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**METHODOLOGY OF RESEARCH ON FUNCTIONALITY OF  
INTERACTIVE INTERNET MAPS**

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VILNIAUS UNIVERSITETAS

GAMTOS TYRIMŲ CENTRO GEOLOGIJOS IR GEOGRAFIJOS INSTITUTAS

KLAIPĖDOS UNIVERSITETAS

ANDRIUS BALČIŪNAS

**INTERAKTYVIŲ INTERNETO ŽEMĖLAPIŲ FUNKCIONALUMO  
TYRIMŲ METODOLOGIJA**

Daktaro disertacijos santrauka  
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## **INTRODUCTION**

### **Research problem**

Cartography nowadays is entering a qualitatively and quantitatively new stage of the development in a modern high-tech era. The map is one of the main cartographic products which takes new forms of expression and moves from the static phase to the interactive and dynamic environment (Kraak and others, 2001). The internet maps are modern and promising tool for conveying geographical information. They facilitate access to a wide range of different themes and usability options of spatial data for specialists in the cartography field. Also, they provides a possibility to visualize and publish the data for the users and to manage it in the internet. New possibilities of internet map functionality which were unreal some years ago now become effective and force to revise classical map design and usability principles. The cartographic community clearly understands the need to develop new quality requirements which would describe usability and efficiency of the internet maps.

Quality of the functionality of the entire possible set of interactive internet map functions is crucially important. Through the functionality the user possibilities (to view, to analyse and to manage the geographic information by means of the map) are expressed. In order to use the internet mapping possibilities with maximal efficiency, the map makers need to define sets of functions which are related to particular type of maps. Also, they need to know how these functions should be implemented in order to meet the requirements of a particular target group of the users. In the 21st century of the methods of cartographic research that are applied in analysis of internet maps do not ensure the solution of this integral problem. The maps functionality quality testing is rarely integrated in the map making process because of its high costs and lack of applicability of the practical results. It motivates to search for new ways and tools to obtain and use information on user needs that is necessary for the internet map makers.

The maps have never been used so wide in the society as nowadays when internet technologies not only have simplified access to the map resources (reference base and

thematic data) but also provide an opportunity to complement visualizations of the data with interactive view, analysis and management functions. The internet maps are becoming an integrated part of continuous decision making processes in the modern society. The scope of application of such maps is continuously changing and growing as the new ideas are created. The internet maps are applied almost everywhere; from the geographical location searches till complex spatial data operations; from visualization of a simple network of shops to spatial data infrastructures and geoportals. Such a wide range of internet map applications forms a new challenge that be taken into consideration while creating recommendations of a good map making practice, related to interactive map function and usability. Considering this, to evaluate internet map quality, integral, oriented to the internet technologies and user needs, and dynamic research is necessary. The survey performed by the author showed that so far there has been no uniform methodology of research into the requirements of users for the internet maps. The research is usually not orientated to specific users of internet maps. There is a lack of detailed studies on the internet map functionality that would consider the users' needs for different types of maps. New methods are necessary that would lead to improvement of the process of interactive map making. The results of many studies on quality of internet maps yield the results that are abstract, controversial and often subjective. Therefore they are either not suitable to use directly in the process of design of new maps and only adaptable in a narrow field of interest.

Currently, the possibility to widely apply the results of internet map quality research in practice is quite limited because there is no clearly defined system that would allow to assess map quality and to define requirements. There is lack of information on how to assess the quality of internet maps and what are the main theoretical principles that ensure good quality. Creation of methodology that would reflect all aspects of map quality assessment becomes the most pressing challenge for the modern cartography. This dissertation is a contribution to this field and an input in modern theoretical cartography. The original methodology of assessment of quality of interactive internet maps has been developed by the author and tested in real environment. This methodology is integral, effective and expandable. It may be

efficiently used for quality assessment and requirement engineering of interactive internet maps.

### **The subject of research**

The subject of research in a broad sense is defined as interactive internet maps and map systems. The subject of research in the strict sense is the quality of geographic information management functions and tools that are provided to the users of interactive internet maps.

### **Aim and tasks**

The *aim of the dissertation* is to create a methodology of a complex interactive internet map functionality research and tools that allow to apply this methodology in practice.

The research aim requires an integral theoretical (methodological) and practical solution that would combine surveys of the users' needs, expert opinions and analysis of existing internet map samples. According to the research aim, several methodological and applied tasks have been defined.

*The methodological tasks of the dissertation are as follows:*

1. To systematize and evaluate the methods that are currently applied in internet map functionality research;
2. To develop an efficient methodology for assessment of the implemented internet map functions;
3. To perform analysis of functions of interactive internet maps of different purpose and complexity;
4. To develop a method of assessment of efficiency of use of particular internet map functions;
5. To create an integrated internet map functionality assessment system.

*Applied tasks of the dissertation are:*

1. To develop software tools for the internet map user needs analysis, that would yield information necessary to define the requirements for internet map functionality;
2. To develop software tools for evaluation of functional quality of internet maps;
3. To perform analysis of internet maps users' needs;
4. To perform analysis on feasibility of the developed methodology and research tools, that would include practical application of the tools for evaluation of the users' needs, and analysis of the users' needs by multiple criteria;
5. To provide recommendations for functional quality of internet maps for different user groups.

### **The novelty and significance of the research**

The novelty of the research and its significance lies in the following:

- For the first time in cartographic research, internet map research methodology has been developed that combines the methods of research on quality of implementation of map functions and on efficiency of use. These research methods are combined with a set of tools for practical evaluation of internet map quality. Until now, there has been no specialized methodology for analysis of functionality of interactive internet maps that would combine both implementation and use issues for assessment of the users' needs.;
- The quantitative quality evaluation system is created in accordance with the qualimetry evaluation principles. This system is exclusive in a way how the results of sociometric research of the experts of the field, of the users and of the representative samples of existing internet maps have been combined in one system of evaluation of the internet map functions. This system encompasses the relative importance coefficients of map functions, the evaluation criteria and indices. Such system of evaluation is not only a tool for research on internet map functionality but also a source of important information that can be applied in modern cartographic theory and



practice. For the first time it was investigated into relationship between map functions and the users' needs: generic map functions, their purpose, implementation methods and parameters of use efficiency have been defined;

- Internet map users' needs analysis and research program CartoUI ([www.cartoui.com](http://www.cartoui.com)) has been developed and implemented. This program implements an original and never until now used research method. It provides a possibility for the research participants to create their interactive internet map. Such research method has been known in other fields of science (e.g. architecture, urban research, computer science). However, it has been never used in cartography. The program implements a set of innovative programming and technological solutions based on results of theoretical research. CartoUI system is sustainable as a permanently available system of investigation into users' needs, which collects information about all the users' needs in a database and provides tools for analysis of this data. It is an input into the science of cartography – a dynamic database of users' needs where information can be analysed in different aspects such as demographical, social or informational;

- Detailed recommendations for map development are provided based on the results of application of the functionality analysis methodology by the author. For the approbation of methodology the analysis of the results was performed and recommendations for maps functionality for different types and segments of the users were prepared. The methodology allows for accurate identification of functionality problems at the level of implementation and graphic interface design of particular functions. Moreover, it provides information on how the problems could be solved. For this reason, the methodology and it's application tools can be efficiently applied in the process of internet map making;

- Exhaustive analysis of internet maps developed in various countries of the world in 2000–2014 was performed and a critical review provided. During the analysis the methods of research of internet maps were systematized and described in detail. First time in theoretical cartography such systematic critical review of research on internet maps is provided.

## **Statements for defence**

The main outcomes of the performed research converge into principal *statements*:

1. It proved possible to develop a methodology for analysis of functionality of interactive internet maps that allows for integral evaluation of quality of implementation and efficiency of use of map functions. It also allows evaluating general quality of map functionality.

2. The system for evaluation of internet map functionality based on qualimetry principles provides a possibility to quantitatively express compliance of internet map functionality to the users' needs. Based on these assessments, it is possible to prepare detailed recommendations for the functionality improvement.

3. The author first time introduces a method of assessment of internet map quality that is based on involvement of users in the process of map design. The users can express their preferences not verbally, but by actions using specially designed graphic interface. Information on users' needs for internet maps' functions that is obtained by means of involvement of the users in map making, is more valuable than information on usability obtained by a follow-up quality assessment of particular map. The proposed system of research on quality of internet map functions is flexible, expandable and adaptable to changing conditions of modern informational environment. It allows accumulating and using the data on users' needs for a long time and analysing it by various aspects.

4. The requirements for the implementation of functions and usability of internet maps' continuously change and vary depending on the purpose of a map and on the characteristics of a specific target group (age, gender, experience of the map use). Nevertheless, the presented methodology foresees unambiguous definition and subsequent implementation of the basic requirements in a given moment of time.

## **Approbation of the results**

8 articles in the scientific journals have been published. The results of the research were presented in the 10 international scientific conferences (7 of them were in the

foreign countries). Detailed list of publications and attendees is added in the end of the summary.

Award was gained for the article „The Possibilities for Functionality Research on Interactive Internet Maps” in 2011 from the International cartographic association. The Research Council of Lithuania in 2012 nominated the author for an incentive scholarship for the academic achievements.

In the topic of dissertation the author conducts lectures and practical sessions („Modern mapping“, „Web mapping technologies“) in Vilnius University. Lectures and practical sessions are for the bachelor students of geography (third year bachelor students, thematic cartography subject) and master students of cartography (one lecture, Cartographic communication subject; practical session, Dissemination of cartographic information in the internet subject).

### **Scope and structure**

The dissertation is structured by the Research Council of Lithuania recommendation (Resolution No. VI-4, 2003) thus the main parts of the paper are introduction, research review, methodology, research results, conclusions, references and annexes. In the dissertation there are 29 figures, 15 tables, list of references (88 items). 17 interactive internet maps have been analysed in detail. The whole dissertation consists of 255 pages (216 pages of the main text and 39 pages of annexes).

## **1. THE PROBLEM OF RESEARCH ON FUNCTIONALITY OF INTERACTIVE INTERNET MAPS**

The need for development of a new methodology cannot just emerge from nothing. In our case, such need is raised because the most of currently used methods of functionality assessment are not optimal and not very much applicable if the trends of modern internet cartography are taken into account. The commonly applied methods of quality assessment seem not so efficient when we think about what information is obtained that could be used for improvement of the internet map quality. The author has analysed many internet map functionality research methods used in practice and performed a critical review. The aim of this critical analysis was to justify the need of a consistent methodology of research and to describe the requirements for such methodology. In this chapter, different methods of analysis of internet maps are reviewed, their advantages and disadvantages discussed, and the costs of implementation evaluated. This information allows to define requirements for the methodology on research of functionality of internet maps that yield the results applicable in practice for improvement of map quality.

Various studies on functionality of interactive internet maps have been carried out for more than two decades. In, 1992, the results of one of the first interactive internet map research were published (Koussoulakou and others, 1992). In a historical context of cartographical research, two decades is not a long period of time. Previous researches on quality cover some technological, communicational and cartographical aspects of internet maps. There is a wide range of studies devoted to the user interface design and to technological implementation aspects of map functionality. There are quite many researchers who have published papers on this topic. Among specialized articles and books, some of the authors should be distinguished: Andrienko G., Andrienko N., Cartwright W., Dykes J., Kraak M., MacEachren A. M., Ormeling F., Peterson M. P., Fairbairn D., van Elzakker C.P.J.M., Nivala A. M. An active interest in the study of interactive maps is supported by the commissions of Geovisualization, Maps

and Internet and by the other commissions of the International Cartographic association.

Interactivity in the cartography can be briefly defined as a feature that allows for users' interaction with map elements. The strength of the interaction is related to possibilities of a particular user to perform actions on the map elements. (Beconytė, 2007). Technology is not interactive by itself. Communication between the user and the computer system implemented via interactive map user interface and interactivity is implemented through the functional map elements (Cartwright and others, 2001; Aoidh and others, 2008). In this content **functionality can be defined as a characteristic of a map (as interactive electronic system) which expresses adaptability of the system to the user needs to manage spatial information** (the extent to which the user is provided with functions he needs in order to accomplish the task with the map and if the extent to which the user can use these functions efficiently). Such a functional duality allows us to outline **two directions of map functionality research. The first one is research on quality of implementation of map functions and the second – research on efficiency of use of these functions.** The author has analysed the methods of analysis of quality of implementation of functions and of efficiency of use that have been applied in various studies and presented in scientific publications.

**Review of research on implementation of interactive map functions.** The author suggests 4 main indicators that would allow describing the merits and demerits of a method of research on interactive map quality:

- The indicator of research duration evaluates the time necessary to carry out the whole research, starting from the preparation of methodology to adaptation of the results to solve particular problems of map functionality. The author proposes to divide the research on functionality into 5 stages: methodological, procedural, executive, analytical and applied.

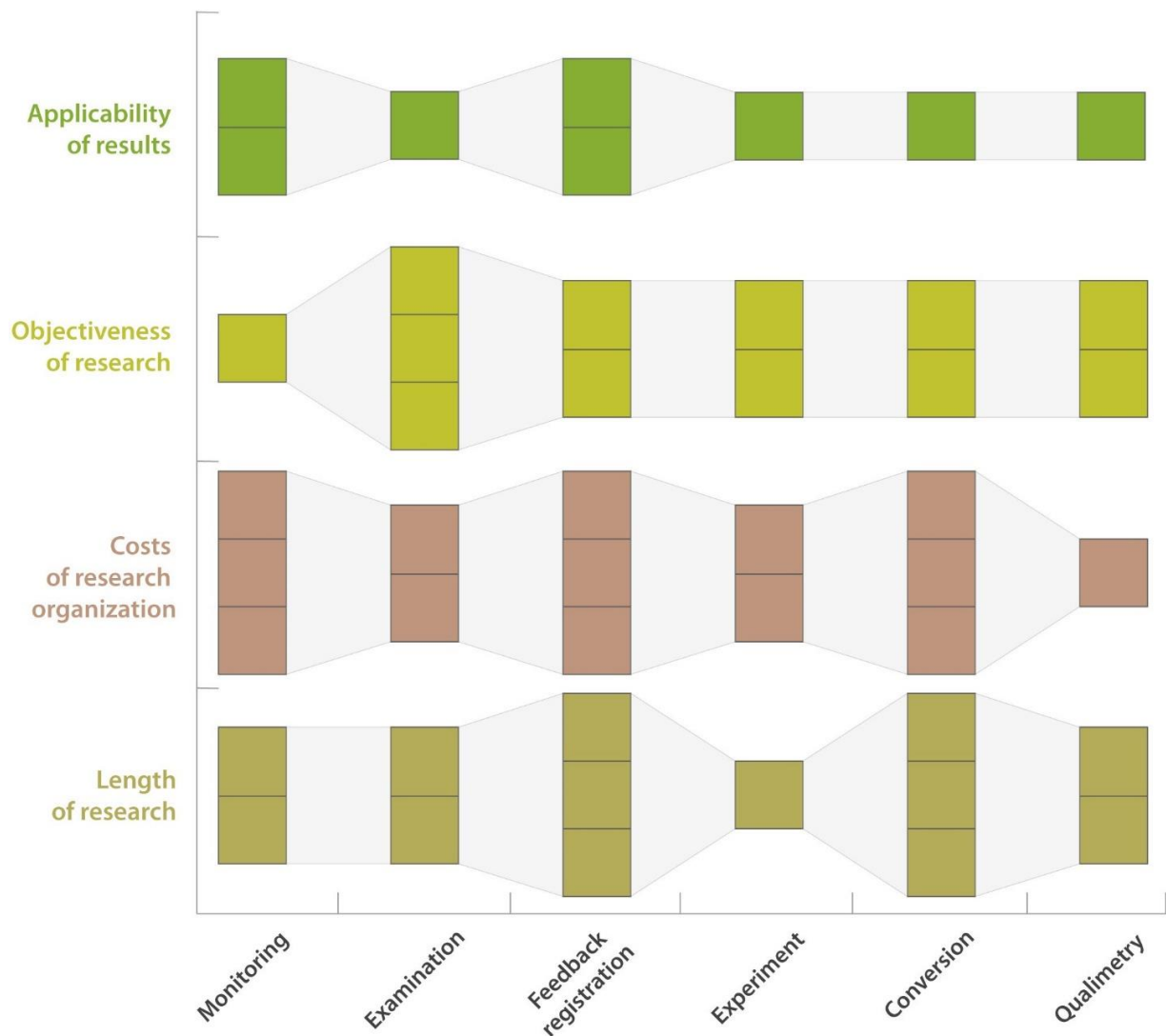
- The indicator of costs of research organization evaluates the resources (technological and human) required during the research. The costs consist of the costs of implementation of a research platform (interactive internet map) and the costs of the survey.

