48:00	12:48:00-19:12:00	19:12:00-25:36:00	25:36:00-32:00:00	32:00:00-38:24:00	38:24:00-44:48:00	44:48:00-51:12:00	51:12:00-57:36:00	57:36:00-64:00:00	Total
KarlstadBuslines	13,7	14,9	15,1	14,9	14,9	14,9	15,1	15,1	15,0	15,1	14,9
Total	13,7	14,9	15,1	14,9	14,9	14,9	15,1	15,1	15,0	15,1	14,9

http://gisarena.fpx.se/GISArenaTest/Default.aspx



KarlstadBuslines.page_13: http://gisarena.fpx.se/GA_DOCS/Region/Varmland/Kommun/Karlstad/ExternData/pdf/Busslinjer/3.pdf (13)


900
800
700
600
500
400
300
200
100
0
500
450
400
350
300
250
38:24:00
51:12:00
64:00:00
Max. response time (s)
Time in seconds
Avg. 90%. response time
Min. response time (s)
Number of active users