# On-demand map design based on user-oriented specifications

**Laurence Jolivet**
COGIT laboratory, IGN France
Laurence.Jolivet@ign.fr

**ABSTRACT:** Map making includes many tasks that can not be entirely formalized if we include in that creation not only the drawing but also the good transmission of information. In order to improve the message of a map, we propose a process that would help a map designer to make choices on the display. This process has been enclosed in three main Web services that interpret user-oriented specifications into a relevant selection of data and definition of styles to draw a map that meets these specifications.
The initial service is a map specifications service. It aims at completing from the context, the abstract definition of a map: we mean the geographical area, the scale, the type of map, the themes to display and other abstract characteristics. The user needs assistance to build these formal specifications, indeed the notions of map model, data relations, or reading level which are specific terms in cartography are not instinctive. This first service aims at providing this assistance.
The second service aims at interpreting the formal abstract specification of a map yielded by the previous service into data selection and styles definition. We would like to propose a legend that respects cartographic rules within the context of the initial map description. In that objective, we constitute a base of cartographic knowledge readable by computer systems. We rely on the literature as well as on existing maps to propose map templates. Though, predefined layers might not always be accurate enough to manage the constraints from the user specifications. To propose new legends or to improve existing ones, we have to encode in an operational model, principles of cartographic theory, definition of standard maps and researches.
The third service that we describe aims at evaluating the map once displayed. Legibility problems, like unexpected interactions between graphical signs, may occur due to the data. The submitted evaluation module mainly focuses on the colour contrasts.
An example of a scenario from a user's specifications to the proposal of a final map is described and discussed.

**KEYWORDS:** mapping, semiology, geographical data, Web services, user specifications, graphical interfaces.

## Introduction

Map design includes dealing with several requirements, and it becomes quite complex when there are many data to manage, and many constraints to consider. Precise demands may concern various characteristics like the dimension, the scale, the data to display, or the symbolisation. Though, the cartographic process has been simplified. More and more people have the opportunity to read or draw geographical data thanks to interoperability standards, Web services and free softwares. Nevertheless, the access to data and to mapping tools is not the guarantee of an optimized map. The effectiveness of a map indeed lies in its ability to convey the message meant by the writer to the reader.

Cartographers have applied scientific principles to improve this ability. Map design has the purpose of visual translation from raw data to information (Robinson, 1995). Graphical semiology enunciates the formalised use of visual variables to depict geographic elements and phenomena, along with their relations (Bertin, 1967).

The objective of the submitted work is to help a map designer, that we called the user, in the selection of data and in the definition of styles. It is necessary somehow to understand his need and to integrate cartographic expertness in order to answer it with a truly on-demand map. The task is quite complex as there is no ready-to-use method. We face two main challenges. First one is the creation of a relevant process for on-demand mapping applications. We must determine which services should be integrated into existing Web mapping architecture. The second challenge concerns the implementation of these added services. Indeed it is difficult to determine what relevant specifications are to ask to a user for on-demand mapping. The specifications cannot be too simplified as it would not be pertinent, or kept complicated as it would not be adapted to a Web application.

The first part of the paper states the context of the research. Then we introduce the three main Web services that have been identified for improving the map making process. Each paragraph details these services. The first service focuses on user's global map specifications. The following one concerns the style definition of the legend. Then, we briefly present an evaluation module that aims at improving the map display.

# II. Challenges of on-demand Web mapping

The Internet has accelerated the access to data and to tools that exploit these data. Hence, challenges of web maps making has appeared: the management and the transmission of information through a network, the communication within requests and responses between clients and remote servers. Besides that, one important part is the implementation of specialized functionalities thanks to Web services. In our case, the proposal of adapted functions included in a general mapping process is at stake.

## II.1 Web mapping challenges

### II.1.1 Evolutions in mapping

Reasons for mapping information are very important in the visual display. The initial role of a map is to locate existing elements of the landscape. First historical maps were representations of the physical world. Then authors tend to focus on specific data in order to deliver more specialised information. It could be by a selection and an accent on a topographic data, like roads (Sanson, 1632). Evolution was also through the themes displayed: not only the physical elements of the real world were drawn but thematic element were discriminated: vegetation, mineral, marine streams or compass variations (Halley, 1701). Statistics were introduced in map representations of phenomena: social tendencies, for example the rate of education, and flows maps. Standardisation became necessary for the symbolisation of such maps, like the colour codes for geological maps settled in the Congress of Bologna in 1882. Cartographic rules were formally settled down, especially later in the early 1950's (Robinson, 1952).

