Modeling of communication in WebGIS for dissemination of spatial data and promotion of spatial analysis.

Sheyla Aguilar de Santana[1]
Ana Clara Mourão Moura[1]

[1] Universidade Federal de Minas Gerais - IGC – Lab. de Geoprocessamento
shesantana@gmail.com, anaclara@ufmg.br

ABSTRACT

This work aims to support the dissemination of geographic information through a system that is available on the World Wide Web. As we are talking about the dissemination of information, it is interesting that the largest group of people have access to that system. In order to have human-computer interaction, it is necessary to use interfaces and interactivity. For this system to be accessible and interactive, he must be able to be communicative in the sense of having elements that decode the language specialist -> end user. Thus, to achieve the system development, this paper makes a review of the processes of communication and interactive human-computer, a review of accessibility, interaction and communicability to be able to achieve the application goal. In the sequence, it is possible to understand the steps taken to create the software. Once studied communicational phenomena, the application is modeled with data from Brazil and Italy. With the prototype we could make test for functionality, usability and multi-access to verify the theory of human-computer interaction really achieved a large group of users.

1. Contextualization

With the exponential growth of people who are connected to the worldwide network of computers, the World Wide Web has become a very important vehicle for dissemination of information for everyone. The most basic form of dissemination in the context of geospatial data, are WebMaps. According to Ramos (2005), from the concept of hypertext, the hipermapas emerged, defined as interactive digital maps, which allow the user to access a series of georeferenced information through links. Technological advances resulted in a new map in which the products are organized more quickly and interaction is almost in real time. Starts up the period of multimedia cartography. The design of interactive multimedia and hypermedia was introduced to refer to the media combined with the structure of interactive links. The emphasis changes from "static" to "dynamic". With this, the media has become the interface of communication between sender and recipient of information, interaction and the key to the formation of knowledge. "Systems are becoming interactive ways to communicate the endless spatial information" (Rijken, 1996, p.37).
The Webgis then can be understood as a system for providing construction and mapping using the interface of the Internet. It seeks to solve the difficulty of taking the information from point to point, or decode the information specialist for the end user. Modeling communication was here an important tool to study and understand how the different types of users use Web browsers and how they decode the information generated within the GIS. With this, you can create geographic information systems

with interfaces to high level of communication and usability and ready to be published on the internet.

2. COMMUNICATIONS MODEL

Within the context of mapping and communication models, the maps arise as important means of communication to provide the user information about spatial phenomena duties of support for decision making and spatial analysis. The role of communication beyond the maps are used as tools for visual analysis, the process called cartographic visualization (International Cartographic Association, 2001). From simplified, means use of visualization methods for graphical analysis and presentation of data (DiBiasi et al, 1992).

The use of maps as a means of communication, there are three elements involved: the cartographer as the transmitter, the map as a channel of transmission, the end user as a receiver. The first model for cartographic communication assumes that there must be an overlap of the realities of cartographers and users so that they understand the significance of representations of information. For the preparation of a map, the cartographer says the world about their perspective and represents the map. The user draws a map of this message. What the map can communicate efficiently, we must evaluate all the conditions of influence in this process, ie the needs of the user, means of presentation, the level of understanding of users, the fact of use, the perception of the user, possibility of techniques and their costs than the complexity of information. Added to these concerns, the process involves two stages: the appearance and form and content in the second stage the details, such as the symbology used.

As the map on paper could not meet all users due to different levels of knowledge and perceptions, will begin a new stage in the process of cartographic communication:

> *"The computer, which until recently was used to automate the production of maps on paper, begins to incorporate a form of interactive mapping and becomes, in this case, not only a means of producing maps, but a means of communication . '(Peterson, 1995, p. 147)*

The interactive maps, or using any media, were seen as a new way to manipulate the information so that the characteristics and phenomena of the real world would be better perceived:

> *"Maps on paper can only represent a world in a static and immutable, the mental representations that are derived from it define the user's interaction with reality." (Peterson, op.cit., P.20)*

As the user can change the map to bring it to their perception of the world, the map is no longer a static and becomes an Open Work, turning into an interactive presentation and controlled by the user. In this theory of Open Work applied in cartographic, the systems are open and the information provided in a communication are not as a fixed and settled, but as a proposal of meaning that the interpretation will be given by each in different ways. Within the Open Work, the code is not hidden, or allows the continued construction by others who want to incorporate the project. Everyone can manipulate information the way you want to understand the information in the system. In order to

make systems that is communicative, functional and accessible, it's need to develop a system with as friendly interface and strong human->computer interaction.

