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Design Guidelines for Pictographic Symbols: Evidence from Symbols Designed by Students

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Abstract. Pictographic symbols are widely used in different kinds of environments because of their potential for delivering complex messages efficiently. However, if they are not properly designed they fail to deliver the intended message. In this paper, we formulate a set of graphic and semantic qualities that contribute to the overall quality of the symbols. We concretize the qualities by analyzing pictographic symbols designed by students from different countries on a cartography course and by identifying typical design errors made by the students. The resulting list of errors can be used as a check list of things to be avoided when designing pictographic symbols.

Keywords. Pictographic symbols, Map symbols, Icons, Design guidelines, Symbol design, Novice designers

1. Introduction

Pictographic symbols are commonly used in several environments, including tourist maps, cell phones, instruction manuals, automobile dashboards, traffic- and safety signs, and airport wayfinding systems, and they define much of the usability of the products or systems they are part of. For this reason, the symbol designer must have good knowledge on the qualities that are needed for creating successful symbols. The advantages and limitations of pictographic communication are studied in several fields, such as semiotics, perceptual psychology, ergonomics, human-computer interaction, cartography, and graphic design. Several qualities that the symbols should possess have been introduced for different purposes of use, such as user interface icons and warning pictorials. Also guidelines have been given for achieving these qualities.

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In paper maps, the pictographic symbols have played an important role for decades and today mobile devices equipped with high resolution displays and GPS receivers are able to visualize map mashups where different kinds of points-of-interets nearby the user are shown on a map. Still, symbol design represents only a fraction of the process of map design and production. Because of this, symbol design is not among the core contents of cartographic education. Therefore, even professional cartographers, let alone growing number of self-educated amateur map makers may lack the knowledge and skills required for designing successful symbols that the professional graphic designers do have. This kind of occasional designers need practical guidelines to design proper symbols. However, there are no solid list of symbol qualities or design guidelines for pictographic map symbols. In this paper, we aim at tackling this problem by 1) collecting a general list of symbol design qualities from different disciplines and 2) formulating a set of concrete guidelines for achieving these qualities. The general symbol qualities describe the desirable characteristics of pictographic *map symbols*. However, the qualities are aimed to be applicable to different contexts of use of pictograms, and therefore seek to benefit professional graphic designers in addition to cartographers. The concrete guidelines describe the list of dos and don‘ts and seek to benefit map designers that are not fully trained in symbol design.

In the next two sections we first present a brief overview of the motivation and characteristics of pictographic symbols, and then, introduce a list of general symbol qualities composed from the related literature. We then present an evaluation and analysis of map symbol designs by university students in order to concretize the qualities by examining how the qualities tend to be violated in practice. Finally, the limitations of the results are discussed and the conclusions are drawn.

2. Pictographic Symbols

Pictographic symbols (also referred to as icons, pictograms, and pictorials) are small graphical pictures that are used to present information (Wogalter et al. 2006), and they are often used to replace textual presentation. The advantage of pictographic symbols over text is that they are language-free (Pappachan & Ziefle 2008), they are more robust to changes in scale, reading speed and distance (Nakamura & Zeng-Treitler (2012), and require less space (Wogalter et al. 2006). The well-known example of the power of pictographic representation is the Isotype system by Otto Neurath. He and his team used pictographic symbols to make statistics more attractive and memorable to less educated people (Burke 2009). In cartography pictographic symbols are used in maps for general public, such as tourist maps, because pictographic map symbols are, if not intuitive, easier to learn and remember than abstract map symbols.

Comprehension of symbols is explained through the semiotic concept of sign introduced by Peirce (1931-58). In semiotics sign is a product of a three-way interaction between the „representamen" (i.e. the symbol), the „object" (i.e. the referent that is represented) and the „interpretant" (i.e. the mental representation of the object), and sign is a sign only when it represents something for someone. Identification of pictographic symbols can also be explained through the processes of object recognition introduced in perceptual psychology, e.g. by Biederman (1987), and by the terms used by Keates (1982). In symbol identification, bottom-up and top-down processes are used simultaneously. Perceptual bottom-up processes allow a symbol to be detected from the background. The symbol is further identified to depict something familiar, for example, a „police car" on a map. The meaning is then interpreted, for example, the police car is interpreted as standing for the location of a „police station". In the identification and interpretation phases top-down processes are incorporated under the influence of semantic knowledge and goals of the user and the context (Pappachan & Ziefle 2008). For example, the goal of a map reader might be to find the location of the nearest police station in the map, and he or she may have an idea of what kind of objects are depicted in the map (e.g. services on a city map).

Pictographic symbols are generally categorized in terms of their visual abstractness and the relation between the symbol and the referent. Visually symbols can be placed on a continuum of abstractness starting from geometric shapes and ending with highly realistic pictures of real world objects (MacEachren 1995). Pictographic symbols can be categorized further on the basis of how the symbol (i.e., the visual representation) is linked to its meaning (i.e., the referent). Nakamura & Zeng-Treitler (2012) provided a taxonomy of representation strategies of pictographic symbols. In their taxonomy, the representation strategies of the symbols were categorized at the general level into arbitrary convention, visual similarity, and semantic association. In representation through visual similarity, the referent is represented by depicting its visual characteristics, for example, a symbol depicting an elephant in a map of a zoo pointing out the location of the elephants in the zoo. In arbitrary convention the symbol is attached to the referent by a convention, for example the Red Cross or the Rod of Asclepius standing for health services such as first aid point in the zoo. In representation through semantic association, the connection between the referent and the symbol is „mediated" by depicting concepts that are semantically close to the referent, for example a coffee cup standing for cafeteria or a knife and a fork standing for a restaurant in the map of the zoo. Semantic association can be further divided to a number of different subclasses such as comparison, exemplification, semantic narrowing, physical or temporal decomposition, body language, metaphor or different types of contiguities (Nakamura & Zeng-Treitler 2012).

Pictographic symbols possess different qualities that define their success, and the goal of symbol design is to maximize these qualities in the symbols. The symbol qualities can be reviewed from the viewpoint of reading the symbols and from the viewpoint of designing them. From the viewpoint of reading the symbols, the qualities of the symbols relate to the efficient (bottom-up) processing of the symbol and to the correct interpretation of the meaning of the symbol that requires higher-level cognitive processes. In addition, the qualities may relate to more sophisticated processes, such as the aesthetic response (i.e., what is felt to be good-looking) and the sensitivity of a symbol (i.e., what is felt acceptable and appropriate). From the viewpoint of designing the symbols, the qualities of the symbols relate either to the graphical representation of or to the (semantic) design idea for the symbol (i.e., the concept(s) chosen for visualizing the referent). For example, the design idea for a „police station" can be a „police car" or a „sheriff's star".

Design guidelines can be classified into descriptive guidelines detailing the characteristics of the end result and into procedural guidelines instructing the design process. Design guidelines are suggested for different uses of pictographic symbols, and several methods are used in achieving the guidelines. Huang et al. (2002) collected the opinions of graphic designers in order to collect the factors affecting the design of computer icons. Apple (2015) gives practical guidelines for designing icons for applications for the iOS platform. McDougall and her colleagues studied how different symbol properties affect the efficiency of symbol identification by organizing several experiments (McDougall et al. 2000, McDougall et al. 2006, Isherwood et al. 2007). In cartography different sets of goals are developed to help design a symbol set for a specific map use, e.g., for mobile maps (Stevens et al. 2013), for humanitarian demining (Kostelnick et al. 2008), and for crisis management (Korpi 2008) but these sets mostly concentrate on the purpose-of-use specific guidelines. Because of the differences in the research methods and in the considered contexts of use of the symbols, different qualities are emphasized in different sets of guidelines. By combining guidelines from different sources, different aspects such as efficiency, aesthetics and cultural aspects can be considered.

3. Survey on the Qualities of Pictographic Symbols

We conducted a thorough literature review to identify the general qualities and guidelines for successful symbols. Guidelines were collected concerning symbols for various purposes of use, such as map symbols, interface icons, warning signs and traffic signs. The materials used were various, as we included studies based on measured performance of the symbols as well as design books and practical design guidelines. Material was included from the past thirty years. Guidelines varied in terms of their format (narrative or listed form) and in terms of their level of detail. We used similar method than Friedman and Bryen (2007) in analyzing the guidelines. All guidelines and qualities were put in a table. Procedural guidelines (e.g. test-before-use) and context-specific guidelines that are not relevant in other purposes of use of symbols were excluded. The remaining qualities and guidelines were sorted according to their contents. Duplicates and closely described guidelines were combined, and the remaining guidelines were categorized. There were a few guidelines that were descriptive and potentially relevant across contexts, but could not be categorized into any categories and were not mentioned in other sets of guidelines. This category of “others” was considered to consist of rarely mentioned guidelines that do not have significant contribution to overall quality of symbols.

The qualities and guidelines can be subsumed under ten categories. We divide these qualities into graphic and semantic qualities on the basis of whether the quality primarily deals with the graphical representation or the semantic content of the symbol (i.e. the design idea). Graphic qualities include simplicity, clarity, visibility, consistency, distinctiveness and aesthetic appeal. Semantic qualities include concreteness, semantic closeness, familiarity, and acceptability. The qualities are explained below with references to earlier studies or practical recommendations. Figure 1 shows examples of high- and low-quality designs according to each quality.

3.1. Graphic qualities

Simplicity

The visual complexity of a symbol refers to the intricacy of the edges, the number of elements, and the level of detail in the symbol (Forsythe et al. 2003). Simple symbols are located more efficiently in a visual search task than complex symbols (McDougall et al. 2006) and are more legible (Wogalter et al 2002, Wogalter et al. 2006). In addition, simplicity in general is noticed to be an appreciated attribute of a range of products among the users (Blijlevens et al. 2009). Therefore, the symbol should not include small details. However, in some situations complex communication of information is necessary for correct interpretation of the intended meaning (McDougald & Wogalter 2014).

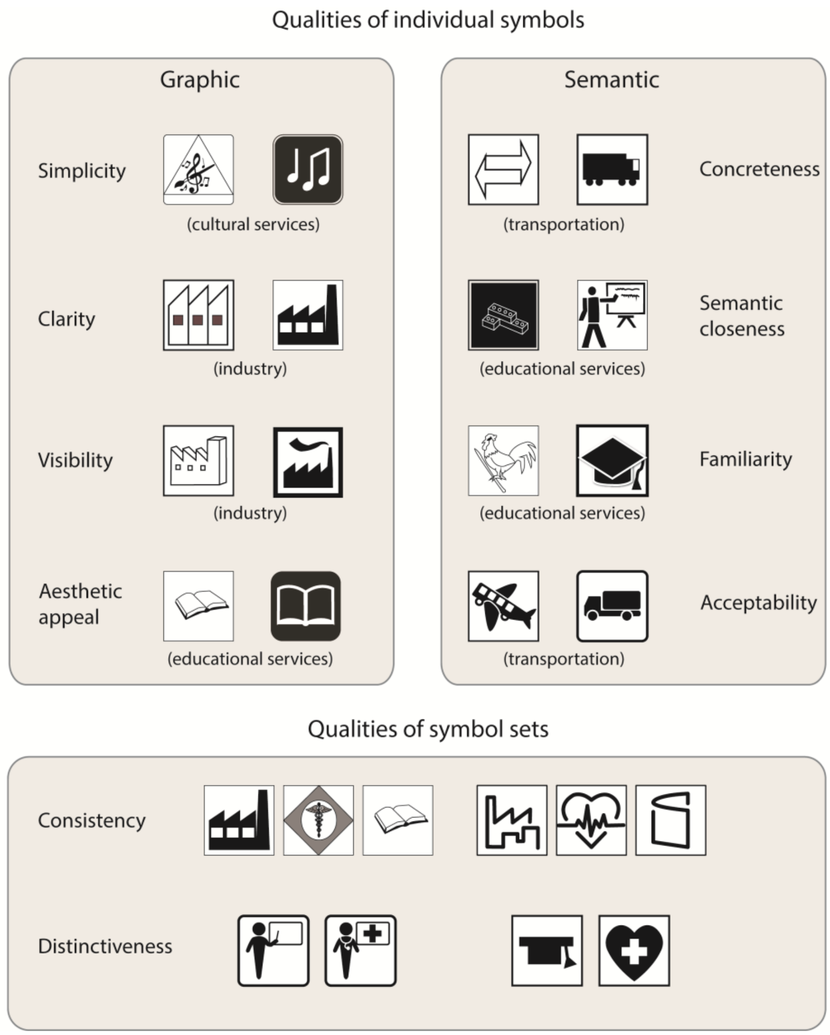

Figure 1. Low-quality (left) and high-quality (right) examples of symbols designed by students for each of the nine qualities.

Clarity

Clarity refers to the ease of recognition of the contents of the symbol unambiguously. For example, in Figure 1, it is difficult to recognize the factory that is used to represent industry. The symbols should be easily recognizable (Huang 2002) when the context is known (Wolff & Wogalter 1998, Goonetilleke et al. 2001, Hsu & Lin 2011). Too many details in the symbol hamper the efficiency of its recognition, whereas the absence (or poor visualization) of the typical elements of the object hampers the accuracy of the recognition (Bruyas et al. 1998, Wogalter et al. 2002). Therefore, the essential parts of the object that contribute best to its recognition should be enhanced, whereas unnecessary elements should be removed (Adams et. al 2010, Tyner 2010, Pettersson 2011, Zender 2006). The symbol may represent only the characteristic parts of the objects because of the human ability to recognize partially occluded objects (Korpi et al. 2013).

Visibility

The visibility of a symbol refers to the ease of detection of the symbol from the background. The contrast between the symbol and the background and the contrast between the pictogram and the frame should be large enough (Huang et al. 2002, Shieh & Huang 2004, Wogalter et al. 2006, Rousek & Hallbeck 2011). If the background is light in color, the symbols should be dark so as to maximize the luminance contrast (Stevens 2013). However, a common problem especially in case of maps and mobile device menus is that the symbols may be used with multiple backgrounds (Korpi 2008, Apple 2015). This problem may be overcome by designing the symbols to be generally distinctive by framing the pictogram or by having a thick enough edge weight. If the symbols include frames, the contrast between the frame and the pictogram should be large enough to distinguish the pictogram. This can be done by using filled figures (Pettersson 2011, Medynska-Gulij 2008) that have a large enough luminance contrast with the frame, or by having bold lines (Wogalter et al. 2006).

Consistency

Consistency refers to the extent to which the symbols designed to a purpose form a visually uniform set. Therefore, consistency is a quality of the symbol set instead of a quality of the individual symbols. Symbols in a set should employ a consistent and unified style and visual appearance so that the symbols look as though they belong to the same set (Horton 1994). This can be achieved by using similar stroke weights, arcs, circle sizes, and perspectives in all symbols (Zender 2006, Korpi 2008, Apple 2015). In addition, when a set of symbols is used together in a display (e.g. map symbols), saliency differences between the symbols should be avoided, if the objects they represent lie on the same level of semantic importance. Visually heavier symbols tend to attract attention (Forrest & Castner 1985), as well as a symbol that is simpler than the other symbols in a display (Huang 2008).

Therefore, the symbols meant to be used together in a display should be consistent in terms of their visual weight (Korpi 2008) and complexity (Stevens 2013). Apple (2015) advise ensuring a consistent perceived size in all the symbols.

Distinctiveness

Distinctiveness of symbols refers to the easiness of discriminating the symbols from each other (McDougall et al. 2000). Also the term discriminability is used from this quality (Huang et al. 2002). Symbols should vary in terms of their global characteristics to ensure the efficiency and effectiveness of visual search of a symbol in a display (Williams 2000, Wiedenbeck 1999). However, distinctiveness is difficult to measure (McDougall et al. 2000).

Aesthetic appeal

In addition to be effective and efficient, symbols should be appealing and aesthetically pleasing in order to give an impression of quality (Korpi 2008, Wogalter et al. 2006). Aesthetics guidelines of symbols are mentioned in literature only broadly, probably because graphic design is commonly considered to be an artistic process that is difficult to guide in practice (Wang & Hsu 2006). Pettersson (2011) states that the horizontal and vertical elements, as well as the dark and light ones, in any information material should be in good balance. The layout of elements in an icon could affect icon quality (Huang et al. 2002).

3.2. Semantic qualities

Concreteness

The concreteness of a symbol refers to the extent to which the symbol depicts real objects, materials, or people (McDougall et al. 1999). A Symbol that is depicted by a geometric form, such as the Red Cross emblem, is visually abstract, whereas a symbol, such as the Rod of Asclepius is concrete, because it depicts real objects, a snake and a staff. Concreteness affects the accuracy of identification (Chan & Ng 2010, Chan & Chan 2013). This suggests that concrete design ideas should be used as far as possible.

Semantic closeness

The semantic distance is the closeness of the symbol to the referent that it represents (McDougall et al. 1999). We use the term semantic closeness after Chan and Ng (2010). The representation is semantically closest to the referent when the symbol physically resembles the referent, i.e. the representation strategy of visual similarity according to Nakamura and Zeng-

Treitler (2012). The representation is semantically longest when the referent is represented through an arbitrary convention that must be learned before in order to be correctly interpreted. Semantic closeness is stated to be the best predictor of symbol interpretability (Ng & Chan 2007, Chan & Ng 2010, Chan & Chan 2013). Therefore, semantic closeness is generally highly advisable for ensuring the correct interpretation of the symbol (Morrison & Forrest 1995, Korpi & Ahonen-Rainio 2010, Stevens 2013, Medyska-Gulij 2008, Huang 2002), and ambiguity, i.e. the possibility to connect the symbol to multiple meanings in the context, should be also avoided (Goonetilleke et al. 2001). In addition, the symbol should cover the whole concept that is intended to be represented, and not just a single sub-concept (Wogalter et al. 2006, Korpi & Ahonen-Rainio 2010, Nakamura & Zeng-Treitler 2013). However, this may be impossible to reach in case of conceptually broad referents.

Familiarity

McDougall (1999) defined the familiarity of the symbols as the frequency with which they are encountered. Frequently encountered symbols are identified generally more accurately than unfamiliar ones (Ben-Bassat & Shinar 2006). Isherwood and McDougall (2007) defined familiarity as also meaning the familiarity of the connection between the symbol and its meaning, e.g., that a book is a well-known symbol for a library. The familiarity of the symbols has a strong effect on the speed and accuracy of symbol processing (Isherwood & McDougall 2007, Chan & Chan 2013), and familiar symbols tend to be preferred by users (Oh et al. 2013). In their practical guidelines, Apple (2015) suggest using "universal imagery that people will easily recognize". In other words, established conventions should be used in symbol designs (Chi & Dewi 2014). However, historical reference itself does not guarantee the correct interpretation for new users (Rousek & Hallbeck 2011). In addition, the designer should take into account the cultural differences when considering the familiarity of the symbols (Piamonte et al. 2001, Shinar et al. 2003, Pappachan & Ziefle 2006, Korpi & Ahonen-Rainio 2010, Blees & Mak 2012).

Acceptability

Acceptability of a symbol refers to the subjective suitability of the design idea for the referent. Users may consider a symbol unsuitable for its referent even though they would correctly identify it (Böcker 1996). For example, two design ideas may be understood equally well as a depiction of a referent, but the users may generally prefer the first over the second. Then the first design idea is considered more appropriate than the second. Design ideas that are acceptable in one culture may be unacceptable in another and some design ideas may even be felt offensive in some cultures (Korpi & Ahonen-Rainio 2010). Respectively, the acceptability of a symbol can be increased by adding desirable elements in the design, such as a helmet on a bicycle rider to promote a desired behavior (Oh et al. 2013).

3.3. Discussion on the qualities

We see the ten qualities as a valid set of design goals that help designers implement successful map symbols. However, the qualities were not defined in equal levels of generalization and agreement in the literature. Simplicity, concreteness and familiarity were examples of qualities that were explained consistently and concretely. Aesthetic appeal was an example of quality that was mostly referred to only vaguely. Semantic closeness was a quality that was defined variable ways. Some sort of semantic association to the referent was the most frequently mentioned quality in the literature, and different terms were used and different points were raised, e.g. “A symbol that evokes different interpretations across objects is ambiguous” (Wogalter et al. 2006), “The meanings of the icon should be consistent with users‘ mental models” (Huang et al. 2002), and “The icon‘s implicit meaning should be close to the intended ones” (Huang et al. 2002). We classified all such statements under semantic closeness, but the semantic connection between the representation and the referent seem to be more complex issue than a single quality. For example, semantic reliability is a quality that might be reasonable to be separated from semantic closeness. Semantic reliability refers to the danger of linking the meaning to an unwanted referent. This might happen if the symbol is semantically close to more than one possible referent.

We categorized the qualities into graphic and semantic qualities on the basis of whether the quality deals with the graphical representation or the semantic content of the symbol. In addition, the qualities can be divided on the basis of which phases of the symbol reading process they contribute to. Visibility is important in the early stage of bottom-up processing whereas semantic closeness relates to the interpretation phase. Aesthetic appeal and acceptability may contribute a little to the efficiency and effectiveness, but are more important when the user forms an opinion of a product.

Symbol qualities presented here are somewhat universal, i.e. the same qualities are useful for most of the uses of pictographic symbols. However, different qualities are emphasized in different contexts according to the constraints typical for the context. In maps and mobile device menus the space available for the symbols or icons is limited, and in maps the (background) map and e.g. crowding of the symbols affect the perception of them. In traffic signs the time available for reading the sign is limited (Oh et al. 2013). In safety signs the correct interpretation of signs is vital, and critical confusions must be avoided above all (Wogalter et al. 2006). Furthermore, different user groups may require an additional emphasis on some qualities. For example aging causes cognitive changes in attention, language, and memory that lowers symbol reading and comprehension abilities (Lesch et al. 2011, Handcock et al. 2004). Therefore, contrast (Nivala & Sarjakoski 2005), clarity, concreteness, and semantic distance (Lesch et al. 2011) especially are suggested to be taken care of when designing symbols for older adults. Also, cultural background of users may affect the relative importance of different qualities (Blees & Mak 2012). At least, familiarity and appropriateness, as the two most culture dependent qualities, should be considered with care when the intended users come from different cultural background. In addition to maximizing the general qualities, the purpose of use may dictate specific needs for the visualization. For example, Stevens et al. (2013) applied skeuomorphic cues to give an appearance of being touchable for interactive symbols.

3.4. Reliability and validity of survey of the qualities

The literature survey was based on 18 sets of guidelines that were from a long period of time and originated from different disciplines. Some of the studied guidelines were explaining earlier guidelines. This kind of second hand guidelines were used if the original was not accessible, but double collecting of same guidelines was avoided. The sets of guidelines were reinforced by research results that concentrate on a specific quality or characteristic of symbols. Besides the materials used, there are probably a number of guidelines available, but it is unlikely that additional sets of guidelines would introduce „new“ guidelines that would be considered as generally applicable. We used a systematic process for formulating the qualities from the collected guidelines and qualities. However, slightly different interpretations of the qualities are possible.

4. Analysis of Symbols Designed by Students

4.1. Material and methods

We analyzed map symbols designed by students to concretize the qualities in practice and to get more information on the variables of symbol design. The symbols that were analyzed originated from a symbol design task that was one of the assignments of an annually organized Master‘s program course „Visualization of Geographic Information“. The symbols were designed by students in four years (2009 and 2011-2013). A little more than a half of the students were Finnish, and the rest came from several countries in Africa, Asia and Europe. The educational background of the students varied but the majority had a major in cartography or geoinformatics. The rest had practical interest in cartography and some studies in the field. None of the students had design background. The task was to design pictographic symbols to represent eight given activity areas of regional planning. The areas varied slightly from year to year, and in total designs for ten areas of regional planning were covered, namely: „agriculture and forestry", „industry", „administrative services", „health services", „social services", „transportation", „cultural services", „educational services", „commercial services", and „environmental care". The students were allowed to design manually by using pen and paper or use design software such as Adobe Illustrator or Autodesk. The students were instructed to design framed pictograms so that the symbols would be detectable from a background map. The size of the symbols was restricted to 1 cm size. Other design parameters were not fixed. The task was given after a lecture and classroom exercises on symbol design.

In the initial analysis of the symbols, many of the manually designed symbols were found to be visually complex and were considered more as drawings than as real map symbols. Therefore, the evaluation of the graphical quality of the manually designed symbols was not expected to provide any meaningful results and manually designed symbols were excluded from the analysis. In addition, the designs that did not follow the instruction on framing the symbol were excluded from the analysis. The remaining 216 symbols (i.e. 27 symbol sets each consisting of eight symbols) were then analyzed by three independent reviewers. The authors acted as two of the reviewers and the third one was a doctoral candidate from the research field of cartography. The symbols were analyzed both individually and as sets of eight symbols. Each symbol (216) and symbol set (27) was given a written report of including problems, if any were found.

4.2. Results of the evaluation

We analyzed the results of the evaluation by the following process. First, the individual problems were separated and generalized from the reviews. For example, the review: “the ear of wheat is lighter than other elements in the symbol, and thus difficult to recognize. It is also too small” was rewritten as two problems: “too light elements in the design” and “too small elements in the design”. Next, the individual generalized problems were collected in a table and frequencies for different problems were recorded. In total, 48 different problems were identified. Similar problems were further categorized. For example, problems such as “thin lines used in the frame”, “thin lines used in a specific element of the pictogram” and “entirely drawn by using thin lines” were combined into “thin lines used in the design”. Comments that appeared only once were excluded, because they were assumed to not be general problems occurring in symbols designed by novice or occasional designers. Most frequent problems were "too detailed presentation" and "thin lines used in the frame or in the pictogram". Finally, the resulting list of 21 remaining problems were classified under different symbol qualities by comparing the problem descriptions with the definitions of the qualities. At least one problem was identified for each of the qualities. The problems are listed and arranged according to the qualities they violate in Table 1.

4.3. Discussion on the evaluation results

The 21 problems found can be used in concretizing the qualities into descriptive guidelines simply by reading the problems as a list of things to be avoided when designing symbols. Pointing out typical mistakes can help the novice designers to pay attention to issues that they might otherwise fail to consider. For example, the problem of "thin lines used in the frame or in the pictogram" can be converted to a guideline by rephrasing it to: "use filled figures or thick lines". However, the problems or resulting descriptive guidelines themselves are, to some degree, generalizations that leave room for interpretation. For example, two judgments of whether a design idea for a referent is "generally well-known instead of local one" may differ vastly due to individual and cultural differences. This is especially a characteristic of the semantic qualities. Therefore, procedural guidelines, such as "test the symbols before use" or "apply participatory methods for design ideas", are needed to ensure the overall quality of the symbols. Aesthetic appeal was also a quality that was sometimes difficult to concretize. In addition to concrete problems such as "not enough space between the pictogram and the frame" there were problem descriptions such as "not aesthetically pleasing". Also, the guidelines do not give exact measures for example for the amount of space needed between the frame and the pictogram, because the measures may depend from the case. Therefore, the guidelines can only be used to draw the attention of the designer to the respective design issues.

Simplicity	• Complex design idea used (i.e. design idea requires detailed representation) • The pictogram consists of several redundant elements (i.e. several pictograms in one symbol)
Clarity	• Unnecessary details that do not contribute to the recognition • The visual representation lacks detail/visual characteristics that would have been needed in consistent recognition
Visibility	• Thin lines used in the frame or in the pictogram with respect to the planned size of the symbol • The luminance or color contrast between the pictogram and the frame is too weak for efficient communication
Consistency	• Visual weight: over- or under-emphasized symbols in the set (e.g., darker vs. lighter); • Complexity: very detailed and very simple designs in the same set • Style: symbols look stylistically different (e.g. different line weights used)
Aesthetic appeal	• Misplaced elements: the pictogram is not in the center of the frame • Not enough space between the pictogram and the frame • Elements placed uneconomically resulting in empty areas • Unrealistic proportions in elements or between different elements
Concreteness	• Visually abstract and unfamiliar design idea used
Semantic closeness	• Unidentified connection between the pictogram and the referent • A single sub-concept is used so that the symbol gets understood too narrowly • The pictogram can be connected to an unplanned referent in the context
Familiarity	• Too local, i.e., not generally well-known, design ideas for symbols used
Acceptability	• Culturally dependent design ideas used (i.e. objects referring to a certain culture are used) • Abnormal or weird design ideas used
Distinctiveness	• Two or more symbols in a set look too similar (i. e. varied only by small detail)

Table 1. The problems identified in the symbols designed by the students.

When evaluating the symbols, we found that the introduced qualities are interrelated and inseparable so that one quality affects others, which is also reported before (McDougall et al. 1999). Therefore, the qualities must be reviewed in relation to other qualities. Too complex symbols are not efficiently recognizable. However, symbols may be also too simplified in order to be accurately recognizable. Concreteness is not a problem in case of familiar symbol such of the (red) cross, but abstract and unfamiliar symbol would be difficult to interpret. Also compromises have to be made between different qualities. Graphical consistency and distinctiveness are qualities of symbol sets, and they have somewhat opposite goals to each other, because consistency guides towards similarity of the symbols and distinctiveness towards dissimilarity. There should be enough variation between the symbols to avoid misidentifications, but the symbols should still look stylistically consistent.

Qualities also build on top of other qualities. Symbols should be visible enough so that the contents can be recognized, and the contents must be recognized before the correct interpretation (with the help of semantic closeness and/or familiarity) would be possible. Furthermore, the representation should be semantically close to the referent or the connection between the symbol and the referent must be familiar to the user before the symbol can be considered acceptable.