Formalised cartographic language deals from geometric projections to graphical semiology. Symbolisation is the key item in the communication between the map maker and its reader. (Bertin, 1967) has listed visual variables that are used in the cartographic representation like the size, the colour, the orientation. These variables are handled according to the type of data, to the type of difference into the data, to the reading level. The choice in legend influence the interpretation of the map. It is necessary to think of the message to convey and then of the symbolisation.

This language has then been included in the numeric map making process. Nevertheless, the Web has widened the production of numeric maps and some challenges appeared with the availability of data and applications.

### II.1.2 Issues at stake

One challenge to face in the map making is the increasing amount of information. We often tend to show all the data available to the detriment of map legibility and efficiency, especially with numeric maps. The Internet allows people to get more involved in the cartographic process, as readers and as map makers. A second challenge is so to facilitate the communication between a user's client and remote functionalities reachable by a network. Users have their own requirements concerning their map making, and these deal with different matters; that can be the selection of a geographical area, or the use to come. The important choice of data symbolisation must also be treated. Yet it is not obvious to answer to all those various requests. Many specialised mapping applications are though developed within a programming context, but the difficulty is to deploy them accurately on the Web.

Several solutions have been given to answer those challenges. First, Web applications have been developed for communication to Web users and for visualisation of information. Countries display their own Geographical portals to offer their inhabitants the chance to visualise national data. For example, the IGN France associates images with cartographic data like topographic layers or specific thematic (Géoportail). Then, we can quote Web services techniques that provide the transfer of mapping information and the use of mapping tools. Pre-defined interfaces allow data mapping and map publishing with few programming skills. Concerning the Web mapping services, the OGC has established standards. For instance, the Web Map Service can reach and display data from several distant servers; it can send back information on that server and on those data. These services do not call treatments on data or on the map, but they answer to a user request with data and give the opportunity to customise them.

The potentiality of numeric map making gives great opportunities to Web users. Though, the efficiency of a mapping may not be optimized. Efficient maps would convey the message that a writer wants to pass on to readers. The common functionalities offered by map services via the Internet do not take into account all the cartographic principles that improve map publishing, and especially the legend definition. Indeed, the automation of the cartographic process is quite a challenge in view of its complexity and of its subjectivity. The OGC style definition format, the Style Descriptor Language, deals with that aspect. Today, the symbolisation of maps is described for each data, but, it does not take into account the semiological rules that improve map reading.

In that context, one of our objectives is to use Web services techniques in order to call mapping functionalities on a remote server and to manage the interaction between those specific functions and users.

## II.2 On-demand mapping

### II.2.1 Map making on user's specifications

The necessity of cartographic functionalities is linked to the automation of the map making process. The drawing of a map depends strongly of its writer's choices. On-demand map corresponds to several meanings. It can signify a customised layout of the map when one is able to choose the front picture or the title. It may also include the determination of the displayed area coordinates. Another large definition is the on-demand mapping of what a map writer wishes to display. This is on this last statement that we work on. Our goal is to help a map designer to select data and to display them with adapted symbolisation. Styles in map that are generated randomly may give original displays but most of the time the lack of consistency penalizes the comprehension. If a map designer wishes that a reader could understand correctly the cartographical representation of his data, he has to make an explicit or implicit analysis on the symbolisation.

The map process, for paper or numeric maps, respects some systematic steps. We have planned to integrate those steps in the data selection and the legend choices. This assumes that we have to take into account some initial specifications. While map making, the first point is to lay down the needs. The answers to basic initial questions influence the final result: the aim of the map, the type of public, the type of information. When the need is set, the information to display is determined. The legend is settled by taking into account the thematic and the relation between them: association, order, difference or quantitative relations. Then the cartographic objects are drawn with the symbolisation. The layout is also important: the scale, the title, the orientation, and the sources. Then problems of readability, of generalisation, and of bad contrasts are resolved. The objective of the submitted on-demand mapping process is to integrate those steps and the cartographical knowledge they rely on.

### II.2.2 The Web mapping general process

The general process of map making corresponds to separated tasks in a production chain. The automation is made possible thanks to several specialised programs. When we help a user to draw his map, we face several challenges. The first issue lies in the configuration to adopt for map services on the Web. The configuration of the services has to be relevant so that to ensure an adapted chain of Web Services. On Figure 1, the services on the right side are the fundamental services in the cartographic process. We can lean on these existing services to deploy our on-demand map chaining (Bucher, 2007): those services are listed on the right part of Figure 1. On the left part, are the three main services that have been identified so to enrich the process.