- The indicator of research objectivity shows possible pre-attitude of researchers and survey respondents (being aware of the problem or not) and possible influence of such pre-attitude to the quality of the results.

- The indicator of adaptability of the results shows the extent to which the result can be adapted to the real practical solutions. In order to find answers to the particular problem related with map functionality, the results of a research have to be always interpreted additionally. Interpretation costs may vary a lot, depending on the research technique.

When the review of the methods of analysis of quality of implementation of functions for the internet maps, presented in scientific literature was completed, the author identified 6 main methods used for internet map analysis: monitoring, examination, feedback registration, experiment, conversion, qualimetry. These methods reflect diverse applications of theoretical and applied science in research of functionality in cartography. On the basis of identified evaluation indicators (time, organization, objectiveness, applicability) the summary of critical analysis of the methods of analysis of efficiency of implementation of internet maps' functions and overall results are provided in the Figure 1.

Summarizing the results of analysis on methods of research on quality of implementation of functions it might be stated that better methods are the methods which rely not on a direct analysis of the users but on analysis of the functional quality of the map elements and their performance (in qualimetry and experimental cases). For analysis of the technological functionality it is better to apply mathematical methods because they provide an opportunity both to analyse the initial project of the map functionality and to define application and operational problems of the map functions after it is created.



1 cell - small/few, 2 cells - average, 3 cells - large/many

**Figure 1.** The results of the methods of analysis of efficiency of implementation of functions (in the diagram number of blocks/squares show values of evaluation indicators).

Implementation of internet map functions requires lots of technological and time resources, therefore, the possibility to define the need for functions and performance properties (even before starting to create a real system) optimize the whole process of development. (Bias and others, 1994). The techniques of qualimetry and experiments allow analysing possibilities of map interactivity without any initially defined requirements for functionality. They allows to search for optimal set of functional elements with taking into consideration the purpose of the map and it's type (for example, using the qualimetric analysis method it is possible to evaluate the compliance of implemented map functions against the defined quality requirements)

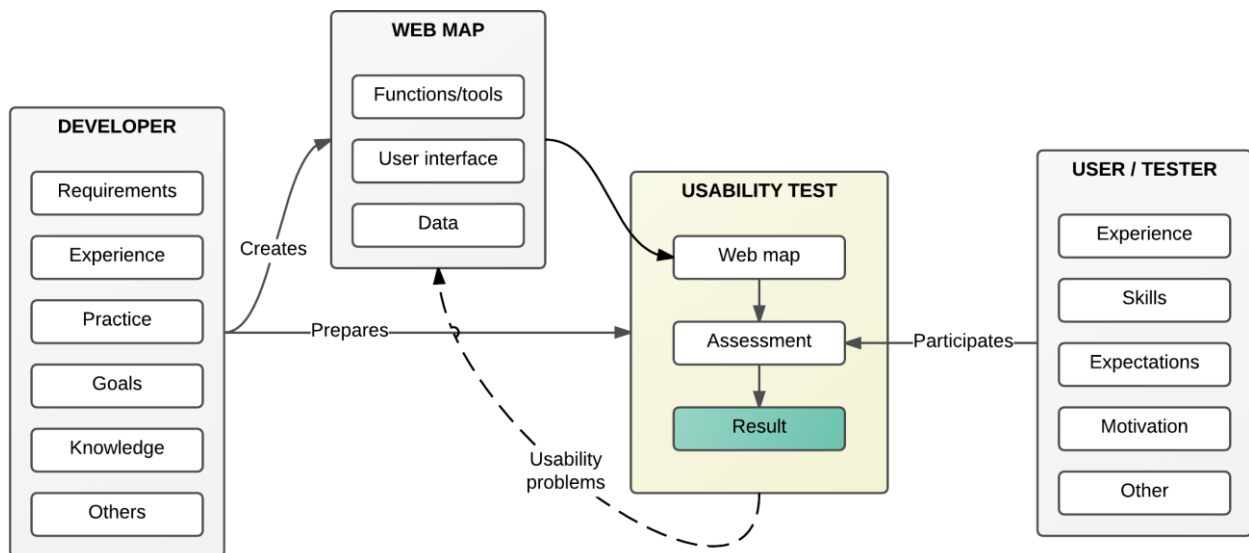
(Balčiūnas and Dumbliauskienė, 2011). Meanwhile, testing and feedbacking, making conventional and observational analysis of the functionality for the particular maps gives knowledge about the quality of used functions but do not answer the question about the types of functions that must be implemented in the user interface. Moreover, for these types of analysis prototypes of the map (test maps) must be created what requires longer time for the analysis and reduces the adaptability of the results in the development process.

**The review of methods of use efficiency of map functions.** The author has distinguished 4 methods that allow assessment of efficiency of use. These methods differ by the type of research objectives. Critical research on the methods of evaluation of efficiency of functions was performed with respect to the specific questions commonly asked by map makers, researchers and map users:

1. Does the analysis of the efficiency of use in cartography provide the possibility to get to know the basic user needs, requirements for the map functionality and quality that can be applied to design better user interface?
2. Can the results of analysis of the efficiency of use analysis be used in the primary map making process?
3. Do standard usability tests applied in modern cartography provide a general knowledge about the user experience and usability of maps?

After evaluation of the results of studies in the quality of the implementation of map functions which were performed using traditional methods known from the IT field, such as usability testing, it can be stated that the results concentrate around the disadvantages of the existing map or a map in the process of design. The figure below (Figure 2) visualizes a schema for application of traditional research methods of internet map efficiency of use.





**Figure 2.** Principal application process for the standard methods of analysis of internet maps' efficiency of use.

In the dominant internet map efficiency of use research process the user is provided with the scenarios (created by the testing person) and with the tasks according to the scenarios. Also the user can additionally evaluate operation and quality of the functions of the map, provide some comments and suggestions for the map functionality. The researcher evaluates the success rate of the performed tasks by following the movements of the users' eyes, the movements of the cursor and by measuring the time while the tasks are fulfilled. Moreover, the testing person is observing other map usability parameters. After testing a group of users, the results are summarized and generalized. Interpretation of the results (if it does not give a direct solution) gives the conclusion of the map usability and provides a suggestion what should be improved in in the map. Hence, the research objective in this process is a particular map. In this case, the user is limited by the graphical and functional possibilities of the given map for the analysis. Evaluation of the map is done by concentrating to the testing environment which has been provided for the user to evaluate. The user does not analyse what is missing in a map whereas exactly this information could help the user to complete some tasks easier. During the testing the tasks are provided by the scenarios and the processes which have to be applied are defined. Thus the user experience is limited by the concrete use cases. The testing scenarios suggest how the user should use the map and it is not necessarily in line with

the individual user experience. Everyone who has ever created a web application knows that if the user is able to do things which were not presumed that she/he can do it, for sure, the user will do it. For example, the user not necessary will search for the location by using place name search. The search may be performed by searching visually, changing the zoom levels; therefore the zoom tools are much more important for such kind of user in the whole map functions content than the direct search functions. A modern map user is a mass user who is not an expert; therefore the expectations of the users while evaluating a particular map may remain undetected. The testing person indirectly affects the user while providing a solution that may be an exciting experience and is studied as is. Thus the question how the map could be optimized and what other functionality may be useful remains unanswered. To answer this question, new, research methodology based on different approach may help. It provides the possibilities to evaluate expectations of the users and their needs by performing both evaluation and design of a particular map and letting the user (theoretically, without restrictions) to choose what she/he would like to see in the map.

The review of research methods of implementation of functions of the internet maps and efficiency of use revealed that some problems in a modern cartography are due to expensive methods of research and limited possibilities to apply the results of research in the early phase of the map development. In general, the usability assessment methods that are applied today in practice of cartography are distinguished by narrow specialization and usually small scope. Regardless of that the results of such research provide a very important information about the particular map features and help to solve partial problems of the map use and application. Nevertheless, what the map makers want, is basic, overall knowledge on map functionality and usability that can be expressed in a form of practical recommendations (Stvilia and others, 2007). The problematic of Internet map functionality was chosen by the author with an aim to offer a new methodology of internet map functionality research which would complement the best practice assessment of quality of implementation of functions and efficiency of use. The attempt was made to describe clear evaluation process that would result in overall map functionality evaluation. The methodology defines the basic

principles of the functionality evaluation. Applying these principles in practice, the above described problems of internet maps functionality can be at least partially solved.

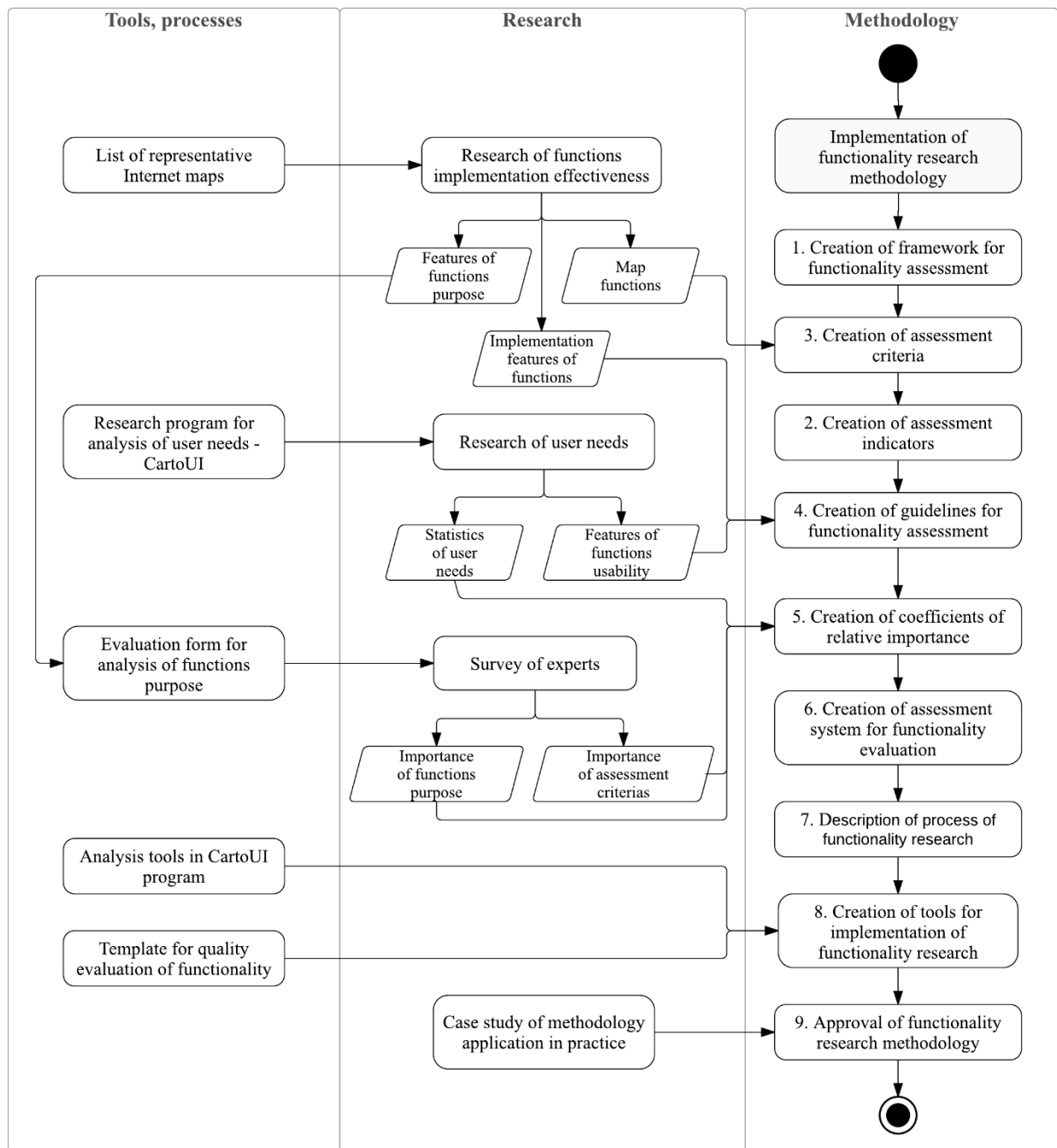
## **2. METHODOLOGY OF RESEARCH ON FUNCTIONALITY OF INTERACTIVE INTERNET MAPS**

**Methodological principles of functionality research.** Functionality of interactive internet maps, together with suitability the design solutions, correctness system of conventional signs, accuracy and other parameters, is a qualitative characteristic of internet map or maps' system that can be measured. Quality in general is one of the most important parameters and the most difficult to describe. It shows the level of compliance of a measured object to the requirements of users. Hardware and software user interface properties and processes specified in the International standards (ISO 9126) are used to improve the quality. In practice of research on the internet maps quality, ISO 9241 (Ergonomic Requirements for Office Work with Visual Display Terminals) and ISO 9126 (Software Engineering Product quality) (e.g. Nivala, Elzakker) are commonly consulted. The ISO 9241 standard describes how to identify information, which needs to be taken into account when specifying and analysing software user productivity and satisfaction aspects. The ISO 9126 standard describes 6 categories which reflect the quality of software: functionality, reliability, usability, efficiency, maintainability, portability (ISO 9241, ISO 9126 and Bevan 2001). Quality is difficult to evaluate, dynamic and subjective. Nevertheless, in computer systems it can be defined and standardized. The parameters of quality need to be combined into a consistent framework, measured, and improved in order to make the software system (in our case, interactive internet maps) more suitable for the user. Quality of map functionality describes the extent to which the system interacts with the users by means of different tools that implement the functions of geographic and cartographic data management.

Analysis of state of the art in the field of maps' functionality revealed a lack of research methods that would give opportunity to perform integral internet maps functionality tests and allow to assess the quality of an internet map in terms of

efficiency of functions' implementation and use. Based on analysis of different methods, the author had described the requirements for an integral methodology of research on internet maps' functionality. A good methodology would allow combining different research techniques. The main idea of the author is to link objective and subjective evaluation criteria that are set by professionals (experts) to the requirements of the users that are extracted from their practical experience.

The methodology of assessment of functionality is based on integral quantitative evaluation of quality and on software tools that implement the requirements for the methodology. The process of development of this methodology required several complex analytical and sociometric studies for defining the evaluation criteria and indicators. The principles of cartographic qualimetry (Dumbliauskienė, 2000) have been transformed in order to fit the process of interactive internet maps functionality research. The methodology was tested by performing quality analysis of internet maps. Necessary tools were developed that allowed automation of collection and processing on the research results. The process of development of the methodology is shown in the Figure 3.



**Figure 3.** The process of development of the methodology of research on internet maps' functionality.

The process consists of several stages.

1. Formation of structure for research on functionality. In this stage, the main parameters of assessment (evaluation criteria, indicator and the relative importance of a factor) are defined.

2. Defining the evaluation criteria. The evaluation criteria represent the directions of research on functionality and based on these criteria, indicator properties

are set. Quality of implementation and efficiency of functions are described by these evaluation criteria.

3. Defining the indicators for evaluation. The indicators of quality of map functionality form the base for quality assessment. The evaluation indexes are linked to currently known representative internet map functions that have been distinguished and described as the result of one of the studies.