The motivation for the approach presented in this paper is based on the assumption that guidelines are best when they are served as a list of simple dos and don'ts. Furthermore, we believe that these dos and don's are most effective when they describe errors that the novices naturally make. However, it is still a hypothesis to be tested that whether communicating these guidelines to the novice designers actually help in avoiding design errors.

4.4. Reliability and validity of the evaluation

Although, we consider the descriptive guidelines presented in this paper as a useful list, we do not claim to have listed them exhaustively. The set of guidelines is based only on the problems we were able to identify from the symbols we evaluated. Although the number of symbols included in the evaluation was high, the number of referents they represented was limited in our study. Therefore, it is likely that there exist problems that just did not appear with our set of referents. However, the referents represent reasonably well the range of map symbols, because in addition to relatively easy referents such as „health services" and „transportation" there were more abstract referents such as „administrative services" and conceptually broad referents such as „cultural services". The three reviewers identified problems generally consistently in the designs, i.e. most problematic symbols were reported by all three reviewers. The reviewers seemed to pay attention to different aspects resulting in different problem descriptions and different frequencies of a specific problems spotted by different reviewers. However, we expect that adding more reviewers would not raise significantly more problems from the symbols. The limitation of the analysis with respect to cartographic applications was that, although the symbols were designed to be map symbols, they were assessed while being located against white background that is not the real environment of map symbols.

5. Conclusions

The cognitive process of reading and interpreting pictographic symbols is complex, and the symbols can fail to deliver the intended message in many ways. Therefore, understanding the different qualities of symbols is important when a new set of symbols is designed or when a set of symbols is chosen for a map or for another communication medium. We identified ten such qualities that can be considered as goals of symbol design. Graphic qualities relate to the visual outlook of a symbol, and they include simplicity, clarity, visibility, consistency, distinctiveness and aesthetic appeal. Semantic qualities relate to the semantic contents of the symbol, and they include concreteness, semantic closeness, familiarity, and acceptability. However, giving precise guidelines instead of general goals or qualities can be helpful in concretizing the qualities for novice designers, and thus, make the qualities more understandable. We concretized the ten qualities by identifying 21 problems relating to them from the set of 216 symbols designed by 27 students of geoinformatics.

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Dynamic Cartography: Map–Animation Concepts for Point Features

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Extended Abstract

Since the late 1970s new software environments and tools (e.g. BRYNJOLFSSON & MCAFEE, 2012) have been providing interactive visualization techniques by allowing to efficiently map real-world and abstract objects and time-dependent phenomena (FRIEDHOFF & BENZON, 1989). Since then, computer animation has become an integral part in all aspects of everyday life. Computer-based cartography has been proven to be an important tool, especially as developments caused an improvement in dynamic data visualization and animation (e.g., Dransch, 2014). The conventional approach of map-frame-based visualization representing individual animation frames by fully-equipped maps has been changed towards a map-element-oriented animation concept in which time is stored as attribute for each object. Cartographic animations can then be implemented as an extension of existing data models.

Our contribution deals with data structures that allow depicting spatial data primitives (OGC 2011) as time-dependent objects in order to access, statistically evaluate and cartographically animate map features. To achieve this we here concentrate on point features as they provide the highest level of abstraction but the lowest level in geometry and topology. In contrast to line and areal features only the position of a point feature is related to geometry which provides an additional level of freedom in modelling as a point's size has only a cartographic and no geometric meaning. Thus, if the lowest level of geometry can be modelled in time any higher-level or derived object can be modelled equally well.

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Time is an attribute which controls the behavior of properties represented by graphic variables. Changes of states occur in (1) composition, (2) size metrics, (3) orientation, or a combination of these variables.

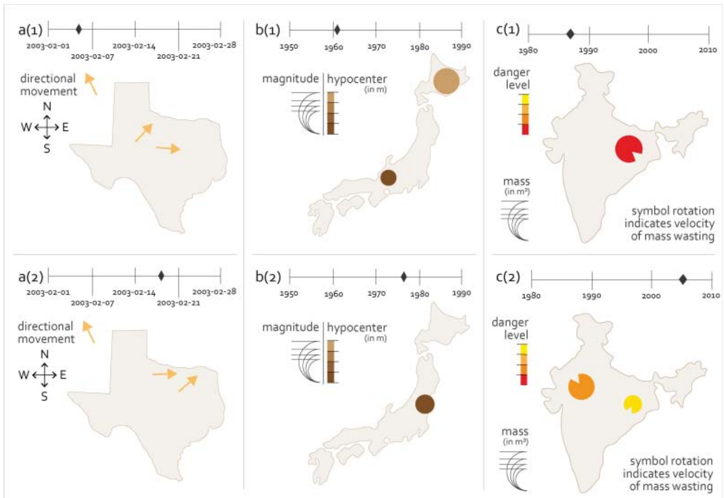

Figure 1: Point features and dimensions in map representations .

A change within a temporal framework defined by two instances provides change rates or velocities. Possibilities of how changes can be displayed depend on complexity and number of attributes but also on the level of measurement (BERTIN, 1983). Figure 1 provides fictitious examples of multi-dimensional point animation represented by symbols carrying various attributes and visualized using different methods (sizes, colours, and angles).

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A Displacement Method for Maps Showing Dense Sets of Points of Interest

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Extended Abstract

In the past, point data only play a minor role in map generalization, as points are either already the result of generalization (by symbolization) or are used for objects which are only shown on large scale maps (e.g. real estate maps). Now, with the growing availability of web mapping services the role of point data has changed: Besides route planning, the most common function of web maps is the visualization of user queries for points of interest (POI). Due to the limited size of commonly used displays, the map extract is often rather small, which results in a smaller scale as would be appropriate for the maps content. At this, the state of the art to resolve occurring cluttered point sets, is on the one hand interactivity (pan and zoom) and on the other hand the selection of points. Thus, often the available space is not optimally used. Therefore we propose a displacement method to improve the readability of dense sets of POIs.

Given are a set of geocoded POIs and their circular map symbols of a fixed size for a given scale. To guarantee a certain accuracy of the positioning, we require that the coordinates of each point are inside its corresponding map symbol. The quality of the placement is measured by the sum of the areas of the intersections of all map symbols. The optimal value is zero, as it means that the symbols do not overlap at all. So the strategy is to assign a distinct area to each point, which is large enough to completely contain the symbol. In order to do so, we chose an iterative method, which applies Voronoi diagrams as auxiliary structures. The initial assignment of areas to the POIs is the Voronoi diagram of their coordinates and the center of the symbols are placed on the coordinates. In each iteration, all overlapping symbols are displaced and the Voronoi diagram is adapted. The method stops, if there are no more overlapping map symbols, or if no point can be moved without

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exceeding the given threshold (radius of the symbols), or if a given number of iterations is exceeded.

The quality of the displacement depends wholly on the calculation of the displacement vectors. So, as to improve the initial placement, small Voronoi cells should be enlarged and the sites should be closer to the center of their Voronoi cells. In order to achieve this, we apply two alternative heuristics: to move point towards the center of a largest inner circle of its Voronoi cell (a) or towards the centroid of its Voronoi cell(b).

We evaluated both methods with five datasets (European towns, airports, towers, hills and peaks) derived from Geonames. To improve the efficiency of the algorithm, we automatically remove isolated points (fix points) and divide the dataset into sets of points, which can be processed independently. For both steps, we apply once again Voronoi diagrams. In *Figure 1* on the left side the divisions for airports are shown and on the right side the result of the displacement with heuristic a).

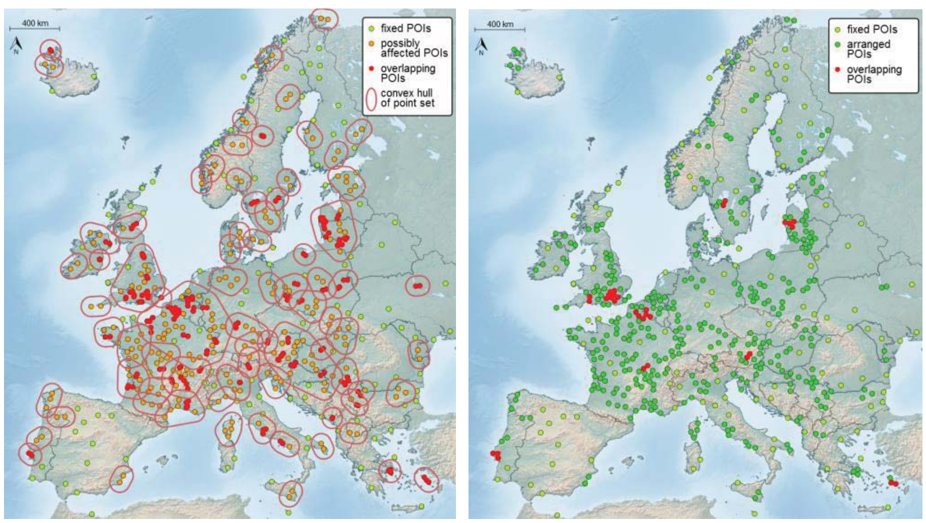

Figure 1. Airports in Europe, division of point sets and displacement result.[1]

For three datasets, the overlap of each symbol could at least be reduced to less than half of the symbol's area. In the other two datasets (peaks and towers) 33.47% and 11.89% of the symbols remain covered in large part. The percentage of solved conflicts varies between 13.2 and 79.7 depending on the density of the dataset.

[1] Parts of base map adopted from Natural Earth

Model of Dynamic Labelling of Populated Places in Slovakia

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Extended Abstract

Text on maps has an irreplaceable function. It increases information value and completes appearance of maps. To communicate spatial information effectively, map features need to be labelled.

The effectiveness and functionality of a map, as a communication medium, undoubtedly depends on how it is labelled. Clarity and legibility are two main objectives which a cartographer strives to achieve and which have direct influence on the perceptual and cognitive process used by map readers to search a certain name on the map and to determine its meaning.

A term dynamic labelling refers such labelling, the characteristics of which are adapted to the creation of labelling in dynamic maps. They are characterized by allowing for continuous zoom and pan. Change of zoom level results in change of scale and also in change of size of the displayed territory. Pan results in change of region of interest. The aim of dynamic map labelling is filtering, selection and placement of labels on the map.

This paper is focused on populated place labelling for multi-scale mapping for the new state map series of the Slovak Republic (SR). The new state map series will be created from data of Basic Database for GIS (BDGIS). Part of BDGIS consists of point layer of geographical names (GN). This point layer should serve for placement of populated place labels. All GN records contain name and coordinate location attributes. Unfortunately, this point layer contains no information about categorization of populated places.

If we construe the map as a tool for transferring information between the cartographer and the map reader, then correctly designed categories of populated places and defined rules of labels placement have direct impact on obtaining information from the map.

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We defined new categorization of populated places as well as font parameters such as colour, height, width and spacing of letters. New categorization is based on number of inhabitants. Towns and villages are divided into unique categories on the basis of last census. We designed four new categories for towns and three categories for villages. Additionally, town and village parts with different names as is the name of the town or village have their own category. In comparison with previous categorization for the state map series we reduced number of categories. Furthermore we applied rules of the digital typography for designing font parameters for each category and scale. The proposed font has to meet requirements for simplicity and good readability in different sizes depended on digital environment. Three font types were tested on the same territory of interest. We decided to use font Arial and smallest size 8 pt. Labels in each category has to be different in size at least for 2 points to ensure clarity. Proposed colour is 80 % of grey scale.

For purpose of populated place labels placement is an important task to correctly define hierarchies, priorities and weights. Majority of cartographic conflicts were caused either by overlapping labels, crossing labels with line objects or crossing labels with areal objects. Numerous cartographic conflicts can be solved by determining correct label placement rules. Line objects must not be overlapped thus we set highest weights to roads and rivers while roads have higher priority. The hierarchy is set on the basis of categorization in meaning populated places with more inhabitants are higher in hierarchy ranking. Model of dynamic labelling of populated places was created in ArcGIS v.10.2.2 and its extension Maplex. This extension provides a special set of tools that allows improving label placement quality.

GN features are all identified by a single XY coordinate. This causes problem when labels for larger towns are placed. We want to ensure that labels occur even when the GN definition point is on a different map sheet. Also in scale 1:25 000 we can obtain better results when positions of labels are calculated for areal features of towns.

The goal in a feature work is to solve problem caused by point character of GN features. We want to define a new relational linkage of names of towns stored in GN database with polygons, which represent their area. Areal features may provide better placement results in populated place labelling. Next step is to define new category for town parts of two largest Slovakia cities (Bratislava and Košice). Bratislava has seventeen town parts while Košice twenty-two. These have individual administrative meaning, which must be reflected in their labelling. Our effort is also to make tests of the labelling model based on eye-tracking technology to obtain feedback from map readers and improve our dynamic labelling model of populated places.

A research in cartographic labeling to predict the suitable amount of labeling in multi-resolution maps.

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Extended Abstract

There have been several works and efforts towards making the best computerized map generalization. An important part of the generalization process, axiomatically, for a map is to understand its components. Furthermore, since the labels are one of the main components of the map - through labeling the user can understand the map a lot easier and more accurate- several works for that purpose were done (Zoraster, 1997; Zhang and Harrie, 2006; Stadler, et al, 2006; Brewer, et al, 2013 ...etc). These works witness a lot of unnecessary data lost, and focus mostly on point labeling, therefore they are not dealing with real time mapping and focus more on a static hardcopy map production. Most of the previous works were focusing on the legibility problems discussed on the cartographic generalization process (amalgamation, displacement, etc.) alone, while our work address more than that ordinary processes. The study focuses more on the online multiresolution map products, also on the significant of the displayed feature at every level of detail, and the amount of displayed labels in every level of detail. Since the multi-resolution map user will be concerned in extracting the most required information from the map, their needs should differ in every level of detail, moreover, the road types which is going to be presented at that certain zoom level should be considered, also trying to make the amount of the displayed data sufficient enough without any shortage or excessive.

In this study, it is expected to develop a proposed methodology for better labelling with the use of intellectual hierarchy while also trying to compose an empirical formula to display the road labels. We started working in defining every road class to its appropriate level of detail, also we are expecting to make our own formula to predict the most suitable amount of labels for the road features to be displayed. We defined the suitable road types

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and classes that would give the map user better understanding at every zoom level. We analyzed the best multiresolution map services, such as Google Maps, Yandex Map, Open Street Map, Bing Map and others. Most if not all of the used popular online map services do not share their used algorithms or models, thus forced us to simulate their displaying system using the artificial neural network means and tools.

The used map services various in content and number at every level of detail, hence we decided to examine these products in several testing central cities around the world (Ankara, Istanbul, Johannesburg, Cambridge, Sydney, etc.) to compose our formula. Our formula is expected to display the best amount of labels along with the most important road features to be labeled at every level of detail. The elements will be used to insure that are (1) the artificial neural system principles means and tools (2) the actual number of road objects and actual number of the labels displayed at each level of detail extracted from the used map services, (3) the field of view (area) of the displaying screen. The composed formula will be expected to provide us the average amount of road labels considering the above mention elements at every level of detail. The composed formula will be compared with the radical law equation of Topfer and Pillewizer (1966) to predict the suitable number of features needed to be shown at the target scale. The formula is expected to be more accurate and suitable for the online multi-resolution map production.

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Pins or Points? Cartographically Appealing Webmaps and Technical Challenges: the Example of "Landschaften in Deutschland Online"

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Extended Abstract

Why should a cartographer use pins when there are "better" ways to express the same data?

Consider new ways of multi-media production, for example an established book series that goes online: In June 2015 the volume "Leipzig" (No. 78) of the "Landschaften in Deutschland" book-series was published. Initially an accompanying web presentation with additional and multimedia content was prepared. For its publications – print and online (IfL 2000–2007, Meusburger/Schuch 2011, Hanewinkel/Losang 2013) – as well as for the transfer of geographic knowledge into a wider public (Lentz/Moser 2013) the Leibniz Institute for Regional Geography (IfL) always puts emphasis on high quality cartographic representation of spatial phenomena in forms of thematic maps and visualizations.

Cartographers are facing new challenges in transforming geographic knowledge into interactive webmaps. Although there are many different tools (software, API, programming languages) for webmapping even by non-experts in cartography the use of special cartographic forms of expression depends not only on the data used and the message desired. One faces technical limitations just as often. Especially the integration of different (technical) forms of visualization often depend on the website-system (CMS). Such limitation can be overcome more or less easily by programming experts, but for non-experts in cartography and programming it is hard to meet the different conditions to make "good" maps.

"Landschaften in Deutschland Online" uses different mapping solutions to visualize spatial information. Occasionally static maps are displayed in the printed book as well as in the Internet. Certainly the website focuses on interactive maps. These were developed using programming languages like

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ActionScript and JavaScript as well as the programming libraries D3.js and Leaflet.js. Additionally the software Mappetizer was used to transfer ArcGIS-based projects into HTML5-based web applications. OpenStreetMap was used as basemap for different applications. The layers needed were specially designed with CartoCSS and delivered as vector tiles hosted by Mapbox.

We want to show special challenges and obstructions in the use of cartographic methods in webmaps on the basis of one specific example (fig. 1). Currently a special combination of different tools together with the website-CMS (static site generator based) supports only the use of pins with corresponding numerals. The pins are interactive and guide the user to the explanation below. From the text the user can come back to the maps and will need the numerals to remember the position of the point of interest. An alternative is the use of an interactive map that shows the houses as areas. Due to the diverse technical development it was impossible to connect the map with the corresponding text easily.

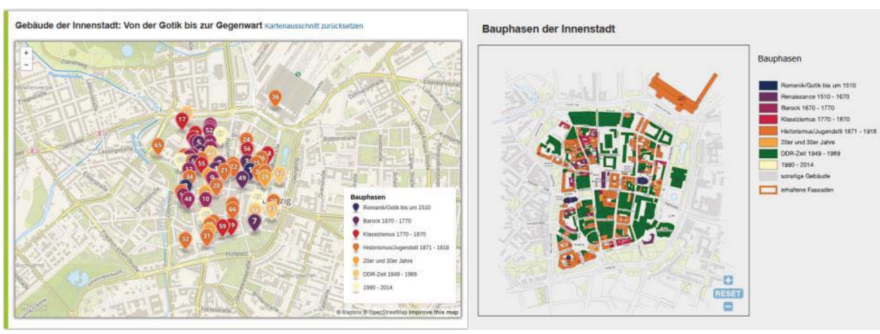

Figure 1. Left: Webmap made with Leaflet.js on specific buildings in the inner-city of Leipzig with indication of their construction phase and interactive links to the explanation below. Right: Interactive flash-converted html5 map, interactive by showing all buildings of the same construction phase but without links to the text (both: http://landschaften-in-deutschland.de/themen/78_B_104-bauphasen-der-innnenstadt/).

We want to discuss possible approaches to solve these problems. The concept of a website-CMS is just as crucial as the applications and tools used. Facing these components the presentation also discusses these approaches in the context of the democratization argument that webmapping is easy to use by prosumers (non-experts in cartography, which produce (and use) maps using tools in Web 2.0). From our point of view a reflection on defined production approaches for creating webmaps in connection to forms of cartographic expression is called for.

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Designing Usable Sequential Color Schemes for Geovisualizations

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Extended Abstract

The contribution aims to introduce the proposal of computational method of designing sequential color schemes of user-specified coloring, number of classes and their mutual color distances specified by CIEDE2000 formula (developed by Sharma et al. 2005).

Color distance (a metrics established by the International Commission on Illumination to quantify the human ability to differentiate between colors) has been empirically proven to be an important factor of overall maps readability (e.g. Brychtova and Coltekin 2015, Brychtova 2015, Brychtova and Coltekin 2014, Brychtova and Vondrakova 2014). Insufficient color distance between cartographic symbols impairs the map-users ability to distinguish and interpret the visualized spatial information.

The method of designing sequential color schemes is based on analytic geometry calculations, specifically on finding the intersection of two subspaces: CIELAB color space and a straight line, on which the color scheme lies. A straight line A_1A_0 is defined by two points A_1 and A_0, where A_1 becomes marginal shade of the color scheme and A_0 is auxiliary shade determining the direction of the color scheme within the CIELAB color space.

The principle consists in finding color shades A_2, A_3, ..., A_n lying on straight line A_1A_0 at given distances defined with CIEDE2000 $\Delta E_{00}(A_1, A_2)$, $\Delta E_{00}(A_2, A_3)$,..., $\Delta E_{00}(A_{n-1}, A_n)$ (see the example on the Figure 1).

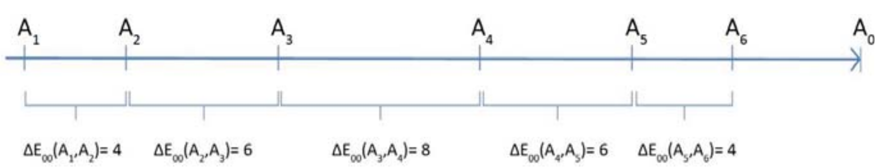

Figure 1. An example of color scheme of 6 classes and color distance between them $\Delta E_{00} =$ (4-8-10-8-4).

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The method is intended for the construction of schemes for *digital maps* only and for this reason their construction is limited by the gamut of sRGB color space.

Between sRGB and CIELAB color spaces doesn't exist any one-to-one correspondence and, at the same time, transformed to CIELAB, the set of possible sRGB colors forms a non-convex shape, therefor out-of-gamut colors can result from the computation. In these cases (when resulting color coordinates are outside the range $R,G,B \notin \langle 0;255 \rangle$) the computation is terminated and the user is notified that in this direction there are no more available color shades.

To access the presented method an on-line tool *Sequential Color Scheme Generator 1.0* was created. It is freely available at **http://eyetracking.upol.cz/color**. Users can manipulate *colors*, *number of classes* and *visual difference* between them by applying color distance steps with CIEDE2000. Each step is instructed with information bubbles.

In the future we want to implement color scheme computation in color space designed for *printing* purposes (FOGRA39) resulting in C, M, Y and K color coordinates. We also want to replace current square color picker with irregular shape of the color space to allow better perception of its dimensions.

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Visual Suggestiveness and Change Blindness in Dynamic Cartographic Visualisations

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Extended Abstract

The movement that appears on the map leads to a perceptive problem known as change blindness. This consists in the failure to perceive changes in the presentation of spatial phenomena, e.g. the appearance, disappearance, location change, or changes in attribute. From the point of view of cartography, this leads to the loss of spatial information and may mislead the map user. The reason may be the divisibility of the user's attention, who must simultaneously look at the map and the legend. Another reason could be the focus on a certain fragment of the map, whereby changes in other parts of the map are not observed.

The subject of research concerned dynamic maps presenting physico-geographical and socio-economic phenomena. Phenomena was presented using point, line and area methods of cartographic presentation. In addition, the visualised phenomena were divided according to two types of dynamics: all were visible and changed simultaneously, or the phenomenon occurred, disappeared, or reappeared.

The most important objectives of the experiment concerned an analysis of the visual suggestiveness of methods of cartographic presentation with regards to the perception of changes on the animated map. In order to suggest responses, use was made of the superimposition of two visual variables – size and colour, and two dynamic variables: order and duration. In the research, we designed a model of concentrated and dispersed phenomena placement.

A total number of 125 students from the Adam Mickiewicz University in Poznań took part in the experiment. The results of the experiment were intended to answer the research question posed: can visual and dynamic

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variables be used to suggest spatial information in dynamic cartographic studies?

The results of the experiment showed that visual variables have a decidedly greater impact on suggesting spatial information than dynamic variables and on reducing change blindness. It was very interesting to observe that the usage of visual suggestiveness in the dispersed model is considerably more effective than in the concentrated model. In addition, suggestiveness is weakest in reducing change blindness in the case of areal methods.

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Preserving attribute value differences of neighboring regions in classified choropleth maps

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Extended Abstract

In **choropleth maps** the underlying attribute values might be represented either in an unclassified or in a classified manner. While the first choice maintains numerical values and their relations (which might be necessary for some exploration tasks), the – more frequently used – second choice has advantages for overall impression purposes by enhancing value differences and allowing for an easier visual matching with the legend.

For a **classification** commonly used methods perform a division into intervals purely along the number line. Methods like equal intervals, quantiles, mean-standard deviation, maximum breaks, or natural breaks are typical representatives which are implemented in standard GI and cartography software packages. It is well known that applying different methods – together with varying the number of classes, the display of border classes (open vs. closed) and the consideration of extreme values – influence the overall visual impression and with that the message of a map. Depending on the task related to a map (or the goal of the cartographer, respectively) specific classifications should be selected on good grounds.

A **limitation** of the aforementioned classification methods, performing a division into intervals along the number line, is that they fail to consider the actual spatial context of underlying data. By doing so, possibly existing spatial relationships of neighboring units or patterns across the entire map space might get lost. Only little work has been performed on this topic, most of it is motivated by the idea of just simplifying the map pattern.

In this contribution we will take up the idea of classifying data for choropleth mapping considering the spatial context. The specific goal is to keep large gradients or similarities of neighboring regions after the data classification step. For evaluating the preservation of attribute value differences a

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suitable measure is needed. As a consequence of the shortcomings of existing indices (like the Tabular Accuracy Index, TAI; or the Boundary Accuracy Index, BAI), a new **Edge Preservation Index (EPI)** is proposed here. It relates the original value difference to the corresponding class value difference – following the idea that there should be a linear correlation between these two differences. The EPI is designed in such a manner that its value and algebraic sign give an indication whether there is a loss, preservation or amplification of value differences of neighboring classes. Furthermore, it allows for the consideration of a flexible number of neighbors – either the preservation at all boundaries is considered, or the preservation of the edges with the p % largest value differences is considered only (i.e., an emphasis on large gradients can be quantified).

Applying this new index it is now possible to find an optimal data classification for the given purpose out of the many options that emerge by varying the number of classes and class boundaries. The figure below shows the results for the best preservation as well as for the largest amplification of neighboring value differences – in comparison to "standard" classification methods the effect of considering the spatial context becomes clearly obvious.

Current work is concerned with an optimization of the implementation of the complex and time consuming algorithm. Based on such an implementation user studies using various data sets will test the our core hypothesis which states that the classification results considering the spatial context will lead to an improved effectiveness for respective tasks.

Figure 1. Classification of population density values for German states (3 classes) applying different classification methods – from left to right: equidistant, quantiles, Jenks, EPI (best preservation), EPI (largest amplification)

Application of Conceptual Model in Thematic Mapping: Representation of Relationships

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The paper addresses the general problem of visualization in thematic mapping. Thematic Web maps become more and more important in our life. Many opinions are formed and decisions made based on what maps the users see online in spatial information sites and portals. In case of maps that show variation of more than a few attributes, communicative quality of the map is very important for appropriate and efficient perception of the information. It is somewhat paradoxical that regardless of growing variety of available cartographical representation tools, same visualization errors are made repeatedly by the amateur cartographers as well as by experienced GIS users. Experiments performed in 2008-2013 showed that the students with some knowledge in cartography easily recognize a problematic map but usually encounter big difficulties with identifying and describing concrete faults. Even professional map makers sometimes make errors, mostly related with representation of series, structures, hierarchies and relationships. In order to improve the skills of the students related to the logical correctness of cartographic sign systems, we introduced two applications based on conceptual modeling technique: (a) for systematic design of conventional signs and (b) for reverse engineering of the model for the subsequent map quality assessment. Both these techniques are used for teaching thematic cartography in Cartography Master study program at Vilnius University, Lithuania.

Entity-relationship modeling is a database modeling method, used to produce a conceptual schema or a semantic data model of a system, often a relational database. We have demonstrated that ER/UML models can be successfully used for the design of a logically consistent system of map signs and for evaluation of correctness of existing sign systems. Current research in this field is carried out with the purpose of refining the proposed algorithm in order to encompass more complex situations, namely, structures, relationships between entities. In the paper, we demonstrate how relation-

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ships of different cardinality and modality could be represented using this method.

Representation of class hierarchies is based on the set of inherited attributes that is common for all the subclasses and is represented by a set of graphical elements. Correspondingly, signs that represent subordinated and coordinated entities share a subset of graphical elements. Representation of compositional hierarchies is similar to representation of structured attributes of a single entity, only the requirements for the visual structure of a compound sign are looser. Other one-to-many relationships often represent some kind of movement or a link in the space and require resolution of the relationship that is not common in other applications. In this case, individual signs for each relationship entity (link entity) are designed. Changes in time are more diverse and difficult to represent – mainly by compound or structural signs. Many-to-many relationships are resolved and relationship entities created, with corresponding graphical signs. Dependent entities that rely upon the existence of other entities are in the most of cases converted into link entities. If the relationship has the modality of zero, linking graphical entities must have an attribute of obligatoriness.

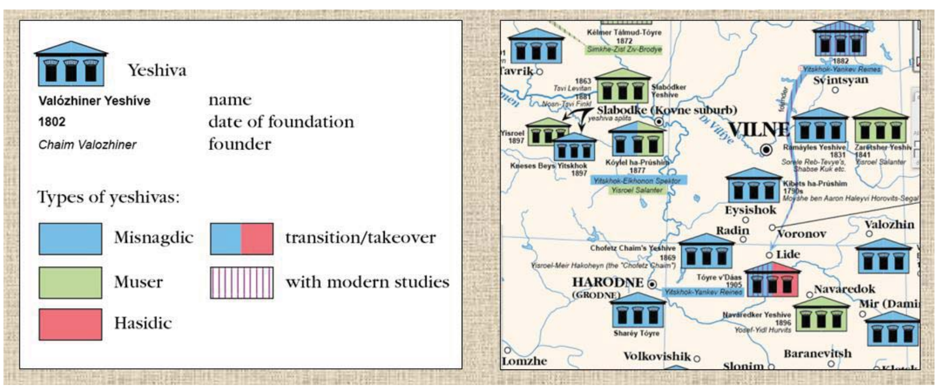

Figure 1. Representation of changes in space and time. Source: Katz D. (2014). Lithuanian Jewish Culture. Baltos lankos, Vilnius: 147.