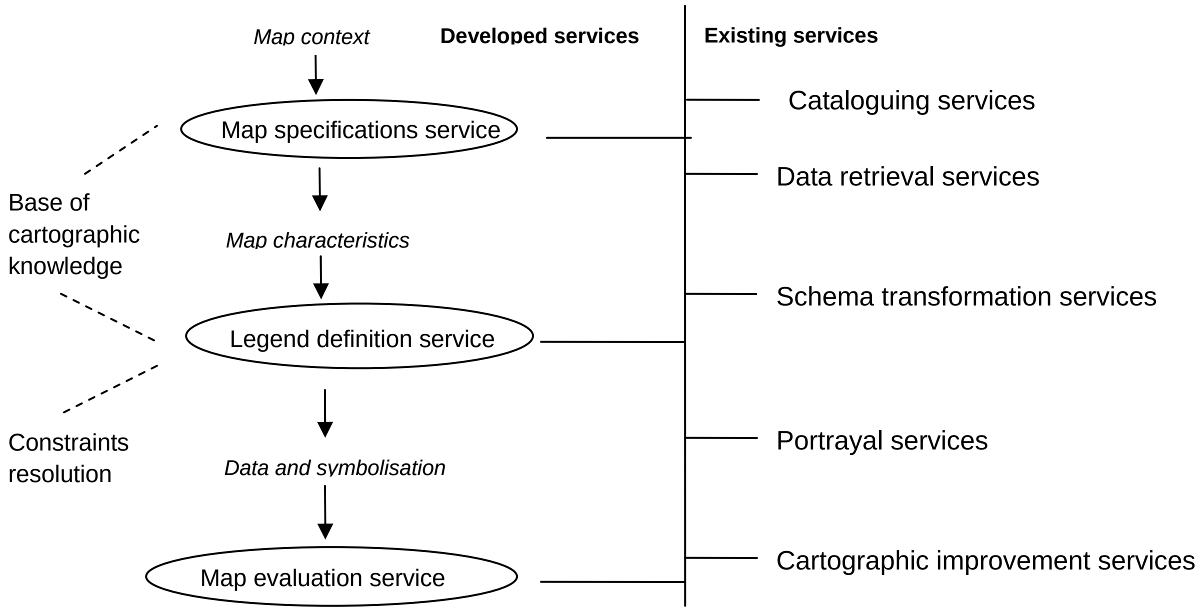


Figure 1: The mapping services.

The initial service of map specifications is necessary to write down the general description of the map bound the rest of the process. The second service, the legend definition service, aims at defining a legend based on the user's specifications. The result is a map that should correspond to the map description and respect cartographic rules. Then the last service deals with map evaluation of colour contrasts. These services are detailed in the following parts of the article. We will focus on the first two services for map specifications and legend construction.

# III. The map specifications service

In this part, the first service of map specifications is detailed. The service translates defined mapping needs into an abstract definition of a map, which is independent from the data available and the display abilities.

## III.1 The formal description of a map

The message a map maker wants to transmit needs to be set into general specifications. These specifications define the formal description of the map and determine the content, meaning the information to display. As the service implemented aims at helping a user to express its need, we first have focused on what and how to ask this need.

The formal description of a map, that we also call its general description, is made up of key parameters: the geographical area, the scale, the type of map and the more subjective aspect of the user's category. In our proposed graphical interface, the choices are limited to listed items. As we said, the first choice concerns the topographical area, more exactly the administrative area. The scale can be fixed here and the final map would be adapted on the display window. The selected geographic environment influences the available data to extract. Then the type of map is a key feature for the determination of the final thematic. In (Brunet, 1987), different types of maps are listed: topographic maps, roads maps, 3D maps, and all the thematic maps with various semiological symbols. We do not use a referenced classification of the types of map, but we list general categories. We recover some of those and distinguish the difference between topological maps, road maps, hazard maps and touristic maps. These maps have significant characteristics. In those examples, we talk of topological maps when only physical elements of the real world are represented. Road maps focus on the traffic network, whereas risk maps contain thematic data on hazards and vulnerability, and touristic maps amplify places to visit and the access to them.

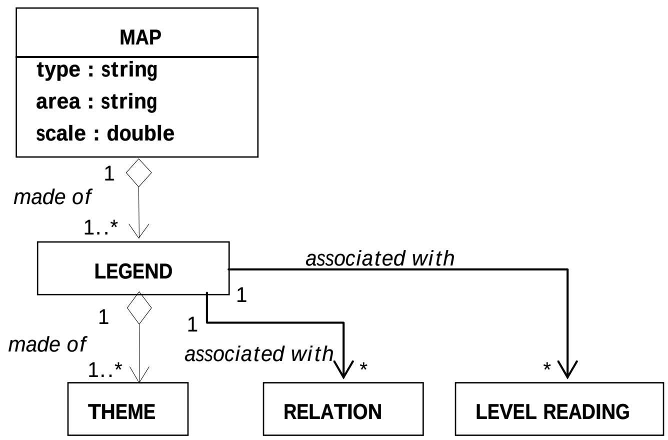


Figure 2: The formal map description model.