4. Developing the guidelines for the evaluation of quality. The guidelines describe how the relative weights of the evaluation indicators are determined according to their importance for quality. The guidelines for can be used by a researcher, when there is a need to assess maps for quality of a particular function. Indicators of implementation and efficiency of functions were defined based on the results of two studies. During the research of the needs of the users, properties that describe the use of a function were determined. In order to investigate the preferences of users related to map functions, the CartoUI ([www.cartoui.com](http://www.cartoui.com)) program has been developed and used;

5. Determining the coefficients of relative importance for the evaluation indicators and criteria It is one of the most important and difficult stage of formation of the methodology of research on functionality. Information on the preferences of users and the results of expert sociometric studies have been used to determine these coefficients for this particular research context. The formulas for estimation of the coefficients and the tables of evaluation indicators and criteria are provided in the dissertation.

6. Development of the system for assessment of functional quality. It is the stage of creation of the methodology, where all the outcomes of previous studies are integrated.

7. Definition of the functionality research process. The methodology of research on internet map functionality is complex and covers the different stages of evaluation, collection of statistical information, information about evaluation indicators etc. The scheme for functionality research was created to make it simpler to use and make sure

that it is used correctly. The schema is orientated to the needs of researchers, who are going to use the methodology or parts of it in their studies.

8. Development of the functionality research tools. A template for evaluation of internet map quality and a supporting additional module have been created for the CartoUI program. It can be used to analyse the results of users' tests and to define their needs. Evaluation template is a table with fields for values, which have to be filled in by the researcher during the evaluation process. CartoUI program's tools allows for the researcher to recalculate the relative importance coefficients and to adapt them to particular users. Also these tools allow to collect information about the functions efficiency properties, which must be used when particular quality of efficiency of use is of interest;

9. Testing the methodology of research on internet map functionality. An experiment was carried out in order to ensure that the created methodology is viable and the estimated indicators of functionality quality are applicable. Based on results of the analysis, some insights have been made This allows asserting that the system is not only suitable for testing and assessing different types of internet maps, but also for extraction of recommendations of their improvement.

In order to create the methodology of research on internet map functionality and to prove its viability and applicability in practice the author has performed these studies:

1. Analysis of the quality of implementation of functions in the representative internet maps. During the research a variety of internet maps was analysed, representative maps were identified and grouped. A set of common internet map functions were defined and the features of their implementation were analysed. On the base of the results of this analysis the functionality evaluation criteria and indicators were defined. The information about different purposes of the functions has been used in the experts' sociometric analysis;

2. During the sociometric analysis the experts, such as internet map makers, administrators and experts of usability were asked to evaluate the importance of

different function groups (by purpose) for the overall functional map quality. Then they were asked about the influence of characteristics of implementation of the functions to the efficiency of use of maps. Based on the results, the criteria of functionality evaluation and relative importance coefficients of the indicators were formed;

3. A sociometric analysis of the user preferences. This study was necessary to create the user-oriented part of the methodology of research on internet map functionality. The research was implemented using specially developed methodology and the CartoUI system. During the analysis, statistics of the functions chosen and defined by users have been calculated. This information was used to calculate the indicators and their relative importance coefficients and to obtain information about efficiency of use of functions.

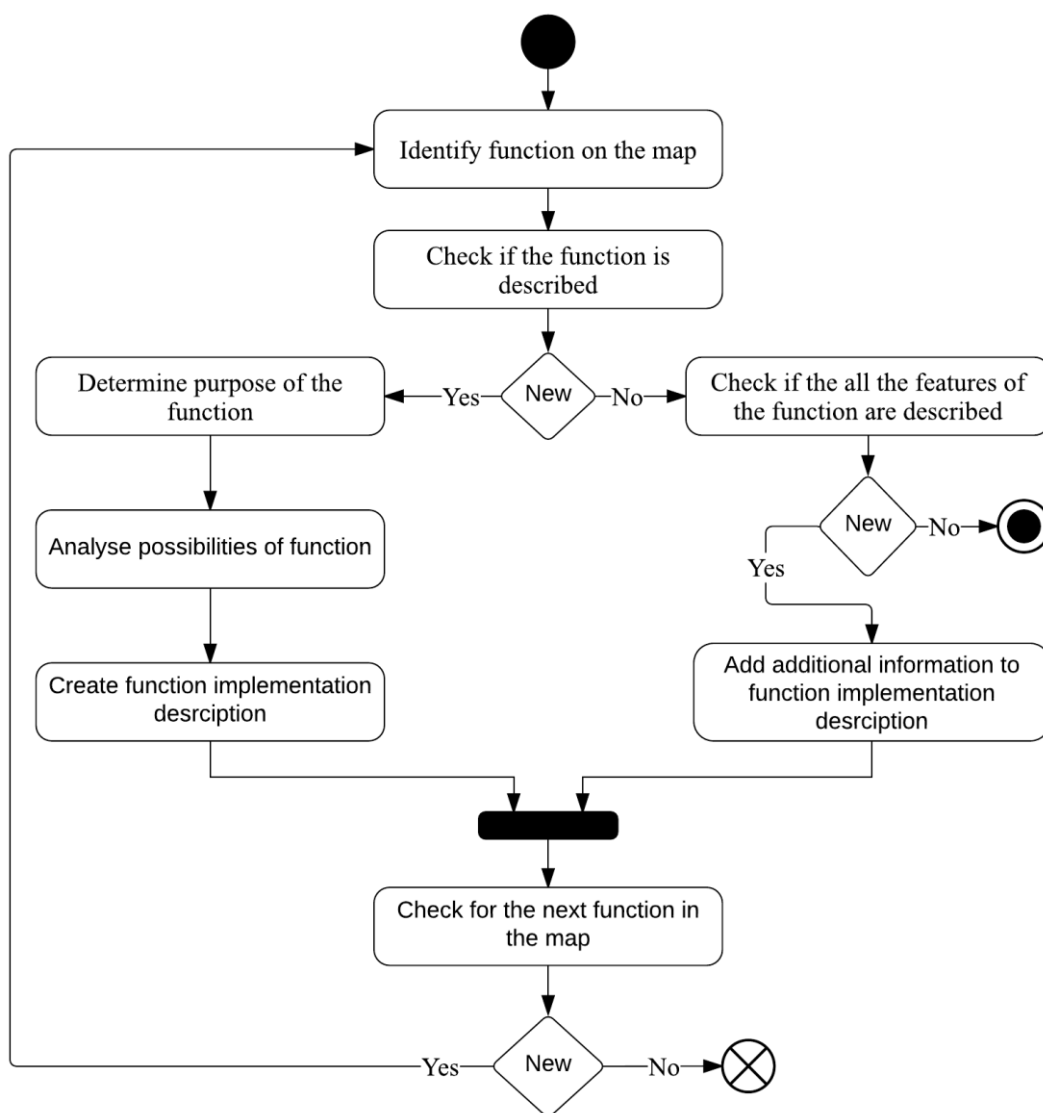
4. Application of the methodology of research on internet map functionality in practice. The methodology was tested for different types of internet maps (view, analytical, management) and proved suitable for quantitative evaluation of their functionality. It allows identification of preferences for different users groups depending on age, gender and map use experience. Thus the methodology was initially approved. Recommendations of the different type of maps and for different groups of users were formulated. Information about the study is provided in the chapter 3.

**Methodology of analysis of quality of implementation of functions.** The quality of implementation of functions is a characteristic of an internet map that reflects the level of technological implementation and possibilities provided by the tools available to the users. For example, a function of object identification that is very often used in internet maps can be implemented in different ways; only one object at a time can be identified or the group of objects, a selected group of objects, etc. Different ways of implementation determine different opportunities for the user. Thus the quality of implementation of functions describes the capabilities of internet maps functions. Also, it reflects how efficiency of use of map varies depending on the varying possibilities of use of functions.



The quality of implementation of functions efficiency is a technological aspect of internet map assessment. Therefore, to assess its quality the identification parameters are formed in a way that assessment of the functions would reflect the opportunities provided by the function’s realization tools.

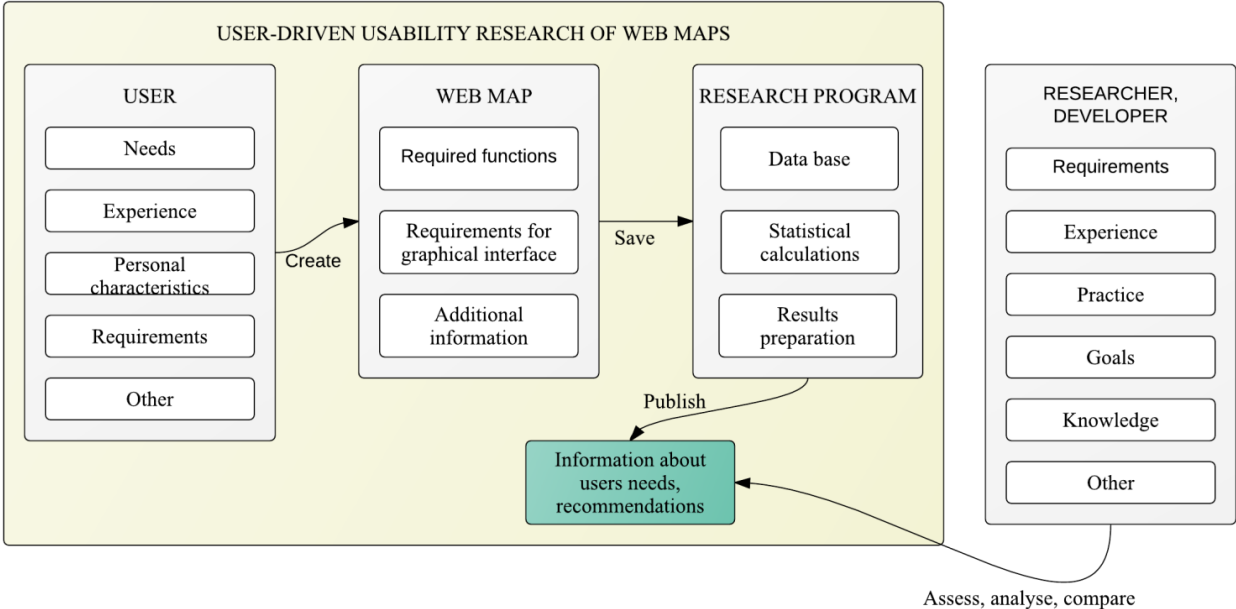
The method of analysis of quality of implementation of functions is based on description of the features of functions and foresees the updates (Figure 4). The list of implementation opportunities consist of information about the implementation tools. For example, scale changing function can be implemented using an interactive cursor, using the scale changing tools or by showing exact number of scale into the search.



**Figure 4.** The process of analysis of quality of implementation of functions

On the basis of the proposed analysis method, analysis of quality of implementation of functions for the representative interactive internet maps has been performed. Based on the results, guidelines that allow improving quality of implementation of functions were created. These guidelines were subsequently used for development of the integral functionality evaluation system.

**Methodology of analysis of efficiency of use.** The main purpose of the original methodology of analysis of efficiency of use of interactive internet maps is to identify generic user requirements for the internet maps. In the theory of modern cartography, needs of common users are transformed into requirements for implementation of functions for different types of internet maps (view, modification, management) and for the graphical user interface (design, arrangement of tools, colours, etc.). Identification of general user requirements was executed not as a use case in the particular maps as it was common before, but by providing opportunity for the users to describe the requested functions and their parameters by themselves (user-oriented case) (Figure 5).



**Figure 5.** The process of analysis of the efficiency of map use

In the user-oriented analysis of efficiency of use of map functions, the main task is to provide an environment where the user can easily and independently create a prototype interface for the chosen type of internet map. The user following her/his

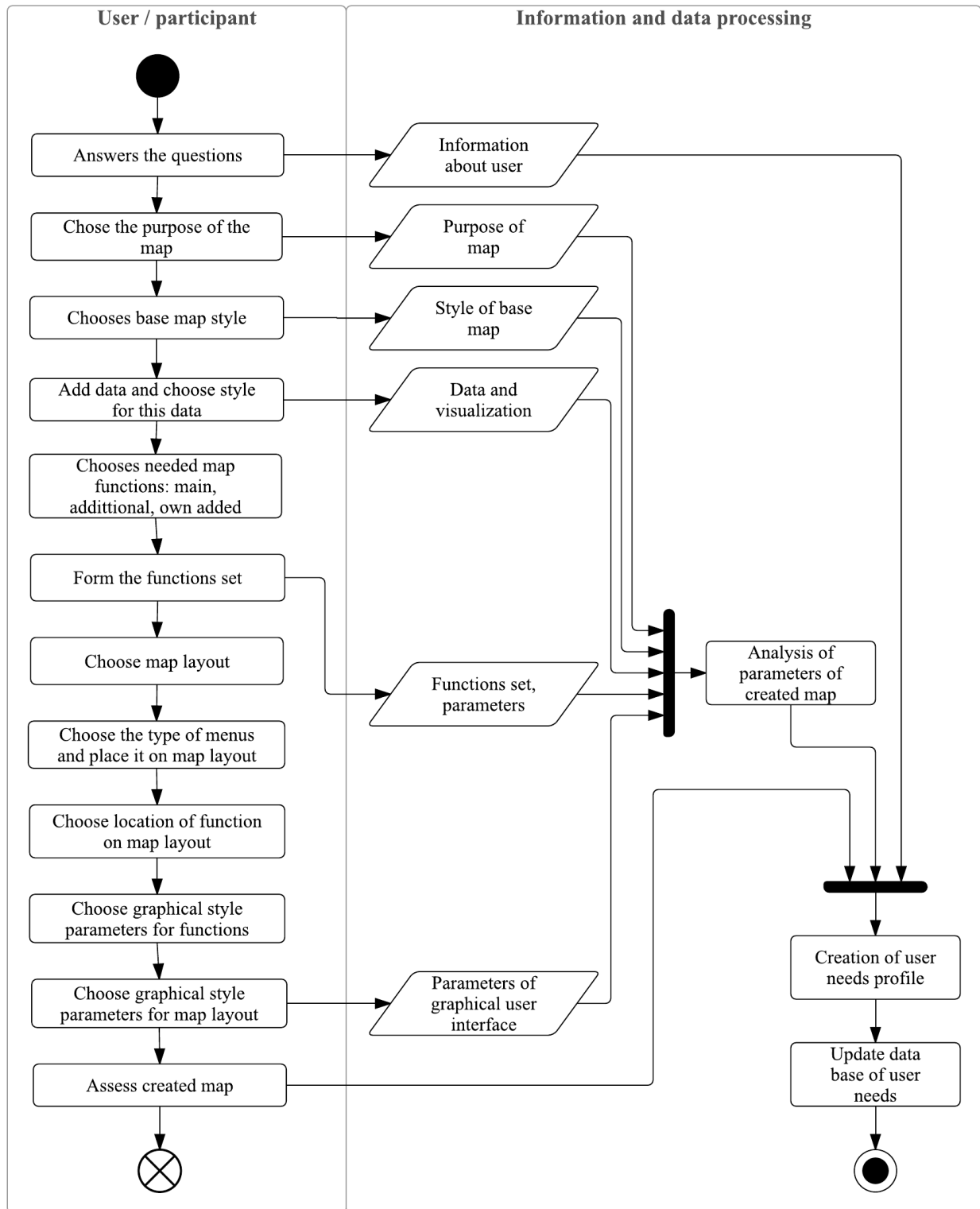
experience of use of internet maps and knowledge creates an own map prototype in the CartoUI program ([www.cartoui.com](http://www.cartoui.com)). The program analyses a map created by the user, calculates the statistics of application of it's functional and graphical user interface features and forms the report. The results collected in the CartoUI system are always up to date and provide information on interactive internet map quality in the aspect of implementation of functions.