3. INTERFACE AND INTERACTION

According to Leite (2000) believes that a man-machine interface is part of an artifact that allows a user to monitor and evaluate the operation of sensitive devices through their actions and able to stimulate their perception. In the process of interaction the user-interface system is the combination of software and hardware needed to enable and facilitate the processes of communication between the user and application. The Common Front Group (1995), an interface design is a combination of art and science. Moreover, it needs to rely on aspects of cognition to your efficiency is full. Another important factor in the design of interfaces is to ensure consistency of application with the use of icons, the name of the functions, location of buttons in different windows always the same, etc.. Some of the important elements in the composition of an interface are: communication and interactivity, navigability and usability, accessibility and applicability.

3.1. Interactive

The concept of objectivity (Souza, 2005) refers to the correct dialogue, through the interfaces, the message from the designer about what the system (which may be a website, a computer program, a video game or interface of the mobile phone), and make clear that this system serves, for whom it is intended, how it works, etc.. The assumption underlying the concept of objectivity is that if a user understands the decisions that the designer has to build the interface, increasing your chances to make good use of that system.
The interaction then becomes an essential factor for which there is a proper dialogue with the user's system. According Makedon (1994, p.41) is the interactivity that "*puts you in control of the system, manipulating the media in several different modes of interaction."* And that will allow the cooperative multiple authors.

3.2. Airworthiness and Usability

It is common, it is the concept of usability, the use of the term "easy to use." It is common understanding that "easy to use" readily be confused with "less clicks to get to an expected response." In short, people confuse architecture with usability of information.
Usability is the technical term used to describe the quality of use of an interface (Bevan, 1995). This is an important quality because it interfaces with usability of users increase productivity, reduce errors and the occurrence (or its severity) and, not least, contribute to the satisfaction of users. Satisfaction is an important criterion, but not the only, to determine the overall quality of application. In general, this is a criterion for the end user purchases a software or regularly visit a site.
Navigability and usability are the same concept, that is: the degree of ease that you may have in contact, maintain interest, navigation and use of hypermedia, ranging from the use of icons, and menus to search by keyword key.

3.3. Accessibility

Accessibility is the term used to describe the usability problems encountered by users with special needs, such as users that have some type of visual or hearing difficulty. Accessibility involves making an interface usable by anyone, regardless of any physical, sensory, cognitive, condition of employment or technological barriers. Accessibility and usability are closely related concepts, as both seek to improve satisfaction and efficiency of use of the interface. However, accessibility refers to a population far broader and more generic.

3.4. Applicability

The applicability of a system also determines the quality of use. This concept is related to the usefulness of this system in a variety of situations and problems (Fischer, 1998). This concept determines how the system is useful for the context in which it was designed and in other contexts that the system can be useful.

4. ROADMAP FOR THE METHODOLOGICAL MODELING A WebGIS.

After studying the most important elements to make a system with a strong human-computer interaction, we are going to develop a system accessible to a large group of people and publish it in the internet. If this application can have a strong human computer interaction through an interface with the main important elements in communication, this could be the beginning of the globalization of information, developing a single database for the dissemination of spatial information. We divided the development in three parts. The first one was the understanding of what is necessary in a system. What people want to be able to do in the application, which tools the system should have and other operational questions.

4.1. Operational Level:

In this stage define what users would like in an application of GIS on the Internet, which the visual characteristics of these elements so that they are communicative, what are the advantages and difficulties to tinker with software already on the market, etc.. The procedure is divided into three steps: definition of tools, building the interface and an indication of the analysis of interest to be covered by the system.