As presented in Figure 2, the UML model of the formal map definition model includes other items than those necessary to extract and portray data. These new items explicitly state what information should be conveyed by the map to the reader, themes, relationships between themes, and how it should be conveyed. The communication levels indicate what information are to be seen at first sight, and what information are to be read.

The formal map definition allows a translation of users' specifications that determines the map content within the data available. Following this definition, thematic domains are presented to the user: it is the data determination module.

## III.2 Data determination module

From the type of map, possible thematic domains are settled. These domains will be used by the data determination module. Indeed the map specifications are sent in a serialized format to a server. A module of data determination relies on the work of (Balley, 2006) about the structure of data and metadata. Filters are defined depending on the thematic domains. The relevant attributes of these data are also shown to the user in case of relations to define, for example, difference between the kind of roads, or order in hazard intensities. In Figure 3 are chained the steps from the user's specifications to the data determination along with their metadata.

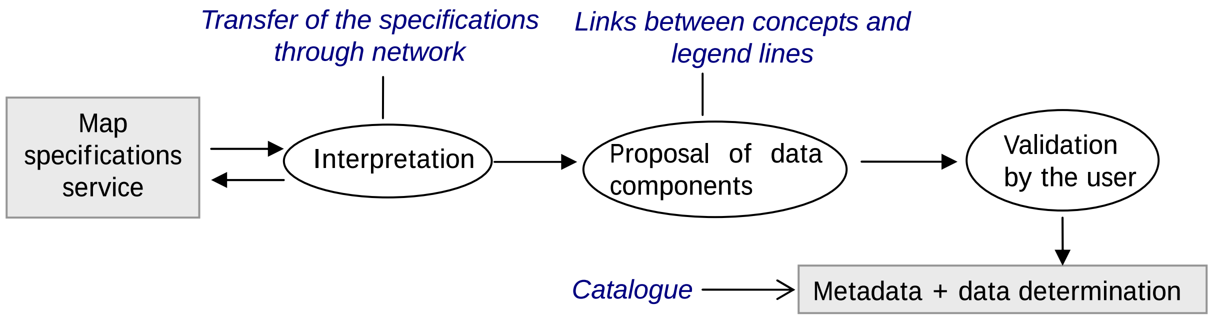


Figure 3: Management of user's formal description of a map.

After the validation by the user of the defined data, the next interface ensues from the category of the user. The non-cartographer user can visualise a map from now on with predefined styles or can choose to reach a simplified legend definition interface. The user who is identified as cartographer or that want to make explicit the symbolisation, can exploit the entire legend definition interface. We must keep in mind that the process is put into Web services and that the interaction between the user on a client and the functionalities on a server should be minimised and at the same time efficient enough to interpret the user needs. In the next paragraph, we focus on the cartographer interface that allows the complete legend definition interface.

# IV. The legend definition service

## IV.1 Approach for legend definition

For some cartographic elements, the task of style definition may appear trivial. The background and the habits of map visualisation prevail, such as for the hydrography. But once the common thematic represented, less conventional styles are still to be selected among great range of possibilities. In order to be able to come out with an entire legend, we create knowledge bases. We have collected this cartographic knowledge thanks to different approaches. One approach is based on templates of existing maps and on standard symbolisation. Though, it may not be sufficient enough when it comes to specific requirements from users. In that case, cartographic rules are formalised and capitalized.

## IV.2 Legend templates

People or institutes in charge of map publishing have expertness in efficient map making, for standard maps as well as for on-demand map. Many maps have been produced by cartographic experts and we can lean on their characteristics. We define legend templates corresponding to those maps. We mean by legend models templates of symbolisation that contain the legend structure and the styles. In the legend structure, we put themes and associated legend lines. Each legend line is made of one wording and one symbol case. In the objective of creating legend templates, an analysis was carried out on the legends of European topographic maps at the COGIT laboratory (Renard, 2008). We don't detail this study though it has confirmed the influence of styles choices on the message transmission of the map. Indeed, the drawing of the same dataset with legends from different mapping agencies has generated different messages. For example, forest areas were qualified differently depending on the colour. Results have been explicitly expressed in our model and the legend templates were defined consequently. The definition of these templates allows the analysis of map message to a reader with displayed data. To get more global on the styles determination, the cartographical principles needed to be integrated.