The same task to design cartographic signs for representation of relationships was given to 20 students – 10 familiar with the described technique and 10 to whom the method was unknown. Comparison of the results supports the hypothesis that explicit use of a conceptual model results in better control over all visualization decisions and consequently more consistent representation of information.

Semantic Representation of Topographic Data for Cartographic Presentation and Application

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Extended Abstract

The U.S. Geological Survey is responsible for topographic mapping of the United States. Historically, this responsibility has been met by the creation and distribution of standard topographic maps as lithographic prints. With the development of digital mapping and operational geographic information system (GIS) capabilities, which began in the 1960s and matured in the 1990s, the USGS has now moved to a completely digital technology to meet this responsibility. Standard 7.5 minute, 1:24,000-scale topographic maps are generated from the digital topographic databases of The National Map and distributed as a layered GeoPDF product, repeating complete coverage of the conterminous 48 states, Hawaii, and the territories, every three years. However, research and development in the broader technological area of geospatial data and information are driving a need for a different representation of geographic phenomena that accounts for the semantics of geospatial information and can be processed and analyzed by machines. For example, representing the source, mouth, left and right banks, tributaries, and other characteristics of a stream and the relationships of that stream to the surrounding landscape are now needed for scientific modeling and management of the stream and its resources and can be used to enhance the cartographic representation of the stream. Similarly, there is a need to access the walls, floor, and mouth of a canyon with any stream or other landscape features associated with the canyon. Representation of these types of geographic feature characteristics enriches data for applications and cartographic product generation. These concepts of geographic phenomena can be represented as semantics, and with the development of the World Wide Web and the associated Semantic Web, each geographic feature can be provided a unique Web address and can be accessed by both humans and machines. The USGS is developing a complete ontology and semantics for all features represented on topographic maps and is making

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these available on the Semantic Web. This presentation will provide the basics of knowledge representation of topographic information through semantics and will detail the ontology and semantics that have been developed for USGS topographic data. The representation uses triples of subject, predicate, and object of the Resource Description Framework (RDF) of the Semantic Web. Vector-formatted geographic data in GIS relational databases can be converted directly from the relational tables to RDF, but terrain and other features from raster and continuous three-dimensional data sources, such as images, scanned topographic maps, digital elevation models, and lidar, are problematic to represent in RDF. The capture and representation of these features in semantic formats are detailed as well as application areas for geospatial semantics including cartographic operations such as generalization, data integration, and automated symbolization.

Combining Two Datasets into a Single Map Animation

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** Aalto University, Department of Computer Science

A comparison of two independent datasets to search for correlations, either instant or lagged, or find anomalies among the behavioural phenomena represented by the datasets, is a common type of task in visual analysis. Presenting these two datasets together on a single map is a widely used method for comparison, also with temporal datasets (Blok et al. 1999). If the datasets are areas or surfaces, they are very likely to overlap each other at least partially. In that case, transparent layers are used to avoid one dataset being covered by the other one. When the transparent data layers overlap each other, a new colour is formed as a combination of the colours of the data layers. There are guidelines for selecting colours for bivariate maps (Brewer 1994) that are analogous to overlapping datasets. However, the bivariate colour schemes are designed for static maps, and there is no knowledge about how movement and variation in the geometry of the datasets affect the perception of the phenomena.

To study the functionality of the bivariate colour schemes applied to map animations of moving areas, we selected two pairs of spatio-temporal datasets for different analysis tasks and implemented map animations for them. The first data pair contained an atmospheric rain model and radar images of rainfall (Figure 1a). To enhance those areas where the model and observations do not match (a task demanded by experts on meteorology), the colours for the visualization were selected to be complementary in such a way that their combination forms a neutral grey. Both datasets were classified into three classes. The second data pair included a model of birch pollen concentrations in air and relative air humidity (Figure 1b). The colours were selected so as to be associative (yellow for pollen, blue for humidity) and their combination to form its own colour (green). High air humidity (over 70%) has proved to reduce the pollen concentrations to less than 50

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grains/m³. These were selected as threshold boundaries of the areas that were visualized.

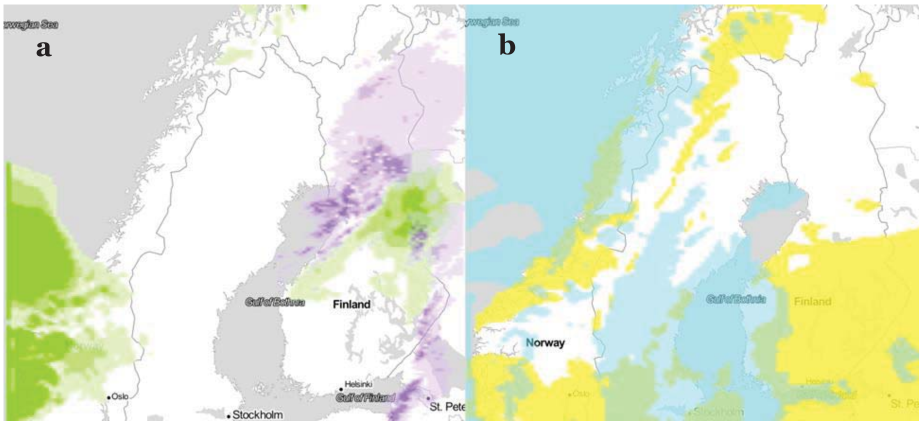

Figure 1. Screenshots of the rain model and rain radar visualization (a) and the pollen and air humidity visualization (b). In (a), the rain model (green) forms continuous areas with high intensity of rain while the radar observations (purple) are more dappled and discontinuous. In (b), the blue layer with high air humidity is spreading from the sea into the inland parts of Finland, wiping away the yellow pollen layer. The layers overlap in the green zone.

The comprehensibility of these visualizations was evaluated through interviews with three different user groups: students, GIS experts, and experts on meteorology. The groups were asked about their opinions about the selected colours and the associations they obtained from the visualizations. All the groups concluded that the neutral grey as a combination of the radar and model was not easily noticed; the interpretation of grey is particularly sensitive to its neighbouring colours, and the differences in the geometry of the datasets increased this effect. The pollen-humidity pair was also difficult to interpret because of the separate, non-predictable movement of the datasets. The green union of the datasets was seen as a third phenomenon of its own, rather than the combination of the other two. Our key finding is that the colour use guidelines designed for static maps cannot be straightforwardly applied to animated visualizations. Further studies should focus on the effects of movement behaviour, geometrical complexity, and the spatial coverage of the datasets.

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The complexity of cartographic presentation types

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Abstract

It seems necessary to verify the classification of the cartographic presentation methods. There is a need for a new, formalized view of the method, as a sequence of steps from data collection to correct presentation, to map. It should be found to distinguish two terms related to cartographic presentation: methods and forms.

A METHOD (TECHNIC) is understood as a transition process from data to presentation, as a certain sequence of actions leading to a meaningful presentation, as a way of proceeding which starts from data leading to a presentation.

FORM is understood as a final effect of this process – a graphic image, a result, a map.

There are five different types of cartographic presentation complexity. In the described subsequent types, one can observe an increasing degree of complexity of cartographic presentation (from the simplest one to the complex one).

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The spatial statistical generalization of information for regional land-use management in Ukraine

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General methodology

Development of technologies for remote sensing are allowed to generate a thematic products of classification, which formed the basis of land use cover (Chuvieco, 1999). These are the basis for land-use management of natural resources and regional planning. European program CORINE has established a single land use cover for Europe on the basis of approved standards. Ukraine in this project did not participate, so a long time accurate data of land use were not available for the territory of Ukraine. This situation has changed with the release of a Chinese global product GlobeLand30, which allows us to estimate the distribution of land use in Ukraine and neighboring countries, as well as to draw parallels with the CORINE data. GlobeLand30-2010, mapping product of global land cover at 30-meter spatial resolution derived from remote sensing images in 2010 is produced.

The dataset covers land area from 80° N to 80° S, consists of 10 land cover types, namely cultivated land, forest, grassland, shrubland, wetland, water bodies, tundra, artificial surfaces, bareland, permanent snow and ice.

The classification images used for data generation of GlobeLand30-2010 are mainly 30m multispectral images, including Landsat TM and ETM + multispectral images and multispectral images of Chinese Environmental Disaster Alleviation Satellite (HJ-1). Cloudless images acquired over vegetation growing seasons within ± 1 year from 2010 were selected. In case the area missing suitable images, the time frame is extended.

Formation program management of natural resources and land use in Ukraine has four levels of organization: national, regional, district, local. At each level, there is a correction of management programs and input data

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used for decision-making in land management. Land uses data are common information basis for management decisions at these levels.

However, at different organizational levels, there are contradictions, which are the main causes of imbalances in the distribution of different types of land use on different territorial levels of government, inconsistency of goals of individual subjects of management, the need for a synthesis of information at higher levels of governance.

To solve these problems it was carried out data processing for land uses and territorial units each level of management. We have downloaded the tile data, which cover the territory of Ukraine. It was further carried out building the tile mosaics and crop it on the border of Ukraine. The obtained data were processed using ArcGis ArcTollbox. The group zonal analysis was used as the main types of analysis tools, which allows to obtain summary statistics for multiple datasets. Zoning is performed using a tool Tabulate Area, which calculates the cross table space between the two sets of data and outputs the table. to raster data set of land cover and vector set of administrative units were used as an the input data. Polygons village councils were used at the local level, polygons cities and districts - at the district level, polygons regions of Ukraine - at the regional level. The results were evaluated relative to zoning average values in Ukraine, regions and districts. The main statistical characteristics that describe the distribution are averages, amplitude, and dispersion of parameters. Also of great importance are the methods of classification used in the construction of cartograms. This approach allows to consider and agree on goals of land management and land use planning at different territorial levels, because it makes it possible to compare the parameters both between the administrative units of the same level, and between the region and its subdivisions.

For all units it was also calculated the Shannon index, which indicates to the diversity of forms land uses, which helps to take into account administrative units with a low level of diversity related to anthropogenic influence (Nagendra, 2002, Ramezani, 2012). The low value of the Shannon index is characteristic of eastern regions of Ukraine, where it is associated with a high level of urbanization and the southern regions, where the level of agricultural land can reach 80-90%. (Fig.1)

Another area of research is related to the need for a generalization of data to speed up the calculations statistic at the regional and national level. In this case, you need to increase the size of the raster cells, which affects the accuracy of calculations and their redistribution between classes. This requires selection of an optimum cell size of the raster, wherein the relationship between the accuracy of the result and the processing speed will be optimal.

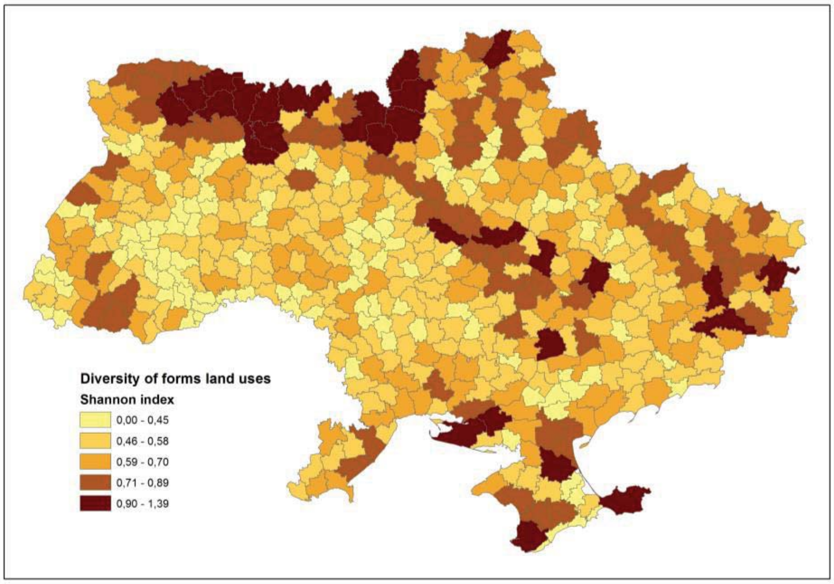

Figure 1. Diversity of forms land uses by the Shannon index in districts of Ukraine.

Current land cover data is one of the basic products the classification big data. They are used as the basis for the management of territorial development at different levels of regional governance. Thanks to International efforts today Ukraine has access to the land cover data with high resolution, but we need that Ukrainian research have been passed on the system basis and have been integrated into the European Research Area. Land cover data provide the basis for the zonal statistics in vertical and horizontal cross-section for the entire territory of the country, which should be used in developing plans for the land use of the territory and the nature conservation.

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Challenging Cartography in ArcGIS from Esri Switzerland

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Extended Abstract

Esri the leading international supplier of Geographic Information System (GIS) software has in the past often been shunned by the Cartographic community for concentrating too much on GIS and too little on cartography.

Since the arrival of Cartographic Representations in ArcMap 9.2 however Esri has put a concerted effort into responding to this criticism and have since come a long way in their cartographic support. Esri have also responded to the steadily increasing interest in both model and cartographic generalisation by extending the palette of tools available in both ArcMap as well as in the Production Mapping Extension with each new release.

Both of these developments have predominantly been driven by the National Mapping Agencies (swisstopo, BEV etc.) interest in starting to use their in-house GIS systems to produce the National map sheets instead of using an alternative graphic based software solution. The National map sheets not only have a very high cartographic standard to maintain but are also often now being derived and produced from a single large scale Topographic reference model and then being automatically generalised into a number of different scale Digital Cartographic Models (DCM's).

Esri Switzerland have taken the existing cartographic possibilities offered in Esri's ArcMap and gone one step further. In collaboration with swisstopo and numerous other cartographic customers the Carto-Tools have been developed which contain a number of Cartographic Processes (CartoProcesses) and tools to help automate map production. These tools automate identified time consuming cartographic processes as well as supporting the cartographers when manually adding the final cartographic touch.

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This presentation will step through a possible cartographic production workflow, based on OpenStreetMap Geo-Data and proceed through each of the steps as shown in Figure 1.

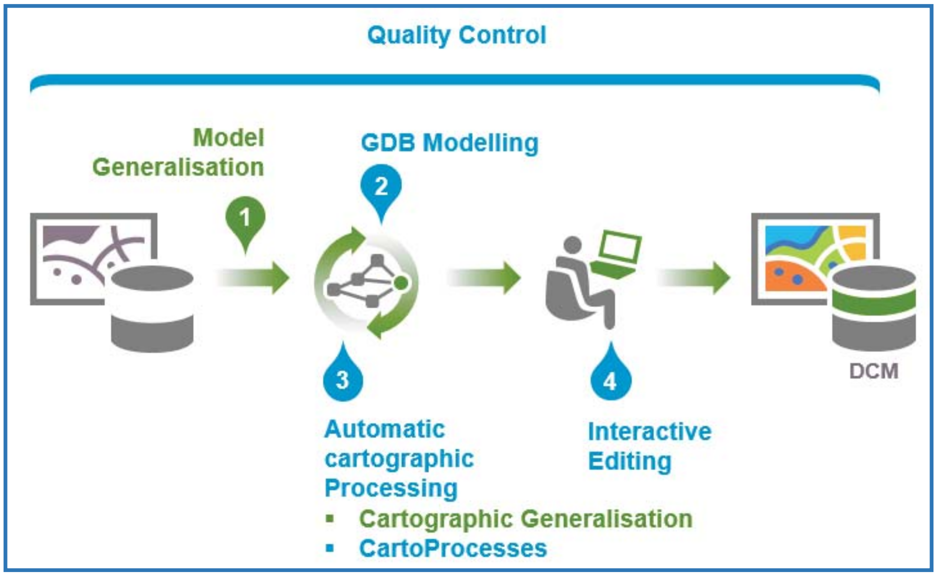

Figure 1. A potential cartographic production workflow

For each of 4 positions shown within the production workflow the following will be presented:

Step 1: Presenting the concepts and an overview of the tools available for Model Generalisation.

Step 2: Will show how an existing Data-Model can be enhanced to support various cartographic features, as well showing how the required symbol catalogue can be applied to the data.

Step 3: Here the tools and concepts for Cartographic Generalisation will be presented, followed by an overview of the CartoProcesses. The CartoProcesses automate identified cartographic symbolisation tasks to help increase the general cartographic quality and final appearance of the end data.

Step 4: Finally a selection of interactive editing tools will be presented. These tools have been developed to help maximise the efficiency of the cartographer by offering a simplified user experience and various tools for supporting complex editing work such as paralleling line features to one another.

New National Maps for Switzerland

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Bundesamt für Landestopografie swisstopo, Switzerland

Extended Abstract

Switzerland's official national map series is being revised. The national map, in existence since the 1950s, is a reliable product. However, from a technical and graphical point of view an update is required to meet growing needs. The data is completely reconstructed using GIS and database technologies. The result are high-quality geographic databases - digital cartographic models (DCMs) - containing vector and raster data.

A revised map design

Thanks to the careful reworking of the design, the map has a fresh appearance and is easy to read. Some of the key visible changes are easily legible text using a new Frutiger font family, the gradation of the road network according to road width and traffic importance in all scales, red for the rail network and railway stations and the introduction of coloured boundary lines (local authority, cantonal and national borders).

At the same time, the typical character of the national map remains, e.g. by retaining the «swiss style» terrain representation with it's traditional combination of rock, scree, relief and sun tone.

Modern production technologies

In 2013, swisstopo began a comprehensive upgrade of the largest official map document for Switzerland – the national map 1:25,000. The conversion has been preceded by years of project work, incorporating important technological developments such as: higher resolution imagery and the construction of a 3D landscape vector model, the introduction of automation-supported generalization and database-supported cartographic editing, the opportunity for automation-supported incremental update or the NSDI (national spatial .

Automatic generalization

The production architecture for the DCMs includes several automation steps, e.g. for data imports, model transformations, model and cartographic

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generalization, quality assurance or data exports. For model and cartographic generalization, a first system was built and is used for DCM25 production. For the remaining scales, swisstopo takes a new approach and builds a new system based on geoprocessing tools, ArcPy and ModelBuilder by Esri. This is achieved using agile development methods inhouse.

A prototype for the DCM50 workflow is now established, a test map sheet has been produced and the results are very good. A prototype for a DCM10 is currently being developed. For the first time, swisstopo will publish a Swiss National Map 1:10 000 in 2016 on geo.admin.ch.

Meeting the growing needs

New usage opportunities are emerging with the new map and digital cartographic model. The DCM is the single source for a variety of cartographic products. Since DCMs are maps and GIS databases at the same time, their content can be enriched with additional data or filtered and rearranged in endless ways. This provides great flexibility to meet the user's needs.

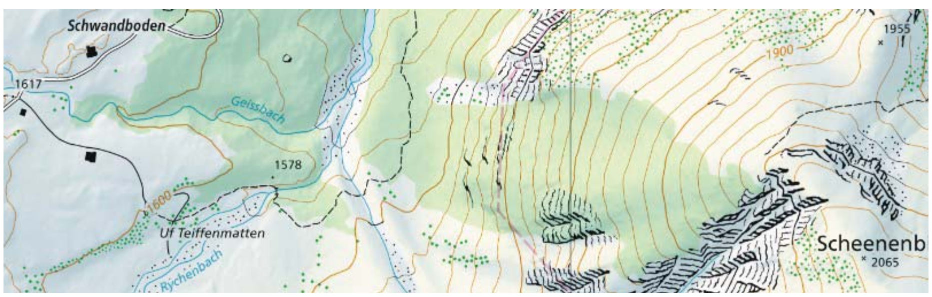

Figure 1. Swiss National Map 1:10 000 (DCM10), mountainous area, draft

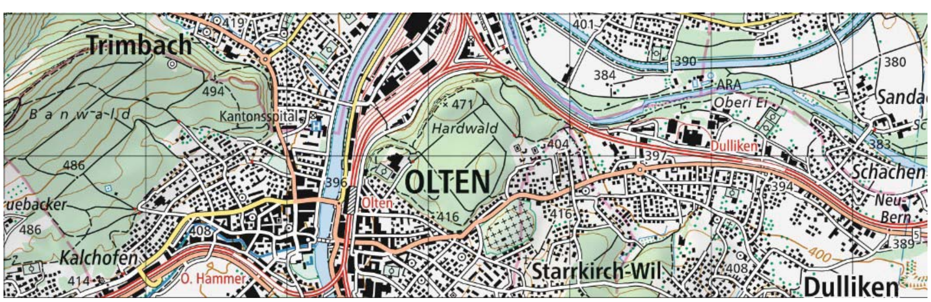

Figure 2. Swiss National Map 1:50 000 (DCM50), urban area, draft

Automated Generalization at BEV – From Base Models to 1:50k Map

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Abstract. In 2014, the Austrian Federal Office for Metrology and Surveying (BEV) started a feasibility study on automated generalization for deriving the topographic map in scale 1:50.000 from the digital landscape model. The key task is to provide tools which are capable of creating a map which is derived from the digital landscape model and has no significant loss in quality and accuracy compared to traditional generalized maps from BEV. In a first step, work packages have been established within BEV to analyse available technologies and gain expertise and answers in order to find a modern and geoinformation system (GIS) based approach of cartographic generalization without losing individual cartographic knowledge and quality of highly distinguished topographic maps.

The basic scale for topographic maps produced by BEV is 1:50.000. The other products in the BEV series of scales (1:250.000, 1:500.000) are derived from this scale. It is important that the basic scale is a fundamental cartographic model with high standards regarding actuality, accuracy, reliability and assured continuous revision. There are several motivations for a new GIS based solution for map production. Advantages of vector data contrary to raster data should allow faster and simpler map revision combined with the possibilities of automation. Another aspect is to provide more diverse and flexible products from a vector based cartographic model (print on demand, web map service, web feature service, spatial analysis capabilities, etc.) A more long term goal is to achieve multiple scale map products additional to the conventional BEV map scales.

Until the year 2014, topographers delivered field mapping and topographic surveying results for two different models: The object based digital landscape model (digital object model) and the raster based digital cartographic

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model (DCM). So topographers provided already generalized correction and revision advice to the DCM where the cartographers did final editing based on common generalization rules. The topographers department at BEV (department of landscape information) made some amendments and reorganization within the processes of topographic survey. There was a change from a CAD system with GIS functionalities to a real and modern GIS. Topographers will soon maintain the digital landscape model only; revisions and corrections in the DCM are therefore not much longer available.

A group of cartographers and GIS experts within the department of cartography started the development of a generalization procedure in the framework of ESRI ArcGIS. ArcGIS Model Builder is the main developing platform to create generalization models where geoprocessing tools deliver a wide range of possibilities. The challenge is to create models which are capable of imitating various skills and intuitive actions of a cartographer. To assure that it is important to have a “thinking outside the box” mentality without losing traditional requirements and generalization rules out of sight.

In a first phase the development team had its first findings regarding methods for automated model generalization (semantic and geometric) from the DLM base model to a DLM model with lower resolution for a specific map scale (e.g. 1:50.000). In a second phase findings about resolving graphic conflicts and partitioning of data were made. The ongoing work of the third phase is about resolving open issues and establishing a first prototype procedure with proof of concept. Thereby very complex and sophisticated models for model generalization of roads, railways, hydrography and buildings as well as models for cartographic generalization were set up. The current status of development brought up a first awareness about future procedures. Among these the enhancement of the DLM with other data such as land cover and cadastral information is crucial. This should be followed by partitioning which splits the DLM into smaller subsets of data with pre-generalization of specific features. Thereafter model generalization will be applied for each partition and further procedures like conflict resolving and cartographic generalization are going to follow before the cartographic partitions will be reassembled. This work is still in progress and will consider other map elements than the ones mentioned before too.

Automated Generalization is a difficult but necessary task for BEV. The development process already showed good and promising results. Development reveals that traditional cartographic knowledge is important but a GIS based approach requires more than that. Expertise and experience in programming, mathematics, trigonometry, geometry, IT, geoinformation and database structures as well as the already mentioned “think outside the

box" mentality are essential. Although it is the idea to have one hundred percent automation, it is not a compulsory requirement which means that there is a possibility of keeping manual intervention in a future digital cartographic production process. The only difference will be that cartographers will maintain a vector based data model instead of raster and that they will do more work in a geoinformation context rather than in a cartographic one.

Keywords. Automated generalization, cartography, GIS, map revision, digital landscape model, digital cartographic model

Exploration and Refinement of Regression Tree Models with Interactive Maps and Spatial Data Transformations

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Abstract. The problem we address is prediction of expected values of some attribute of spatial objects based on values of other attributes, including the geographic positions. A common approach to obtaining such predictions is regression modelling. It is highly desirable that predictive models are not only accurate but also understandable to the users, which gives preference to simpler models. We propose a set of visualization techniques and interactive operations that supports exploration, evaluation, refinement, and simplification of regression tree models. In particular, the analyst can investigate how the model components and their properties are related to the spatial distribution of the objects, and can make the model better account for the spatial aspect of the data by generating new space-based attributes and supplying them to the model building tool.

Keywords. Predictive modelling, geovisualisation, analytical cartography, visual analytics

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Structuring Relations Between User Tasks and Interactive Tasks using a Visual Problem-Solving Approach

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Extended Abstract

This paper presents a refined taxonomy of user tasks and interactive tasks based on a review of the fields of information visualization, geovisualization and visual analytics. User tasks refer to cognitive operations performed by a user to address domain problems, whereas interactive tasks refer to selecting and performing visual encoding and interactive techniques in sequences to fulfill a user task. Both user and interactive tasks consist of multiple primitives, leading to the existence of many task taxonomies described from diverse perspectives. Moreover, the associations between user tasks and interactive tasks are often disconnected, leaving a gap in between. This disconnect results in a clear need to classify all of the primitives and organize them into a logical structure. Our aim is to meet this need to support those who seek parameters for designing visual solutions to users' domain problems.

We first define the relations between user tasks and interactive tasks according to their role in a visualization design process, which aims at solving users' problems (Figure 1). Users have domain problems, which can be translated into user tasks. Taking into account user tasks and related data, a designer should provide visual solutions by developing an interactive visualization environment consisting of visual representations and analytical functions. Meanwhile, interactive tasks are part of the visualization environment design. Interactive tasks should provide sequences of interactive functions to allow users to accomplish user tasks through interactively exploring in the environment. Therefore, user tasks play an important role in both domains of user's problem and designer's visual solutions, whereas interactive tasks are a key factor in the domain of designer's solution.

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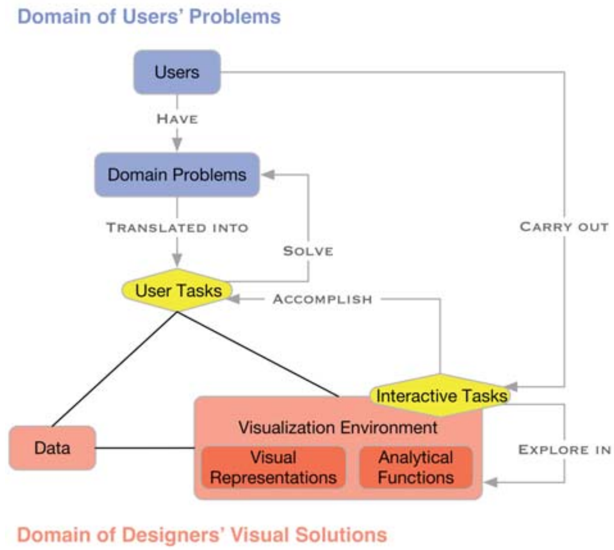

Figure 1. The roles that user tasks and interactive tasks play in a visual problem solving approach, consisting of a user's problem domain and a designer's visual solution domain. The problem domain introduces user tasks translated from user problems, and the solution domain provides visual solutions to the user tasks through interacting with a visualization environment. The user tasks bridge the two domains, and the interactive tasks are one of the components to be designed in the visualization environment.

We then identify three primitive user tasks—*identify*, *localize* and *compare*—and all other user tasks are considered as compound tasks consisting of sequential primitives. This way allows complex tasks to be decomposed into sequences of simpler tasks. Moreover, User tasks can be conducted in an elementary level targeting at low-level data characteristics of data components (i.e. data values of attributes), or in a general level targeting at the pattern emerging from the data components that are treated as a whole.

Furthermore, we analyze the definition and examples of interactive functions in the existing taxonomies, in order to clear up the confusion caused by the diverse vocabulary used in literature. We then merge these interaction functions with same/similar end purposes into eleven categories: *re-encode, arrange, coordinate, aggregate/segregate, filter, derive, navigate, query, search, select* and *enabling*. The resulted taxonomy provides the interactive primitives. Interactive tasks are further composed by sequences of these interactive primitives.

We expect this refined taxonomy to provide a more intuitive view to visual solution designers for understanding the role that both tasks play, and further to help designers come up with suitable visual solutions for users.