4.1.1. Tools: To determine which tools would be needed within the application, we selected twenty-seven people with different abilities in using the computer and the Internet to answer a questionnaire and do some practical tests to assess where the difficulty of handling. In the first questionnaire people responded what tools they use most when working in display systems, such as photos' systems, then what are the main tools when it comes to maps. These data were tabulated and define the tools for the system. Once defined the tools, the twenty-seven people answered to another questionnaire in which they had to draw what the main graphic that came into his head to represent the tool button. That for the system to be built by different users and is easy to manipulate when in the Internet. In the final step, these users use different applications to test if the symbols chosen were actually communicative. For basic use of tools, the buttons were set to zoom, pan, refresh, fit view, information. For interactive tools, were defined: measure words, measure area, consult the database, insert xy, insert graphics, insert text, lens, interface with Scielo (Scientific Electronic Library Online),

interfacing with Google Earth, 3d models, interface with servers and printing photos of thematic maps.

4.1.2. Interface: To be defined as the interface was also selected a group of thirty people with different knowledge about the use of computers and the Internet. They discuss everything related to layout, for example, where the tools should be located where the menus should be located, what the characteristics of the caption should be open, or which of these features the user can customize according to their interests. This discussion was made through two tests: a questionnaire asking about their preferences and other test by checking the response time of users on different interfaces. The result will be in the implementation part. The menu system was very well received by all users. The top menu bar were easily accessible resembled almost all software available in the market today, as was seen in the tests. In the legend the items listed are: Opacity, New name, Find, Test, Labels, Filter, Table, Chart, Edit Legend.

4.1.3. Analysis: In this step a group of four experts answered a questionnaire saying what would be the minimum territorial analysis. Were cited the analysis of territorial area of influence such as centroid, buffer, groups, dissolves, and distance between points and query by attribute space. Because the application was tested in both operating systems, Windows and Linux, the application that runs on Linux family has more than one tab is the "analysis". This view is responsible for developing tools of map algebra. This tool allows you to complete the algebra of maps with images and the crossing matrix in order to reach the synthesis maps. This tool uses the mathematical algorithm of the software Grass adapted to the application.

4.2. Interface Costumization

The interface was chosen, based on tests of communicability that would be a clean interface, in which most of the screen was available for viewing on the map (Figure 3)

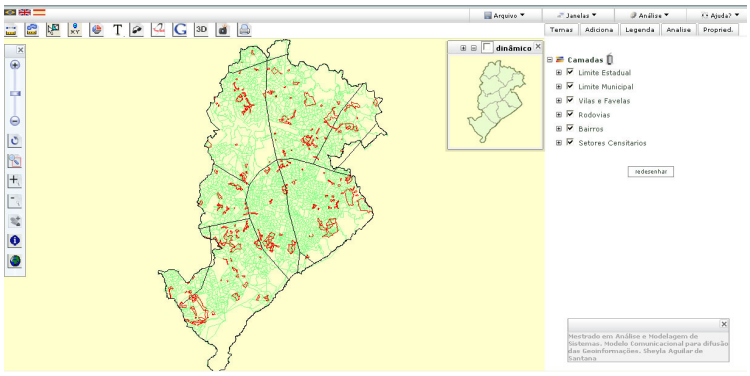

Figure 3 - Interface customized.

In this custom interface, the basic toolbar is positioned in the left corner of the screen, the interactive tools on the top bar and the area for manipulation of layers on the right side of the screen. There are two tabs available from the control layer. The tab "add" is responsible for the download and upload files and tab "legend" for displaying the components of the legend of the issues visible. For the application on Linux, there is a third one for analysis where it will be possible to map algebra.

For the interface elements to be customized by users, the tab "Properties" was prepared as follows (Figure 4):

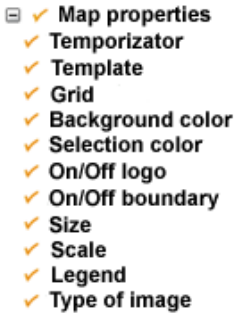

Figure 4 - Proposal for customization of the properties of the map.

As the legend is an item that has received much attention by all users, it can be customized individually, as the desires of view of each User. The proposal is that by opening the little arrow down, available four squares that means: if the scale of the theme is compatible with the map, delete topic, up and down the layer and zoom the layer (Figure 5).

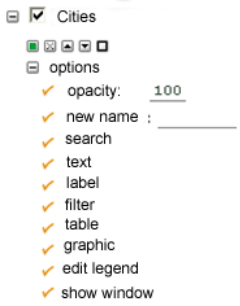

Figure 5 - Proposal of elements to be customized for User home.