Such method of user needs analysis allows to generate information useful to the map maker and to the evaluator who does not have to be present during the test. Before the analysis, the user is asked to fill in a questionnaire in order to get to know the social characteristics of the user. Later on, this information is used for the different types of analysis of the user preferences. During the analysis, the users choose or describe the use case of the map, specify functions and the layout as well as the user interface properties. The user defines the parameters of the map (chosen functions, design of tools, position of the tools the layout etc.) and all this information is captured. Configurations of the maps created by the user are processed, compared between each other and evaluated by their significance. The user indicates the significance of the map by choosing functions which are the most relevant for him/her. For example, one user only specifies some functions that are absolutely necessary and the others as complementary. Statistically, the results of the extended testing are maps with the most typical functionality and graphical user interface which can be analysed by different social characteristics of the users. The researcher can apply these results for designing new map features and orientate then to a particular target group.

**The analysis of user preferences and the program.** As it was said above, for analysis of the users' needs for the interactive internet maps, the author developed a web application program CartoUI ([www.cartoui.com](http://www.cartoui.com)) for user-driven map analysis. The tools for analysis of users' needs in this program are based on theoretical principles of analysis of efficiency of use of map functions.

The essence of user-driven map analysis is that the user is provided with all the tools necessary to create and specify features of the prototype map. The application can collect information about the process and provide it to the map makers and

researchers. The schema of the process of the web application CartoUI is shown in Figure 6.



**Figure 6.** The process of analysis of users' needs in the CartoUI

The main differences between standard methods of users' needs analysis and the method offered by the author is the process of the test. The user is provided with a

„blank sheet“ instead of a particular map, thus the user can decide which functionality and graphical user interface is good for this type of map. Such an interactive method of the analysis reflects tendencies of the WEB 2.0 technologies where the user is not only a content user but also is an author of it. As the result, while the user is creating the map, the web application continuously monitors actions of the user, processes and analyses information.

Thus, the author has developed the methodology of research on functionality and developed the CartoUI software that implements a part of this methodology related with analysis of user needs. In this system the author also implemented the methodology of analysis of efficiency of use of map functions that is reflected in guidelines on how to determine the coefficients of relative importance of quality indicators.

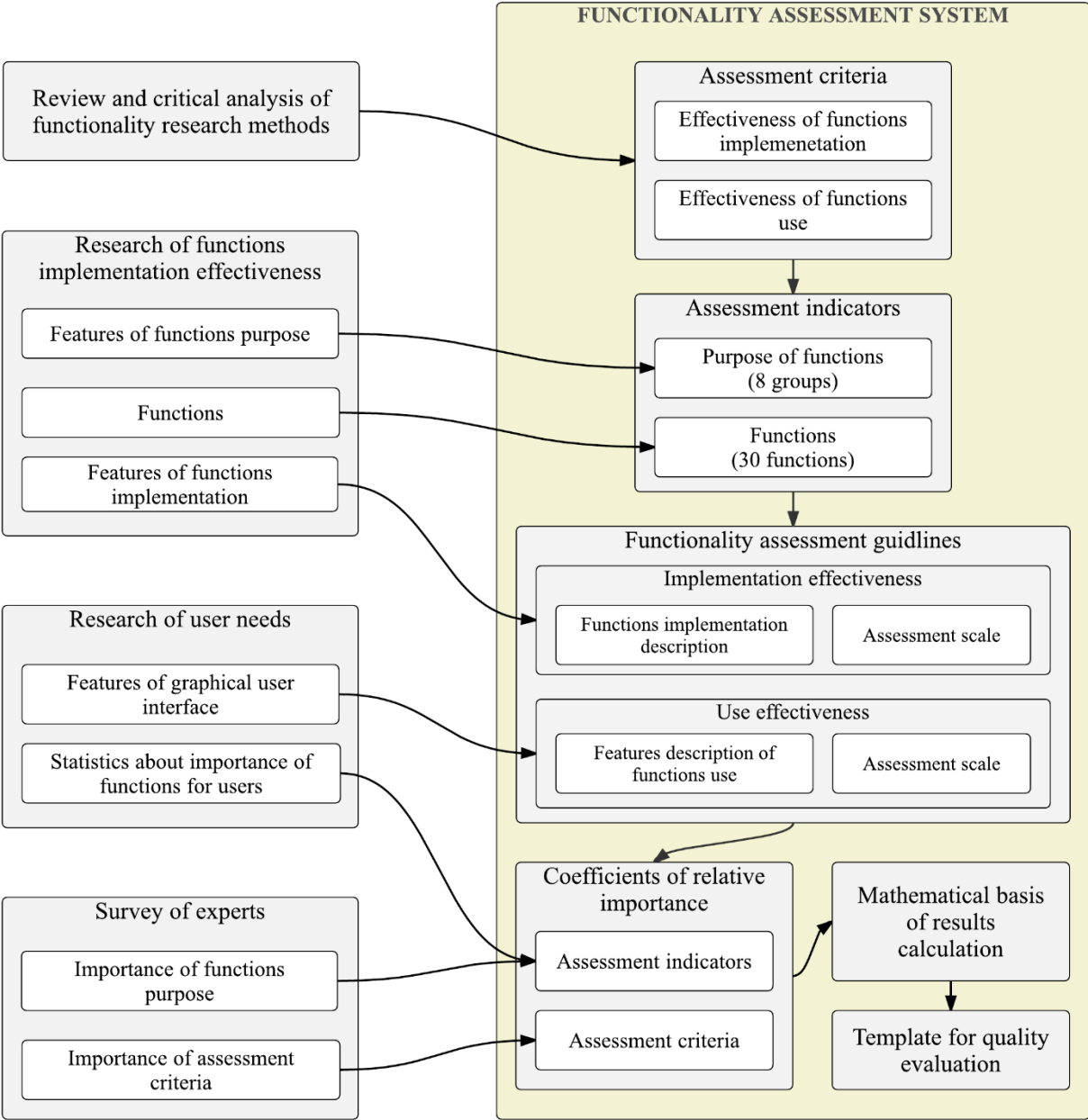
Considering the performed analysis and practical experiments, the integral evaluation system of assessment of internet map functionality is based on strong theoretical and practical base for the functionality evaluation. It is presented in detail in the Chapter 3.

### **3. THE RESEARCH RESULTS**

**An integral quality assessment system of interactive internet maps.** On the basis of the new methodology of interactive internet maps functionality analysis (presented in the chapter 2), the system for assessment of functional quality has been developed. This system ensures correct application of the functionality analysis methodology in practice as it provides access to the functional assessment requirements, principles, processes and necessary software tools. The functionality assessment system reflects the applied aspect of the created methodology and is one of the main results of this dissertation.

The structure of the functionality assessment system is predetermined by logical requirements of qualimetric evaluation. Also the requirements for methodology of analysis of functionality requirements for technological implementation of map functions and principles of analysis of the efficiency of use have been taken into

consideration. For the purpose of analysis of map functionality, qualimetric evaluation is defined as the comparison of the evaluated characteristics of the map objects with the reference values (quality of implementation of functions and efficiency of use) which are defined as a quality reference (maximal correspondence of functions to the needs of the users in a given context and maximum of implemented geographic information management possibilities for a given map). The conformity of a particular map is expressed mathematically. Considering all these requirements, an integral applied evaluation schema (represented in the Figure 7) has been implemented in the methodology of the applied assessment of functionality.



**Figure 7.** The components of the system of internet map functionality assessment

The capabilities of the internet maps in the context of functional quality assessment are expressed by the quality of implementation of the internet map functions (what the user can do with the tools that implement the functions), usability of the functions (whether the user can use the functions conveniently) and efficiency criteria. Depending on the functional evaluation criteria several indicators of quality are defined. The capabilities related to a particular map are considered while evaluating the quality of implementation of functions, (for the actions with a map or with the data) and usability is considered while evaluating the efficiency of use.

For evaluation of functionality of the internet maps, the evaluation indicators are related to particular map functions. Some attributes, such as quality of implementation and efficiency of use are assigned to these functions. Additionally, the functions are grouped by their purpose. A group of functions is an additional logical element of evaluation which is used for orientation of evaluation of particular functions depending on the significance of purpose and on the overall map quality.

In order to define the indicators for the system of assessment of functions' implementation, the study of implementation of the same functions in a set of representative interactive internet maps was performed. This study was carried out based on the methodology of analysis of implementation of map functions (presented in the Chapter 2). The analysis of functionality has been performed for the 17 interactive internet maps. Interactive internet maps of different types (thematic, specialized and general geographical maps) were investigated. The list of interactive maps used to specify functions is provided at the end of the thesis. During the analysis the functions and the way how they are implemented in the representative maps were analysed. The diversity of functions in the maps and the possibilities of user to take advantage of these functions by using corresponding tools were analysed taking into account differences between the same functions in different maps and different possibilities to perform the tasks by using the tools.

As the result of the analysis, **30** dominant and generic map functions were identified. The most important task here was to describe the quality of implementation of functions by properties (function implementation, possibilities provided by different

functions, their advantages and disadvantages). The result of the analysis is a description of the possibilities of implementation of each function. This information was integrated in the practical guidelines for functional evaluation of maps. The functions have been grouped by the purpose of application into **8** groups (Table 1).

**Table 1** . The generic functions of interactive internet maps

Groups by purpose	Functions
Map review	Zoom, pan, show legend, share place
Data identification	Object identification, search, data filtering, change layers
Layout management	Change layout, change map size, manage map elements
Data visualization	Change visual classification, change symbols, change colours palette, change labels
Data analysis	Get data statistics, query database, spatial analysis, choropleth analysis
Management of mathematical base	Change coordinate system, show coordinates, perform measurements
Resource management	Add own maps, create new data, change data classification, comparison
Data management	Change object's attributes, save map, embed map, print/export map

The Map functions and their groups (evaluation indicators) and evaluation criteria together form a base of the system for assessment of functionality. In order to create a consistent and flexible system for assessment of functionality, it is not enough to have the base. Coefficients of relative importance (weights) have to be set for the evaluation indicators and for their groups. The coefficients of relative importance specify the quantitative relative differences between evaluation criteria and indicators and their share in evaluation of the overall map quality. The system for assessment of functionality of interactive internet maps encompasses two criteria (quality of implementation and efficiency of use), 30 indicators (based on the selected representative functions) and the coefficients of relative importance for each criterion and function. In order to estimate the coefficients of relative importance, two sociometric studies involving experts of cartography and map users were carried out.

The aim of the sociometric study of the experts was to find how functions and efficiency of use of them in a map influence overall functional quality of the map and



how important is usability of different functions in maps of different purposes. The relative importance coefficients for the evaluation criteria and for the representative functions were determined after processing of complex questionnaires completed by the group of 30 different experts such as cartographers, information technologies experts, geographical information systems' experts, geographers and specialists of other fields who actively use internet maps.

The aim of sociometric analysis of the users was to find out what are the preferences for functionality of map expressed by their users (which functions are needed by different users and how these functions should be made accessible in the graphical interface in a way that the user could use them conveniently). The sociometric analysis of users has been performed by means of the internet application CartoUI ([www.cartoui.com](http://www.cartoui.com)) that was developed by the author for this specific purpose. The aim of the CartoUI application is to allow the user to create internet map for a chosen purpose. The program collects all the inputs in the database while the users create their maps. Collected data in a database and the analysis tools of the CartoUI allow performing integral analysis of user preferences and thus determining their needs. CartoUI can provide reports on know which functions, menu items and user interface structure, style features and other parameters are the most popular among the users.

The relative importance coefficients reflect the importance of a particular function of interactive internet map to the users. The level of importance has been calculated from the reports on how often this functions had been chosen by the respondents while creating maps in the CartoUI application. These coefficients have been calculated for all 30 functions. Use of these coefficients for each evaluation indicator provides a possibility to take into consideration the needs of the user. The coefficients are automatically recalculated as the users' preferences change in time.

In order to assess map functionality objectively and to get reliable results the functionality assessment guidelines (instructions) have been defined. The guidelines of assessment define features of functional implementation and efficiency of use as well as the evaluation scales (qualitative categories in a quantitative aspect). The evaluation

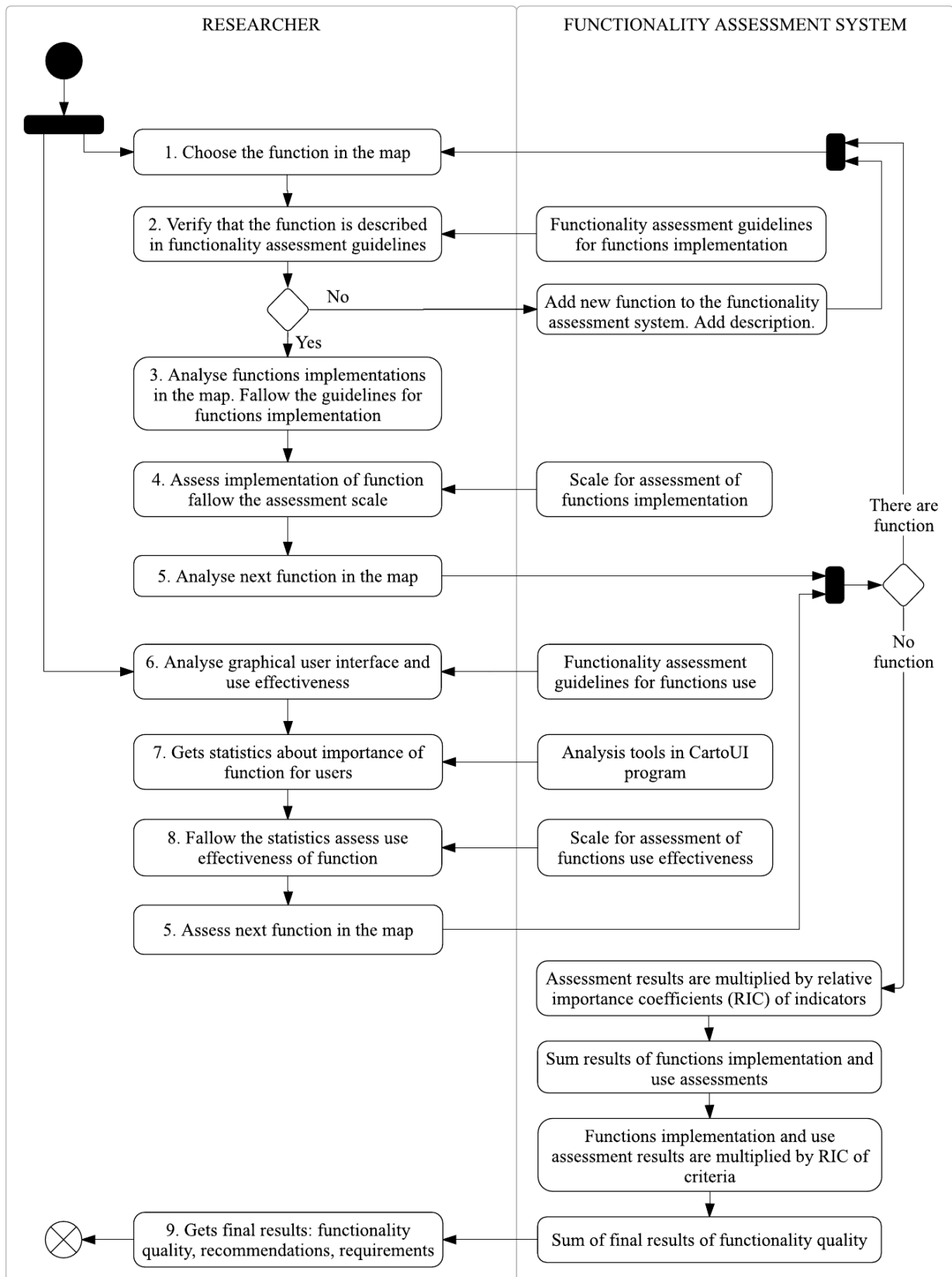
scales are applied for measurement of quality of implementation of functions and for efficiency of use. Hence, functionality assessment guidelines is a tool which guides researcher while assessing implementation of the functions and usability efficiency in the internet maps.