## IV.3 Cartographic rules management

In cartography, a lot of rules and conventions guide the realisation of a map. Some rules are accurate: ‘shape can not be used to translate quantitative relation in data’. Some conventions are little accurate and allow a large range of possibilities: ‘natural elements in usual hues’. These statements have been integrated in legends of standardised maps. The application of symbols to cartographic elements is difficult to formalize for a whole map. Besides there are no finalized choices even if common styles are found in maps and facilitate the comprehension of the information. In our on-demand mapping process, the user’s requirements have to be translated thanks to adapted symbolisation but also regarding to semiology principles. In our case, we only deal with the colour variable in the definition of the style in order to simplify the formalisation. In fact we call colour the association of two variables: the hue and the value. The palette used is made of 156 colours and has been set by (Chesneau, 2005); the main colours are presented Figure 4. The selection of these colours is justified by restricted reference need that enables constraints management. In that palette, the themes of the data limit the symbolisation possibilities.

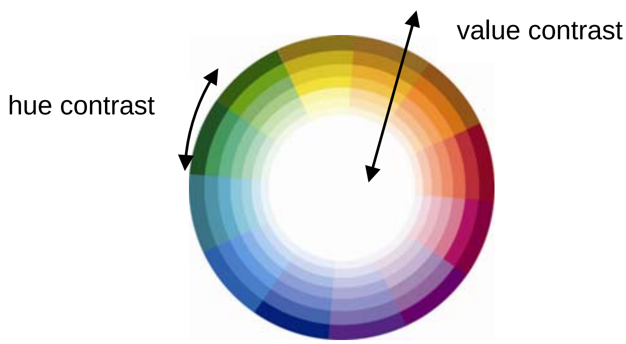


Figure 4: Main colours palette used for styles’ definition without the brown and grey colours.

The type of data should also be taken into account. Works have already been carried out on style definition topic. We can quote the ColorBrewer tool (Brewer, 2003) that proposes predefined color ranges to portray efficient thematic maps, i.e. a range is adapted to display a given set of categories and a given type of relationship between these categories.

One challenging task is to choose the best colour for each legend line in the pre-selection of colours, depending on the interaction between the displayed objects. We build a base of cartographical knowledge for managing the constraints on the symbolisation. Theoretical rules are part of the base.

Table 1: Example of cartographic rules management.

| *Rule* | *Act upon* | *Name* | *Ordered hue ranges* | *Value ranges* |
|---|---|---|---|---|
| themes display | theme's legend lines | Hydrography | Blue, Violet-Blue | |
| themes display | theme's legend lines | Buildings | Orange, Red, Purple, Grey | |
| data type | legend line | Surface | | medium, low |
| reading level | reading level's legend lines | first level | | high |

This knowledge base is firstly used to express every constraints associated to the map. Two types of constraints are associated to a map:

- constraints yielded by the application of cartographic rules to the initial specifications. For example if the map legend includes a hydrological theme, the style of legend elements belonging to this theme should have a blue hue colour ;
- constraints directly expressed by the user. For example the user wishes to portray specific buildings in a given colour or he wishes that there is some yellow colour in the legend of the final map. The management of the constraints deals with the importance of each constraint and the harmony in the symbolisation into the legend.

After the production of these constraints, a fixed strategy is applied to propose styles in a given order so as to obtain a complete map which constraints are the most likely to be satisfied in and which every legend item has a style. The geographical objects are extracted and associated with the corresponding colour styles. The final map is finally display on the client interface. The user receives the serialised data that are associated with their symbolisation. Nevertheless, this display can be modified: to help these customised changes, an evaluation service of the map legend calls specialised functions of colour contrast improvement.

# V. The evaluation service

## V.1 Evaluating the colour contrasts

In the process of on-demand maps, evaluation is a necessary step. It is not easy to give a global judgement and we tend to separate the elements or the areas of a map. Though, it would be useful to have tools that estimate maps' releases. The map creation is long and for lack of reconsidering all the previous choices, the opportunity will be given to modify only few elements. We are aware that we cannot associate to a map one mark that would take into account all mapping aspects. This is the reason why this Web service we introduce focuses on one aspect of the map: colour contrasts. The service leans on an algorithm that was developed in another context (Buard, 2007). Relevant methods have been identified and matched with the on-demand map model.