Tests made in the operational phase to the creation of two toolbars. One of the basic uses and another for interactive use. After testing the communicability of the icons and their positions, the tool deployed is illustrated in Figure 6.

Figure 6 - Basic Tools

For toolbar with elements defined as more interactive and different from usual in many applications were made to better assess which of these were of interest to keep the prototype. The tools were implemented in Figure 7:

Figure 7 - Interactive Tools

As we are dealing with tools that will actually be judged for their interactive capabilities, each one must have some kind of way to attract the User and at the same time facilitate its usability, even for users who are wont to use geoprocessing applications. All tools included in the prototype passed a test with twenty-seven users to evaluate not only what the best imaging, but also what was the best way to put the tool available for it to be used without major difficulties. All tools described are designed to suit the users' suggestions and correcting some errors noticed by the media masters degree - on the usability - while using some software that provide the same tools. For all tools, it became clear that the best available is by opening a dialog box explaining and showing the steps to be followed by the User for its correct use (Figure 8).

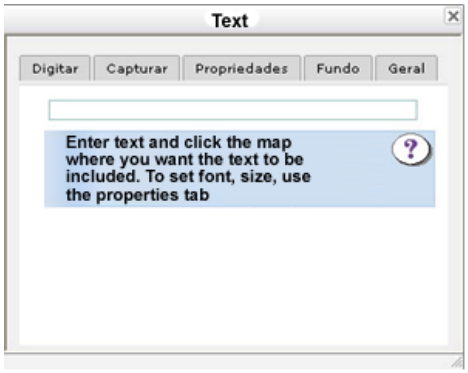

Figure 8 - Example of tool that uses the dialog box.

The application was completed in the development and parameterization of the interface and tools with the End User. From there began the steps of communicability testing and usability testing of empirical evaluation, performed in the laboratory to have more control over final results, the importance of which was discussed in the previous item.

After the establishment of systems to different servers and operating systems has been selected a user group of thirty people from different areas of knowledge and with different degrees of knowledge about the use of computers and the Internet. These two tests were aimed to collect quantitative and qualitative information for the improvement of WebGIS.

5. Case Studies:

The first case study for the construction of the prototype is the city of Belo Horizonte, as well as being an area with a large range of information available, is a city that is growing very much in the GIS and also of urban growth. In this sense, to plan, you need

to know. In order to provide a tool to aid decision making, the system is being developed for the city of Belo Horizonte.

With the ease of acquisition of the database, the first prototype was built in Belo Horizonte for the first tests of communicability. These tests were analyzed as were the tools, interface, and other important components of the software.

In a second time, it was decided, as part of project activities Alfa-FARO (Latin America Academic Training - Academic in Rocks and GIS), with the participation of the Federal University of Minas Gerais (BR) and Università degli Studi di Bologna (IT), the organization of three case studies, one of Italy (on the Carrara marble) and two Brazilians (for the portion of the shales in the Middle Jequitinhonha - MG and granites in the region of Candeias - MG).

6. TESTS WITH USERS

Running tests with people at all levels of the hierarchical pyramid of users is the last step provided to validate the software, having the function to identify critical situations in their use. The purpose of these tests is to provide a means of checking individual components in the system proposed by groups of users, and so systematic an average consensus to see if you can create an application communicable and accessible to most users. There are several approaches that are used to evaluate the errors in specific components of a system, such as data entry, parameter passing, network interface, among others (Sommerville, 2000). According to Leite (2000), evaluation or verification of software can be achieved through activities of correction, validation and usability. The software is considered correct when it suits your specifications and can be tested by end users with the proof of the program. The proof of the program is based on controlled laboratory tests to verify the adherence of the software to your specification and formal conceptual definition, described here in the methodological chapter. The validation is to determine if the features, architecture and interface to meet users.

When dealing with software applied to mapping, there are few studies on testing communicability and usability that make use of the practical assessment of the User.

Testing of software includes two important questions:
1. What we want to be tested?
2. How to perform the tests?

The software HealthVis was tested and evaluated by MacEachren (1995) in order to evaluate the interface of a mapping system directed to the analysis of multiple variables with temporal variation. This software has been tested by people with tasks of varying difficulty and aimed to: assess the interpretation of the symbolization of maps and interactive controls, analyze and document the limitations of the application and to characterize the efficiency of the software. The test was controlled in the laboratory.