The guidelines for assessment of quality of implementation of functions of internet maps foresee different possibilities for implementation of the functions. The results of the analysis of the representative internet maps accomplished by the author provided possibilities not only to identify indicators in the evaluation system but also to define different implementation features. These functions are related with assessment schema which shows how the possibilities, provided for the user, vary while implementation of functions changes.

The guidelines of assessment of efficiency of use of internet maps define graphical user interface features which illustrate how the user can effectively apply functions in the map. For the guidelines for implementation of the functions, the results of the analysis of preferences of the users were obtained from the CartoUI application. The results can be viewed in the internet application CartoUI ([www.cartoui.com/analysis.php](http://www.cartoui.com/analysis.php)).

Thus, the guidelines for assessment of the quality of implementation of functions specify how the functions work. Another part of the guidelines devoted for assessment of efficiency of use specifies how access to a function can be provided for the user for the convenience of use.

The system for assessment of functionality of internet maps is integral (combines different assessment criteria and indicators), dynamic (the researcher can apply different relative importance coefficients values depending of the target group of the users) and consistent (because of integration of different evaluations, guidelines and analysis tools of the application CartoUI). In order to ensure that the process of assessment of map functionality is carried out correctly and completely it is necessary to describe the process in detail (Figure 8).



**Figure 8.** The process of assessment of functionality of an internet map

During the assessment process it is necessary that the researcher considers and evaluates implementation of functions and the efficiency of use. The evaluation should

be performed according to the prepared guidelines and to the evaluation schema (Figure 8). Such formalization of the evaluation process allows ensuring that evaluation of functionality is performed based on the same methodology and that the results are comparable.

Methodology and practical analysis tools as a basis for the analysis methodology are created. The methodology and practical analysis implementation tools give a possibility to analyse features of functionality as a complex of features and their compliance to the needs of the users. In order to assure that that the system for assessment of functionality is applicable in real situations, it is necessary to make a full analysis of usability of it in practice.

#### **Application of the methodology of assessment of map functionality in practice.**

Before stating that the methodology is fully completed and suitable for application in practical cartographic research, a case study was carried out that allowed to approbate it. It was based on testing the usability assessment measures and tools for assessment of functionality of the particular maps. The process was analysed in terms of correctness of actions and accuracy of the results thus check the possibilities of the system's application in practise.

Two tasks of application of methodology of assessment of interactive internet maps functionality application have been distinguished:

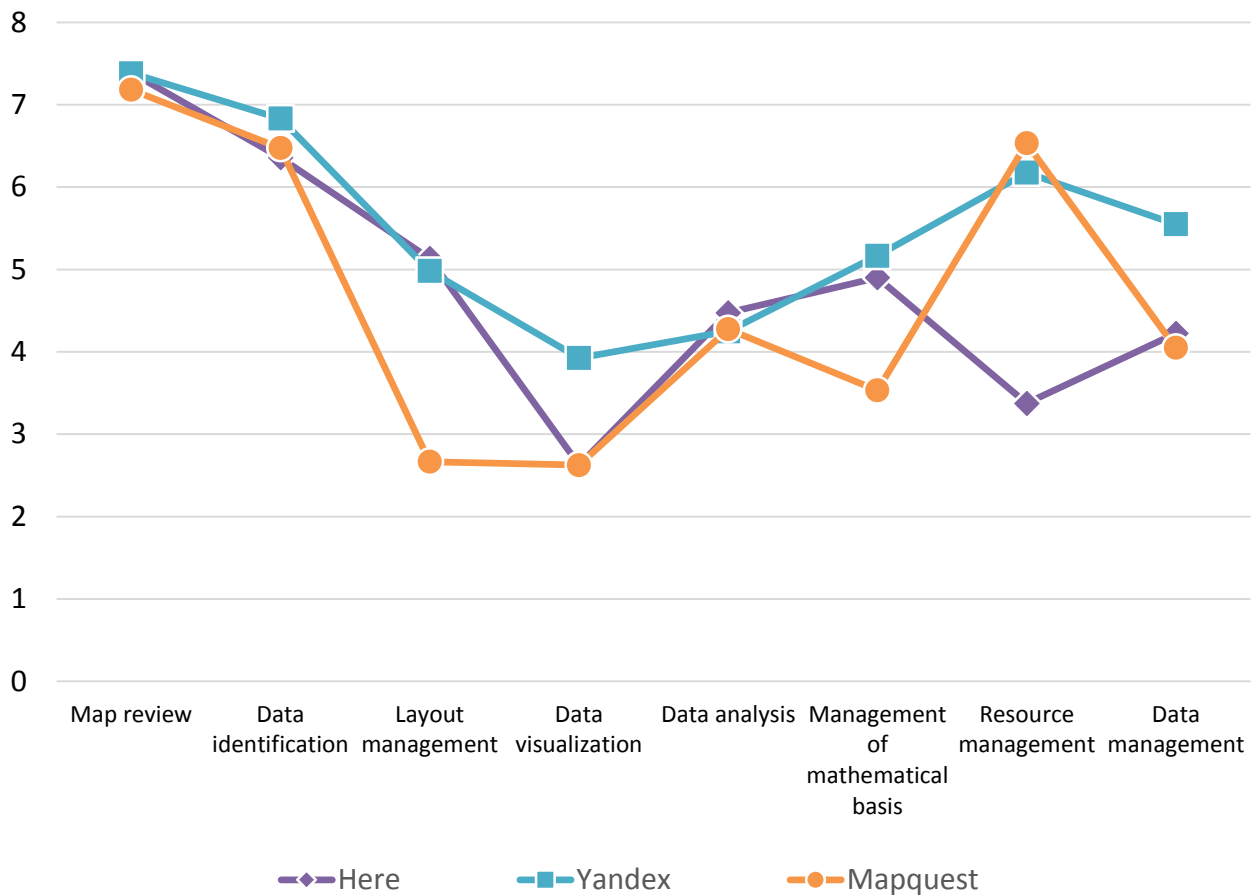
1. To evaluate and compare functional quality for the different interactive internet maps. The analysed maps belong to the three different types defined by the author (maps primarily designed for geographical data view, analysis and management) The quality of functionality has been evaluated for 8 interactive maps: Here ([here.com](http://here.com)), Yandex ([maps.yandex.com](http://maps.yandex.com)), Mapquest ([mapquest.com](http://mapquest.com)), MapBox ([Mapbox.com](http://Mapbox.com)), CartoDB ([cartodb.com](http://cartodb.com)), Google maps ([maps.google.com](http://maps.google.com)), ArcGIS online ([arcgis.com](http://arcgis.com)), OpenStreetMap ([openstreetmap.org](http://openstreetmap.org));
2. To evaluate the needs of the different groups of the users for interactive internet maps. The preferences of the surveyed users have been analysed by their age (three groups are defined: <25 years, 25-35 and >35 years), gender and experience of map use. . By the experience of use, three groups of users have been distinguished: a)

users who use maps once a week and even more rarely, b) users who use maps a few times per week, c) users who use maps everyday. The analysis of user preferences has been performed using the same CartoUI ([www.cartoui.com](http://www.cartoui.com)) internet application developed by the author.

For the each case of the analysis, initial hypotheses had been formulated. As the hypotheses are supported by the results, it gives an important information for the development of cartographical theory and demonstrate suitability of the proposed a methodology of the functionality analysis. The hypotheses were:

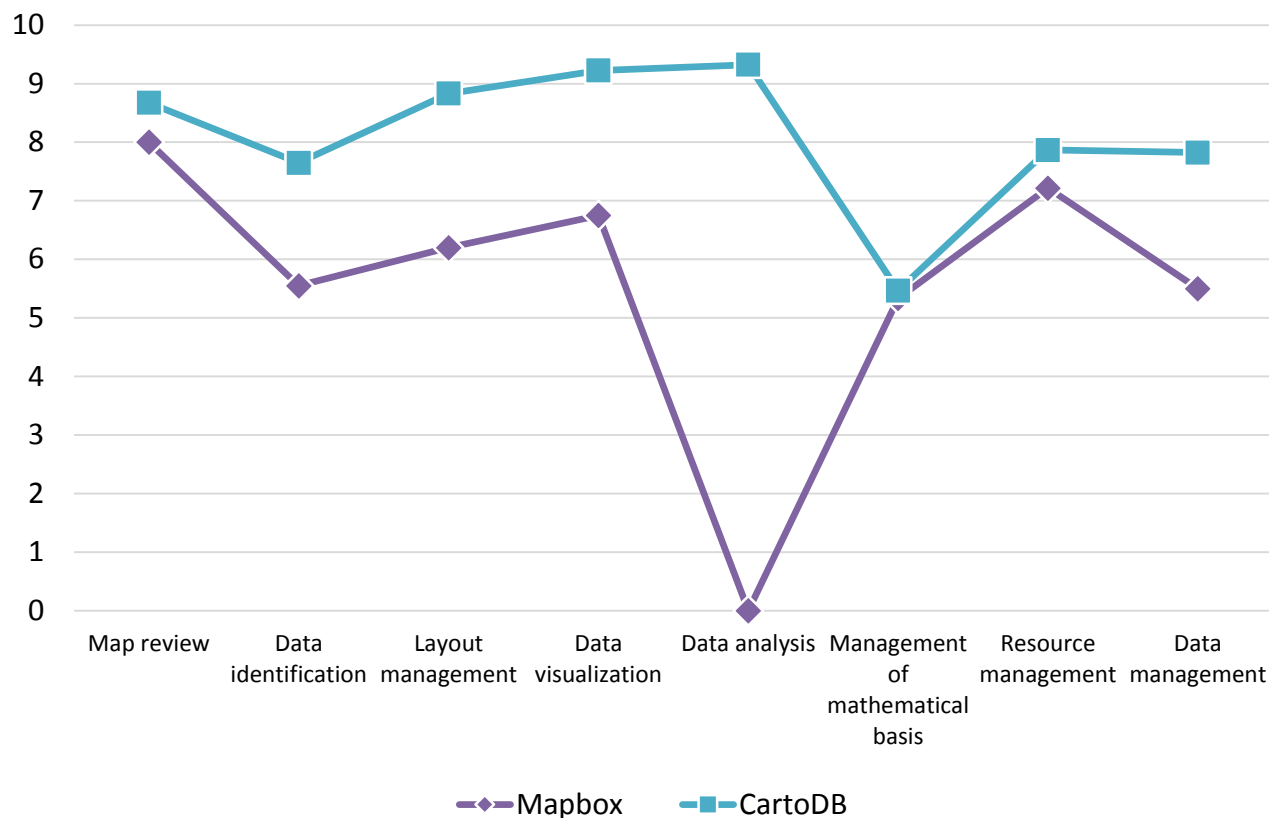
1. Internet map quality of implementation of functions and efficiency of use vary depending on the purpose of the map;
2. Evaluation of quality of Internet map functionality depends on the different preferences of different groups of the users.

**The results of analysis of different types of interactive internet map functionality.** The assessment of functionality of 'View' type maps by the purposes of functions revealed that for this type of maps the best implementation of functions (geographical data view and identification) is achieved when the functions are compared with each other (Figure 9). Analysis of the functions of the 'view' purpose are the most stable and the quality of implementation of functions starts to vary a lot when the purposes of functions are changing. The functions of view and identification purposes are implemented more often and their implementation is more effective (functions for the view and identification performances are more often chosen by the users and cover a wider range of possibilities). Also, the implementation of functions is better for these purposes.



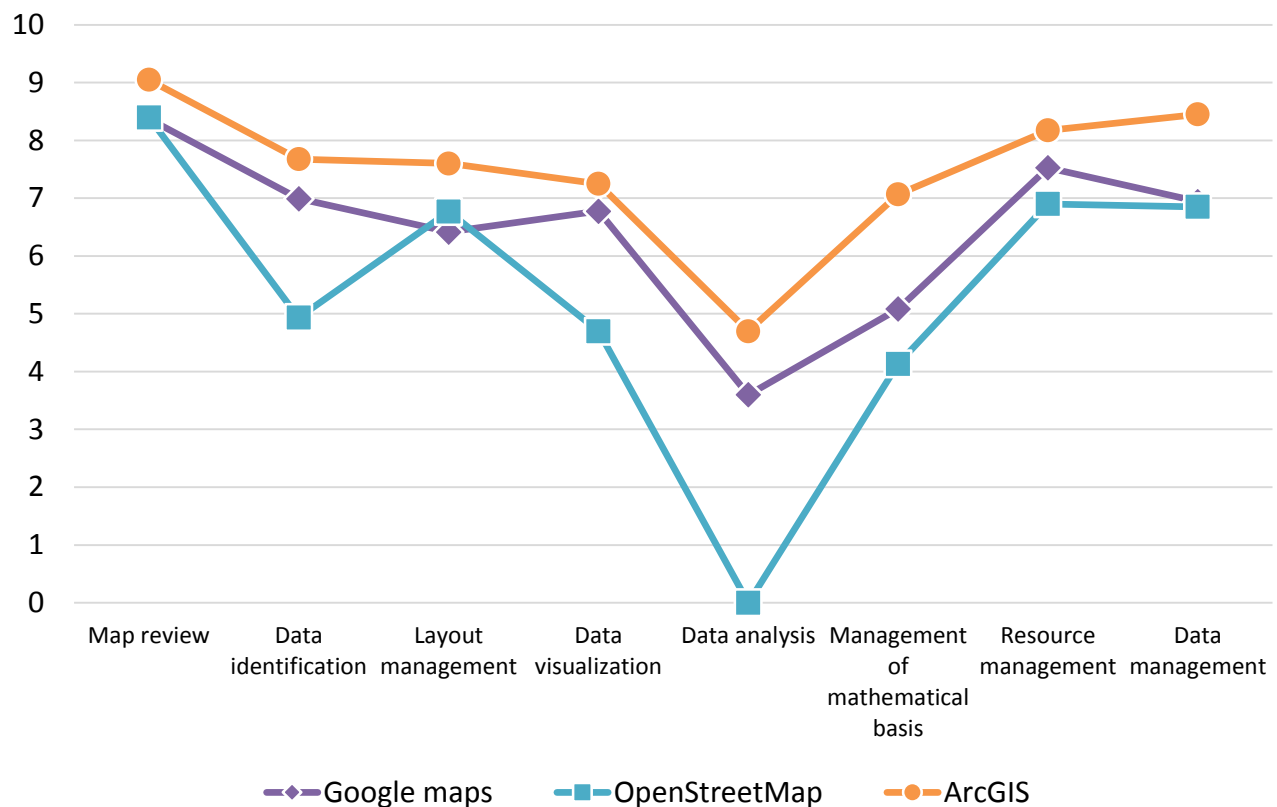
**Figure 9.** The results of functionality assessment by the purpose of functions purpose for Internet maps of “view” type (10-point scale)

Analysis of assessment of functionality of analytical maps based on the purpose of functions revealed that target purposes and base data view functions are implemented in the maps the most efficiently (Figure 10). Average assessments of visualization, analysis and functions of the view purposes, implementation and efficiency of use quality are higher than average of all the assessments.



**Figure 10.** The results of functionality assessment by the purpose of functions in Internet maps of analytical type (10-point scale).

The highest scores of the functions in the maps of the ‘management’ type were given to data management, resources of the map management and view purpose functions (Figure 11). The functions for the view purpose are distinguished as effective functions for the all types of the analysed maps and the sum of this purpose functions score is the highest. Without the functions of this purpose, the target functions score is much higher than the average. At present, the score of implementation of other functions for the other purposes has not reached the average value. These results support the hypothesis that implementation and efficiency of use of internet map functions vary depending on the map purpose. Also, these results prove the tendency of the visualization and analysis types of maps. The quality of the functionality assessment score depends on the map application purpose.