### V.2 The evaluation method

The purpose of the third service is the evaluation and the improvement of colour contrast on maps. There are several ways to evaluate the colours: one goes down to cartographical objects and another only uses the legend description. The estimation of global colour contrast of the cartographical objects calls for heavy calculation that can take time especially in architecture of server's requests and responses. Indeed this method stated during the PhD of (Chesneau, 2005) focuses on each object: the global notation of the map includes each surface, colour and mainly neighbourhood. The module also presents proposals for improving the colour contrasts thanks to a modification of the worst contrasted colour. We will not detail this method further more; it is presented in (Buard, 2007). The second approach of the map evaluation is linked to the legend. The quantitative aspect of the symbolisation is let aside. The evaluation of a legend integrates the legend structure: semantic of the legend themes, importance of the data, relations of order, difference or association. A mark is then associated to colour contrast in absolute terms. The method relies on the different types of colour contrast inspired from theory and experts tests, and applied to cartography.

It is interesting that the analysis points out one element to change in order to improve the map readability. The following step is to propose a new symbolisation to the user which may validate or not. Besides the cartography and colours theory, the subjective view can not be rationalised.

## VI. Example by a scenario

This part details a simple scenario of map creation following the on-demand map process. In order to analyse different cases, we worked on several user's specification. As listed before, we focused on different types of map and on colour display. We will explain the example of a hazard map display. This particular situation illustrates the process of map creation from user specifications on general map characteristics and on styles' definition. The prototype of the mapping process has been developed on the Eclipse platform. It is based on Web services languages for the communication between an external client and the functionalities on a server: information is written in SOAP standard language of the OGC that allows transfers on networks.

The initial point of the creation is general specifications that precise the map context. The initial graphical interface allows a user to notify his preferences. The user is shown choices of available geographical areas, scales and types of map. From these specifications, we call a data determination module that selects the customised legend themes. One parameter concerns the following interface of the legend specifications. It can give access to simplified legend definition, or to complete definition of the legend that integrates specialised vocabulary in cartography. In the last case, users have the opportunity to define the legend structure, included the name of the themes, the legend relations, for example an order between data or attributes and the style of the legend line. Figure 5 shows the legend definition interface: the user is guided in his selection. The themes and the legend lines have already been defined, though it remains possible to display the values of an attribute.