Visual Analysis of Floating Taxi Data based on selection areas

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Extended Abstract

Tracked movement from numerous observed objects includes often large data size and is difficult to handle, especially in terms of visualization. In the following we describe the possibility of getting more insight into massive movement data. Our inspected data set consists of more than 7000 observed taxis in Shanghai and is referred to as Floating Car Data (FCD). With this term numerous approaches appeared in the last decades facing the problem of how to connect digitized road network with tracked positions of moving objects. The aim is often to improve the modelling of traffic in road networks. Since FCD sets of taxis have often large size not only problems of reasonable processing are appearing but as well advanced ideas of geovisualization. Established interactive traffic maps show one possible solution for the visual inspection. Other approaches use advanced techniques for the detection of interesting patterns, which may be connected with appearing events (e.g. congestion).

Visual analysis tools for large FCD sets utilizing linked views were investigated by for example Tominski et al. (2012) and Ferreira et al. (2013). They make use of area selections for recorded tracks of moving objects with the aim of representing more detailed information at certain locations. Following up on this approach, we introduce a method for detailed spatiotemporal inspection of FCD partitions: selection areas for linking traffic flow information with diagrams and other visual representations. Besides information based on FCD, it is possible to link other data sources, like air quality measures, data on the public transport and traffic accidents or data coming from social networks. These interactive area selections may have the aim of detecting spatiotemporal correlations between vehicle traffic and pollution in the area around a certain building or crossroads. We analyze the relation between global and local view of derived (averaged) traffic flow

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parameters and the comparison with additional interpolated data on particulate matter (PM2.5). The components of a possible linked visualization display for the described example are pictured in Figure 1.

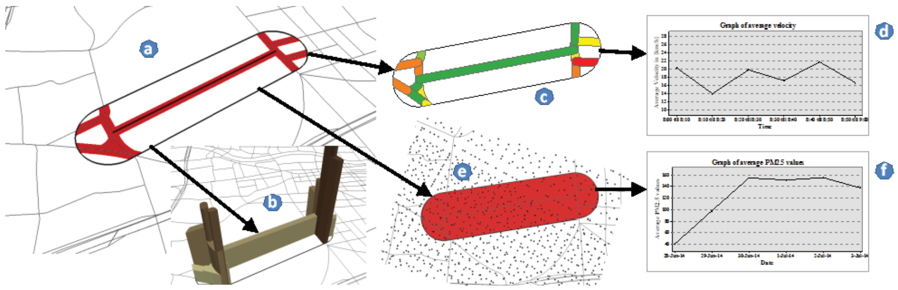

Figure 1. Possible display of a global and local view on FCD with (**a**) road selector on road network; (**b**) extrusion of road segments based on taxi density; (**c**) coloration based on average velocity ranges; (**d**) graph of average velocity; (**e**) proportion of interpolated PM2.5 values and (**f**) associated graph.

This method of inspection helps to discover different aspects of traffic and its correlation with air pollution. Resulting from this knowledge, it may be possible to facilitate further processing and visualization steps for FCD. The association of different data sets is only based on a selected area in space (selection areas) and the time component. Graphical data representations include 3D surface extrusions and other visualization techniques based on density estimation, interpolation and weighting of taxi FCD records and trajectory partitions within selected areas.

Our idea consists of providing traffic information ("microscopic" traffic patterns) for a possible end user and of giving additional information on "the raw" FCD and on other information, like air quality. With this method, we aim to extend the concept of a static traffic map for providing more interactivity in the visual analysis process. This may help to detect long term trends of the inspected quantities of selected areas. The proposed method can be tested based on its practical ease of use for a potential user. The results of this evaluation may be the initial point for the conception of a possible graphical user interface (GUI) for the visual analysis of FCD.

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The Multiperspective Visualisation of the Spatial Behaviour of Smartphone Users

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Extended Abstract

Smartphone users perceive urban space through map applications, but decidedly more frequently through the lens of the smartphone. The widespread photographing and the subsequent placement of pictures on social portals is an important method of conveying spatial information. The research object is to obtain information on the temporal and spatial behaviour of smartphone users and the perception of such pedestrians in urban space as regards the geometry of routes traversed in time, and taking pictures of objects and events that are of interest to us. The essence of the activity was to elaborate multiperspective visualisations enabling an analysis and interpretation in many different aspects. The most important objectives when elaborating visualisations include capturing the dependence between the intentions of the pedestrian and the route actually traversed thereby (Golledge 1999), the type of photographed objects, and a comparison of the geometry of routes and times for numerous pedestrians, who have the same starting and end point.

A group of 30 smartphone users were invited to take part in the experiment. Each participant separately received the following task: to walk from the central station to the town hall using a freely selected route and take photographs of interesting objects. The routes recorded in GPS receivers and a breakdown of individual responses to questions before and after execution of the task constituted the basis for the execution of four visualisations:

• **map** with 30 routes and track points (classification of routes according to five preferences provided by participants: the shortest route, map-based navigation, tourist attractiveness, habits, light signalling systems);

• **space-time cube** (classification as above);

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• **vertical column diagram in a linear composition** – routes and track points, and the number of photographs taken according to the types of objects;

• **cumulative flow cartodiagram** – the most preferred sections, stops/stopovers according to the number of track points; attractive objects according to the number of photographs.

Each of the elaborated visualisations presents spatial data from a different perspective and visually strengthens other aspects of the behaviour of participants of the experiment. The majority preferred traversing the shortest route to the target location, however the presentation on visualisations of determinants of urban space considerably clarifies the deviations from the initial intentions of smartphone users. The authors would like to put forward the following questions for discussion at a conference: to what extent should cartographic visualisation simplify the perception of the behaviour of pedestrians in the city? Does the complementarity of visualisation make it easier to analyse the specificity of behaviour of smartphone users in urban space?

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Mapping a city's activity. A project of volunteered geographic information using mobile mapping collection

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Extended Abstract

The work done deals with volunteered geographic information, based on a mobile mapping collection tool to retrieve geographical data from an urban fieldwork.

The research has been carried on during the past academic year, involving students from the course of Geography of Networks, within the post graduate degrees in 'Economics' and 'Business' of the University of Trieste (Italy). In this framework the aim was twofold. On one side the idea was testing the potential of crowdsourcing in retrieving data following a bottom up approach, relying on a set of trained and aware 'urban sensors' as data collectors for some particular urban phenomenon. On the other side the aim was deriving first-hand geographical data concerning a particular topic and analyze its spatial distribution in space by means of Geographical Information Systems and spatial analytical tools. In this case this was represented by the urban 'movida', or the analysis of the areas of the city that are more or less active during the days (nights!) and during the week. This major aim was also coupled with an ancillary one, that is the coverage of wi-fi hotspots and networks over the urban area of Trieste. It is known that many Italian cities still do not allow a very wide coverage of wireless networks allowing people to access the Internet. The city of Trieste is suited with a certain degree of coverage, particularly in main roads and squares, both in terms of the free

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wi-fi coverage managed by the municipality as well as the academic network of Eduroam system, quite spread over European and world cities hosting universities and research centres.

Neogeography and VGI. The rationale behind the project deals with the phenomenon of Volunteered Geographical Information (VGI), as coniated by Goodchild (2007) that, as a particular case of Neogeography (Turner, 2006; Graham, 2009; Warf and Sui, 2010) sees the involvement of citizens in collecting geographical data, as a particular case of user-generated content. In this field one can find examples including OpenStreetMap, Google Earth or Wikimapia as results of the 'democratization' of GIS in last decades allowed by the spread of Internet and low cost devices, as large scale projects involving the participation of volunteers. Other examples include the use of citizens over specific projects over a certain amount of time or the use of finalized user groups to target some specific issue. The applications are wide and generally deal with public utility projects on environmental or social issues, as well as humanitarian ones. These latter motivations are particularly interesting as many free and open source projects and platforms have been developed. That, coupled with the widespread use of smartphones and tablets and Internet connection allows easier and faster data collection and sharing.

The choice of the mobile data collection kit – GeoODK app. We were searching for low cost and low skill requiring solutions in order to be used for a research involving students and with a minimum effort in programming and customizing IT component, the aim being on focusing on the social aspects of the project and therefore in order to leave us time and resources to concentrate over the kind of data to be collected. After several tests we approached the Open Data Kit environment and appreciated very much its structure and application. The ODK Collect app was therefore tested as a tool for mobile data collection, given the high possibilities of customizing its content according to different projects.

We decided to use an advanced version of ODK, as GeoODK, an open source platform created by the University of Maryland and International Institute of Applied System Analysis that is composed of two parts. On one side, one can download the mobile application GeoODK Collect that runs on Android smartphones that can be also used in offline mode. on the other side there is a web system (Formhub or ODK Aggregate) that aggregates data, lets you visualize on the screen the map of data, modify or delete data or export data in CSV, KML or XLS files.

In addiction, for those who do not have a smartphone or have a different operative system running (such as iPhone-users or Windows-users) the web system allows to collect data using a web form of the survey (using Enketo Smart Paper).

The creation of form can be designed with an Excel file that must be composed by two worksheets, needed to set up the parameters of the forms: one is ‘survey’ and the other is ‘choices’. After loading the file in the Formhub account one have, just for the first time, to set the app settings to download the form to start collecting data.

The choice of the volunteered and sensors. *Students from post graduated courses*. As this study of the “city’s activity” emerged as an applicative example of the study of “Geography of networks” within the post graduate degrees in ‘Economics’ and ‘Business’ of the University of Trieste (Italy), we decided to involve the student of this course, suitably trained by the authors through a small presentation to use the mobile application or the web form available thanks to Enketo Small Paper.

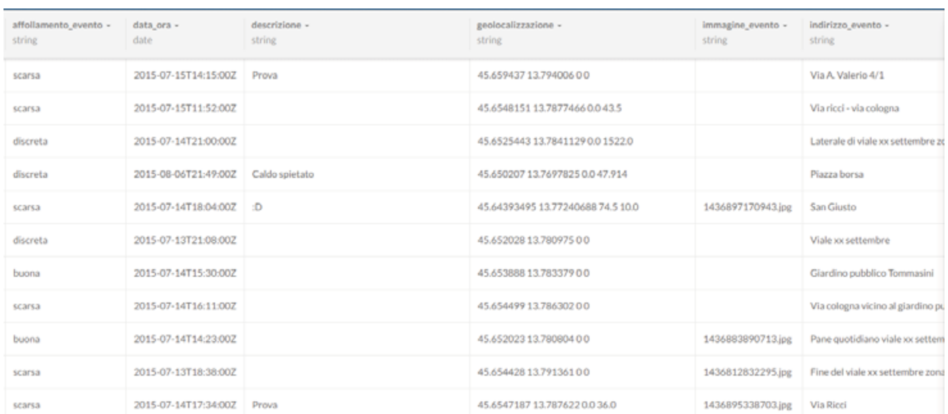

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Figure 1. A screenshot of the table visualization of the collected data

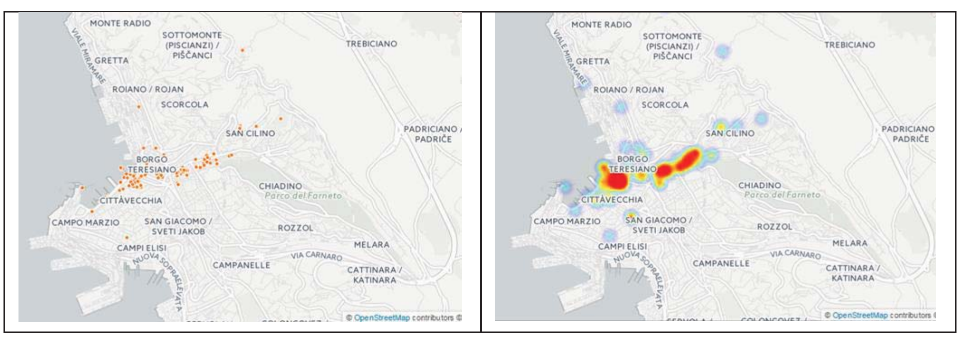

Figure 2. Map view of the data collected and a density map of the event data of Trieste’s Movida

In addiction, an advertising campaign on Facebook was made, together with the creation of a Facebook page “Data collection about movida and free wi-fi in Trieste”. The data collection campaign took place during the summer period and involved volunteers in mapping places in the city of Trieste, stating the presence of public or private wi-fi network, as well as he level of ‘crowdness’ in the venues considered. These two elements were considered interesting to be studied, in order to map places where people actually move in different days and times of the year, as well as understanding the level of coverage of the wi-fi network. These elements were considered interesting both for experimenting visualization techniques and also to provide local authorities with a set of information on where to address investments in wi-fi development and coverage according to the presence of users.

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The cartographic visualizations of the population movements during mass events with the use of drone (UAV)

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Extended Abstract

Cartography, both analog and multimedia, is facing a big challenge in the visualization of population movements during mass events. The aim of this study is to demonstrate some possible methods of the cartographic visualizations of these movements on analog and online maps. The basic material for the visualizations were images taken using a drone.

Drones, or unmanned aerial vehicles (UAVs), are increasingly used in many areas of life. Thanks to their small size and the possibility of mounting cameras on them, they are being used more and more widely to obtain spatial information in the form of high resolution images. This allows, among other things, the monitoring of spatial and temporal variability of short-term phenomena. One of such phenomena are mass events, where a lot of people are gathered on a relatively small area in a short time unit. Thanks to the acquisition of images from the air at specified time intervals, it is possible to register the movement of the participants of the event.

The year 2015 is the International Year of Map. On this occasion, on 23 April the Department of Geography and Geology of Adam Mickiewicz University in Poznan celebrated a National Geographer's Day. One of the highlights of the day was a big barbecue organized on the clearing next to the Department. It was a perfect occasion to take advantage of a drone to obtain photographic material presenting the movement of participants. The event lasted from 4 pm to 11 pm. The flight mission lasted over four hours and during that time the UAV acquired, in several batches, over 2000 images. The photos were used to determine the main directions of the move-

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ments of the participants. Besides, the use of appropriate visual variables (Bertin 1967, Carpendale 2003) presenting the motion allowed the development of a set of static cartographic visualization.

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Everyone needs a map! – Evolving information society to provide insight from big data

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Extended Abstract

Online map products are essential tools for helping us respond to some of the biggest issues in the world, from emergency response during disasters to tracking forest change and preserving endangered languages before they become extinct. As our world changes, maps are becoming increasingly important tools for people and organisations to tell stories in time and space. To present geo-spatial information clearly and concisely, one must overcome a number of challenges so that "Users can interactively choose a location to map and the features to include on the map" (Peterson 2007).

The first challenge is around users. There are a whole host of different types of user of geo-spatial information, from government researchers to academics, NGOs and the general public. Tools and visualisations can achieve impact by focusing on a number of these groups, so long as they're targeted in the right way and tools respond to their specific motivations to interact with data. The motto "if it's too inconvenient I'm not going after it" (Connaway et al 2011) holds true here, with ease of access, convenience and satisfaction determining decisions to find data.

Linked to this is the choice of communication channel to engage interested users. Especially with the predominance of a worldwide web, it can be easy to assume that anyone can find a map that interests them. But there are huge differences in the types of people using various channels to access information (Cartwright 2008).

With a target audience and channel selected, the next step is to think about the different devices used to view maps and how that affects the design of geo-spatial information. Smaller screens and screens that are touched, as opposed to screens controlled with a mouse, change the way data need to be displayed. Designers and developers must always be conscious of the day-to-day work to be completed by the user on the application or tool, to avoid bad experiences that make them stop using applications: "it needs to be clickable (or tappable)" (Gothelf and Seiden 2013).

As well as the physical interaction, map design also needs to consider the cognitive interactions between a user and the data, "but the tools of cartography are always changing and often borrow from other technologies" (Brewer 2005). More and more, users want to be empowered and able to change and customise the display, or even to add new data in different ways to shed more light on a topic. Good design provides intuitive interfaces to the data and displays it in a concise way, while bad designs can suffer from 'analysis paralysis' and unclear display. Providing the right level of control and customisation is crucial for satisfactory engagement and learning.

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At Vizzuality, we really believe design must be centered on users: interfaces need to attend to users' needs and must be easy to understand and use, letting them focus on what they are really interested in instead of allowing them to do hundreds of things they will never use or understand. "As far as humanly possible, when I look at a web page it should be self-evident. Obvious. Self-explanatory." (Krug 2006). Maps are about information, so designers should do all they can to avoid confusing the user.

That said, the talk concludes with a look to the future and the window of opportunity that has been opened at the intersection of all of these points to innovate, inspire and improve our world. Visualisation can "help to inform and educate as well as encourage people to change their lifestyle" (Krätzig & Warren-Kretzschmar 2014), so is an important element of achieving 'the world we want'. In a world where technological capabilities are constantly improving, it's important to assess the best ways to deliver maps to users. The points outlined above will be a useful starting place to ensure tools make the most of the possibilities of new technologies and ultimately deliver impactful work.

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Towards Mapping Experience Design for the Internet of Things

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Extended Abstract

We are witnessing a fundamental transformation in how Internet of Things (IoT) is having an impact on the experience users have with data-driven devices, smart appliances, and connected products. The experience of any place is commonly defined as the result of a series of user engagements with a surrounding place in order to carry out daily activities (Golledge, 2002). Knowing about users' experiences becomes vital to the process of designing a map. In the near future, a user will be able to interact directly with any IoT device placed in his surrounding place and very little is known on what kinds of interactions and experiences a map might offer (Roth, 2015). The main challenge is to develop an experience design process to devise maps capable of supporting different user experience dimensions such as cognitive, sensory-physical, affective, and social (Tussyadiah and Zach, 2012). For example, in a smart city of the future, the IoT devices allowing a multimodal interaction with a map could help tourists in the assimilation of their knowledge about points of interest (cognitive experience), their association of sounds and smells to these places (sensory-physical experience), their emotional connection to them (affective experience) and their relationships with other nearby tourists (social experience).

This paper aims to describe a conceptual framework for developing a Mapping Experience Design (MXD) process for building maps for smart connected places of the future. Our MXD process is focussed on the cognitive dimension of an experience in which a person perceives a place as a "living entity" that uses and feeds through his experiences. We want to help people to undergo a meaningful experience of a place through mapping what is being communicated during their interactions with the IoT devices situated in this place. Our purpose is to understand how maps can support a person's experience in making better decisions in real-time.

Our design proposal is based on the premise of cognitive adequacy of a map as raised by Strube (1992) and Klippel et al. (2005) which takes into account a certain correspondence between perceptions or internal representations (i.e. cognitive maps) and external environment (i.e. smart-connected places) for a given experience. Therefore, the proposed MXD process

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consists of four phases that support an iterative process where the outcomes of one phase are used as an input for the next phase (*Figure 1*).

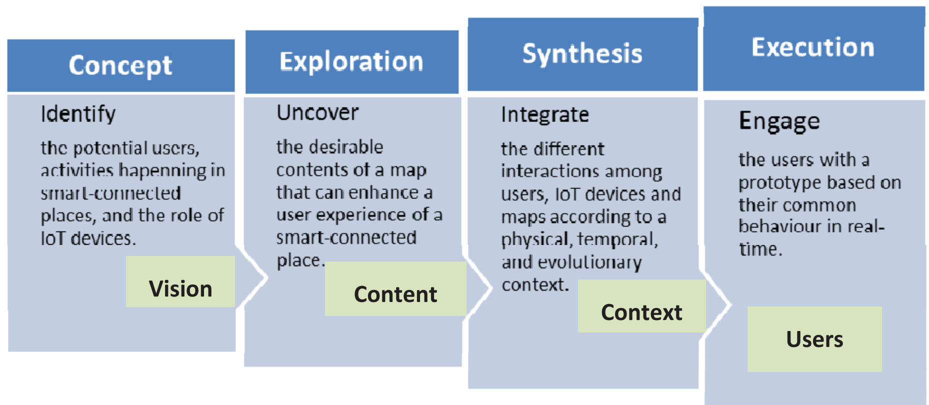

Figure 1. Overview of the four phases of our mapping experience design process.

The proposed MXD process is currently being developed for enhancing a tourism experience in a city where the aim is to allow tourists improve their experience with smart-connected places and help them to make better decisions during their daily tourist activities. The preliminary results are promising towards making maps of the future that fulfill true user needs in an effective understandable way by enabling new experiences in an increasingly interconnected world. Our proposed MXD process is a new approach that has moved away from the origins of mapping design to communicate the cartographer´s representation and interpretation.

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Intersection of Geospatial Big Data, Geocomputation and Cloud Computing

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Extended Abstract

Big data is defined as high volume, high velocity, and/or high variety information assets that require new forms of processing to enable enhanced decision making, insight discovery and processes optimization (Laney 2012). Data component of big data can be broken down into two broad categories: human-generated and machine data. Machine data are generated automatically by machines without direct intervention of humans. Sensor generated data (like data generated by jet engines for monitoring the status and performance of engines) falls into the machine data category. Utilizing the mentioned machine data by using efficient and automatic approaches at large scale for research purposes largely ignored until recently. To be more specific, machine data has always been used for research purposes (like manual image processing of satellite images) and the automatic analysis of huge amount of machine generated data using supercomputers or volunteer computing has been done since late nineties. However the automatic analysis of machine data using new model of computation is new in big data world. The mentioned computation model is based on new advances in parallel processing and distributed computing and is very different from the traditional distributed computing. In addition, this new model of computation can be used to store, process and analysis of dark data which are operational data generated by sensors without any explicit intension for extract valuable insights. In fact, machine (dark) data has vast and as yet untapped potential as a source of highly valuable information, as they contain important insights about the system as well as users of the system. Often data component of big data has a positional component as an important part of it in various forms. Given the above definition of big data, many researchers believe that geospatial data has always been big data! In contrast, as it defined by Pouria Amirian (Amirian et al. 2014), "geospatial big data" term should be used only if the positional components in big data extensively used in storage, retrieval,

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analysis, processing, visualization and knowledge discovery. In other words, if some data in a big data system have positional components and/or used for simple visualization it is not necessarily considered as geospatial big data. Based on this definition, geospatial big data systems need certain type of techniques, algorithms for efficient management, analytics and sharing. In fact the mentioned needs are one of the challenges of GeoComputation (Amirian et al. 2014). As it mentioned by many researchers, management and analysis of geospatial data is complex and requires specific storage, processing, analysis and publication mechanisms (Taniar et al. 2013, Mahboubi et al. 2013). In fact management and analysis of geospatial data have been always revealed the limitations of information systems and computational frameworks. Some researchers agreed that geospatial data may represent the biggest big data challenge of all (Davenport 2014).

The focus of our ongoing project is on finding useful insights from data generated by Point-Of-Care diagnostics sensors using specific techniques of geocomputation in the cloud. However by including location of the sensors in the analysis and by inclusion of other geographic layers, whole new set of useful questions can be addressed and therefore many new useful insights can be found. In addition using elastic computational resources provided by cloud computing and new computation model of big data technologies, it is possible to overcome one of challenges of geocomputation which is obtaining computability on geographical analysis problems. This paper will explain the challenges, opportunities and findings of a research project currently being done at the Oxford University in collaboration with Stanford University.

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The graphical attractiveness and perceived effectiveness of cartographic presentations of spatio-temporal accessibility

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Apart from the objective criteria, such like the correctness and the time of acquiring information from the map (Mersey 1990, Leonowicz 2006), the cartographic presentation may be consider from the point of view of its effectiveness observed through the eyes of the viewer (perceived effectiveness) and graphical attractiveness. These two subjective criteria have become the subject of research into methods of cartographic visualisation (Slocum et al. 2009) of the spatio-temporal accessibility.

A comparison was made of 6 mapping techniques based on a monocentric road network model. The analysed methods included two-dimensional and three-dimensional visualisations in three colour scale variants. All of the graphical solutions were based on elements of reference: points, lines, or surfaces. Perceived effectiveness was researched on the basis of visualisations of spatial accessibility measured along roads (road accessibility in kilometres), while graphical attractiveness - on the basis of visualisations of temporal accessibility counted in minutes. Test tasks covered by the internet survey consisted in a comparison of 6 mapping techniques and an indication of the best and worst visualisation.

The number of positive and negative votes of respondents to the internet survey was used to calculate measures of perceived effectiveness and graphical attractiveness for each mapping technique. The impact of various colour scales on indications given by survey participants was also analysed.

The results of research, that is a breakdown of responses given by 180 persons, confirmed that the graphical attractiveness of cartographic visualisations of spatial accessibility on the monocentric model depends on the graphical variables used, but this does not translate into perceived effec-

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tiveness. First and foremost, the most interesting conclusions include the following:

• users of statistical maps perceive three-dimensional methods as less effective than their two-dimensional equivalents;

• the stepped statistical surface method is considered as one of the most attractive graphically and the least effective in the conveyance of information;

• according to users, the scale of spectral colours is superior to the hypsometric and bipolar scales.

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Mapping Opportunities for Enhancing Effectiveness of Health Care System by GIS Based Accessibility Analyses: Locating Core and Support Services within Long Distances in Northern Finland

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Abstract. Finnish healthcare services have pressure for reorganisation. Particularly peripheral areas having decreasing and aging populations are challenging for health care, which is indeed evident in Northern Finland. Transport of goods and travels of people form an essential factor in designing effective and reachable health care network. In addition to accessibility of population to core health care services, such as health centres and hospitals, accessibility of support services, extending from pharmaceuticals and medical equipment to laundry, need to be managed effectively. In this paper, geographic information systems (GIS), accessibility analyses and spatial data covering population, road network and potential locations of service and storing facilities are applied to analyse spatial context of core and support health care services with aim to indicate potentials to increase cost-effectiveness of service network within long distances. In analysing accessibility, location-allocation (p-median) and vehicle routing analyses are applied with aim explore accessibility issues in service network coverage and in locating warehousing functions by potential delivery routes. By location allocation, efficiency of service network may be enhanced with minimum harm to equality and centralised logistics may improve cost-effectiveness of support services. By these analyses, the study has also a practical aim to establish future scenarios for health care design in Northern Finland.

Keywords. Accessibility; Transport; Health care; Geographic information systems (GIS); Long distances; Sparse population

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1. Introduction

A number of accessibility analytical approaches are developed to measure and optimize accessibility in spatial and geographic context. Geographic information systems (GIS) is applicable framework in analysing accessibility by using spatial data of transport networks, supply and demand (Páez et al. 2012). Furthermore, accessibility in the context of health care has been analysed by as a spatial problem in many studies. To mention some examples, location of health care services in relation to location of potential patients been considered by location-allocation approach in planning purposes in analysis covering Southern England (Harper et al. 2005). Accessibility to health care is measure by floating catchment area and traditional gravity-based methods in Chicago (Luo & Wang 2003) and by the gravity integrated two-step floating catchment area in Springfield, Missouri (Luo 2014). Mestre et al. (2015) propose two location–allocation models for the strategic planning of hospital networks by the case of in Portugal, with aim to inform how the hospital system may be reorganised geographical access is wanted to be improved while minimizing costs. In health care service network, also accessibility of supporting services, transport of goods and warehousing may affect to the cost-efficiency by decreasing costs related to stock, shelving and deliveries. Thus, optimizing accessibility of warehousing facilities and spatial components in supply chains are also essential to be considered, and various techniques are available for this purpose (see Melo et al. 2009).

Health care accessibility analysis carried out within long distances and covering deeply rural or peripheral areas are rare and matter spatial accessibility in health care logistics is rather unstudied field. In Finland, location-allocation analysis has been applied in planning of special health care in sight of birth hospital network (Huotari et al. 2012) and in optimizing coverage of emergency departments of the basic health care (Huotari et al. 2013). Accessibility issues in health care in Northern Finland give and interesting and also challenging field for optimisation as deep and regressive periphery characterises much of the northernmost areas, rural zones in southern areas are mainly vital and population is increasing in a few growth centres and their fringes (Fig. 1). There are no signs that migration to cities and ageing of the population, except in a few local occurrences, would slow down in the future. Thus, peripheries of Northern Finland have a clear demand for health care services, but supply will get more complicated all the time due to diminishing volumes of demand.

Present economic conditions set a high pressure to rationalize the use of public funds in social and health care sectors. The basic health care system and partly also the health centre network originates to 1970s and Finnish hospital network originates to 1950s-1970s (Vuorenkoski et al. 2008).

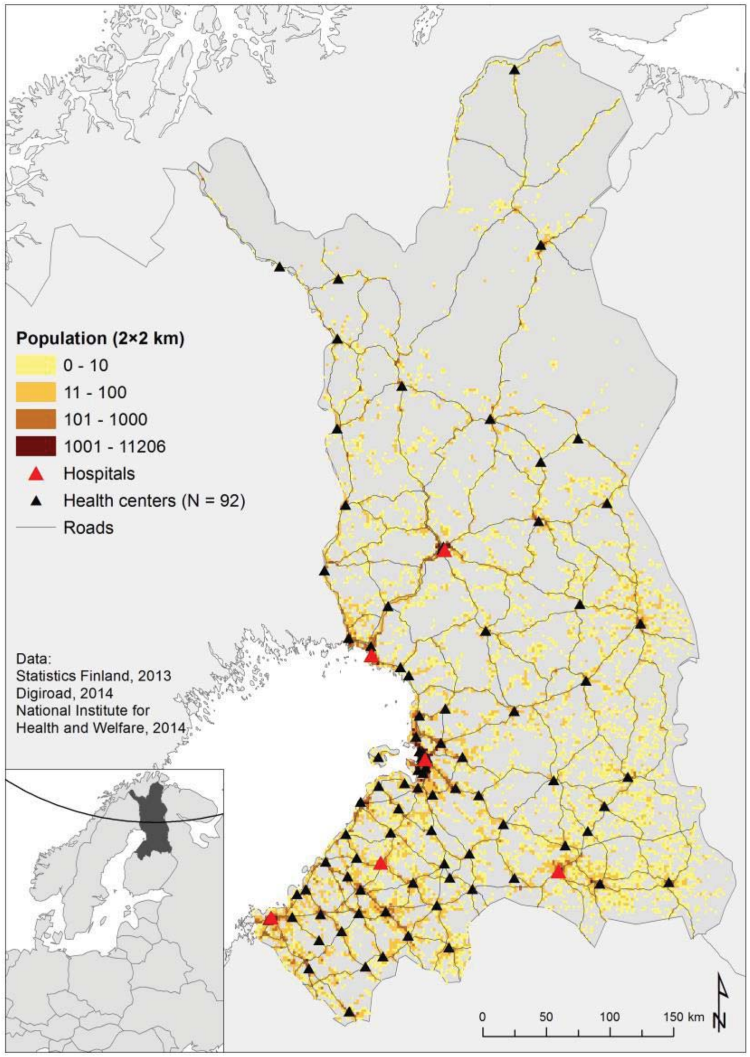

Figure 1. Key health care services and population structure in Northern Finland.