Following the steps outlined in item 2.8 on empirical evaluations, and based on testing done in software HealthVis, the first step towards the creation of usability testing is to outline the objectives and functions of the test. In this work we have to evaluate three major items of WebGIS: to check the interpretation of the symbolization of maps and interactive controls (communicability), evaluate and document the limitations of the

application (infrastructure) and to characterize the efficiency of the software (usability).

In a second step it is important to define the issues that we want to respond to these tests.

- The use of the software requires some training or prior experience?
- Users see the use of WebGIS as an improvement on the traditional maps?
- What changes should be made in the prototype?
- The application is communicable?
- The application is accessible in terms of usability?
- User beginner will gain knowledge of cartographic concepts to the point of becoming a User intermediate and so on, ie users can change the pattern of knowledge with the encouragement of the application?
- What are the minimum infrastructure for the application to have his best performance?

The third step was to define the tasks to be performed to reach the expected answers. The proposed test for all users was composed of a list of activities to be implemented in the published application on the web. The task list was a little large to be able to assess the three variables in the same test. The tasks performed in the first phase were to assess the interpretation of symbolism, in the second phase to evaluate the usability of tasks running in the application tools, and the third was to evaluate multi-access, response infrastructure hardware to check the settings to have a minimum quality of service to requests sent to the software. Each activity has placed on the test particular relationship with a specific task implemented in WebGIS. The guide was designed to minimize the involvement and presence of the developer to assess whether the language of callouts in the software is adequate, if the icons are communicative, and the ease of use by users. The tests were videotaped so that we can observe the human-computer interaction.

7. USERS

Having defined what would be the script of the tests selected users, which resulted in a group of thirty people. For each group of users defined by Cooper (op. cit), there are 10 participants. These users were classified as follows:

- Novice computer users: They have cartographic knowledge nor intimacy with computer / internet. - This group was composed of merchants, housewives, etc..
- Intermediate users: They have some knowledge mapping and use internet and computer with a regular frequency, but not daily. This group was composed of students of geography, geology, engineering, ect.
- Users: Specialist knowledge in cartographic concepts and use computer and internet as a tool for daily work. This group was composed of professional GIS and information technology.

The first step after selection of users was to instruct them on how to perform the test in order to avoid biased or erroneous results. There was to send the list of activities by e-mail with installation files of three programs on the computer where the test would be conducted and a link directing to one of three servers hosting where the User would make the race. One of the programs sent to the recording of tasks through the webcam, the other records the activities at the screen (tool used in the video production class) and finally a digital timer that will give you cut the time as the task ends to measure time

spent in each activity. This timer generates an Excel table with the record time. Finally, we call a verbal commentary on the use of software, its critical and relevant points, and answers the questions:
1. Do you think the WebGIS meet the proposed objectives?
2. The interface is easy to use?
3. The interface is easy to understand?
4. Dialogues interface - User is self-explanatory?
5. Do you value the environment is exploratory?
6. Do you consider that the layout of the interface helps in the development of activities?

Asked to go all users verbalizing their thoughts during the test run so that the researcher could better understand the features of each User. With the applications of film installed, ask users to begin the timer and begin to perform the tasks. After the completion of each of them gave them a cut of time the stopwatch. After completion of all tasks, the developer responded to the questionnaire was the verbal comments and sent by e-mail all files from the shooting, stopwatch, etc..

Responses to query communicability were obtained by interpreting the behavior of the User to the tasks ahead, through a camera that was filming the whole activity. The answers to usability were obtained by recording the movements on the screen to perform the tasks, checking the weather to carry out an activity, the number of errors and the types of errors. Finally, the test infrastructure was a result of the screen images of users and the response time of hardware, internet link, and other variables for the implementation of actions, to know which operating system, server, link is more appropriate the installation of the software. It is worth noting that for users who do not have much knowledge of computer / internet, the researcher was present for the assembly of the environment for running the test. However, during implementation, the researcher was next to clarify any doubts, but not so close as to take away the freedom of the User.