**Figure 11.** The results of functionality assessment by the purpose of functions of Internet maps of “management” type (10-point scale)

The results of the different types of interactive internet maps functionality assessment allow:

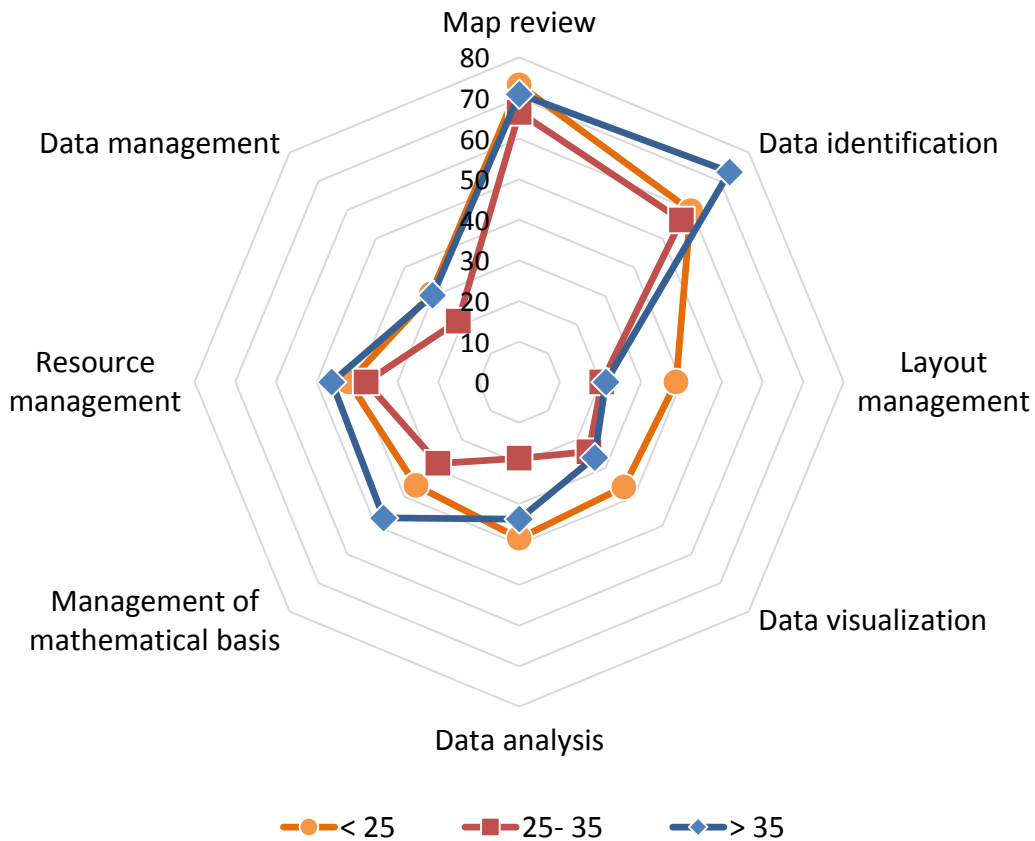
1. To support the hypothesis that quality of the functions depends on the type of the map;
2. To identify the trends of changes in understanding quality ;
3. To state that the highest functionality quality evaluations are characteristic to these functions, which purpose directly fits with the maps applications’ purposes and to functions that implement the base map view possibilities;
4. To observe the recent tendencies of the internet maps development; that target purpose functions of the map tend to become more complex and the quality of the maps functionality decreases;
5. To provide detailed recommendations for development of different types of interactive internet maps (recommendations are provided throughout all the dissertation).



**The results of interactive internet map user needs analysis.** Completed user needs analysis let to prove and form functions assessment relevant importance of the coefficients. Moreover, this analysis demonstrates variety of the methodology and application possibilities for the different purposes of the internet maps. User needs analysis results are presented in three ways, when the users are grouped by age, map usability purpose and gender.

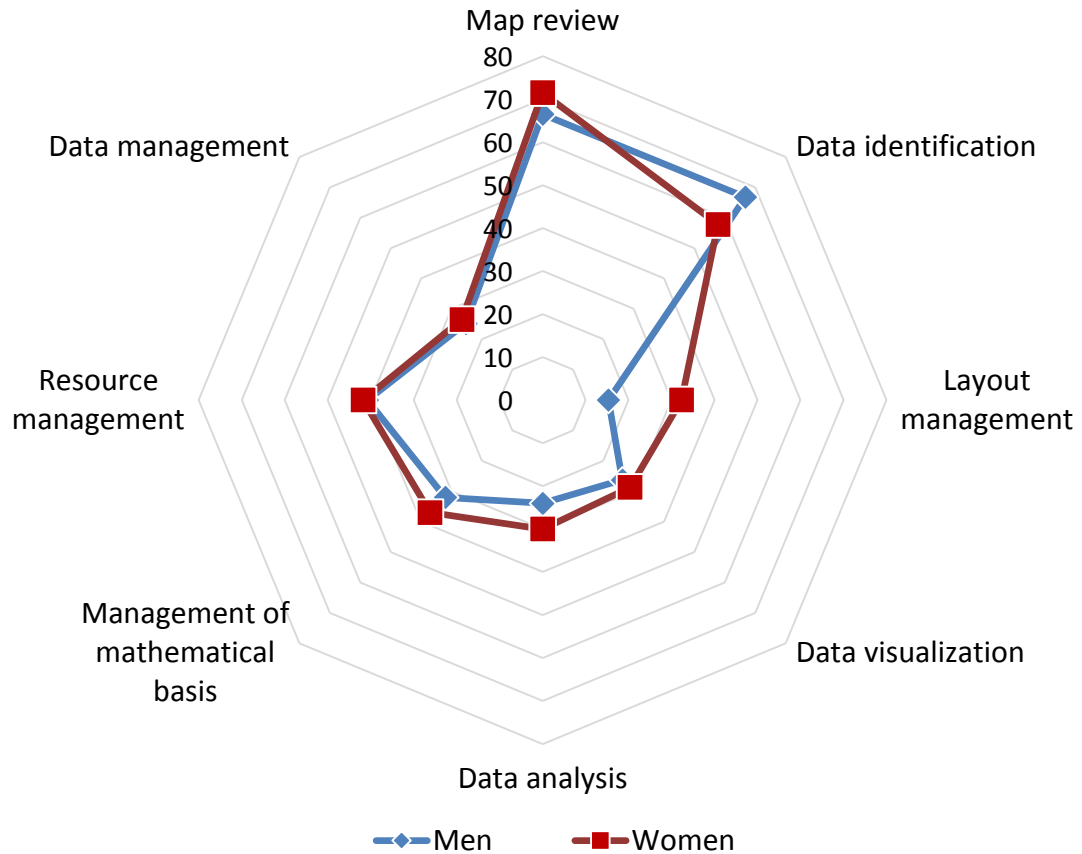
By analysing needs of the users (by the functions purposes) the main tendency becomes that for the all age groups of users the data view and functions of the identification purposes are more actual. View functions in the maps are more (73%) prioritized by the younger users and middle age users (67%) but at the same time older users give a priority to the functions of the identification purpose.

The results of the analysis (Figure 12) revealed that creating maps for the user younger than 25 years old it is important to emphasize data view, identification and management of maps resources functions realization. These functions are dominant between the maps created by the users of this age group. The users from 25-35 age group in the maps want to see less functions but their applied functions are more concentrated to the data view, identification and map resources management. For other functions less attention is provided. Users older than 35 years without basic view and identify map functions also actively use mathematical base and maps resources' management functions.



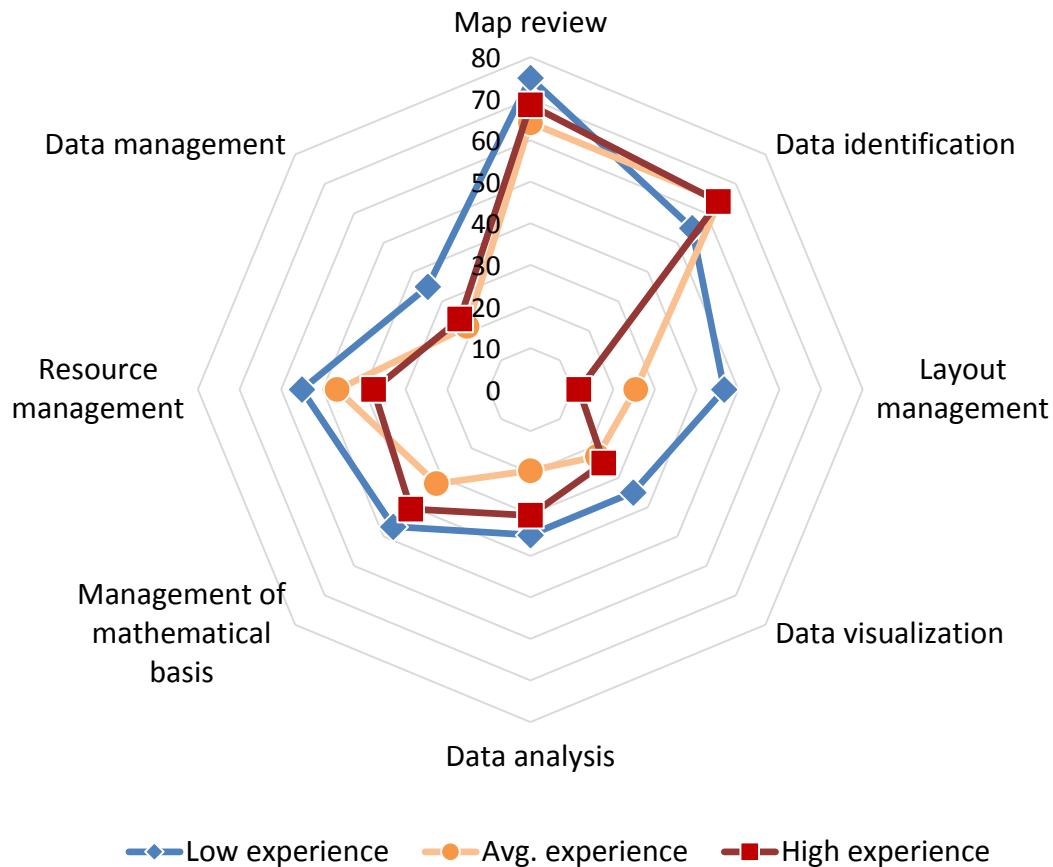
**Figure 12.** Need for generic functions by different age groups of users (percentage)

Analysis of different gender users' preferences by the purpose of the functions revealed that in maps which were created by men, data view and identification functions are applied most often (Figure 13). Women mainly used map view purpose functions in 72 percent of their maps but the identification purpose functions were applied only in a little bit more than a half of the created maps. Also, significant differences have been observed in application of graphical user interface changing functions. These functions were used by 32 percent of women and only by 15 percent of men. Also women more often than men used data analysis and mathematical base changing functions. A tendency is revealed, that maps created by men are distinguished by functionality more concentrated to implementation of a few particular functions (data view, identification, map resources management) whereas maps created by women have functionality more diverse and typically with more complex analysis type functions in it.



**Figure 13.** Need for generic functions by men and women (percentage)

Analysis of user needs of users with different experience of map use revealed that the more experience in using maps the users have, the less functions they choose (Figure 14). The group of the users who use maps rarely (once per week and even more rarely) use up to 5 functions with different purposes in maps while the users having medium experience use only 3. Among the professionals functions of only 2 different purposes are common. The reasons for such variety of functions can be different. Small maps use experience shows that particular map use case (user would use maps more often) is not formed and this results in less concentrated and numerous needs of various functions. The users who uses maps more often know exactly what they need, therefore it is easier for them to set the limited number of the most important functions. Generally, the research resulted in conclusion that small map use experience leads to the need for more various and numerous functions while higher map usability experience leads for less and more concentrated functionality.



**Figure 14.** Need for generic functions by groups of users with different experience (percentage)

Summarizing the said, the results of the analysis of the needs of all three groups of the users (by age, gender and experience) support the hypothesis that social and demographical users’ characteristics have influence for their preferences for map functionality. This fact should be considered while creating new maps which are tailored for the particular groups of the users. Detailed internet map development recommendations for different social groups of the users are provided throughout all the dissertation and reveal the benefits of application of the methodology of the functionality analysis in practice. The biggest advantage of the methodology – possibilities to apply the results of research immediately and directly in the map making process – has been successfully demonstrated.

These results define recommendation for the particular internet map functionality development for the different age of the users. **The map makers on the basis of these results can prioritize implementation of the map functions considering the specifics of**

**the target group of the users. At present, these results confirmed the hypothesis that requirements for internet map functionality by different age map users are different.**

## **CONCLUSIONS**

### **Theoretical conclusions**

1. The quality of functions is a complex property of an interactive internet map that generalises the possibilities of application of this particular map for the tasks related to geographical information management by a particular user group. The quality index allows to evaluate the set of tools that is provided for performance of particular tasks, the efficiency and usability of these tools. Therefore a research into functionality of interactive internet maps must be firstly based on the set of initially defined requirements for the functions by the target group. Only then the degree, to which functionality of particular meets the requirements, can be estimated. Analysis of diverse representative internet maps, their functions and the corresponding tools has revealed that there are 30 generic functions common to modern internet maps. They can be implemented in different ways and are not equally important. These functions have been analysed and grouped into 8 groups according to their purpose. The author argues that the indices for assessment of quality of map functionality must be directly linked to these functions. Implementation of these or analogical functions of a particular map is tested in terms of usability and efficiency. The list of reference functions must be changeable in accordance to changes as new functions appear or their relative importance changes.

2. Original method of research into the users' needs has been developed. Instead of the popular approach that is based on study of existing maps, this method allows the user to express his needs interactively, by graphic interface that allows him to create a map model for the chosen purpose, to define required and optional generic map functions and to immediately see what it would look like. This method has been implemented and allowed to collect information that can be used to find out what are general expectations of a particular target group to the interactive map and, correspondingly, to define the basic requirements for the maps' functions. This method

allows achieving better quality of map functionality. The system can be used for a particular research limited by a period of time and a particular target group. On the other hand, all information accumulated during previous researches, can be taken into account.

3. quality of implementation of interactive map functions that allows for more objective assessment of technological level of implementation and of dependence of efficiency, integrity and interaction level on the way the tools, related to the functions, are implemented.

4. The users have clear preferences of graphical properties of tools that implement important functions. Popular values of graphical attributes can be determined. They are variable and can be viewed at analysis area of the CartoUI program at: [www.cartoui.com/analyse](http://www.cartoui.com/analyse). The results of tests performed by 72 users by 2014-10-06 have been used to determine the coefficients of relative importance (weights) of functions to the users.

5. The author proposes a method of research into efficiency of use of map tools that is based on the results of investigation into internet map users' needs. This method allows evaluation of importance of particular functions to the users and assessment of implementation of the tools (graphical interface design, position of tools, intuitive understanding of the purpose etc.).

6. An original system for evaluation of quality of internet map functionality quality has been proposed based on the principles of qualimetry (when the properties of usability and efficiency of considered internet map functions are assessed against the referenced values determined by experts of the field).

7. The referenced values of the tools and efficiency of use are set based on the results from three studies: (a) study of the users' needs, (b) sociometric study of 30 experts and (c) study on efficiency of tools that implement functions. The system of referenced values, in a particular technological and temporal context, enables a researcher to objectively evaluate how the map functionality satisfies user needs, to identify advantages and disadvantages of implementation of particular map functions, to evaluate effectiveness of use of the tools.

8. Based on the results of the analysis and in accordance with the methodology of research on implementation and usability of interactive maps functions, relative weights have been calculated for the functions, function groups and for the aspects of evaluation. The coefficients of relative importance of functions reflect the priorities of users when choose desired geographical data management functions. The coefficients of importance of functions' groups (by purpose) and of the aspects of evaluation reflects the priorities set by experts and express the estimated impact of the different function groups to the overall quality of map functionality. The combination of both users' and experts' evaluations is an advantage of the system of assessment of functionality as it allows for more objective assessment that does not only rely on non-professional opinions.