However, the legal outline for geographically extensive health care in Finland is still clear. Public authorities have to organize adequate social and health care services, and promote the health of the population (Constitution 731/1999, 19§ 1999) and local and regional authorities are responsible to provide health care services to the residents locally unless regional centralization of services is justified in order to ensure the quality (Health Care Act 1326/2010, 10§ 2010). Thus, basic health care services are organised mainly in publicly health centres, special medical care is given in 20 central hospitals (five in Northern Finland), while highly specialised medical care is concentrated in five university hospitals (one in Northern Finland). Even though, services are given by the authorities, citizens are free to choose the desired health centre or hospital, and accessibility is clearly an essential factor in this.

In this paper, the aim is to introduce and pilot accessibility analytical perspectives in optimizing effectiveness health care services within the context of reducing resources, long distances and sparse population structure, which are evidently present in Northern Finland. First it is analysed, how service network and accessibility of basic health care changes in the case of potentially reducing number of service units, if the spatial structure of services are optimised. Second, the scenario of centralised warehouses supporting material deliveries of health centres is scrutinised by simulating potential delivery routes in relation to potential warehouse locations. We seek to answer to the following research questions:

1) How health centres should be located to reach the population of the most effectively, if number of service units has to be reduced?

2) How decreasing amount of health centres would affect to the accessibility of services?

3) What would be the most optimal location(s) of centralised warehouses serving health centres, and how effectively centralised warehouses would be linked to health centres by optimised delivery routes?

4) How decreasing amount of health centres would affect to the optimal locations of warehouses?

2. GIS based accessibility analyses and their implementation to the study

This study relies on GIS based accessibility analyses and spatial data. Key methods applied to accessibility analyses are p-median location-allocation analysis and vehicle routing functions connected to cumulated opportunities index. The data of the study consists of route-able road network data with metric accuracy, health care facility locations and population grid cell data at 2×2 km resolution. All data management, analyses and maps are produced by ESRI ArcGIS and Python scripts.

2.1. Location-allocation

GIS based location-allocation methods are applicable in optimizing basic health care service network in relation to residential locations in the extent of the Northern Finland, as citizens have been free to choice of hospital or health centre, when using public services since 2014 and distance is clearly an essential factor in selecting services. Location-allocation refers to spatial optimization of facility locations by transport costs in relation to distribution of service demand and study settings may include e.g. median problems, covering problems and central problems (Miller & Shaw 2001). In this study, p-median i.e. minimize impedance approach is used as aim is to increase effectiveness of non-urgent basic health care. As the travel time sum of population to health centres is minimised, the analysis maximises the average accessibility of population, but does not take the spatial coverage into account. In this study, location-allocation analysis was applied to four scenarios of diminishing service network. Present network of 92 health centres were reduced in 10 facility intervals until to 52 and optimal accessibility of population the network was computed for each scenario.

2.2. Vehicle routing and hub location-allocation

There is pressure to rationalize also warehousing functions of basic health care, and centralizing warehousing activities to one or a few warehouses is relevant opportunity for this. By centralizing warehousing functions, cost-effectiveness may be increased remarkably by the scale economies as wastage may be reduced, inventory turnover may be higher, reserve stock may be decrease and quality and quantity of stock item may be rationalised. Thus, scenarios for locating centralised warehouses serving health centres are considered in this study. Accessibility of warehouse locations, or their combination, is considered by applying 'vehicle routing problem' (VRP) method in establishing optimised routes for deliveries to health centres. By the definition, the solution for VRP calls for the determination of a set of routes, each performed by a single vehicle which starts and ends at its own depot, fulfilling all the requirements of the customers and minimizing transport costs (Baldacci et al. 2010). Computationally VRP is a superset of the classical traveling salesman problem (TSP), in which set of stops is organised optimally. As the TSP is a combinatorial problem, there is no straightforward way to find the best sequence and heuristics are needed to be used to find suitable solutions in a reasonable time. ArcGIS Network Analyst VRP solver was applied in this study and it operates on the basis of a fastest route origin-destination matrix and the heuristics used in this process are based on implementation of a tabu search metaheuristics which are further developed (ESRI 2012).

In this study, warehouses are supposed to be located within one or a few of the six hospitals of the region. Optimal delivery routes and related accessibility are computed by using all

$$n=2^T-1$$

combinations (n=63) of warehouses (T=6) which would potentially be applied. Effectiveness of different scenarios is considered on the basis of travel time needed for delivery routes connecting all accessible health centres to warehousing functions. Routes are generated via road network and by using travel speed estimated. Time budget for each route is nine hours of driving time and service time and 10 minutes penalty is given in the beginning and for every stop in a route.

2.3. GIS data

Accessibility analyses of the study are based on the leas cost path routes and road network data including speed limits for travel time estimates. Road network data consist of all regularly used roads including regional and local main streets, collector and feeder streets and private roads allowed for public use (Finnish Road Administration 2014). The speed limit based travel time estimates are highly accurate in Northern Finland, due to low effect of congestion in the area. However, travelling speeds in built-up areas are increased by 25 %. A few road ferry connections exist at the research area and estimated travel speeds of cable ferries are of 10 km/h and of larger ferries 20 km/h.

Data of Finnish health care facilities are maintained by the National Institute for Health and Welfare. Basic health care and hospital facilities were positioned by geocoding street addresses of facilities in relation to GIS data of road network. In Northern Finland there were six hospitals (being active in special health care, advanced surgery and births) and 92 health centres in the end of year 2014.

Population grid cell data of Statistics Finland consists of register based information of residential locations of Finnish citizens (Statistics Finland 2013). Originally 250×250 m grid cell data is aggregated to 2×2 km resolution grid cells to keep amount of observations (N=10249) suitable for computation power. The population of Northern Finland (734925 in habitants by the grid cell data) is included to the analysis. In accessibility analyses, locations grid cells are represented by their centroids.

3. Accessibility approach to rationalisation of health centre network

With the present, relatively dense, service network, accessibility to basic health care may be considered to be at relatively high level, as 78.4 % of population reaches the nearest service in 10 minutes and almost all citizens reach health care in 30 minutes (Table 1). Even though the population in Northern Finland can be characterised as dispersed, majority of population is located to cities and rural towns which are covered well by health centres. However, in rural and particularly in deeply peripheral areas travel times to services are high (Fig. 2), but correspondingly the amount of population living in these areas is low.

Travel time threshold (minutes)	Health centres (N), Accessed population (%)				
	52	*62*	*72*	*82*	*92*
10	69.5	73.4	75.9	77.4	78.4
20	89.2	91.4	92.8	94.0	94.4
30	96.3	97.1	97.5	99.7	99.7
45	98.9	99.4	99.4	99.5	99.5
60	99.6	99.8	99.8	99.8	99.8
90	99.9	99.9	99.9	99.9	100.0

Table 1. Accessibility of basic health care. Share of population accessed by different size health centre service networks optimised by accessibility.

In the scenarios of considering the decreasing amount of health centres, accessibility effects of removing services strikes firstly to the populations in small towns in southern parts of the area and secondly to the sparsely populated northern and eastern areas (Fig. 3). A main reason to this is the relatively extensive service network in the south, where a majority of small towns have their own health centres. In the case of services would be withdrawn from a few these towns, services would still be available in neighbouring centres. However, even though the service level in general would remain in decent condition in these towns, the local effect would of course be notable. As the coverage of service network is already almost at the minimum level in northern and eastern parts of the region, location-allocation analysis saves mainly the service units at these areas. Thus, in the scenario where service facilities are reduced remarkably (from 92 to 52), population accessing services in 10 minutes decreases notable 8.9 %, but for population accessing services in 30 minutes suffer the decrease of 1.4 %, (table 1).

However, in the case of most sparse service network, travel times to basic health care increase very radically in remote areas and hinterlands having low populations (Fig. 4).

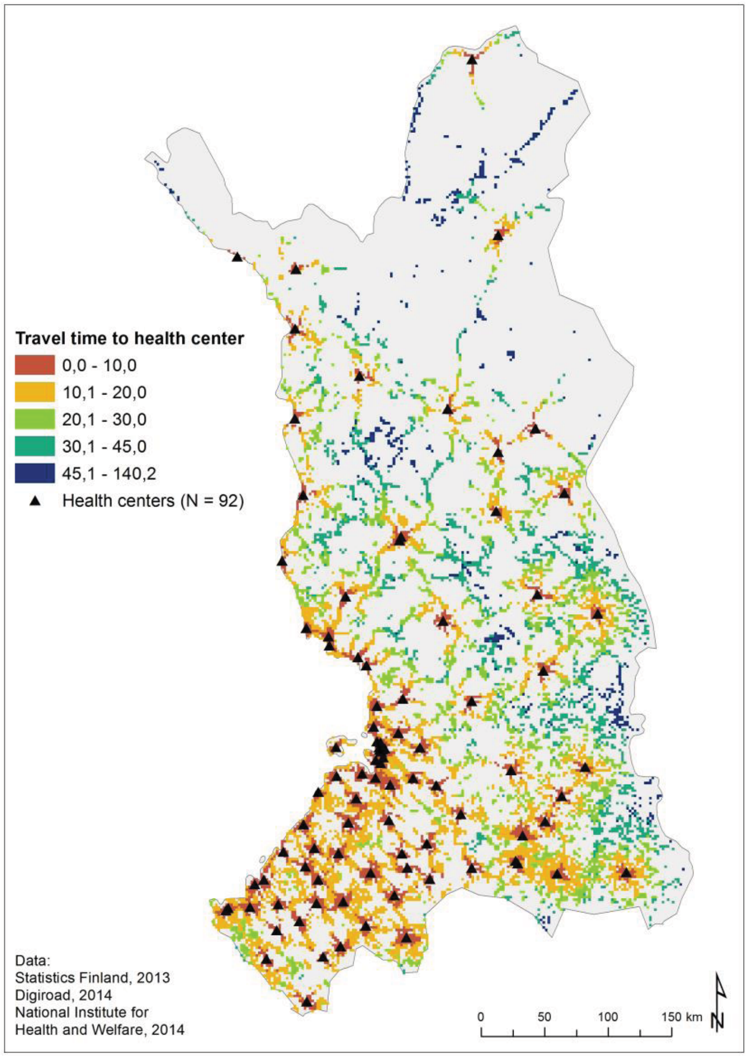

Figure 2. Accessibility to basic health care as estimated fastest route travel times by a passenger car.

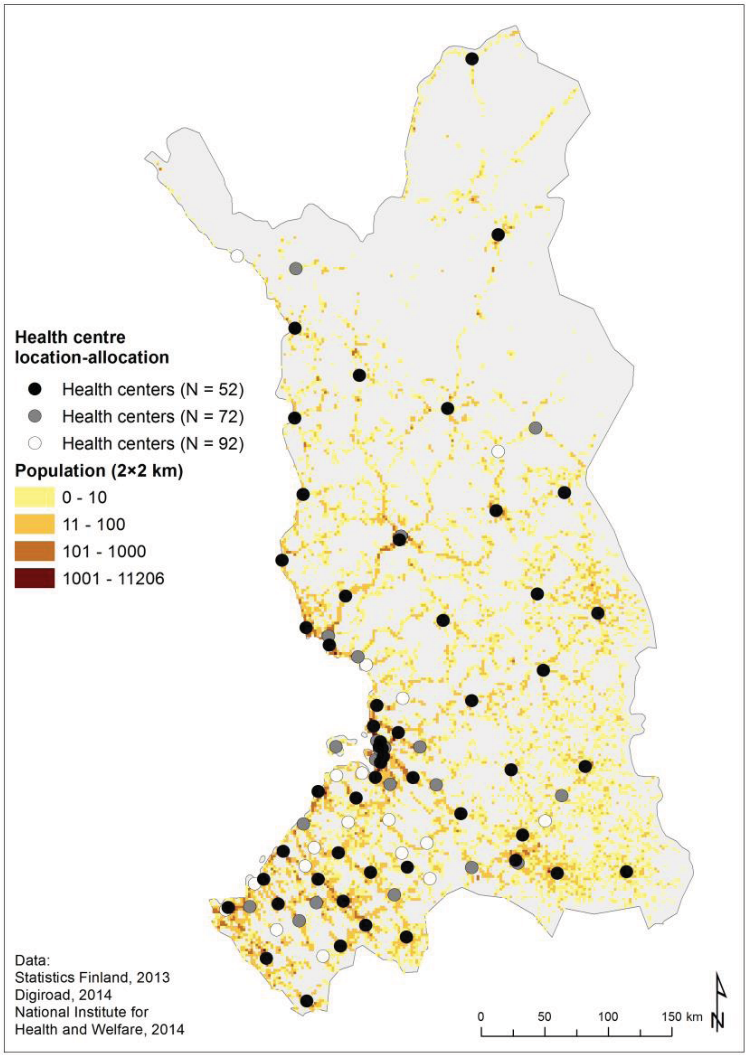

Figure 3. Health centre network with present coverage (N = 92) and examples of health centre networks with limited number of service units (N = 72 and N = 52) optimised in relation to the population structure by accessibility.

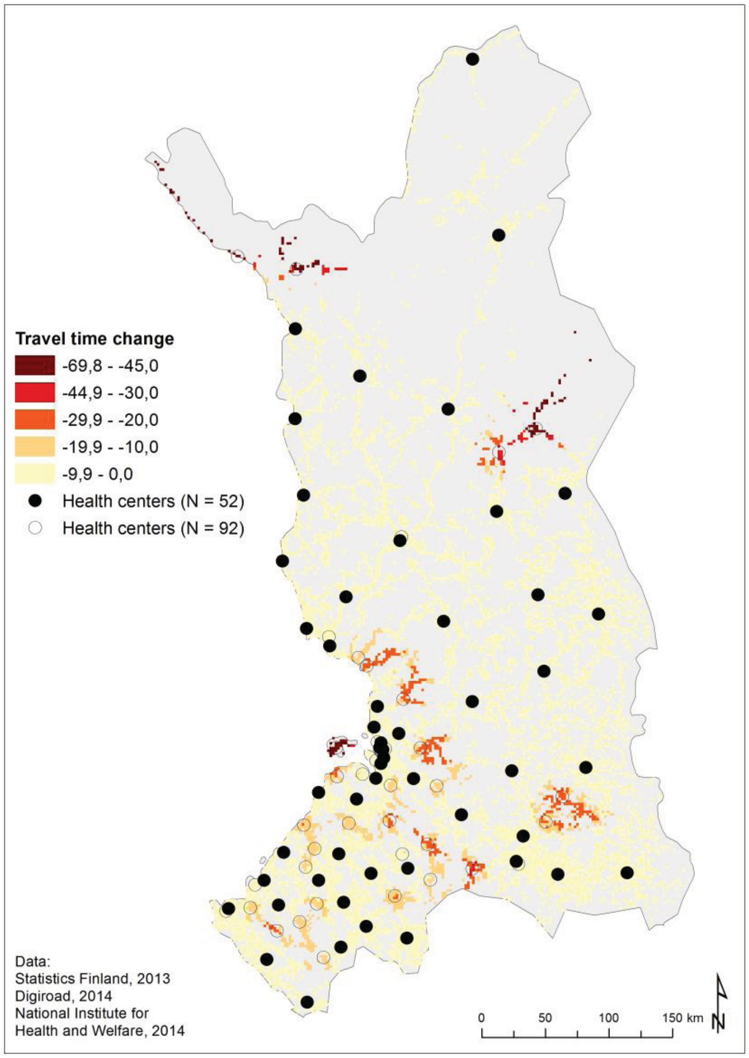

Figure 4. Travel time increase (minutes) in relation to accessibility of closest health care centre in present (N=92) and limited (N=52) service networks.

4. Optimizing centralised warehouse locations and delivery routes to health centres

Locating centralised warehouses serving health centres is considered by effectiveness of computational delivery routes. Analysis consists of 63 different warehouse location combinations, when one, few or all of the six hospitals of the Northern Finland are considered as potential site of a warehouse in turn. In each of these scenarios, delivery routes connecting warehouse(s) to health centres are established (Fig. 5). Five routes are allowed to be generated for each warehouse and each generated route is allowed to be continued until nine hours is reached with 10 minute time penalty in the beginning and during every stop. In addition, potential future health centre networks included to the analysis (see chapter 3).

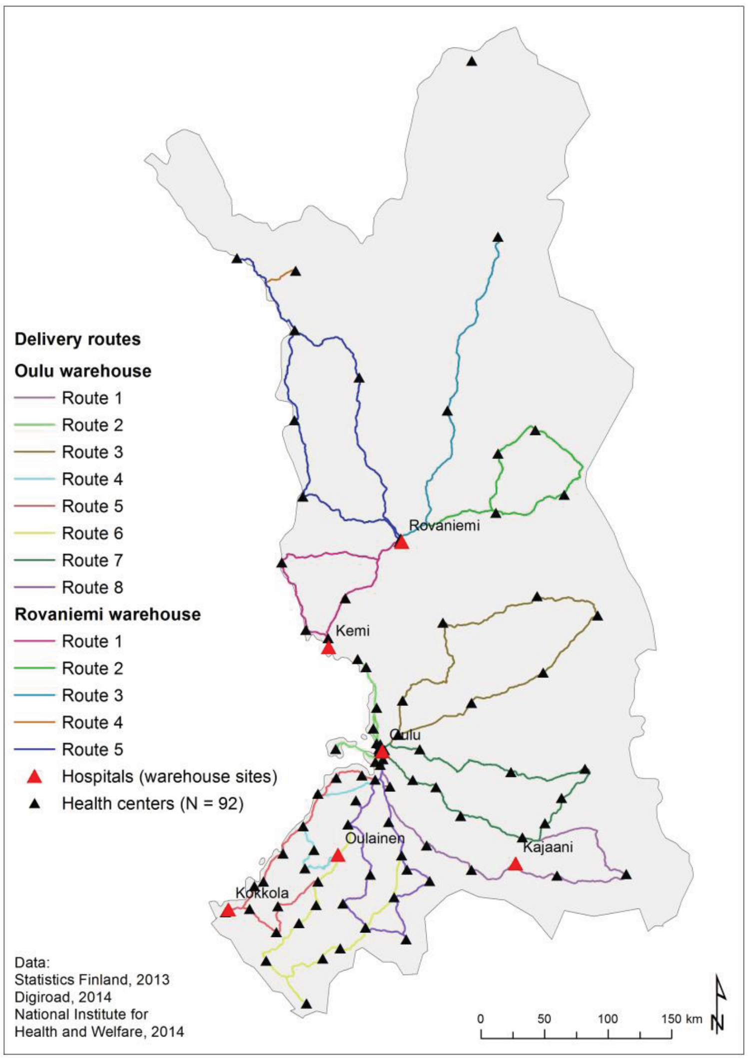

Figure 5. Delivery routes of the most optimal scenario of two warehouses, locations in Oulu and Rovaniemi.

For locating one warehouse on the basis of most efficient routes in reaching health centres, the location of Oulu university hospital would be clearly the best in sight of accessibility. Results are corresponding with scenarios of different size health centre network between 52 and 92 units. From warehouse located in Oulu, 87-90 % of health centres can be reached in all scenarios.

By locating two or more warehouses, all but one (the northernmost) health centres could be reached (table 2) by delivery routes, if one of the warehouse would located to Rovaniemi. In the case of locating two warehouses, minimum travel time in delivery routes is achieved by locating one warehouse to Rovaniemi and another to Oulu or Oulainen. Effectiveness in locating second warehouse to Oulu or Oulainen is almost similar when considered as travel time. Nevertheless, if the warehouse would be located to Oulu, it could be effectively integrated to warehouse facilities of Oulu University Hospital.

Number of health centres reached	**Driving time (h)**	**Warehouses included**					
		Kok.	***Rov.***	***Kemi***	***Oulai.***	***Kaj.***	***Oulu***
91	92.4	0	1	0	0	0	1
91	92.9	0	1	0	1	0	0
91	104.7	0	1	0	0	1	0
90	114.0	1	1	0	0	0	0
88	86.1	0	0	1	1	0	0
88	91.4	0	0	1	0	0	1
88	100.7	0	0	1	0	1	0
87	98.3	1	0	1	0	0	0
87	129.2	0	1	1	0	0	0
83	78.8	1	0	0	0	0	1
83	81.2	0	0	0	1	0	1
83	82.7	0	0	0	0	1	1
79	73.9	0	0	0	1	1	0
79	83.3	1	0	0	1	0	0
78	84.4	1	0	0	0	1	0

Table 2. Combinations of two warehouse locations, number of accessed health centres and total driving times of delivery routes.

With case of locating three warehouses, the result includes more options for variation, as efficiency of three different settings are within the marginal of 1.3 % in total driving time (table 3). Warehouses location setting including Rovaniemi, Oulu and Kokkola or Oulainen is almost as effective as setting with Rovaniemi, Kajaani and Oulainen.

Number of health centres reached	Driving time (h)	Warehouses included					
		Kok.	*Rov.*	*Kemi*	*Oulai.*	*Kaj.*	*Oulu*
91	85.6	0	1	0	1	1	0
91	86.7	0	1	0	1	0	1
91	86.7	1	1	0	0	0	1
91	89.7	0	1	0	0	1	1
91	91.2	1	1	0	0	1	0
91	91.6	0	1	1	1	0	0
91	91.7	0	1	1	0	0	1
91	93.7	1	1	0	1	0	0
91	98.1	0	1	1	0	1	0
90	104.4	1	1	1	0	0	0
88	80.0	0	0	1	1	1	0
88	80.3	1	0	1	0	0	1
88	82.8	0	0	1	1	0	1
88	83.8	0	0	1	0	1	1
88	85.6	1	0	1	1	0	0
88	86.0	1	0	1	0	1	0
83	74.7	0	0	0	1	1	1
83	76.7	1	0	0	0	1	1
83	79.6	1	0	0	1	0	1
79	73.1	1	0	0	1	1	0

Table 3. Combinations of three warehouse locations, number of accessed health centres and total driving times of delivery routes.

Nevertheless, it is important to notice that the increasing number of warehouses do not decrease the total travel time remarkably (table 4). Total cost in reaching present health centre network or limited number of units in different scenarios by using six warehouses decreases travel time only 14–17 %, in relation to using two warehouses. When comparing the effectiveness of delivery routes of most efficient two and three warehouse settings, by adding a third warehouse, only 7–11 % of driving time could be saved. Increasing amount of warehouses from three to six, the total driving time reduces by 3–6 %.

Number of warehouses	Number of health centres, total driving time (h) / accessed health centres				
	52	***62***	***72***	***82***	***92***
1	67.7 / 47	65.4 / 54	73.1 / 64	72.4 / 72	74.7 / 80
2	61.4 / 51	73 / 61	79.3 / 71	82.1 / 81	92.4 / 91
3	55.2 / 51	65.3 / 61	70.6 / 71	75.5 / 81	85.6 / 91
4	53.5 / 51	64.8 / 61	69.2 / 71	72.5 / 81	83.3 / 91
5	51.8 / 51	63.6 / 61	66.1 / 71	72.1 / 81	81.3 / 91
6	52 / 51	63 / 61	66.7 / 71	70.5 / 81	80.8 / 91

Table 4. Effectiveness of transports and number of warehouses and health centres

5. Discussion and Conclusion

This study gives a preliminary sight in optimising geographic aspects in core and supporting services of basic health in the Northern Finland. Findings of the study show that regional level accessibility is not harmed remarkably if 10–20 health centres would have to be withdrawn from areas having presently dense service network. However, local effect on accessibility might still be notable, particularly in the most sparsely populated peripheries. If health centre warehousing is wanted to be enhanced by centralised solutions, there are no remarkable geographic obstacles for this, even though the distances between health centres in the region may represent extreme in the context of the Europe. Only northernmost health centres of the study area are poorly accessed by generated delivery routes. Analyses indicate that Oulu is highly suitable site for centralised warehouse, and if two or more warehouses are aimed to be located, Rovaniemi shows as a very favourable location.

There are some opportunities to enhance this analysis in the future. Simple travel time estimates may be developed further by including real or estimated costs to analysis, in relation to travel time, distance, frequency as well as amount and quality of goods. Equally accessed nodes could be weighted by volumes in route generation. The effectiveness of route solver in designing routes may affect to the results in some extent. As vehicle route problem is solved by functions applying heuristics, only sub-optimal route setting is found. Thus, the differences between effectiveness of route solvers would be worthwhile to be compared, to increase the validity of results.

Finally, long distances are important factor that has to be taken into account in designing the health care services in northern context. In designing different level service networks, mobile services, warehousing functions or deliveries, locational analysis and GIS are an effective analytical framework to be applied in optimizing the spatial components of activities and facilities with motivation to design more effective services.

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Spatial analysis of police open data as a part of community policing – an example of Pardubice city (Czech Republic)

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Extended Abstract

Spatial data collected by the police has considerable potential for spatial analysis. Such analysis can help to improve the performance of the police itself, raise public awareness of local issues, and serve as an input for decision-making processes in other institutions. For these reasons we believe that police data should be, with certain limitations, distributed as open data freely available to everyone to use and republish as they wish, without restrictions from copyright, patents or other mechanisms of control.

In this paper, we demonstrate the possibilities of spatial analysis and cartographic visualisation of crime data. We provide two use cases based on data gathered by the municipality police in Pardubice, the tenth largest city in Czech Republic. Our approach is inspired by risk terrain modelling introduced by Caplan & Kennedy (2011). The input dataset contains a geolocated list of minor criminal offences that occurred in the city in 2014.

Crime incidence statistics were produced by the Municipality police of Pardubice. The dataset contains all reported incidents in the city area in 2014. Because of different terms of references for Municipality police and the Police of the Czech Republic the dataset includes rather minor offences. Each dataset entry is classified by the offence type, and holds information on the date and time, on-the-spot fine fees, as well as notes on actions taken by the police and the resolution of the event. Geolocation is provided by the address and GPS coordinates in WGS84 georeferencing system stated in decimal form. The validity of GPS data was manually confirmed on the subset of data by comparison with stated address.

Use case 1 – gambling sites

The influence of gambling sites on population is a subject of several studies, focusing on social capital (Barmaki 2001; Griswold & Nichols 2006), gambling problems (Fischer 2001), effects of regulation (Hansen & Rossow

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2010), accessibility (Robitaillle & Herjean 2008) or availability (Jacques, Ladouceur & Ferland 2000) of gambling and video lottery terminals.

There were over 57 000 gambling sites in the Czech Republic at the end of the year 2014 (Ministry of Finance 2014). Permission and licence for casino, gaming machine or roulette is granted by the Ministry of Finance of the Czech Republic. The list with locations of permitted gambling sites is legally open data provided by the Ministry of Finance. Addresses of these places were geocoded in QGIS 2.6. Fig. 1 shows the distribution of gambling sites in the city center of Pardubice.

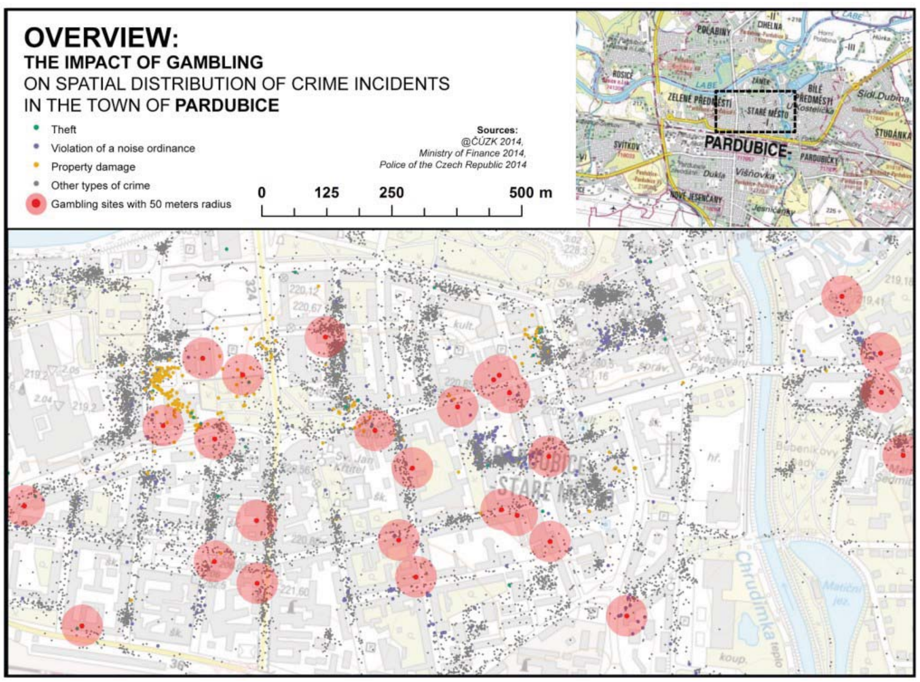

Figure 1. The distribution of gambling sites and crime incidents in the Pardubice city centre.