8. Results

Among the new users it was felt that issues relating to the interpretation of symbols have been successful, since the vast majority was able to find tools and menus at the same speed as the other groups when it was made clear which tool should be used. When the question left clear task, but did not indicate which tool should be used, the percentage of people with reaction "Where?" Increased. The tasks include exploring the WebGIS had many expressions such as "What now?" And "Help". The review said that for users who do not have intimacy with computer and internet would require a prior training to fully use the application, not because of the difficulty of understanding the language, but the lack of knowledge and intimacy with your computer. Comments from members of the group for "confirmed that approximately 80% of people found the application of communicative and simple interface, although not able to finish all the tasks required. Many attributed the difficulty in handling the application with the fact that they do not know about cartographic concepts and often not understood very well that serves the software, capabilities, features, etc.. All ten of this group said that the

environment is exploratory and of great interest to the area of geoprocessing. All agreed the presence of tutorial. The intermediate users resulted in the highest interest in the software and the public able to draw more income potential of a Web GIS application. In the communication were found some flaws in the application, such as lack of tips - tips for use, data without metadata, among others. The analysis by this group was a little more critical towards the tasks of usability. It was felt the strong presence of the expression "OK. Done, "" Go the other way myself! "And" No, thank you. "This last expression bear fruit verbal comments to the effect that it was unclear how the designer would like to perform the task, but the User would prefer to adopt a path that felt easier . The runtime of the tasks was low when it was interpreting the symbols and average when it came to usability testing. With the evolution of the test, the last task, it was noticed that users of this group already had more control over the tool and could lead to the application correctly. The main comment was the verbal testimony of that application is easy to use, the interface is nice and light, and the potential application are very useful for knowledge of an area and for the people who work with decision-making. Many said they started the frequent use of the application and stated that the printing tool thematic maps drawn according to the User's decision is one of the most interesting. There was some suggestion of inclusion of new tools related to geostatistics. Many cited the ease of uploading and downloading of databases as a very good item. The expert group there was a great ease and speed throughout the test. There were a few comments on terminology used, mainly on the analysis, which they considered to be confusing. Positively evaluated the use of explanatory dialog box for each tool. The runtime of the tasks was small, with small errors. This group was able to identify some tools with errors and failures. Almost all users in all the tasks displayed the words "OK, Done.". This group assessed the application as very useful, accessible interface, and highlighted the fact that it is an unfinished work, that is, considered a super positive aspect can use the codes to continue the development from the point tested. This group has made some suggestions as:

• Insert a tool that allows simultaneous viewing of two different maps allowing analysis;
• Save the file in the form of custom XML instead of *. map to facilitate the handling of this option to save the map.
• Consider the safety issue to upload files and text editing.

With the tests was possible to find these answers to the questions posed at the beginning of the chapter:

• The use of the software requires some training or prior experience? When we are talking about User beginner, there must be training for the better handling of the tool.

• Users see the use of WebGIS as an improvement on the traditional maps? A very frequent comment in all groups was the sense that this tool meets the new

concepts and development of multimedia cartography, it allows evolution of analogue maps to interactive maps.

• What changes should be made in the prototype?
- Evaluate the functionality of the tool Scielo
- Place-tips guide
- Check-how to deploy the information security;
-Save the custom map XML
-Changing the terminology in the analysis menu.

• The application is communicable?

Yes, the application had a good response to the tests of communicability. Surely you can not make an application that is fully communicated to all people, not least because communication depends on the experiences of each individual. Anyway, the tests showed a positive response to this item.

• The application is accessible in terms of usability?
For those who have some intimacy with cartography and computer, the applications are accessible and easy to use. The response time for the tasks illustrated this nicely.

• User beginner will gain knowledge of cartographic concepts that could become a broker and so on?
The User beginner would have difficulty in advancing to the intermediate stage is not gain any statement, and it is important to remember that the newcomers have difficulties that make them think about quitting the software. Since the intermediate group have great potential to become a Power User.

• What are the minimum infrastructure for the application to have his best performance?
It was possible to make 20 simultaneous accesses and opening of different sessions to see which set of server and infrastructure best met the application. The deskserver in Italy was what had the worst response, since it bore more than 10 people simultaneously accessing. Windows Server and Linux responded very well to the application. Not been any error page during the tests, but the speed of response to the requests of users varied widely in the three servers. The simultaneous multi-access tests showed that the optimal configuration of hardware is based on a redundant server architecture, application server and a database, as illustrated in Figure 37, and software that is stored on the Windows Server 2003, minimum, or Linux.