### **Practical conclusions**

1. The quality evaluation results revealed that implementation of functions in different types of internet maps and efficiency of their use vary depending on the purpose of map. Analysis and assessment of functionality of three different types (view, analysis and management) of internet maps highlighted the current tendencies of internet maps, implementation of functions and the problems of usability. During the study a connection between different types of maps and their functions has been identified that can be used for regulation of internet map making.

2. The results of analysis of the users' needs for different internet maps revealed that age of the users, gender and the map usability experience have significant influence to their the requirements for the map functionality. The number of the map functions, the purpose of the functions and applicability of different functions varied among the different age groups (< 25 years, 25-35 years, >35 years). To identify these requirements the users' needs analysis program CartoUI can be successfully applied.

3. Application of the methodology of research on internet map functionality analysis for different types of cases resulted in practical recommendations. It can be stated that it is appropriate to apply this methodology for the different types of internet maps, for users' needs analysis, for obtaining information about the

implementation of functions and their usability. It became possible to prepare concrete recommendations for functionality design that are orientated to certain map making processes for the maps of different types and tailored for different target groups;

4. The users' needs analysis system CartoUI provides an opportunity not only to perform specialized internet map users' needs analysis but also to obtain the statistical information about the users' needs for different target groups. Also, there is a possibility to analyse this data in a different aspects and for different types of maps. All obtained information can be easily used in map making process and in the requirements' specification stage. Due to possibility to easily obtain necessary information, some of costs can be spared by map makers in comparison with the costs related to standard methods of analysis (surveys and feedback). The method of evaluation of the users' needs and the CartoUI software reflect the main applied purpose of this dissertation.

#### **LIST OF PUBLICATIONS ON THE DISSERTATION TOPIC**

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## **CURICULUM VITAE**

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# SANTRAUKA

## ĮVADAS

### Tiriama problema

Šiuolaikiniame modernių technologijų laikmetyje kartografija išgyvena kokybiškai ir kiekybiškai naują raidos etapą. Vienas iš pagrindinių kartografijos produktų – žemėlapis – įgauna naujas raiškos formas ir iš analoginės statiškos perkeliamas į interaktyvią, dinamišką aplinką (Kraak ir kt. 2001). Interneto žemėlapiai – tai moderni ir itin perspektyvi geografinės informacijos perteikimo priemonė, suteikianti kartografijos srities specialistams didelės apimties, įvairios tematikos bei paskirties erdvinių duomenų srautų vizualizavimo ir publikavimo galimybių, o naudotojams – šių srautų valdymo internete funkcijas. Atsiradusios anksčiau neįsivaizduotos interneto žemėlapio funkcionalumo galimybės verčia peržiūrėti klasikinius žemėlapio kūrimo bei naudojimo principus. Taip pat kitaip, daug sudėtingiau, apibrėžti kokybės reikalavimus, kurie identifikuotų interneto žemėlapio naudojimo efektyvumą.

Funkcionalumo (interaktyvaus žemėlapio funkcijų visumos) kokybė interaktyviame interneto žemėlapio naudojimo procese yra kritiškai svarbi, nes būtent nuo funkcionalumo priklauso ir per jį išreiškiamos naudotojo galimybės: peržiūros, analizės ar visapusiško interneto žemėlapio valdymo. Taigi, norint efektyviai išnaudoti interneto žemėlapio galimybes, žemėlapio kūrėjams reikia žinoti, kokios funkcijos turi būti susietos su konkrečiu tipo žemėlapio, kaip jos turi būti realizuotos bei specialiai pritaikytos tikslinės naudotojų grupės poreikiams. 21 a. kartografinių tyrimų praktikoje taikomi interneto žemėlapio tyrimų metodai dar vis neužtikrina kompleksinio šios problemos sprendimo, o žemėlapio funkcionalumo kokybės tyrimų vykdymo procesas dėl per didelių jo kaštų bei gaunamų rezultatų praktinio pritaikomumo stoko retai kada realiai integruojamas į žemėlapio kūrimo procesą. Šios priežastys skatina ieškoti naujų būdų, priemonių, kurios užtikrintų interneto žemėlapio kūrėjams būtinos informacijos gavimą ir tinkamą panaudojimą.

Žemėlapiai dar niekada nebuvo taip plačiai naudojami visuomenėje kaip šiandien, kai interneto technologijos ne tik supaprastino prieigą prie žemėlapių resursų (georeferencinių bei teminių duomenų), bet ir suteikė galimybę pačiame žemėlapyje interaktyviai pateikti šių resursų peržiūros, analizės, valdymo funkcijas. Interneto žemėlapiai tampa neatsiejama šiuolaikinėje visuomenėje vykstančių procesų dalimi, jų paskirtis kinta, auga ir auga praktiškai neribotai – tiek, kiek leidžia jų naudotojų idėjos. Interneto žemėlapiai taikomi praktiškai visur, nuo geografinės vietovės paieškos, iki sudėtingų erdvinio duomenų operacijų, nuo paruoštųjų tinklo pavaizdavimo sutartiniais ženklais iki erdvinio duomenų infrastruktūrų, geoportalų. Toks platus interneto žemėlapių taikymo spektras formuoja ir naują žemėlapių funkcinę bei naudojimo paskirtis, kurios turi būti įvertintos sudarant šių žemėlapių kūrimo gerosios praktikos rekomendacijas. Atsižvelgiant į tai, interneto žemėlapių kokybei apibrėžti reikalingi kompleksiniai, į interneto žemėlapių technologijas ir jų naudotojų poreikius orientuoti bei nuolat atnaujinami, dinamiški tyrimai. Šis poreikis atspindi interneto žemėlapių tyrimams keliamus reikalavimus, kuriems vykdyti, kaip atskleidė autoriaus atlikta tyrimų apžvalga, šiuolaikinės kartografijos teorijoje iki šiol nebuvo suformuota vieninga metodologija. Dėl šios priežasties trūksta išsamių interneto žemėlapių funkcionalumo pagal naudotojų poreikius bei skirtingus žemėlapių tipus tyrimų rezultatų, kurie padėtų tobulinti šių žemėlapių kūrimo procesą bei praktiką.

Šiuo metu galimybės interneto žemėlapių kokybės tyrimus plačiai taikyti praktikoje ribotos, nes nėra aiškiai apibrėžta, kaip būtų galima efektyviai ir objektyviai įvertinti jų kokybę, kokie vertinimo kriterijai turėtų būti naudojami. Dėl nesuformuotos vieningos tyrimų metodologijos, trūksta teorinių žinių kaip organizuoti internetinių žemėlapių tyrimus, kokiais principais reikėtų vadovautis, ką ir kaip vertinti. Šių metodologinių trūkumų pašalinimas tampa vienu aktualiausių iššūkių šiandieninei kartografijai ir jos teorijai. Šiai problematikai tirti skiriama ir ši disertacija. Autoriaus siūloma originali interneto žemėlapių kokybės vertinimo metodologija gali būti realiai ir tiesiogiai panaudota interneto žemėlapių kūrimo procesuose, yra kompleksiška, efektyvi ir plečiama, todėl gali būti pritaikyti kylančioms interneto žemėlapių funkcionalumo tyrimų problemoms spręsti.

## Darbo aktualumas

Kaip pagerinti interneto žemėlapių kokybę? Šis klausimas aktualus tiek žemėlapių kūrėjams (kartografams, projektuotojams, programuotojams), siekiantiems sukurti geresnę naudojimosi žemėlapiais patirtį, efektyvesnes priemones erdviniam duomenims pateikti, tiek naudotojams, kuriems žemėlapiai tampa kasdieniu įrankiu geografinėi informacijai valdyti. Interneto žemėlapiams kurti skirtų taikomojo programavimo sąsajų tobulinimo bei debesų kompiuterijos dėka, kurti interneto žemėlapius tapo kur kas paprasčiau, tam dažnai nereikia net bazinių programavimo žinių. Tačiau kartu tokios atviros galimybės kiekvienam kurti ir publikuoti interneto žemėlapius sąlygoja jų kokybės problemas. Reikiamų funkcijų trūkumas ar nereikalingų perteklius, per daug apkrauta, sudėtinga grafinė naudotojo sąsaja, nepriimtinas ar neaiškus grafinis stilius – tai problemos su kuriomis susiduriama naudojant interneto žemėlapius. Šios problemos nėra technologinio pobūdžio, todėl jų išspręsti vien tobulinant programinį kodą, ar kompiuterinę technologiją nepavyks. Todėl informacijos apie interneto žemėlapių funkcionalumo pritaikymą skirtingoms naudotojų grupėms bei skirtingiems žemėlapių tipams identifikavimas tampa svarbiausiu klausimu, sprendžiant interneto žemėlapių kokybės problemas.

Tyrimų metodologijos ir priemonių, kurių taikymas leistų nustatyti interneto žemėlapių kokybę bei funkcijų realizacijos ir naudojimo patogumo trūkumus vadovaujantis naudotojų poreikių analize, aktualumas kartografijos, geografinių informacinių sistemų kūrimo srityse yra itin didelis. Aktualumą pabrėžia ne tik poreikis gerinti interneto žemėlapių kokybę, bet ir tobulinti šiuolaikinės kartografijos teorijos bei tyrimų praktikos pagrindus. Kaip atskleidė atlikta interneto žemėlapių tyrimų praktikos analizė, dažniausiai funkcionalumui bei naudotojų poreikiams tirti taikomi bendrieji kompiuterinių sistemų kūrimo ir naudojimo reikalavimai, pvz. naudotojo-kompiuterio sąveikos, į naudotojo orientuoto dizaino. Tačiau žemėlapių ir bet kurio kito interneto turinio ar programos naudojimo, informacijos įsisavinimo principai nėra tapatūs. Atitinkamai skiriasi ir naudotojų poreikiai. Dėl šių priežasčių interneto žemėlapiams tirti pritaikytos metodologijos bei priemonių sukūrimas tampa vienu iš prioritetinių, tačiau dar neišspręstų kartografijos mokslo uždavinių. Šio uždavinio sprendimas praturtintų

turimas kartografijos teorijos žinias apie interneto žemėlapių kokybę bei naudotojų poreikius, o kartografinių tyrimų praktika būtų pritaikyta specializuotiems interneto žemėlapių funkcionalumo tyrimams vykdyti. Kad šios problemos sprendimas išties aktualus pagrindžia ir Tarptautinėje kartografų asociacijoje įkurtos net trys komisijos, kurių veikla siejama su interneto žemėlapių kokybės tobulinimu (interneto žemėlapių, žemėlapių naudojimo ir naudotojų klausimų, geovizualizacijos).

Jeigu analoginių žemėlapių atveju kokybę galime apibrėžti per grafinių ir informacinio turinio savybių vertinimą, tai interneto žemėlapių vertinimas turi apimti funkcijų realizaciją bei naudojimosi patogumą. Internetinio žemėlapio kokybė - integralus vertinimo matas, kuris gali priklausyti nuo žemėlapio paskirties, technologinių savybių, tyrėjo kompetencijos, pasirinkto tyrimų metodo. Dėl šios priežasties kyla poreikis apibrėžti interneto žemėlapių kokybės sampratą, jos vertinimo kriterijus ir rodiklius, kuriais vadovaujantis tyrėjai (kartografai, žemėlapių sudarytojai) galėtų įvertinti kuriamų ar jau sukurtų žemėlapių atitikimą kokybės reikalavimams. Reikalinga vieninga vertinimo sistema, kuri užtikrintų ne tik priemones interneto žemėlapių kokybės kontrolei vykdyti, bet ir taptų žemėlapių kokybės rekomendacijų šaltiniu.

Taigi siekiant užtikrinti aukštą interneto kartografijos produkcijos kokybę du svarbiausi prioritetai yra:

- Šios srities tyrimų metodologijos teorinio pagrindo suformavimas;
- Praktinių tyrimo priemonių, aktualių interneto žemėlapių kūrėjams, naudotojams bei jų tyrėjams (kartografams), sukūrimas.

### **Tyrimų objektas**

Disertacinio darbo tyrimų objektas *plačiąja prasme* - interaktyvūs interneto žemėlapiai ir jų sistemos. Tyrimų objektas *siaurąja prasme* – interneto žemėlapių geografinės informacijos valdymo funkcijų kokybė.

### **Darbo tikslas ir uždaviniai**

Atsižvelgiant į šiuolaikinėje kartografijoje kylančias interneto žemėlapių kokybės užtikrinimo, funkcionalumo bei naudotojų poreikių tyrimų problemas, apibrėžtas

disertacinio *darbo tikslas* – sukurti kompleksinę interaktyvių interneto žemėlapių funkcionalumo tyrimų metodologiją.

Darbo tikslo įgyvendinti reikalingi kompleksiniai teoriniai (metodologiniai) bei praktiniai sprendimai. Turi būti atlikti žemėlapių ir naudotojų poreikių tyrimai, kurių reikia metodologijai pagrįsti. Taip pat turi būti sukurtos technologinės priemonės, skirtos tokiems tyrimams vykdyti. Darbo tikslams įgyvendinti išskirti metodologiniai ir taikomieji uždaviniai.

Disertacinio darbo *metodologiniai uždaviniai*:

1. Susisteminti ir įvertinti interaktyvių interneto žemėlapių funkcionalumo tyrimuose iki šiol taikytus metodus;
2. Sukurti interaktyvių interneto žemėlapių funkcijų realizacijos efektyvumo vertinimo metodiką;
3. Atlikti skirtingos paskirties interaktyvių interneto žemėlapių funkcijų realizacijos analizę;
4. Sukurti interaktyvių interneto žemėlapių funkcijų naudojimo efektyvumo vertinimo metodiką;
5. Sukurti kompleksinę interaktyvių interneto žemėlapių funkcionalumo kokybės vertinimo sistemą.

Disertacinio darbo *taikomieji uždaviniai*:

1. Sukurti programines interaktyvių interneto žemėlapių naudotojų poreikių tyrimo priemones funkcionalumo reikalavimams nustatyti;
2. Sukurti programines priemones interaktyvių interneto žemėlapių funkcinės kokybės kompleksiniam vertinimui atlikti;
3. Atlikti interaktyvių interneto žemėlapių naudotojų poreikių tyrimą;
4. Atlikti sukurtos metodologijos ir tyrimo priemonių taikymo praktikoje galimybių analizę;
5. Parengti funkcinės kokybės rekomendacijas skirtingo tipo bei skirtingoms tikslinėms naudotojų grupėms skirtiems interaktyviems interneto žemėlapiams.