The first use case analyses how gambling sites influence the number of crime offences in their surroundings. The Czech Republic legislation does not permit the presence of a gambling site in a 100 m distance from specified buildings such as schools, hospitals, or places of worship (Act No 202/1990). Our findings support the validity of the 100 m threshold as it roughly agrees with the 85-120 m influence reach we found in the input dataset. For the purpose of our analysis, we devised a method of concentric buffer zones to observe if the change in the relative amount of crime incidences of different types depends on the distance from the gambling site. With this method, we identified three crime types that appear to be significantly influenced by the proximity of a gambling site: theft, violation of noise ordinance and property damage. The results suggest that the distance of highest influence is 15 meters, where the amount of crimes culminates (see Fig. 2). The threshold beyond which the gambling site ceases to influence the crime rate falls between 85 and 120 meters.

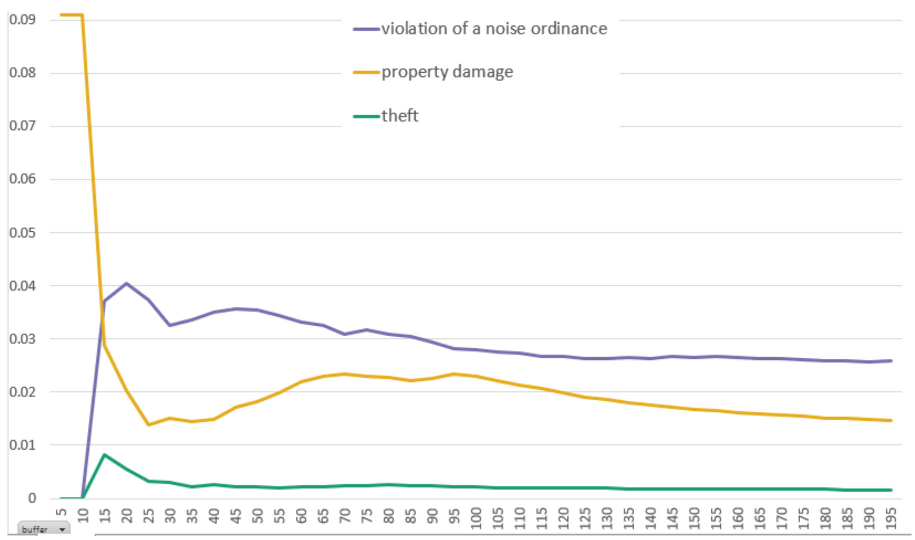

Figure 2. The Impact of the distance from a gambling site on the relative amount of three selected crime.

Use case 2 – traffic offences

The second use case is focused on possible methods for accident prevention and enhancing urban transportation planning by using data of committed offences. This topic is covered, for example, by Levine (2008), Cinnamon et al. (2011) or by Gundogdu (2011). Traffic offences have been extracted from source data and they have been devised in two parts: offences caused by pedestrians and offences caused by cyclists.

For the second use case, the offences dataset has been combined with other open data stored in RUIAN (Registry of Territorial Identification, Addresses and Real Estates) registry, e.g. streets and buildings. Different methods have been used for processing and analysing this data. Temporal analysis groups the offences by date ranges (see Fig. 3). For cyclists, the number of offences is highly dependent on the weather conditions, peaking during the summer holidays, August and September. This probably reflects the new trend of active holiday spent on bicycles. For the pedestrians, the results are quite reverse as more offences were noticed during the winter months.

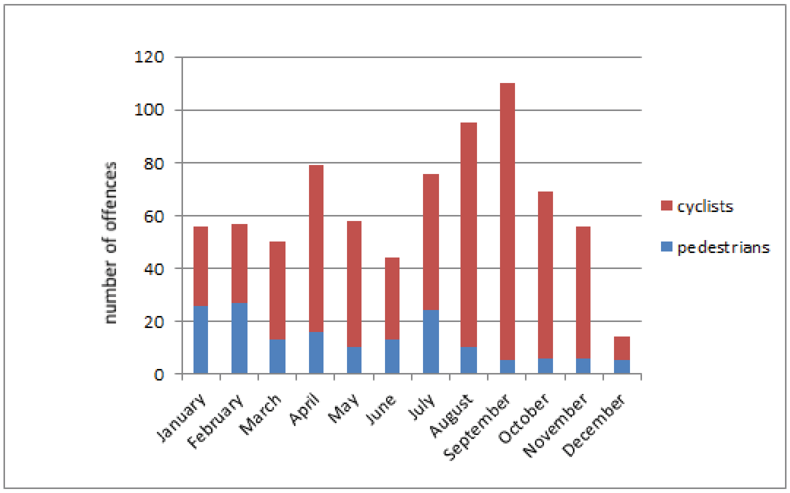

Figure 3. Monthly distribution of offences committed by pedestrians and cyclists.

Along with the temporal analysis, heat maps were also created to localize areas with the highest concentration of offences. Hot-spots of traffic offences have been extracted from the heat map. The data was filtered by pedestrian and cyclist offences into separated layers. Then we assessed these separate layers by using the "*Kernel Density*" analysis. Important clusters have been extracted semi-automatically from these heat maps. ArcGIS 10.3 was used for this step of data processing. Workflow has been developed in Model Builder. Most important parameter of this workflow is threshold that is set for reclassification of raster data. Threshold values are different for offences caused by pedestrians (0.003) and cyclists (0.002). Output of this workflows point layers have been exported to MS Excel and there, the contingency table was created.

Some hot spots from the city center are shown on Fig. 4. For example area C is on frequented road with heavy traffic in rush hours. The traffic lights in this crossroad don't change the interval so some of the pedestrians try to pass the road on the red light. The construction of overpass would solve the problem. Another solution would be in optimization of the traffic light intervals. The J spot is located in the park. There are no bicycle lanes in this park and there are also only one-way roads around the park that complicates mobility of cyclists and they use the park as a significant shortcut.

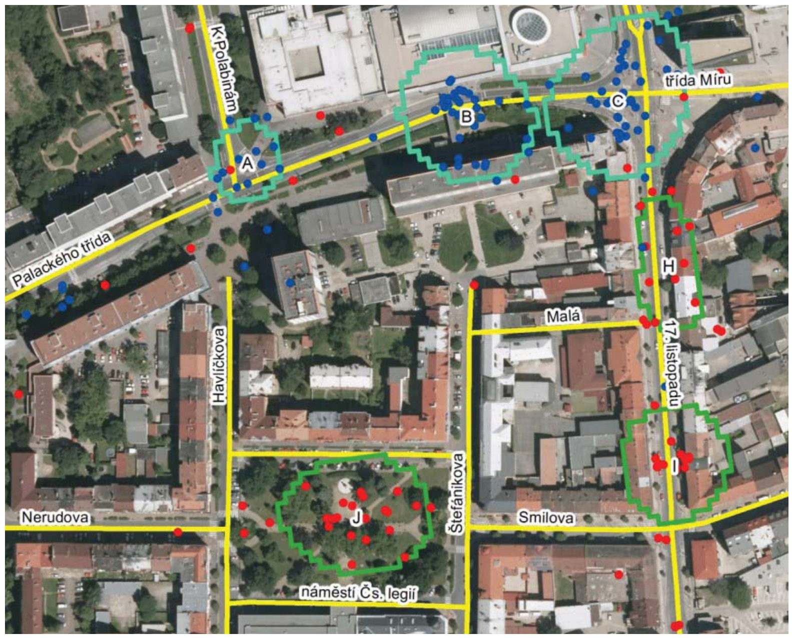

Figure 4. Overview of the offence clusters in the city centre (blue – pedestrians; red - cyclists).

Conclusion

Results of both aforementioned use cases can be used by both police and public administration authorities as a supportive source for community policing. Community policing is a strategy of policing that focuses on police working closely with members of the communities. In this concept, police forces are seen as part of the public and should not be considered only as a tool of repression Office of Community Oriented Policing Services (2014). Analysis of data collected by the police can positively affect not only the safety but generally the quality of life and urban transport.

It should be noted that each type of offenses requires the selection of specific methods of analysis. We started from the general work dealing with crime mapping in GIS (e.g. Caplan & Kennedy, 2011), but it was necessary to concentrate on analytical methods closer related to solved topics, which were impact of gambling sites on amount of offences and distribution of traffic offences caused by cyclists and pedestrians.

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Towards Better Urban Travel Time Estimates Using Street Network Centrality

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Extended Abstract

Accurate vehicle travel times are a prerequisite for many applications in the mobility domain as well as applications which are interested in effects of reachability. This paper describes a novel approach to estimate travel times and their diurnal variation in urban street networks which uses only static map attributes and centrality measures extending the work presented in Leodolter et al. (2015). The method provides a low-cost alternative to expensive travel time measurement campaigns. By integrating closeness and betweenness centrality measures, the model is expanded to take advantage of previously neglected spatial information.

Centrality measures have been used, for example, to study city structure (Crucitti et al. 2006) or explain land use intensity (Wang et al. 2011), and retail and service activity (Porta et al. 2009). In the context of motorized traffic, betweenness centrality has been used as an indicator to predict traffic flows. For example, Jiang (2009) shows that street hierarchies derived from street length, connectivity, and betweenness are a good indicator for traffic flow. Puzis et al. (2013) present a betweenness-driven traffic assignment model which can take into account travel demand and model travel times. Similarly, Gao et al. (2013) combine betweenness with travel demand data and geographical constraints to predict traffic flow. To the best of our knowledge, there is no work so far which uses centrality measures to model travel times and their diurnal variation. Our model predicts vehicle travel times for a given time of day in 15 minute intervals.

We use one year's worth of floating car data (FCD) from about 3,500 taxis, a street network from OpenStreetMap for Vienna, Austria and the Ordinary Least Square linear regression model for estimating travel times presented in Leodolter et al. (in press). This model is extended to include closeness and betweenness centrality measures to addresses shortcomings of the original approach which ignores spatial network aspects. Centrality measures

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are modeled separately by functional road classes (FRC) and calculated using geometric distances for the shortest path.

Based on the estimated model coefficients, the following conclusions can be made: (1) The highest speed estimate increase is observed for important (in terms of betweenness centrality) network links at the periphery. (2) The closer a link is to the network center, the less its speed estimate depends on the betweenness. (3) The relationship of betweenness and closeness respectively, and the speed estimate highly depends on the FRC.

First results show that including centrality in the model reduces the error (RMSE between mean FCD speeds and model predictions per 15 minute interval) by about 8 percent for the whole network or 20 percent for the central city districts. Improvements can be observed especially for important network links in the city center – such as arterials and bridges – as well as rural roads at the periphery. However, for some links the extended model performs worse, probably due to misleading betweenness values. To deal with this problem, we plan to recalculate betweenness based on travel time and implement local centrality which reduces the distortion that lowers centrality values near the edge of a network. This should furthermore enable us to identify multiple centers in a network such as smaller towns surrounding the main city.

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Spatial-Temporal Modeling of Linguistic Regions and Processes with Combined Indeterminate and Crisp Boundaries

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Extended Abstract

The intention of Language Geography – a branch of classical Human Geography (Carvalho 1962) – is to enhance the usability of digital language and dialect databases and foster visual exploration of linguistic data. Currently, linguistic phenomena are commonly mapped in a static manner, which results in maps with dialect regions or isoglosses. Isoglosses define the geographic boundary of a linguistic feature, such as the pronunciation of a vowel, the meaning of a word, or the use of some syntactic feature.

Due to the fact that language and dialect are dynamic phenomena per se, a digital representation can serve as solid basis to model this fact. Hence, we apply the theory of fuzzy sets (Zadeh 1965) and indeterminate boundaries to Language Geography. Given the fact that language regions and isoglosses may move and/or change their shape over time, boundaries between adjacent regions are not always crisp – but they can be crisp if, e.g., a natural barrier hinders the movement of people and thus the exchange of language. This is true for, e.g., mountain chains or oceans, which constrain the movement of people. The same can be said about barriers having been introduced in the late 19th and in the 20th century, when language became a major identifier for each country and there were more and more efforts to use political boundaries also for outlining cultural (and especially linguistic) domains.

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In addition, language islands and regions may arise from scratch as well as existing language regions or islands may disappear over time – which has to be modeled accordingly. Globalization and urbanization fosters this creational process of new language islands and regions within existing language regions. Hence, these regions have no crisp border, but share a certain part of space with fuzzy memberships of the involved linguistic regions (Burrough 1996, Worboys 1998).

The article at hand covers spatial-temporal modeling of language phenomena based on fuzzy sets, indeterminate boundaries, and spatial-temporal change of spatial entities (see Medak 1999, Hornsby and Egenhofer 1997, Hornsby and Egenhofer 2000). Hence, linguistic processes are analyzed regarding the implications on space and time, i.e. the change of linguistic regions over time with respect to their shape and attributes in space and time, i.e. the change of linguistic regions over time. The paper highlights the representation of linguistic regions with combined indeterminate and crisp boundaries – i.e. frontiers and borders. Both boundary types are necessary in order to model the spatial-temporal dynamics of language phenomena. The article analyzes further the emerging, ending, moving, and merging of linguistic regions and phenomena with respect to space and time as well as boundary types. In order to represent frontiers or indeterminate boundaries, fuzzy logic is employed.

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Atlas of Switzerland goes online and 3D – Concept, Architecture and Visualization Methods

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Keywords. National Atlas, Web Cartography, 3D Visualization

Interactive atlas systems are products of high cartographic quality and user-targeted functionality. During the last two decades, numerous interactive atlas and mapping systems have been developed. These systems offer a variety of mainly statistical 2D map types like choropleths, point symbols and charts, and partly some 3D map types like panoramic views and block diagrams. They also include a bundle of atlas functionalities for spatial and temporal navigation, map visualization, and layer handling. With the rise of high-speed Internet connections, various online atlases appeared facing the challenge of streaming map data with good performance.

The *Atlas of Switzerland (AoS),* an example of a mature digital atlas, tries to advance the trends of 3D mapping, online and mobile applications in combination with existing atlas functions in its next version. The AoS is mandated by law by the Swiss Federation to visualize themes from different fields such as socio-economy, ecology, history and energy, etc. in an ongoing long-term project. Since its beginning in 1961, the aim of this Swiss national atlas is to offer cartographically sound maps in combination with additional information to the general public in order to visualize visible and hidden structures and processes.

The concept of 3D-based cartography will be pursued, where a 2D map is considered as a special case of a 3D map setting. Within this 3D environment, new rules, interactive methods and user-friendly tools for 3D navigation in space and time, map graphics and layer handling, and explorative analysis will be developed. The atlas should stand for a world of experience and discovery, inviting people to explore its thematic content, and interrelations. Conceptual considerations are also dedicated to the *Graphical User Interface (GUI)* of the 3D atlas: the GUI should work for desktop and mobile applications, and consider reduced feature and layout complexity as well as responsive design. A flexible GUI for different platforms has been set up therefore with methods of interaction design (IxD).

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As an *architectural framework* for future AoS products and affiliated atlases, the AtlasPlatformSwitzerland (APS) has been implemented. The APS is divided into a back-end and a front-end part. On the back-end, the APS Editor facilitates composing map layers, adding media elements, and creating tile caches (TFS and TMS). Once a map is ready to be published, metadata is exported from the database in JSON documents, which are – together with the map tiles – hosted on a scalable web server. On the client-side, the APS front-end architecture consists of an atlas core (APS Globe) and a Web application UI. An important part of the APS Globe is its 3D visualization engine osgEarth, – a dedicated virtual globe.

The APS aims to provide eye-catching but still readable *3D visualizations* to raise the interest of the public. Depending on the source data type, the APS includes cartographic 3D representation techniques like billboards, 3D solid charts and 3D symbols for point data, curved lines for trajectories, extrusion for areas (Figure 1), and terrain modeling for volumes. Considering the combination of thematic layers with terrain interaction, its LOD behavior, occlusion and performance need to be taken into account. The challenging part is to make an intuitive visualization both in 2D and in 3D. Map readers get an overview from the birds-eye perspective and more details when tilting the globe.

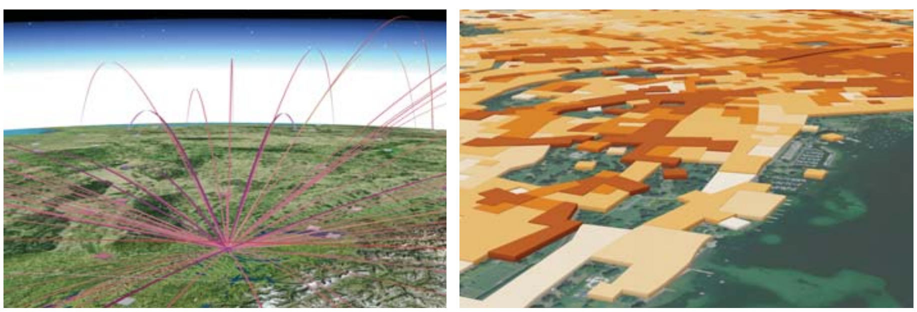

Figure 1. Linear trajectories: Direct flights (left); Extruded polygons: Settlement development (right).

The launch of the new product line *Atlas of Switzerland – online* is scheduled in spring 2016 as a desktop version for Windows. In the upcoming years, the functionality and content of AoS – online will be enriched stepwise according to user needs, and completed with an OS X Mac version. A version for tablets, AoS – mobile, is also planned. Both versions will offer a broad range of thematic maps, visualized with 3D techniques, giving professionals and inexperienced users the opportunity to combine and explore different geospatial phenomena in a modern atlas user interface.

Web-based Interface Development for 3D Geo-spatial Data Visualization – An Open-source and Plug-in free Approach

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Extended Abstract

The visualization of results from urban energy simulations is a crucial part in the field of energy research as they act as the main communication tool between scientists and decisions makers. Results from energy modelling and simulations are usually directly linked to spatial objects such as buildings or city furniture. Therefore, the visualization in 3D plays a significant role as results are usually not only aggregated by the building object itself but at a finer scale such as building wall or building roof surfaces. This requires a higher grade of visualization and therefore 3D becomes a necessity (Nouvel et al. 2014). Furthermore, the display of energy simulation model results in 3D enables the decision makes to better emerge into the problem and to view results from multiple perspectives.

While recent years have seen numerous 3D web Application Programming Interfaces (API) ranging from GoogleEarth to Unity's Game Engine, most of the currently available web mapping services that do visualize 3D are based on browser plug-ins and require the user to install one or more programs locally on their computing device. Furthermore, they also do not provide a wide range of custom functionalities specific to the application area of urban energy analysis and the cartographic visualization of those results. This research explores the usage of freely available open-source resources for the creation of a plug-in free web-application interface for 3D geospatial data to display energy related modelling and simulation results. The objective is to provide an alternative to current browser based interfaces which rely on browser plug-ins. A Level of Detail 1 (LoD 1) CityGML 3D model of the city of Karlsruhe, Germany consisting of over 87000 buildings is used as a test data set. The data set was compiled using OpenStreetMap (OSM) data and

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outputs from energy simulation models. All spatial and non-spatial data is hosted in a PostgreSQL database with a PostGIS extension that provides spatial capabilities (Simons and Nichersu 2014). As the main requirement is independence from browser plug-ins, HTML5 and freely available JavaScript libraries are used for the web-application creation while the 3D aspect is controlled by WebGL through the JavaScript library Three.js. As a proof of concept multiple cartographic and GIS functions have been implemented in this interface including classification of building attributes, attribute selection and manipulation, descriptive statistics, spatial buffer analysis and the retrieval of simulation results from a PostgreSQL and PostGIS data infrastructure.

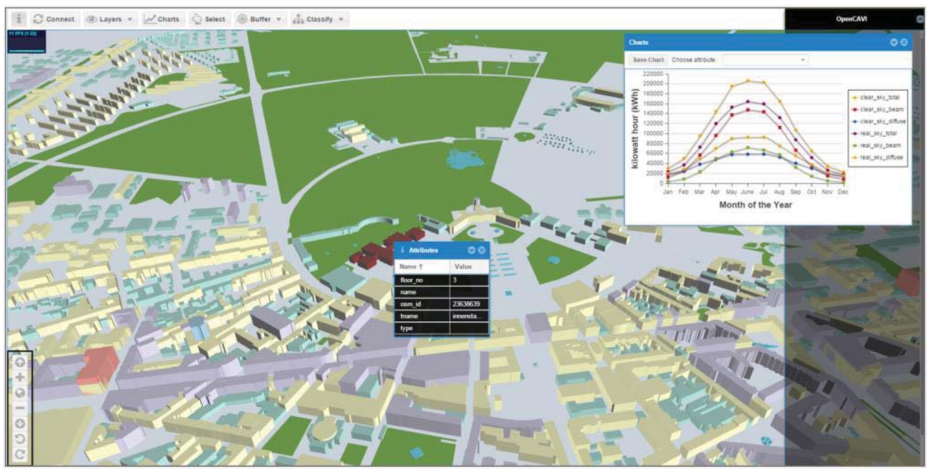

Figure 1. 3D web interface showing energy mode outputs in a web browser

The presentation and the full paper will discuss case studies and future enhancement opportunities for the proposed interface. Furthermore, lessons learned during the development process will be discussed in regards to recent new Web3D developments.

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Advanced CityGML Visualization in 3D Environment

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Extended Abstract

The CityGML (Kolbe et al. 2005) is uniform standard for the exchange of three-dimensional data about urban space. The data can be used to create advanced visualization for various purposes. Unfortunately, the standard CityGML is not a popular source of input data for visualization software. Currently, are available open source solutions dedicated to the CityGML data, that can display geometry and texture with simple shading (Aristoteles, FZKViewer, tridicon(R) CityDiscoverer light (Rothe & Janne 2009). Some of the available applications allow better visualization of data, generating shadows (LandXplorer CityGML Viewer (Döllner 2006), CityGML SpiderViewer). Available solutions are enough to review the data, but if we want to present CityGML data in better image quality we need to use CAD programs, that use algorithms allowing advanced visualization of 3D data. There are also gaps in the capabilities of CityGML presentation in the form of symbolization based on available object attributes.

Lack of high-quality visualization and data symbolization led the author to verify the CityGML visualization capabilities in an advanced open source application named Blender. The application has the ability to easily add-ons programming in Python language. Software also allows you to perform advanced 3D visualization in the form of rendering. The main effects of increasing the quality visualization by the program Blender is drop shadows, ambient occlusion, reflection and refraction of light and environmental effects (clouds, fog, air pollution).

The author decided to create an original plugin to support CityGML data in the Blender application. Data, which was visualised, were loaded from the CityGML database, created in the PostGIS environment using available tools 3DCityDB Importer Exporter (Kolbe et al. 2013). Through a psycopg2 library (Hajji 2008) offering communication with the PostGIS database in python, was possible to reference to individual tables with the Blender

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application environment. Piece of code responsible for importing data (*name and building_root_id* attribute) from table building in PostGIS database:

```
import psycopg2
import bpy
try:
   conn = psycopg2.connect("dbname='Citygml_wizualizacja' user='postgres'
host='localhost' password='password'")
except:
   print ("error")
cur = conn.cursor()
cur.execute("SELECT name, building_root_id FROM building")
tabela_budynki=cur.fetchall()
cur.close()
conn.close()
```

Performing SQL queries to the respective tables is possible to generate objects semantic, their corresponding names and their hierarchy. Using the geometry fields in the table surface_geometry is possible to generate the object mesh. An exemplary flowchart to generate data for buildings is shown in the *Figure 1* below.

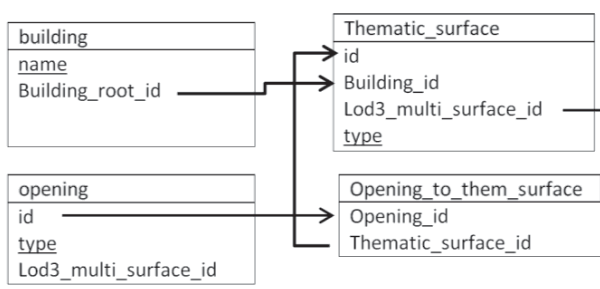

Figure 1. Generating scheme for the building data. Underlined attributes are used to define the name of 3D objects in Blender software.

Imported data, through enhanced visualization tool, may be presented in many different ways. A simple visualization of data in real time is done using OpenGL API (Rost et al. 2009). Additionally, we have access to significantly expanded data rendering options. Rendering allows for advanced three-dimensional data processing, adding to objects advanced textures, analysis of reflections, shading and light scattering, antialiasing the edges of objects, add effects in the form of fog, air pollution. The result of rendering is high quality image showing 3D data. In the figures below (*Figure 2 and 3*), we can see a sample CityGML database visualization.

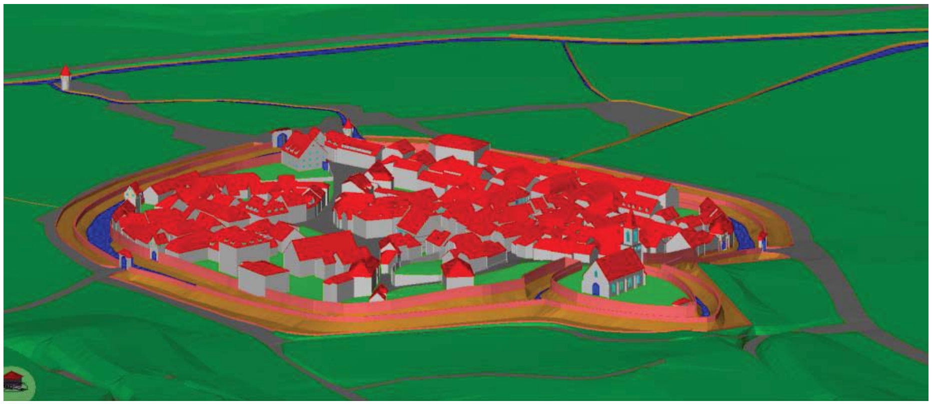

Figure 2. Visualization virtual 3D city model of Ettenheim in Germany. Visualization performed with the FZKViewer program. Data derived from (Research Center Karlsruhe).

In conclusion, the visualization of three-dimensional data is an important process which allows to see the spatial data. Commercially available visualization tools for CityGML data are simple, the effect of visualization is correct, but the quality is not satisfactory. In order to improve the quality of the resulting image, should be carried out data rendering, using specialized applications. High quality images allow a better understanding of three-dimensional data, shadows allow better assess the depth of the image and locate components in 3D space.

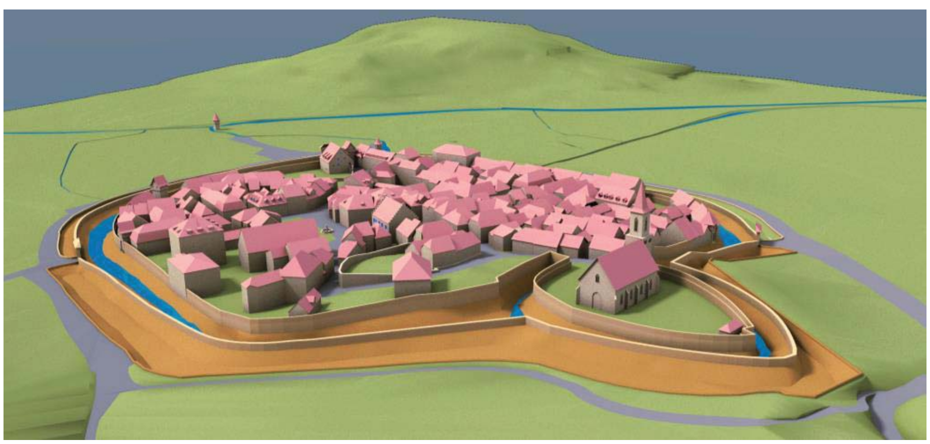

Figure 3. Visualization virtual 3D city model of Ettenheim in Germany. Visualization performed with the Blender and author scripts. Data derived from (Research Center Karlsruhe)

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ELF Basemap – Offering a European Reference Map Service

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Extended Abstract

The European Location Framework (ELF) project [1] is working to create the first implementation of a geospatial reference data infrastructure based on national information assets (Jakobsson 2012). The ELF project is supported by a consortium of 30 partners across Europe, including National Mapping and Cadastral Authorities (NMCAs), industry and research. The project started in 2013 and launched first services in 2014 at the ELF Platform [2], the core of the technical infrastructure. The ELF Platform connects the data services provided by the NMCAs and, in the future, other data providers. Using the ELF geo-tools, the national datasets are transformed by the NMCAs to conform to the applicable ELF/INSPIRE data and product specifications. The ELF Platform further comprises the view and download services that provide users access to these datasets (Jakobsson and Ostensen 2015).

The project is currently working with 14 countries to start provision of ELF/INSPIRE based services for utilization at European, cross-border and national use level. ELF Basemap is a specific view service and one of the key outputs of the project as it offers a visual access point and thus an interface between the reference data infrastructure and the users. ELF Basemap aims to be used both as background map and in combination with other types of information, composed of many themes and available in different visualisations. Table **1** summarizes the basic map concept of the ELF Basemap.