The results of the tests it became evident that there are cosmetic problems that delay the implementation of the task or irritate the User but either way the person can still end execution of the activity. Another positive point was the realization that the catastrophic problems (prevent the User finishes executing the task) were more related to people in the group of newcomers and not necessarily the issues related to functionality of the

interface. The problems considered serious (hinders the task), for example, errors in terminology, were revised to fit the application.

9. Conclusions:

The research focused on cartographic visualization is to develop new methods of representation and presentation of geographic information. The International Cartographic Association (ICA), in its recommendations, raises the importance of adding new interactive features.

To achieve the goal, was used as a theoretical base on WebGIS, through literature, emphasizing the issue of interactivity. The theory was able to prove that there is an interest in the mode of presentation of data through the static change to digital. The conclusions drawn from the practice tests were:

• It was clear that the environment of the prototype is easy. This can be verified by the positive responses related to ease of use, present in most of the functions tested. Even without 100% of tasks performed, users identified that the application is user friendly and easy to use.

• The ease of use for assessing the interface is designed to be appropriate for the application. Due to the lack of knowledge of a computer user group interface was designed to minimize the incorrect actions of the User as careful choice of symbolization.

• The requirements for the functions available in the prototype are intertwined with the specific knowledge of users. Beginners just waiting to view the map, brokers hope to make simple queries to the database and expect to find many advanced tools allowing to manipulate the representation of spatial information. All users were assisted in their demands, according to the evaluation of the users.

• It was noted that the application meets the demands interdisciplinary, as users from different fields of knowledge said the WebGIS is a tool that allows the construction of various thematic maps that serve as a suitable tool to perform analysis and regional decision-making and to the open consultation, or explore different combinations of information in order to bring answers to the questions.

Assessing the responses obtained with the users, it was concluded that the prototype achieved its objective of serving as an aid to understanding, utilization and analysis of spatial data for a large number of people. The communication model followed the trends of multimedia mapping software to be concerned with the dissemination of data in an accessible way is an open work. This model could be used in any area of knowledge, whereas spatial analysis from the use of maps are applied to any situation in which the necessary knowledge of the spatial phenomena and their interrelationships, and thus reproducible.

10. Bibliography:

- CARTWRIGHT, William; PETERSON, Michael P.; GARTNER, Georg. **Multimedia Cartography**. Alemanha: Springer, 1999. 343 p.

- COMMOM FRONT GROUP. **Some background on user interfaces.** Disponível em <http://cfg.cit.cornell.edu/cfg/>. Acesso em 28 Jul 2008
- ECO, Humberto. **A obra aberta**. São Paulo, Perspectiva, 1962.
- FAIRBAIN, D.J. The frontier of cartography: mapping a changing discipline. **Photogrammetric Record**. Vol.14, n.84, p.903-915, 1994.
- FISCHER, G. (1998) ."Beyond 'Couch Potatoes': From Consumers to Designers." In: **Proceedings of the 5th Asia Pacific Computer-Human Interaction Conference.** IEEE Computer Society, 2-9, 1998.
- ICA - INTERNATIONAL CARTOGRAPHIC ASSOCIATION – **Penn State University. Commission Overview.** Disponível em: <http://www.geovista.psu.edu/sites/icavis/com_overview.html>. Acesso em 22 maio 2008.
- LEITE, J.C. DESIGN DE INTERFACES DE USUÁRIO. 2000. **Notas de aula de engenharia de Software.** Disponível em: <http://www.dimap.ufrn.br/~jair/ES>.Acesso em: 28 Jul 2008
- MAKEDON, Fillia et all. Issues and Obstacles with Multimedia Authoring. **Proceedings of the EDMEDIA 94**. Educational Multimedia and Hypermedia, 1994. 38-45,. 1994.
- PETERSON, M. P. Elements of Multimedia Cartography. In: CARTWRIGHT, W.; PETERSON, M. P.; GARTNER, G. **Multimedia Cartography** . 1a ed. Berlin: Springer-Verlag, 1999, 343 p.
- RAMOS, C. **Visualização Cartográfica e Cartografia Multimídia: Conceitos e Tecnologias**. São Paulo: ed.UNESP, 2005.
- SOUZA, C. S. 2005. **The Semiotic Engineering of Human-Computer Interaction**. MIT Press, Cambridge, MA. 2005, 257p.