## Darbo naujumas ir reikšmė

Darbo naujumą ir jo reikšmę išreiškia šios jo savybės:

- Pirmą kartą kartografinių tyrimų praktikoje sukurta interneto žemėlapių tyrimų metodologija, apjungianti funkcijų realizacijos ir naudojimo efektyvumo tyrimo metodikas (kurios taip pat yra darbo dalis) į bendrą tyrimų priemonių kompleksą, skirtą įvertinti interneto žemėlapių kokybę;

- Pritaikius kvalimetrinio vertinimo principus, sukurta interneto žemėlapių kokybės kiekybinio vertinimo sistema. Šios vertinimo sistemos išskirtinumas – ekspertų ir naudotojų sociometrinių tyrimų rezultatų pritaikymas interneto žemėlapių funkcijų santykinės svarbos koeficientams apskaičiuoti bei reprezentacinių žemėlapių funkcionalumo analizės rezultatų pritaikymas vertinimo kriterijams ir rodikliams suformuoti;

- Sukurta interneto žemėlapių naudotojų poreikių tyrimų ir analizės programa CartoUI ([www.cartoui.com](http://www.cartoui.com)). Ši programa realizuoja unikalią ir kartografinių tyrimų praktikoje iki šiol netaikytą tyrimų metodiką – suteikia galimybę tyrimo dalyviams savo reikalavimus interneto žemėlapių funkcijoms bei grafinei naudotojo sąsajai pateikti patiems interaktyviai kuriant žemėlapius. Toks tyrimų metodas yra žinomas kitose mokslo srityse (pvz. architektūroje, urbanistikoje, kompiuterinių sistemų kūrime), tačiau kartografijoje dar nebuvo pritaikytas. CartoUI programa – tai nuolat veikianti naudotojų poreikių tyrimų sistema, kuri kaupia naudotojų poreikių informaciją duomenų bazėje ir suteikia įrankius atlikti šių duomenų analizę;

- Pritaikius sukurtą funkcionalumo tyrimų metodologiją parengtos detalios rekomendacijos skirtingo tipo bei skirtingoms tikslinėms naudotojų grupėms skirtiems interneto žemėlapiams kurti;

- Atlikta pastaruosius du dešimtmečius įvairiose pasaulio šalyse vykdytų interneto žemėlapių tyrimų apžvalga, kurios metu buvo išskirti ir detalios aprašyti interneto žemėlapiams tirti naudojami metodai. Atlikta išskirtų metodų kritinė analizė. Pirmą kartą pateikiama susisteminta kritinė interneto žemėlapių tyrimų apžvalga papildo šiuolaikinės kartografijos teoriją naujomis žiniomis.



## **Ginamieji teiginiai**

Darbo tyrimų kryptis atskleidžia šie *ginamieji teiginiai*:

1. Taikant autoriaus sukurtą interaktyvių interneto žemėlapių funkcionalumo tyrimų metodologiją **galima kompleksiskai ištirti** konkretaus žemėlapio funkcijų realizacijos ir naudojimo efektyvumą;

2. Kvalimetrijos principais pagrįsta funkcionalumo vertinimo sistema suteikia galimybę **nustatyti bendrą tiriamo žemėlapio funkcionalumo kokybę**, kiekybiškai įvertinant jo funkcionalumo pritaikymą naudotojų poreikiams;

3. Pirmą kartą pasiūlytas interneto žemėlapių kokybės tyrimų metodas, įtraukiantis naudotojus į kūrimo procesą ir leidžiantis išreikšti jų nuostatas per grafinę žemėlapio kūrėjo sąsają. Suteikus galimybę tyrimo dalyviams savo **reikalavimus interneto žemėlapių funkcijoms pateikti patiems interaktyviai kuriant žemėlapij**, galima gauti informacijos apie jų poreikius, kuri yra daug vertingesnė už informaciją, gautą atlikus konkretaus žemėlapio patogumo naudoti tyrimus. Autoriaus sukurta tyrimų sistema yra lanksti, plečiama, pritaikoma besikeičiančioms informacinės aplinkos sąlygoms, leidžia kaupti ir naudoti duomenis apie naudotojų poreikius įvairiais aspektais, ilgą laiką;

4. Reikalavimai interneto žemėlapių funkcijų realizacijos ir naudojimo savybėms nuolat kinta laike ir priklauso nuo žemėlapio paskirties bei tikslinės naudotojų grupės savybių (amžiaus, lyties, naudojimosi žemėlapiais patirties). Vis dėlto, naudojantis sukurta metodologija, konkrečiu laiko momentu **pagrindiniai funkcionalumo reikalavimai gali būti vienareikšmiškai apibrėžti ir įgyvendinami**.

## **Rezultatų aprobacija**

Darbo tema paskelbti 8 straipsniai recenzuojamuose mokslo leidiniuose. Darbo tyrimų rezultatai pristatyti 10 tarptautinių mokslo konferencijų (7 iš jų vyko užsienyje). Detalus su darbo tema susijusių publikacijų bei dalyvautų konferencijų sąrašas pateikiamas prieš naudotos literatūros sąrašą.

Už straipsnį „The Possibilities for Functionality Research on Interactive Internet Maps“ 2011 m. gautas Tarptautinės kartografų asociacijos apdovanojimas. Lietuvos mokslų taryba 2012 m. skyrė skatinamąją stipendiją už akademinis pasiekimus.

Disertacinio darbo tema autorius veda kviestines paskaitas bei praktinius užsiėmimus: „Modernieji kartografavimo metodai“, „Interneto žemėlapių kūrimo technologijos“. Paskaitos ir praktiniai užsiėmimai vedami Vilniaus universiteto Geografijos bakalauro (Teminė kartografija, 3 kursas) ir Kartografijos magistro (Kartografinės komunikacijos pagrindai, 1 kuras, praktinis užsiėmimas; Kartografinės informacijos sklaidos internete, 1 kursas) studijų programų studentams.

### **Darbo apimtis ir struktūra**

Darbas sudarytas iš šių pagal Lietuvos mokslo tarybos 2003 m. nutarimą Nr. VI-4 rekomenduojamų pagrindinių dalių: įvado, tyrimų apžvalgos, darbo metodologijos, tyrimų rezultatų, išvadų, naudotos literatūros sąrašo ir priedų. Darbe yra 29 iliustracijos, 15 lentelių, išnagrinėti ir naudoti 88 literatūros šaltiniai, 17 interaktyvių interneto žemėlapių. Visą darbą sudaro 255 puslapiai (216 puslapių pagrindinio teksto ir 39 puslapiai priedų).

## **IŠVADOS**

### **Teorinės išvados**

1. Kompleksinė interaktyvių interneto žemėlapių tyrimų metodologija turi apimti tiek funkcijų realizacijos (technologinių galimybių), tiek funkcijų naudojimo efektyvumo (taikymo galimybių) kokybės vertinimą.

2. Interaktyvių interneto žemėlapių funkcijų realizacijos kokybės vertinimą tikslinga vykdyti nustatant funkcijos teikiamas galimybes geografinių duomenų peržiūros, analizės, valdymo veiksams atlikti bei įvertinant jos reikalingumą naudotojams.

3. Interaktyvių interneto žemėlapių funkcijų naudojimo efektyvumo kokybės vertinimą tikslinga vykdyti nustatant kaip funkcijos grafinės savybės žemėlapių

naudotojo sąsajoje (funkcijos įrankio fono, teksto spalva, dydis, meniu, kuriame ji pateikiama, tipas) atitinka naudotojų keliamus reikalavimus bei jų poreikius.

4. Sukurta interaktyvių interneto žemėlapių funkcijų realizacijos tyrimo metodika, leidžia objektyviau, negu iki šiol nustatyti funkcijų teikiamų galimybių technologinio įgyvendinimo lygį bei įvertinti, kaip kintant funkciją realizuojančių įrankių savybėms, kinta jų taikymo efektyvumas, kompleksiskumas bei interaktyvumas.

5. Sukurta interaktyvių interneto žemėlapių funkcijų naudojimo efektyvumo tyrimo metodika, suteikia galimybę įvertinti konkrečių funkcijų svarbą naudotojams bei šių funkcijų naudojimo savybių (funkcijų sąsajos grafinio dizaino, padėties grafinėje naudotojo sąsajoje, interaktyvumo, intuityvumo) efektyvumą.

6. Naudotojų poreikių tyrimą vykdant ne per iš anksto nustatytą interneto žemėlapių naudojimo atvejų išbandymą konkrečiuose žemėlapiuose, o suteikiant galimybę naudotojui pačiam interaktyviai susikurti pasirinkto tipo interneto žemėlapių sąsają, galima iš karto apibrėžti apibendrintus pasirinktos naudotojų grupės reikalavimus funkcionalumui, juos verifikuoti ir įgyvendinti.

7. Sukurta originali interaktyvių interneto žemėlapių funkcionalumo kokybės vertinimo sistema, kuri realizuota remiantis kvalimetrijos principais ir atliktų trijų tyrimų: (a) naudotojų poreikių, (b) ekspertų sociometrinio ir (c) funkcijų realizacijos efektyvumo – rezultatais. Ši sistema tyrėjui leidžia konkrečiame laiko-technologiniame kontekste objektyviai įvertinti tiriamo žemėlapių funkcionalumo atitiktį naudotojų poreikiams, identifikuoti konkrečius žemėlapių funkcijų realizacijos ar naudojimo efektyvumo privalumus ir trūkumus.

## **Praktinės išvados**

1. Skirtingo tipo interaktyvių interneto žemėlapių funkcionalumo kokybės tyrimo rezultatai atskleidė, kad funkcijų realizacijos ir naudojimo efektyvumas kinta priklausomai nuo žemėlapių paskirties. Taikant sukurtą metodologiją atliktas trijų tipų (peržiūros, analizės bei valdymo tipo), 8 žemėlapių funkcionalumo vertinimas išryškino pagrindines skirtingo tipo žemėlapių funkcionalumo kūrimo tendencijas: a) aukščiausi funkcionalumo kokybės vertinimai yra tų funkcijų, kurių paskirtis tiesiogiai atitinka

žemėlapių taikymo paskirtį, b) bendrai visuose tirtuose žemėlapiuose efektyviausiai realizuojamos bazinės geografinių duomenų peržiūros ir identifikavimo galimybės, c) žemėlapių tikslinės paskirties funkcijoms tampant sudėtingesnėmis, bendra žemėlapių funkcionalumo kokybė mažėja;

2. Skirtingų interaktyvių interneto žemėlapių naudotojų grupių poreikių tyrimo rezultatai atskleidė, kad naudotojų amžiaus, lyties bei naudojimosi žemėlapiais patirties savybės turi įtakos jų keliamiems reikalavimams funkcionalumui. Priklausomai nuo šių naudotojų savybių kinta žemėlapių funkcijų aibės dydis (pvz. naudotojų, kurie žemėlapius naudoja kartą per savaitę ir rečiau, poreikiams realizuoti vidutiniškai reikia 15 funkcijų, o naudotojams, kurie žemėlapius taiko kur kas dažniau – užtenka 11), funkcijų paskirtis (pvz. moterims du kartus dažniau reikia žemėlapių grafinės sąsajos keitimo funkcijų nei vyrams, atitinkamai 32 proc. moterų ir 15 proc. vyrų), reikalingiausios funkcijos (pvz. naudotojams iki 25 m. svarbiausios mastelio keitimo, kartografinio vaizdo navigacijos, tuo tarpu vyresniems nei 35 m: objektų paieškos ir objektų informacijos identifikavimo funkcijos);

3. Sukurtos interaktyvių interneto žemėlapių funkcionalumo tyrimų metodologijos taikymo praktikoje atvejo analizės rezultatai patvirtino, kad yra tikslinga šią metodologiją taikyti skirtingo tipo interneto žemėlapių funkcionalumui vertinti, naudotojų poreikiams tirti, informacijai apie kuriamam žemėlapiui keliamus funkcijų realizacijos ir naudojimo efektyvumo reikalavimus gauti.

4. Taikant sukurtą interaktyvių interneto žemėlapių funkcionalumo tyrimų metodologiją pavyko parengti konkrečias į žemėlapių kūrimo procesą orientuotas funkcionalumo rekomendacijas skirtingo tipo (11 rekomendacijų) bei skirtingoms tikslinėms naudotojų grupėms (8 rekomendacijos) skirtiems žemėlapiams.

5. Taikant sukurtą specializuotą naudotojų poreikių tyrimų programą CartoUI pavyksta gauti statistinę informaciją apie naudotojų poreikius skirtingo tipo, paskirties žemėlapių funkcionalumui bei atlikti jų daugiakriterinę analizę. Paprastas šios informacijos gavimas žemėlapių kūrėjams taupo kaštus, kurie susidarytų atliekant tyrimus naudojant klasikinius metodus (apklausos, grįžtamojo ryšio). Naudotojų

poreikių informacijos pateikimas konkrečių žemėlapių funkcijų lygmenyje leidžia detaliai apibrėžti naudotojų reikalavimus bei tiesiogiai juos pritaikyti žemėlapių kūrimo procese.

### **Bendras tyrimų rezultatų vertinimas (diskusija)**

Interneto žemėlapių funkcijų realizacijos bei naudojimo efektyvumo tyrimų metodų kritinė analizė atskleidė, kad pagrindinės šiuo metu kartografijos tyrimų praktikoje naudojamų metodų problemos yra susijusios su: brangia tyrimų realizacija, ribotomis galimybėmis tyrimus taikyti pradiniam žemėlapių kūrimo etape, ryškia orientacija į konkrečių programų vertinimą ir tuo sąlygojamą rezultatų taikymo siaurumą, naudotojų poreikių ir patirties vertinimų stoka. Apibendrintai galima teigti, kad šiuo metu tyrimų praktikoje vyrauja metodai, kurie sukoncentruoti siauros specializacijos ir apimties tyrimams vykdyti.

Autoriaus sukurta kompleksinė interneto žemėlapių funkcionalumo kokybės vertinimo metodologija, kuri apima išskirtas pagrindines geografinės informacijos valdymo funkcijas ir kokybės vertinimo kriterijus, yra pirmas žingsnis į vientisą interaktyvių interneto žemėlapių teoriją. Šią metodologiją galima lengvai plėsti, pritaikyti atsižvelgiant į besivystančios technologinės ir informacinės aplinkos poreikius. Sukurta veikianti naudotojų poreikių tyrimo ir analizės programa CartoUI suteikia galimybę ne tik vykdyti specializuotus interneto žemėlapių naudotojų poreikių tyrimus, bet ir gauti statistinę informaciją apie skirtingų naudotojų grupių poreikius, juos analizuoti skirtingais pjūviais, vertinti naudotojų reikalavimus skirtingo tipo žemėlapiams. Ši informacija gali būti lengvai pritaikyta interneto žemėlapių kūrimo procese, reikalavimų specifikavimo stadijoje.

Žemėlapių kūrėjai gali pasinaudoti CartoUI programa viešai ir nemokamai – ne tik specialiam tyrimui surinktais, bet ir nuo sistemos gyvavimo laiko pradžios sukauptais duomenimis. Tai leidžia sutaupyti kaštus, kurie susidarytų atliekant tyrimus naudojantis anksčiau įprastais metodais (apklausos, grįžtamojo ryšio, konkrečių pavienių žemėlapių tyrimais).

Tolesnės šios srities tyrimų kryptys ir praktiniai veiksmai galėtų būti tokie:

1. Galima atlikti platesnį jau sukurtų skirtingų tipų interaktyvių interneto žemėlapių tyrimą siekiant patikslinti ir, jei prireiks, papildyti kokybės vertinimo rodiklių sąrašą bei atnaujinti jų santykinės svarbos koeficientus.

2. Ateityje reiktų nuolat kaupti duomenis CartoUI programoje. Didėjant tirtų asmenų skaičiui galima patikimiau įvertinti naudotojų poreikius ir pastebėti jų statistinius pokyčius.

3. CartoUI programa gali būti efektyviai pritaikyta interneto kartografijos edukacijos procese kaip priemonė, kurią taikant galima sužinoti, kokie pagrindiniai elementai sudaro interneto žemėlapius, kaip jie apjungiami tarpusavyje, kokios šių elementų savybės.

4. Galima periodiškai viešai skelbti duomenis apie aktualius naudotojų poreikius, kad tomis žiniomis galėtų pasinaudoti visi interneto žemėlapių kūrėjai.

5. Reikia skatinti profesionalius interneto žemėlapių kūrėjus vertinti jų sukurtų produktų kokybę naudojant parengtą metodologiją. Mokymo tikslams kuriamų interaktyvių interneto žemėlapių funkcionalumo kokybę turėtų vertinti ekspertai ir aprobuoti prieš pradėdant juos naudoti.

Tam, kad sukurta interaktyvių interneto žemėlapių funkcionalumo tyrimų metodologija liktų gyvybinga, reikia bendradarbiauti su ją taikysiančiais tyrėjais ir su poreikių tyrimų sistemos CartoUI naudotojais. Jų komentarai gali padėti greitai pastebėti pakeitimus vertinimo sistemoje ar metodologinius netikslumus.

## **CURICULUM VITAE**

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