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Map type	European Reference Map
Aim of map use	A reference background map to enable professional users to display their data in client applications such as websites, GIS and increasingly mobile devices; background data for other types of applications
Map content	General description of the man-made and natural landscape with specific interest for transport infrastructure, administrative boundaries, hydrography, location of settlements, relief and land cover information
User	Professionals and general public
Map function	Discovery, information, cognition, communication, and social function
Map use situation	Indoor (outdoor)
Area of interest	geographic Europe
Scale	pyramid of digital maps at different zoom levels - 1:1000000 – 1:2300
Output medium	ELF BaseMap Service (WMTS)
Source Data	Digital vector data from pan-European and national contributions within the European Location Framework (ELF): EuroGeographics existing data at Global and Regional level as well as National basemap data Digital Terrain Model Over Europe (EU-DEM)

Table 1. Basic concept of the ELF Basemap

Currently, the project team is developing the ELF Basemap specification and technical guidance documents for the production of the view service. The specification document details the map concept and describes the map content and design following the approach described by Hopfstock (2010). It is accompanied by a ScaleMaster document and Styled Layer Descriptor (SLD) file. The ScaleMaster [3] is a structured diagram organizing multiscale mapping from multiple sources and registers the selection and generalization decisions for the each level of zoom. The SLD file documents the portrayal rules. Finally, the ELF Basemap service consists of a pyramid of digital cartographic images at different zoom levels delivered through a Web Map Tile Service (WMTS).

Major challenges in the development and production of the ELF Basemap specification and service are the data content and its visualization in a multinational production effort. Hopfstock and Laurent (2015) question the fitness-for-purpose of INSPIRE data for cartographic applications due to the complexity of the INSPIRE data model, missing information and heterogeneous data content allowed to offer in INSPIRE. The project also investigated several approaches to produce the ELF Basemap from national offerings.

In order to test and evaluate the map concept and envisaged production process a pilot ELF Basemap service has been set up in spring 2015 for the Nordic cluster and the Netherlands. Meanwhile more countries have started the production of national ELF Basemap contributions (Denmark, Poland, Czech Republic and Belgium). Table 2 provides an example of the current look and feel of the pilot ELF Basemap at different zoom levels. Given the feedback from the project partners the recommended production process seems to be feasible but the map concept and especially the portrayal needs further revision.

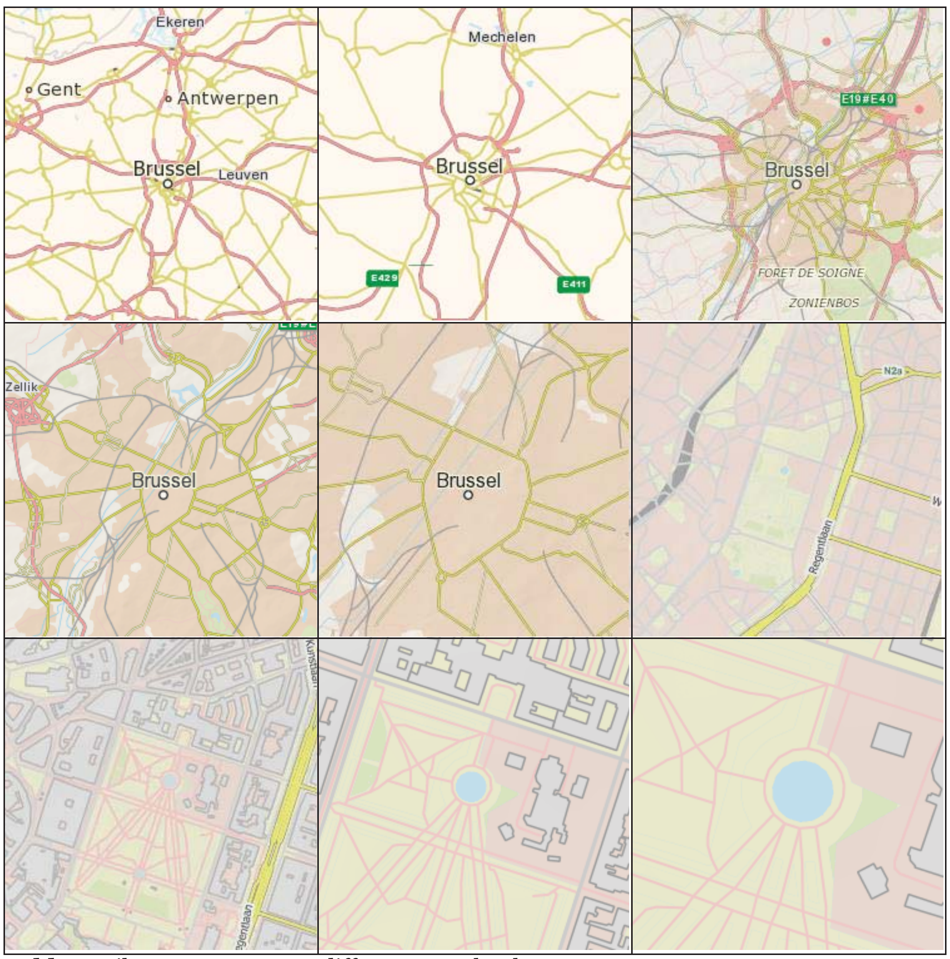

Table 2. Pilot ELF Basemap at different zoom levels

In conclusion, the main objective of the ELF Basemap service is to support the efficient use of the European reference data collection by connecting and integrating multiple datasets. It is an integral part of the ELF platform giving access to the European reference data in a user-friendly and understandable way. However, the multinational production effort based on ELF/INSPIRE data poses some challenges.

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Web Links

[1] www.elfproject.eu

[2] www.locationframework.eu

[3] scalemaster.org

The Wheel of Design – Usability Driven Improvements to the GeoVITe User Interface

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Extended Abstract

GeoVITe (GEOdata Visualization and Interactive Training Environment) is a geodata-sharing portal, providing ETH Zurich employees with direct access to Geoinformation and Geoservices through a user-friendly Web-based graphical user interface (GUI) as shown in *Figure 1*. At ETH Zurich, geodata are needed in a wide range of academic disciplines such as environmental management, architecture, transport planning, landscape development, infrastructure management and many others fields.

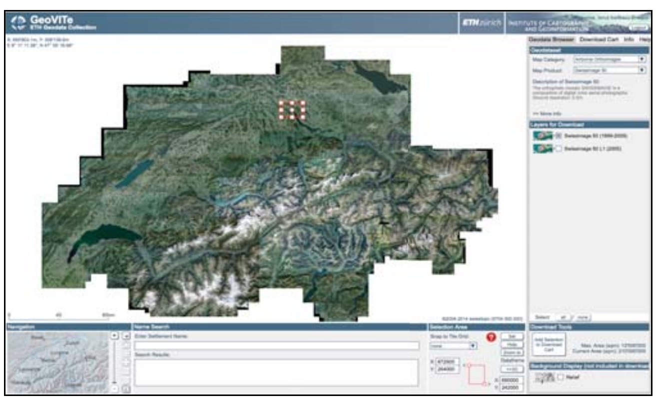

Figure 1. GeoVITe user interface

The guiding functional requirement for the GeoVITe geoportal is that a user should visually navigate (spatially, thematically and temporally) the spatial data, select the desired dataset and area, and directly download the required data in a straightforward manner through a standard Web browser. GeoVITe was therefore designed to identify, select and swiftly download the correct dataset using a service-driven architecture (Iosifescu et al. 2011).

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The current user interface of the GeoVITe portal implements the above functional requirement by providing a clear visualization of available geodata products, by facilitating the choice of the right data (map product and location), and by hiding the complexities related to merging and extracting the needed data extent while seamlessly integrating specific services such as reprojection of data or on-demand generation of contour lines from digital elevation models. Recently however, Geodata4SwissEDU, a two-year cooperation project between three partners (the ETH Library, the Institute for Cartography and Geoinformation at ETH Zurich and the HSR Hochschule für Technik Rapperswil) and substantially co-financed by swissuniversities.ch, aims to extend the easy access to geodata to the entire public universities and research institutions' landscape in Switzerland. In the frame of this project, the GeoVITe GUI was put under scrutiny with the help a professional usability test. The usability test, which was performed using eye-tracking equipment in a laboratory setting, has revealed some important facts and suggestions for improvement. For example, the usability test captured the subjective satisfaction of the users (on a Likert-type scale from 1 to 7) and the necessity of existing functionalities (on a Likert-type scale from 1 to 4). These results allowed the technical design and development team to focus on the aspects that are the most important for the users and create improved design alternatives such as the one presented in *Figure* 2.

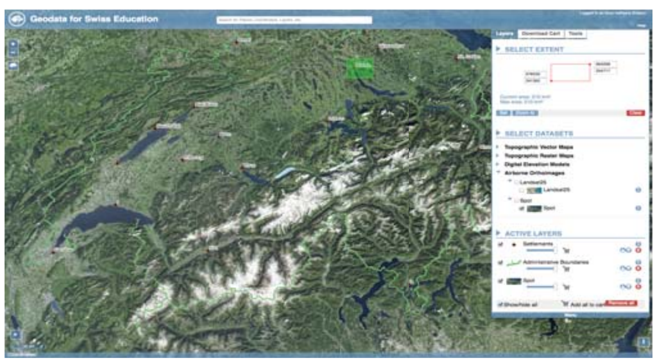

Figure 2. Design alternative for the GeoVITe user interface

As outlook, the possibilities for scaling of the back-end computing infrastructure using Amazon Web Services are discussed. The discussion of the different GUI design alternatives based on a usability study is of interest for any cartographer involved in user interface design for geoportals.

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Towards Cartographic Portrayal Interoperability – the Revision of OGC Symbology Encoding Standard

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Extended Abstract

For thousands years of art and science of map making, maps are visualization tools for knowledge discovery by making use of the highly developed human pattern recognition skills (Slocum et al. 2010). Definitely their power is emphasized through the Spatial Data Infrastructure (SDI) paradigm (Craglia 2010, Tóth 2012) with a main emphasis on reusing and combining data from different sources hence increasing the production of maps and allowing infinite visual spatial analysis possibilities.

Interoperability with standards plays a key role to bridge the heterogeneity between systems. Concerning cartography, in general, Fee (2009) underlines that sharing the “cartographic code” has always been a problem: when you get some data (e.g. shapefiles) you often do not get symbology. Depending on the used system, rarely you have a side-car style file (e.g. ESRI lyr file or any other X specific style file) and anyway, the used style language is neither standardized so as you do not have any guarantee to be able to load it in your non-X tool. The use of Web Map Services (WMS) standard (De la Beaujardiere, 2006) from the Open Geospatial Consortium[1] (OGC) does partly give a solution which standardizes the way for Web clients to request maps with predefined symbolization. But, as Iosifescu-Enescu (2009) does put forward,

[1]http://www.opengeospatial.org/

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we agree on how it is also important to have at disposal a standard to allow user defined symbolization when requesting a map over the Internet. In other words, it does push portrayal interoperability one level further by the sharing of the “cartographic symbology recipes” that allows the SDI user to rework and customize a shared map in her/his desktop GIS. For WMS, this is the role of the Styled Layer Descriptor (SLD) specification (Lupp 2007) which extends WMS to allow user-defined styling together with the Symbology Encoding (SE) specification (Müller 2006) which allows to describe a symbology recipe. Even more, Ertz (2009) describes a context of collaborative authoring where several users contribute to the creation of a map, each user using her/his own software. These are common use cases which require a standardized way to author and share cartographic symbology recipes.

As Standard Working Group chairs at the OGC, we would like to share experiences and results concerning the ongoing revision of SE. Indeed, given the results of previous research work about SE (Ertz 2007, Bocher 2011) and several other pending change requests received by the OGC (Ertz, 2010), our motivation is firstly driven by a common claim about enhancing SE with new styling capabilities, reason why we decided to pursue our research work at the heart of the OGC. But more importantly, beside this valid claim, it has been noticed that some fundamental requirements were disregarded. Hereinafter we summarize additional basic principles that would help in the future SE to be able to better solve the above common use cases.

While SE seems to be focused on the encoding of symbology instructions, it is the underlying cartographic symbology model which is essential to consider before inserting new encodings of must-have styling capabilities.

It shall be established in strong relation with a clear definition of a rendering algorithm. Current SE does carry an ambiguity that doesn't guarantee the purpose of such a symbology standard that is to get the same visual rendering from one system to another.

It shall define clearly to what kind of data model the styling capabilities are designed for, e.g. discrete point GridCoverage (Baumann 2012, Portele 2007). Current SE does not specify this with no ambiguity in reference to other OGC standards, which may also cause an interoperability default.

It shall be modular with an extensible core (OGC Policy SWG 2009) that does allow to add new capabilities according to predefined extension points so as to ensure consistency of the model for the long-term. The definition of a minimalist core and surrounding extensions is also a way to lower the implementation bar allowing step-by-step conformance for the implementors (e.g. from simple or dashed stroke symbol to complex stroke extensions like compound stroke; from marker symbol to complex graph-based diagrams extensions like pie chart).

When new capabilities are requested through the Change Request process[2] from OGC, the good practice is to always design the integration in the symbology model with consistency. This is by identifying redundancy and trying to make the underlying concept of the new capability the most generic possible to be useful for several different use cases.

The symbology model shall adopt an approach of separation, this is a conceptual model being an encoding-neutral model with extensions offering several encodings. While XSD/XML is usually the default encoding for several OGC standards like GML (Portele 2007), such an approach does make sense nowadays according to the various encoding flavor that may exist and which are preferred by different cartographic tool users communities (CartoCSS[3], MapServer map file, etc).

Among others considerations (on performance, pre-processing, conformance testing, etc) altogether, these principles shape a strategy that should support the major claims about styling enhancements and favor a largest adoption of the standard.

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Modern Methodology for Planetary Mapping

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Abstract. In the paper we describe methods and stages of planetary mapping using modern advances in the geoscience, Internet and web technologies. The mapping workflow and new maps of celestial bodies have been presented. Our approach based on developing spatial information web-system which integrated various functions and possibilities for storage, image processing, spatial analysis, and visualization of results of planetary cartography using remote sensing data of moons and planets of the Solar system

Keywords. planetary cartography, GIS, geodatabase, data model, spatial analysis, Geoportal, web-mapping.

1. Introduction

Nowadays the rapid development of GIS and web-technologies as well as terabytes of data obtained from different planetary missions provides big opportunities for mapping and study of extraterrestrial territories by cartographical methods. Here we present the modern workflow for mapping of the terrestrial planets and their satellites based on results of photogrammetry image processing and spatial analysis of newest remote sensing data received by scientific spacecrafts (Fig.1).

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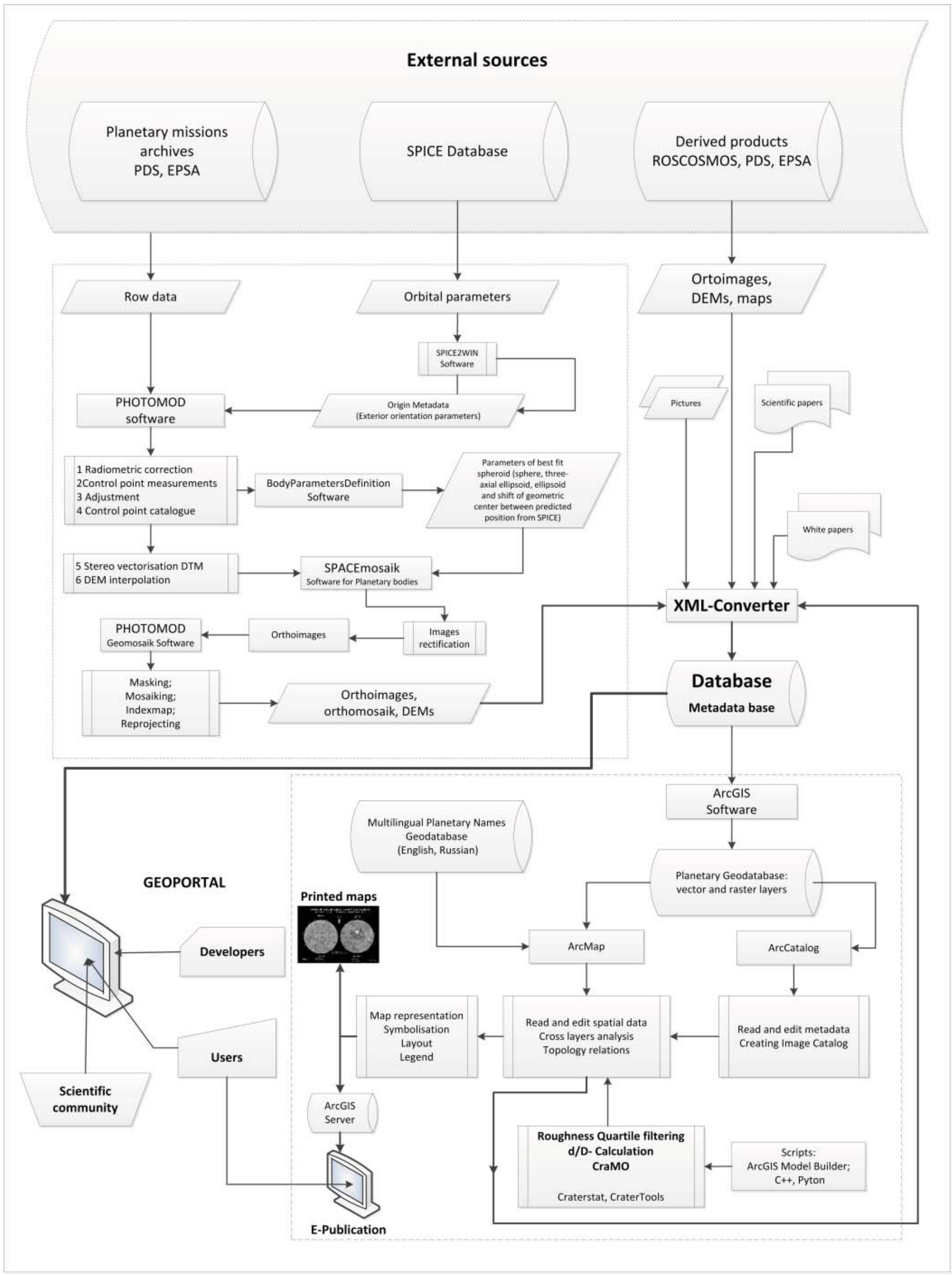


Figure 1. The flowchart of the mapping of celestial bodies based on photogrammetric (PHOTOMOD software), GIS (ArcGIS software) and web-techniques (Geoportal and ArcGIS online).

2. Data processing

2.1. Data sources

The most of planetary remote sensing data are structured according to the Planetary Data System standard (PDS) and provided by special nodes (www.pds-geosciences.wustl.edu) or national archives (NASA, ESA, JAXA). The most new planetary data were received recently from various missions, mainly lunar and martian: Lunar Reconnaissance Orbiter (NASA), SELENE/Kaguya (JAXA), Mars Express (ESA), Mars Global Surveyor (NASA) and from recently finished mission to Mercury – Messenger (NASA). All these missions provide wide range remote sensing data of the planetary surface: high resolution images for region of interest (ROI), e.g., for lunar landing sites up to 30 cm/px; global mosaics (up to 100 m/px); laser altimetry data; Digital Elevation Models (DEM) from 1-10 to 100 m/px. These datasets usually need to be processed for further using in GIS.

2.2. Photogrammetry image processing

In addition to data from planetary archives, we produced our own data based on photogrammetry image processing of raw non-calibrated data. For creation of new spatial products such as DEM or orthomosaics we use PHOTOMOD™ software (www.racurs.ru/?lng=eng&page=634) which was specially updated for celestial bodies (Zubarev et al., 2012). The results of processing are the basic data for planetary mapping such as control point networks, which provide coordinates for surface objects. We produce the control points networks for different celestial bodies (Fig. 2) based on bundle block adjustment of coordinate measurements by least squares analysis techniques using large numbers of overlapping stereo images. Typically, during the adjustment, also position and pointing data is improved for the images involved. This is crucial for the production of geometrically accurate maps.

The results of data processing are orthomosaics and DEMs for the celestial bodies (global extent) or for ROI (local extent) like landing sites, rovers traverse, unique geological objects, etc.

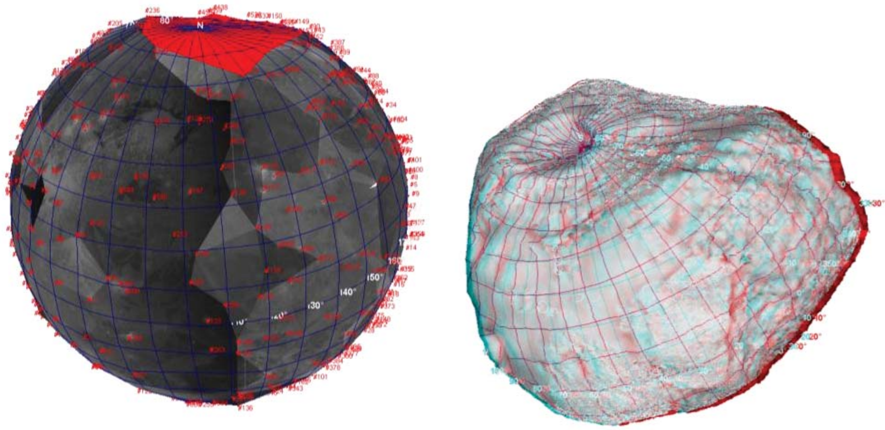


Figure 2. 3D planetary control points networks: for Ganymede (left) and for Phobos (right).

2.3. Data transformation

Using unification of metadata based on various standards like PDS4 (Crichton et al., 2012) and FGDC (http://www.fgdc.gov/index.html) we transform data into standard format and projection, which carried out with special developed software Converter, based on XML-schemes (Karachevtseva et al., 2014). It provides the spatial and information description of the data at SQL-geodatabase.

After the processing we can also use data in ArcGIS software (http://www.arcgis.com/) for spatial analysis, cataloging of planetary surface objects and for further thematic mapping based on spatial referenced data.

3. Mapping

3.1. GIS catalogues of surface objects

The catalogues of spatial objects are the keys to geomorphological study of the surface of planetary bodies. Such catalogues not only highlights location and spatial distribution of objects, but includes their morphometric parameters (Basilevsky et al., 2014) or results of cluster analysis (Kreslavsky et al., 2014a), surface dating or calibration of automatic object detection. Maps, derived from the catalogues, show various spatial parameters of study area, for example, craters density (Fig. 3).

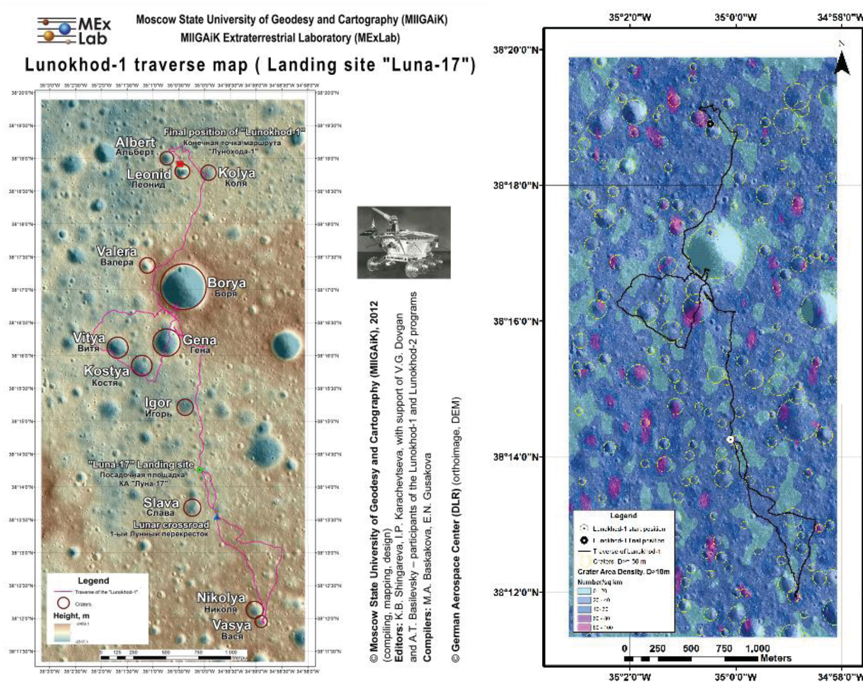


Figure 3. Maps of the landing site of first planetary rover Lunokhod-1 controlled distantly from Earth: Base map (left); Map of craters density (right).

3.2. Maps of relief characteristics

Maps of relief characteristics are a useful instrument for morphological study of surface (Kreslavsky et al., 2015), for example, for estimation of safety for landing of spacecrafts (Karachevtseva et al., 2015a). Mapping of statistical characteristics could reveal inconspicuous on the physical maps structures of surface (Kokhanov et al., 2013). As result of morphometric study of Lunar and Mercurian relief we have prepared maps of topographic roughness of these planets (Fig. 4). Also the first hypsometric Mercury globe (Fig. 5) has been created based on new DEM, which completely covers the planet's surface with resolution 22 000 m/pixel. Global Mercury's DEM was produced in German Aerospace Center (DLR) based on limb measurements (Elgner et al., 2014) of MESSENGER wide-angle camera (MDIS WAC). For mapping DEM has been processed in MIIGAiK using ArcGIS 10.3 software: Mercury's relief is shown by contours (in 500 m) and with color hypsometric scale in 16 intervals (Zharkova et al., 2015). The elevations are referenced to the sphere with radius 2 439 700 m recommended by International Astronomical Union.

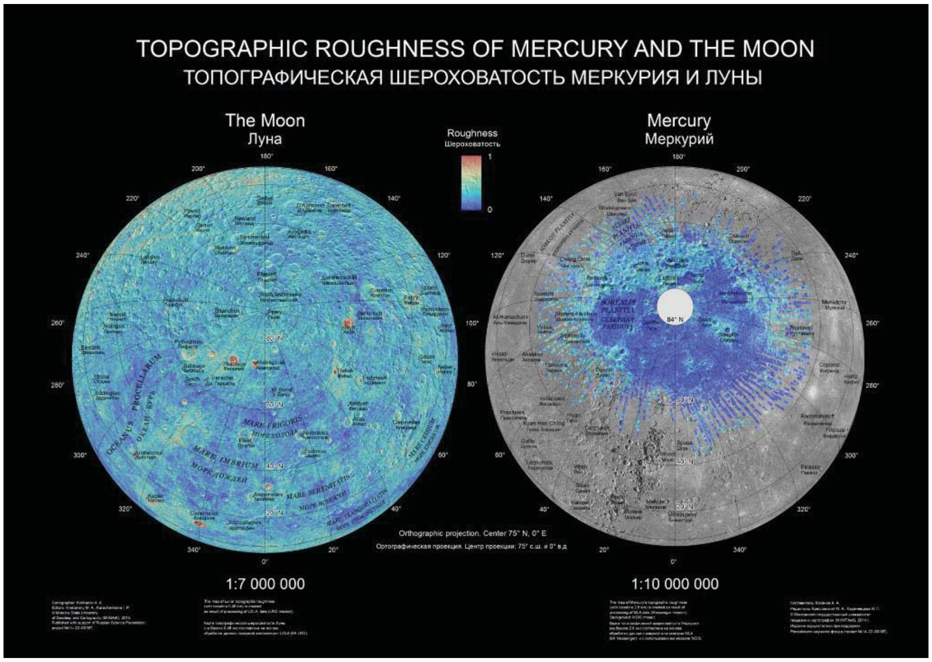


Figure 4. Wall maps of topographic roughness at the one layout: The Moon (left) and Mercury (right) (Kokhanov et al., 2014).

Figure 5. Mapping of Mercury relief: the first hypsometric globe (left) with diameter 15 cm and scale 1:32 500 000; Pamphlet to accompany with global topographic maps (1: 60 000 000) of the northern and southern hemispheres in azimuthal equidistant projection (right).

3.3. New tools and software

Additionally to the existing planetary tools such as CraterTools (Kneissl et al, 2011) or Craterstat (Michael et al., 2012), new different methods and algorithms of calculation of morphometric parameters have been developed for realization in ArcGIS software. Using Python we have developed the tool for roughness estimation based on various approach (Kokhanov et al., 2013), e.g. the roughness can be calculated as the interquartile range of the second derivative of the relief. As there are no universal methods of roughness calculation, this type of estimation provides symmetrical scale-defined stable results. For automatization of calculation of the morphometric parameters the special model has been developed based on ArcGIS Model Builder. The developed algorithms (Roughness Quartile filtering, d/D-Calculation, CraMO, see Fig. 1) provide the measurement of surface roughness, morphometric characteristics of relief features such as profiles, depth and form of objects, which can be used for morphological analysis of craters degradation and properties of surface.

4. Map publishing

4.1. Printed maps

The examples of successful realization of described workflow are the results of mapping of celestial bodies: map of the parameters of Lunar relief (Kreslavsky et al., 2014b), hypsometric Mercury Globe and maps (Fig.5), hypsometric map of Phobos (Fig.6), hypsometric map of the Moon (Fig.7), and new maps in Phobos Atlas (Fig.8) as well as online maps and Geoportal (Fig.9-10).