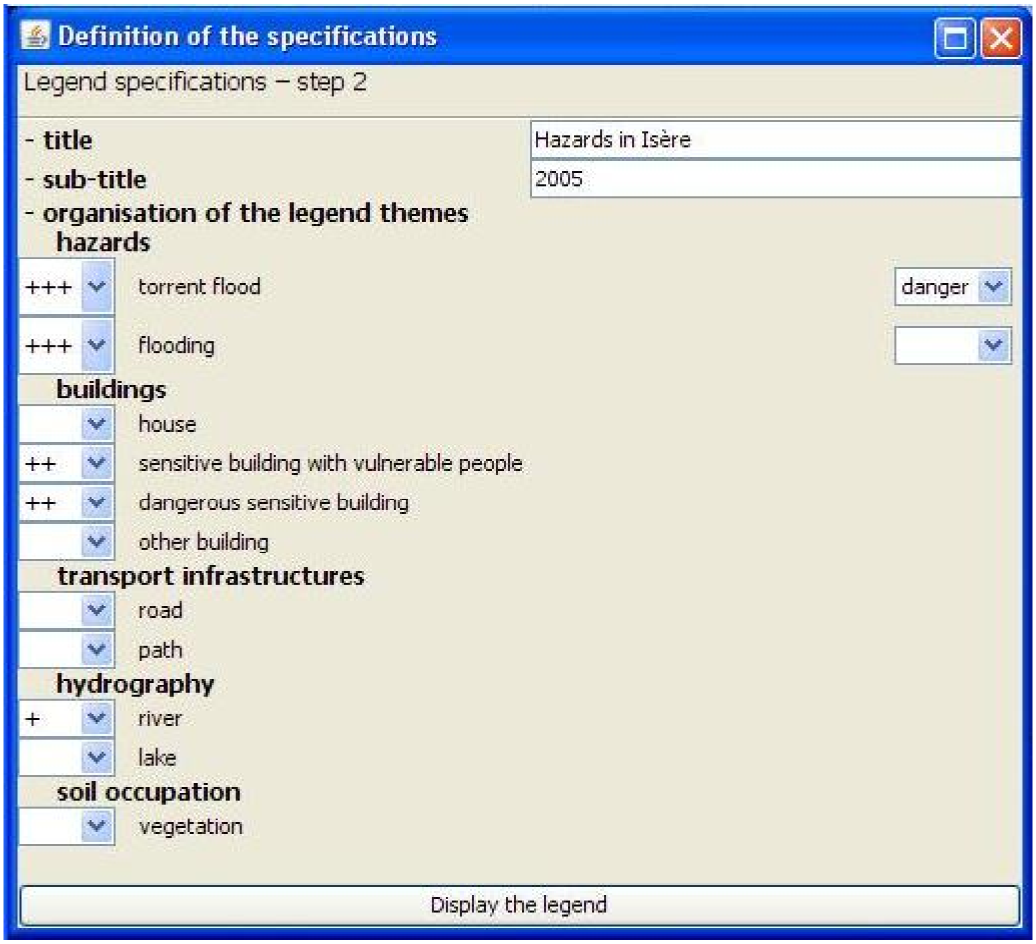


Figure 5: Request interface for map specifications.

The module of legend creation takes into account the semantic of the legend themes. It also integrates the importance allocated by the user to legend lines, which is expressed by zero to three plus symbols, like in Figure 5. As example of constraints translation to symbolisation, a great importance granted to a legend line restricts the possible colours to high values. The selection is also made thanks to large semantic limit, for example, the preferential selection of blue hues for hydrography or green ones for vegetation theme. In case of lack of specifications, the legend is yet created thanks to legend models.

The visualisation of the data and of the resulted legend is shown on the GIS (OpenJUMP).

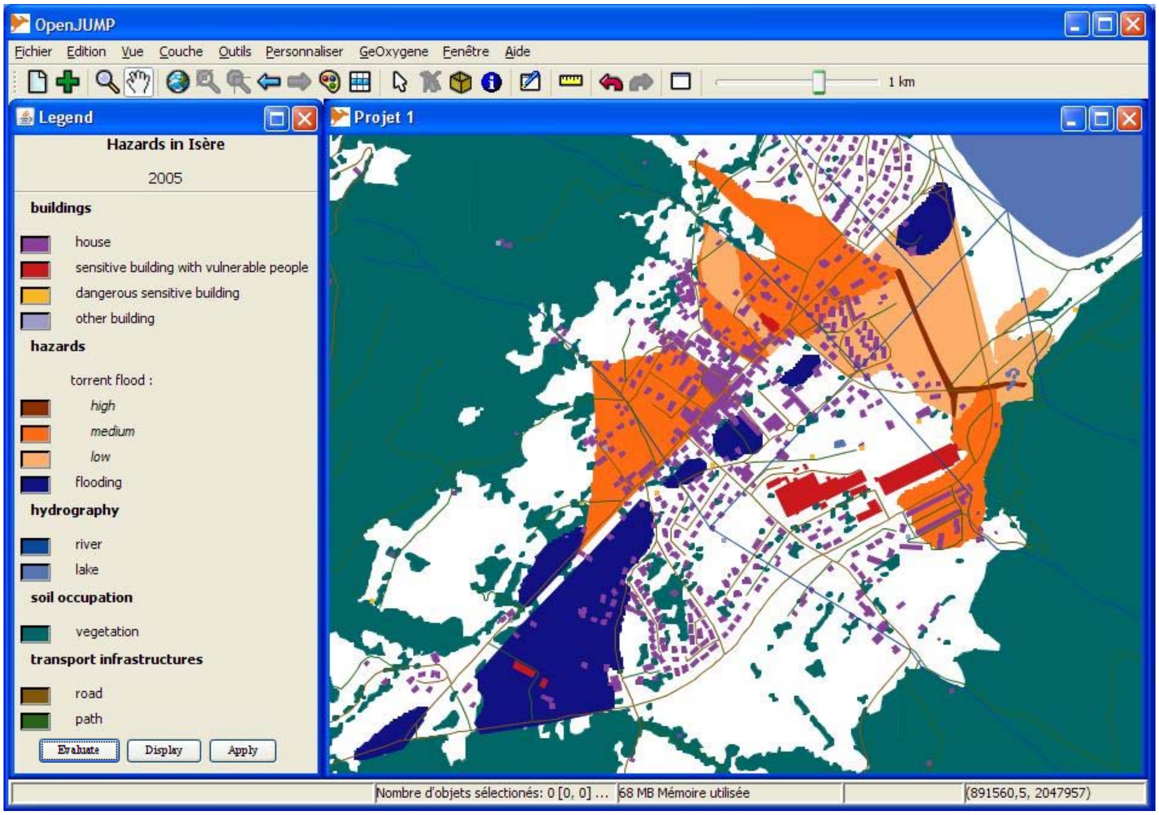


Figure 6: Final map display.

The user still has the opportunity to select other style colours. Indeed the server sends back a list of adapted colours and the limited choices are available via a palette. The evaluation module sends back the less contrast colour and a proposal to replace it.

This scenario illustrates the possibilities to call our cartographical functions thanks to Web services techniques. The work focuses on how to facilitate the communication between an internet user and map creation functionalities. The value added to services of map display is a help in symbolisation choices.

# VII. Conclusions

The presented work deals with complex tasks as it tackles an automation of cartographic creation with an objective of good visual display. Cartographers' steps and thoughts have been simplified and formalised in a generic process. Besides, part of knowledge was integrated in web service approach.

The Web services technology allows the call of specialised functionalities that are developed in specific platforms and programming languages. The modular approach through Web services facilitates the consideration of user choices. Mapping follows chronological choices. On-demand map depends on the specifications asked to the user and on the order of these specifications. The definition of the map contains general terms like its type, and very precise description such as the colour applied to a line legend. The challenge is to determine exactly what the different natures of specifications influence. The type of map can act upon the data displayed, but the semantic of the data can also have an impact on the symbolisation. The knowledge in cartography and in geographical information sciences represents great resource for interpreting the need and for settling the visualisation.

The realisation of a map thanks to programming operations needs the exploitation of cartographic knowledge bases. In our process, we used basic principles in order to open the possibilities resulting of user specifications, and also in the objective to simplify the interaction between the user and the cartographical functions on the server. The goal was indeed to display maps with adapted symbolisation. We took into consideration semiological rules thanks to the semantic of the data themes. Semiological aspects could be exploited for qualifying a phenomenon: danger or a feeling: sad, or a sensation: fresh, like in (Kurokawa, 2007). It would enlarge the vocabulary used for the communication between maps writers and readers. For the enrichment of the on-demand map process, it would also be interesting to include taxonomy on cartographical terms. This would widen the consideration of the context in the map creation and improve good response to user specifications.

# REFERENCES


Badard, T. and Braun A. (2003) ***« Oxygène » : Une plate-forme inter-opérable pour le deploiement de services Web géographiques.*** Bulletin d'information de l'IGN n°74. 2003.

Balley S. (2006) ***A web interface to explore and restructure a dataset,*** in proceedings of the GISRUK conference, Nottingham.

Bertin, J. (1967) ***Sémiologie Graphique,*** Paris, Mouton.

Brewer, C. Hatchard, G. and Harrower, M. (2003) ***ColorBrewer in print: a catalog of color schemes for maps.*** Cartography and Geographic Information Science, vol. 30, n°1, 2003, pp. 5-32.

Brunet, R. (1987) ***La carte mode d'emploi.*** Édition Fayard/Reclus.

Buard, E. and Ruas, A. (2007) ***Evaluation of colour contrast by means of expert knowledge for on-demand mapping,*** ICC Moscow 2007.

Bucher B. Buard E. Jolivet L. and Ruas A. (2007) ***The need for Web legend services,*** W2GIS 2007.

Chesneau, E., Ruas, A., Bonin, O. (2005) ***Colour Contrasts Analysis for a better Legibility of Graphic Signs on Risk Maps.*** In International Cartography Conference ICC' 2005, Proceedings, La Coruna, Spain, 2005.

Christophe S., Bucher B., Ruas A., ***A dialogue application for creative portrayal,*** in proceedings of the XXIIIe International Cartographic Conference, Moscou, 2007, to be published

Domingues C., Bucher B., ***Application d'aide à la conception de légende,*** actes du colloque SAGEO, Strasbourg, 2006.

Géoportail IGN. http://www.geoportail.fr/

Halley, E. ***A new and correct chart shewing the variations of the compass in the Western and southern oceans,*** 1701

Kurokawa, C., Ota, ***M. Portrayal schema design and mechanism for the map personalisation,*** ICC, 2007

Open Geospatial Consortium. (2006). ***OpenGIS® Web Map Service Implementation Specification. OpenGIS® Implementation Specification. Beaujardiere (de la),*** J. (Ed), 2006. http://www.opengeospatial.org/standards/wms∞∞; updated 2007/03/28

OpenJUMP. http://openjump.org/wiki/show/HomePage

Renard, J. (2008). ***Caractérisation et analyse des légendes des cartes topographiques européennes.*** Internship's report de mastère Carthagéo Paris.

Robinson, A.H. (1952). ***The Looks of Maps.*** Madison: University of Wisconsin Press.

Robinson, A. H., ***Elements of Cartography, sixth edition.*** John Wiley and Sons, New York, 1995

Sanson, N. ***Carte géographique des Postes qui traversent la France.*** 1632