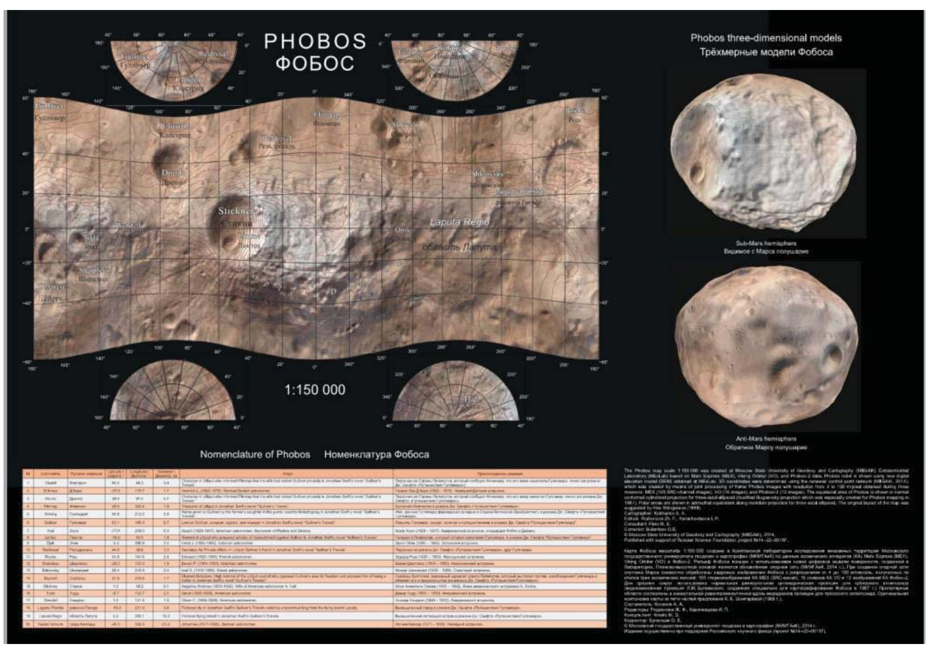


Figure 6. Hypsometric wall map of Phobos.

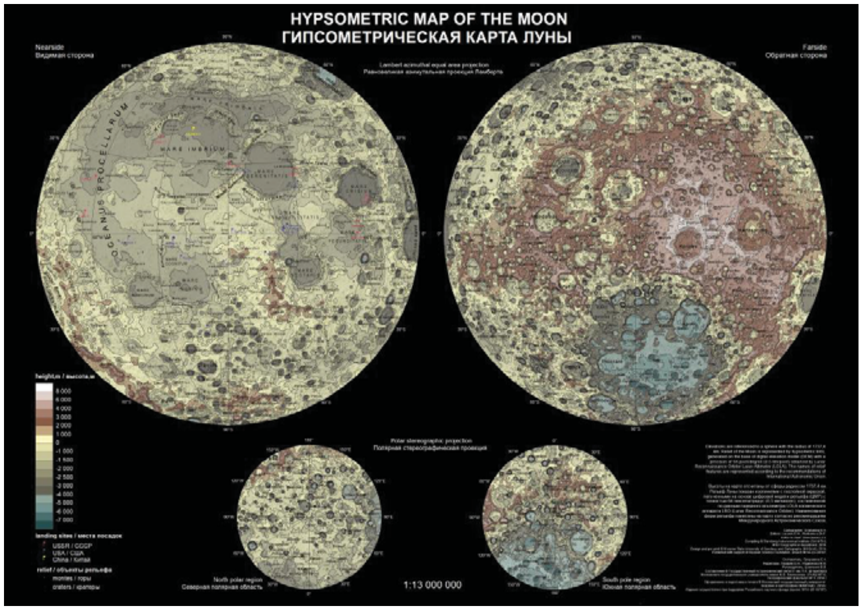
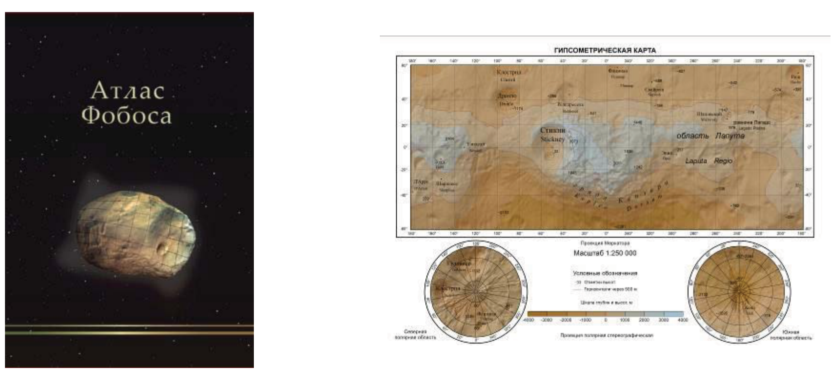


Figure 7. Hypsometric wall map of the Moon.

Based on the physical and thematic maps of Phobos the new planetary Atlas has been developed (Karachevtseva et al., 2015b). Phobos Atlas contains over 40 maps with size 32×22 cm, which represent miscellaneous characteristics of surface and physical properties of one of Martian satellite, as well as description of study and results of Phobos research. (Fig. 8). Despite the fact that the atlas is prepared in Russian, feature names on the maps are presented in bilingual form (Russian and English), so Phobos Atlas can be used by international community.



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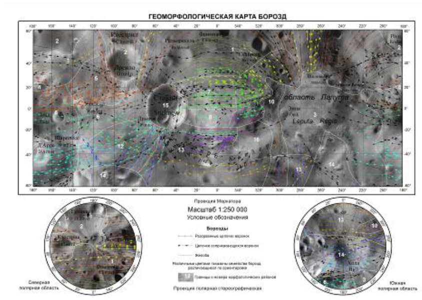

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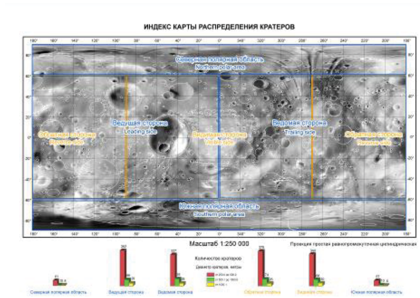

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Figure 8. The Phobos Atlas: a) the Atlas cover, based on DEM and results of 3D-modeling; b) the layout of Hypsometric map; c) the layout of Geomorphological map of Grooves; d) the layout of Map of Craters distribution.

4.2. Web-mapping

Some new original planetary maps are published using ArcGIS online services with presentation of the design it gives the ability to scale and get more details than from paper map. For example, web-based techniques were implemented for online mapping of Phobos (http://bit.ly/Phobos_topography) and lunar landing site (http://bit.ly/Lunohod_1).

4.3. Geoportal

For sharing and visualization of results of image processing and data analysis the Geoportal as Geodesy and Cartography Node (Fig. 9) has been developed (Karachevtseva et al., 2014). The Geoportal (http://cartsrv.mexlab.ru/geoportal/) provides access to the spatial data of studied celestial bodies (the Moon, Phobos, Mercury and Ganymede) and contains raster and vector layers of various extents (from global to local) as products of different processing levels equipped with spatial metadata.

For further development, we propose to organize access to the data using a new architecture based on info-communication solution and cross platform (desktop, web and mobile application) for representation of spatial planetary data in 3D web GIS.

Our approach provides possibilities to represent planetary data in 3D-form for scientific use: for geological study and morphometric measurements, planning of future missions. A new developed architecture provides possibilities to organize "online laboratory" based on interactive tools widely used for planetary studies and realistic representation of result of scientific research as well as collaborative research and joint online meeting within common spatial context to share and discuss observations (Fig.10).

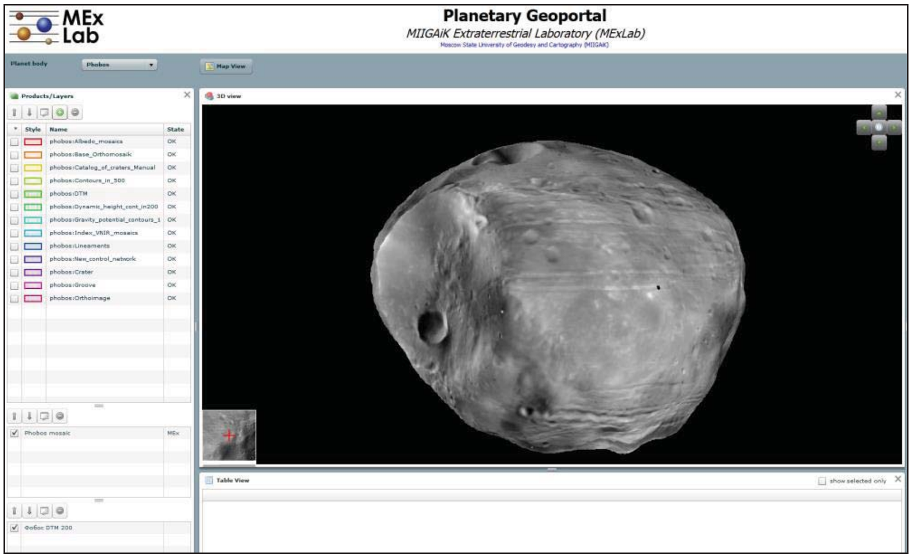

Figure 9. MIIGAiK Planetary Geoportal: three-dimensional view of Phobos surface.

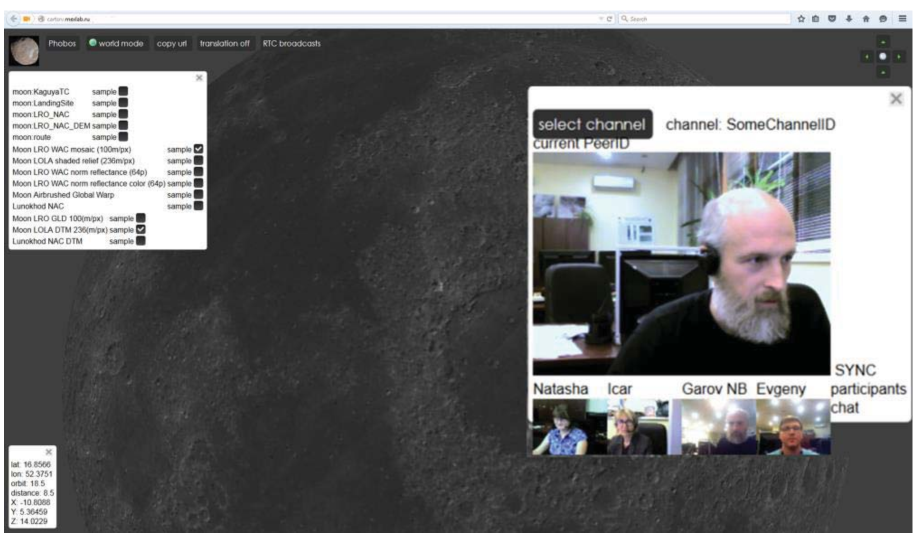

Figure 10. MIIGAiK Planetary Geoportal: new prototype of 3D web-GIS based on three-dimensional view of the Moon surface in teleconference regime including video/audio broadcasting.

5. Conclusion

We have developed the methodology of mapping of celestial bodies using modern approach based on GIS and innovative web-techniques which includes various stages: from raw image processing to online maps. The proposed methodology has been implemented for planetary mapping of various planets and satellites; the results can be used for Solar system research, for planning of future missions, etc.

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Web maps adaptation for smartphones

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Abstract. Digital maps were at the beginning of their usage intended for viewing on regular and big screens. Nowadays more and more users watch them on small screens, smartphones and tablets. We can indeed use the same maps on all platforms, but the user experience on small screens is limited due to the size of the screen and user requirements. A method of adaptation of a web map for smartphones is presented in the case of touristic map of Novo mesto, Slovenia.

Keywords. Interactive maps, web maps, smartphones

1. Introduction

Development of computer, information and communication technologies enabled evolution, initially from printed maps to static digital maps and then from static digital maps to interactive digital maps, multimedia maps, 3D maps etc. Digital maps are usually made to be used on laptop or desktop displays, large screens and projectors. However, the number of sold smartphones increases constantly; according to numerous sources, i.e. Statista (2105), there were over 1.2 billion sold smartphones in 2014. More and more users tend to use maps on their smartphones. Maps are used for navigation, orientation, location based services etc.

At the beginning, the same maps had been used on smartphones and tablets as on the normal displays. But quite some problems with readability and user interaction occurred on small screen devices and adaption of maps for proper viewing and interaction on smartphone screens became necessary.

In our case the tourist map of the city Novo mesto was initially created as a static map. In the second stage, interactive content in the form of POIs for touristic map was added. Finally, interactive web map was customized for

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viewing on small screens, from 4 to 10 inches, which are typical sizes for smartphones and tablets.

1.1. Concept of mobile cartography

According to Reichenbacher (2001), the key components of mobile cartography are information, context, user, visualization and technology. Figure 1 shows basic concept of mobile cartography.

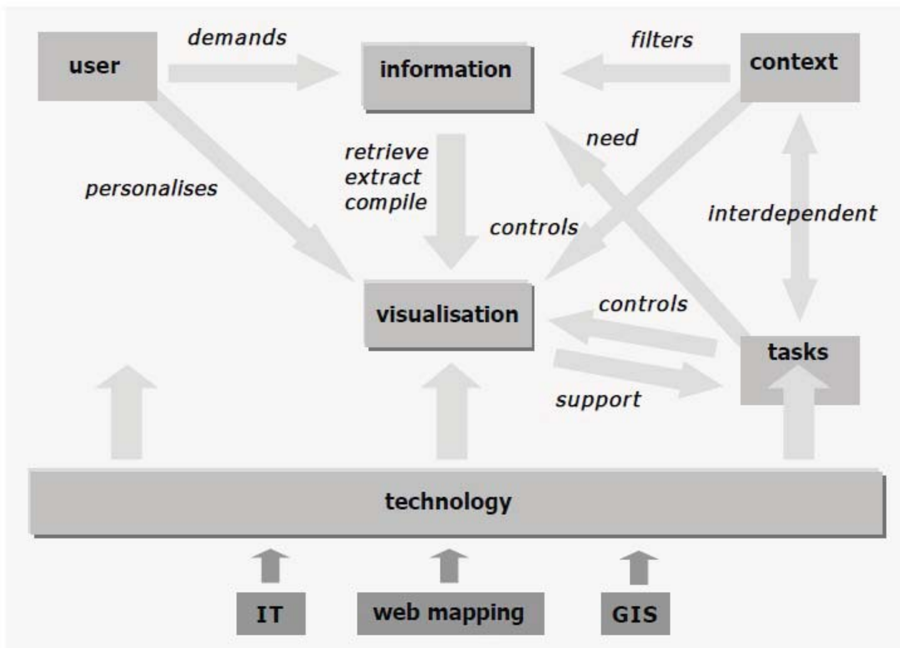

Figure 1. Conceptual framework of mobile cartography (Reichenbacher, 2001).

1.2. Demands for mobile cartography

The greatest problems for mobile cartography are characteristics and limitations of mobile devices: screen size, mobile data bandwidth and new types of data formats (KML, SVG, etc.). Recommended features for mobile cartography are therefore:

- mobile device with high resolution screen,
- use in direct sunlight and in the dark,
- location sensor (GPS, mobile network), and
- high bandwidth of mobile data transfer. (Reichenbacher 2001)

Icons on mobile maps have to be big enough for the touch with the thumb and there should be enough separating space between the icons.

Mobile maps are mostly used for location based services in the proximity of the user while in motion. GPS technology is mostly used for location and navigation. Single hand use of maps is preferable. (Kaasinen 2005)

Entering text on mobile devices can be time consuming so users prefer existing list of hits which, of course, needs to be regularly updated. The text font needs to be of proper size and simple so it can be read on a small screen. (Kaasinen 2005)

Interactivity is also an important feature of mobile maps. Interactive icons with hyperlinks prevent overfilling of the map; furthermore they can add multimedia content to the map and thus enriches the map. Graphic icons enable personalisation of the map.

2. Creating basic interactive web map of Novo mesto

2.1. Basic map data

The case map of Novo mesto is made in Gauß-Krüger (transverse cylindrical) cartographic projection. All the source data is provided by SMA (Surveying and Mapping Authorization) of Slovenia. Vector data was edited in ArcMap 10.1, map frame in AutoCad 2013, the map itself was created in OCAD 11 and icons in Photoshop editor. The details on the map consist with the scale of 1: 5000. The scale of the displayed map is of course variable. The resolution of the map is 600 dpi.

The map is touristic; the main purpose is to inform users of touristic sights and landmarks of Novo mesto, accommodation, cuisine, recreation and other features which a tourist in Novo mesto would be interested in.

2.2. Map creating procedure

Vector data from the national topographic database is in "shapefile" format. All the data was imported, edited, categorized and merged in ESRI ArcMap software. Edited data was exported in the shapefile format. Map frame was created in AutoCad and exported in vector form.

Topographic data was imported in OCAD 11 software where custom made cartographic symbols were assigned to vector data. The outcome of each topographic element was instantly tested on a smartphone.

Narrow streets in the downtown presented a problem because their true width in the scale was too narrow to include the names of the streets. So the streets had to be widened and as a consequence, displacements of buildings were performed, done mostly with manual editing. Some of the problems and their solutions can be seen on Figure 2.

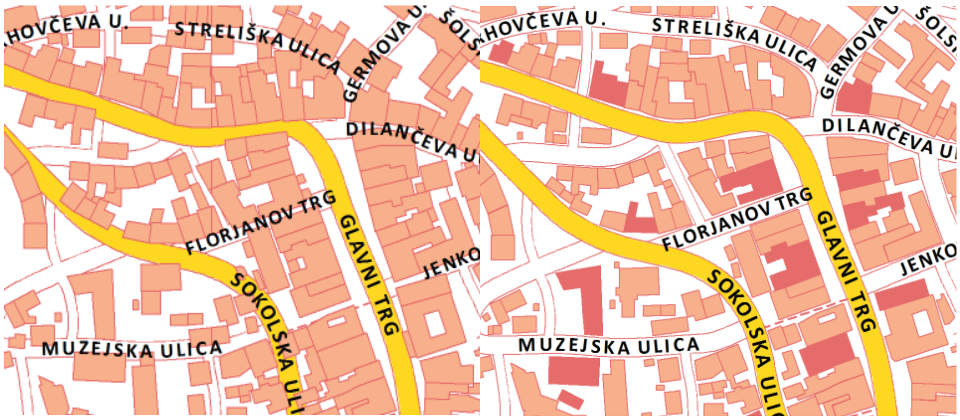

Figure 2. Problems with narrow streets (left) and the solution (right).

Missing or altered objects were added or edited according to ortophoto images.

A database was created in Ocad in order to make an interactive web map. The database consists of 27 datasets which are divided among 6 categories (landmarks and attractions, accommodation and restaurants, free time activities, sports, transportation and other). Suitable objects were manually appointed to corresponding datasets, labelled and if applicable, a hyperlink was added.

Creating icons was another special task. Ocad offers 2 options – marker can be a transparent circle or a graphic icon. In order to achieve associativity and overall clearness graphic icons were manually created, as depicted in Figure 3. Web icon frame (the same for each category) and a graphic were merged in Photoshop editor to form an icon shown in the map.

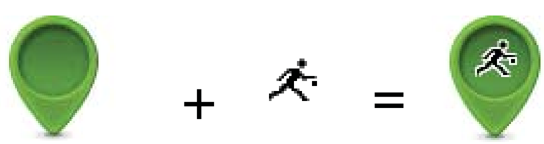

Figure 3. Creating web icons.

3. Adaptation of the map for smartphones

Ocad export module can create zoom levels from the same origin map. This usually works without problems on regular size screens, but not on small screens.

3.1. Problematic default web map

Even if different origin maps are used for zoom level, the icons are shown at each zoom level by default settings, as can be seen on Figure 4. The map is useless in such output.

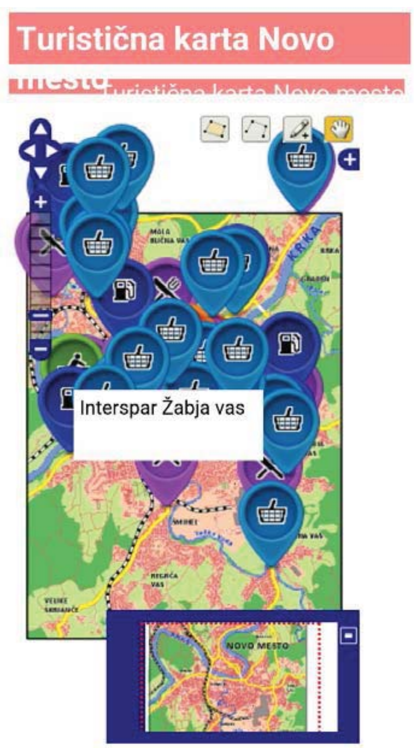

Figure 4. Problems with the mobile map in the default view.

The map required some tweaking in order to be usable on smartphones.

3.2. Customizing the map

A separate map was made for each zoom level. 7 levels of view are possible with each level with a different LoD (Level of Detail). Zoom levels and LoDs can be seen on Figures from 5 to 8 and on Figures 10 and 11.

The default view, shown in Figure 5, includes names of the city, city quarters and all water streams.

Figure 5. Default view of the map.

The zoom-out level (Figure 6) features only names of the city and the main river. There's also the 2nd zoom-out level which is similar to the 1st one, only made even smaller.

Figure 6. Zoom-out level.

The 1st zoom-in adds some topographic symbols to the default view, see Figure 7.

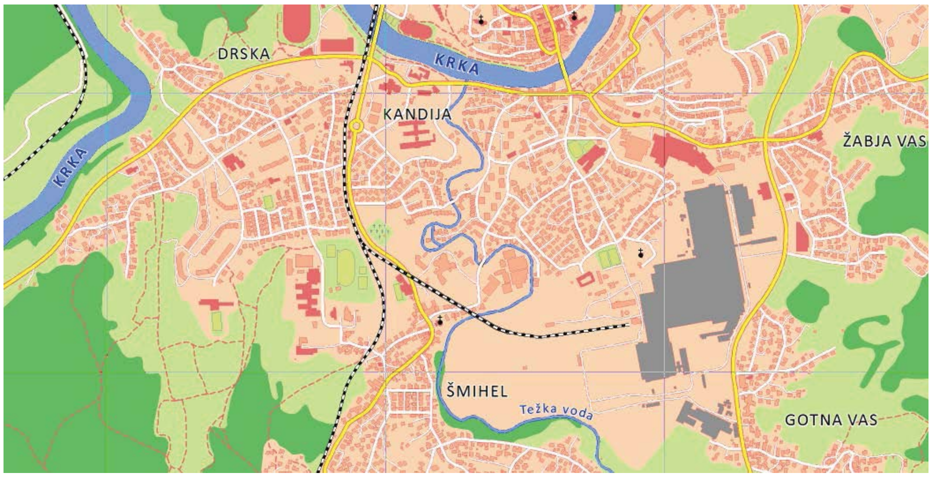

Figure 7. 1st zoom-in level.

The 2nd zoom-in includes names of the main streets, as can be seen on Figure 8.

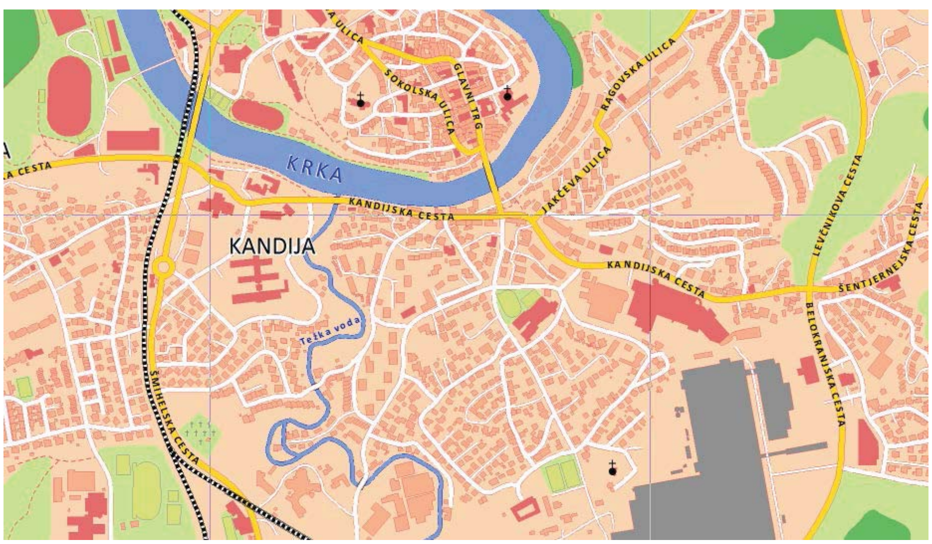

Figure 8. 2nd zoom-in level.

The next zoom-in level can be seen on Figure 11. Names of all the streets are shown. Only the final zoom-in features POI icons, see Figure 10. A tap on an icon opens a popup window with text description. Some info windows include hyperlinks as example on Figure 9.

Figure 9. POI popup window with description and hyperlink.

3.3. Testing the map

The map was tested:

- on different operating systems for mobile devices (android, iOS),
- on different screen sizes,
- on different browsers, and
- for the suitability of map elements.

Map elements were evaluated by different groups of people, young (around 10 years) and middle aged (around 50). Icons were correctly recognized and street names could be read by all participants.

The map is shown correctly on all operating systems and all browsers on mobile devices. Figure 10 shows a screenshot of iPad 4 (iOS, Safari browser, 9.7 inch, 1536 x 2048 pixels) while Figure 11 shows a screenshot of LG G3 (Android, Chrome browser, 5.5 inch, 1440 x 2560 pixels).

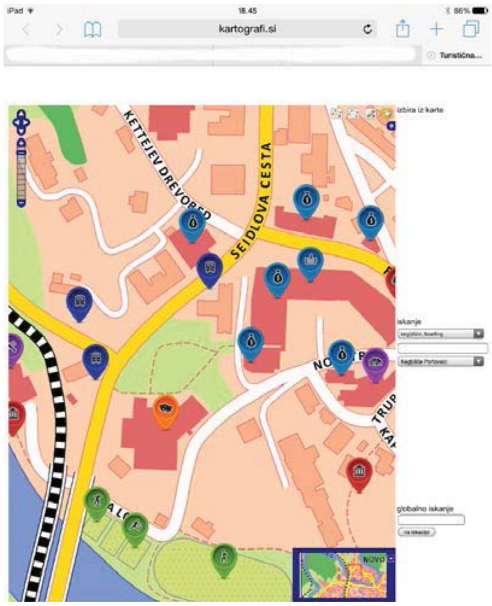

Figure 10. Map on iPad 4.

Figure 11. Map on LG G3.

The map can be used on even smaller screens, i.e. iPhone 5s (4 inch, 640 x 1136 pixels). Street names can be easily read and the map works flawlessly.

The map can also be used for location based services. The map was geolocated with Custom Maps application. Figure 12 shows the map in the Custom Maps with position marker visible in the bottom left part of the screen.

Figure 12. Map in the Custom Maps application.

Ocad software supports export to GeoTIFF. Geolocated TIFF can be opened and used with GPS position in various apps, i.e. PDF Maps. Figure 13 depicts current position (blue circle) of a user on the map.

Figure 13. Map with current GPS position in the PDF Maps application.

4. Conclusion

OCAD 11 software is easy to use and very handy for making web maps. However, default web maps are optimized for viewing and interacting on regular computer screens. Luckily, OCAD made web maps can be altered for different purposes. The POI menu can be customized using CSS, i.e. web map of Žirovnica as seen in Figure 14. User can choose which icons are visible.

Figure 14. Map menu customization (http://kkfdz.fgg.uni-lj.si/izdelki-diplome/zirovnica/).

Customization of a map for smartphones requires a deeper approach as many aspects need to be addressed. Screen size is the main factor. Content differs by the zoom level, street names have to be big enough so they can be read even on the smallest screens. Icons should be associative and large enough, but for that reason they can be only shown in the detailed view in large zoom.

The mobile map of Novo mesto is user friendly. Zoom-in can be achieved by double tap, pinch to zoom or by tapping on the plus icon or slider in the top left part of the screen. User can pan the map by the buttons on the top left side of the map or by swiping the screen in any direction.

The map works in any mobile environment: on any screen size, in any browser in any operating system. The map can be used to display current location of a user using GPS positioning.

The final product is an example of customizing a web map for use with smartphones by complying all characteristics and limitations of mobile devices. However, there's still room for improvement. For one, web map style could be programmed so only selected icons would be visible.

The map is available at http://kkfdz.fgg.uni-lj.si/izdelki-diplome/novomesto/. It can well be used on regular size displays; however, it is optimized for use with mobile devices.

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Building GIS Database for Web Atlas of the Tay Nguyen Region in Vietnam.

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Extended Abstract

The Tay Nguyen region or the Central Highlands of Vietnam comprises the 5 provinces of Gia Lai, Đăk Lak, Kon Tum, Đak Nong and Lam Dong. It covers a total area of about 54641.1 km.sq. Population is 5.460 million in the year 2014. The region is composed of series of contiguous plateaus that wedged between coastal provinces to the east and nearly 400 km border with Laos and Cambodia to the west. The region has a geopolitical importance for Vietnam not only the economic - social development, but also the national security.

In the period of 2011 -2015, the Tay Nguyen 3 Program was established with the four main objectives: (1) Evaluating of the natural resources and environment, economics, culture and society of the Central Highlands after 20 years, since the program Highlands 2 was ended in 1988. The result is used as basics to propose and build arguments for the sustainable development program of the Central Highlands, phase 2010 - 2020 and vision to 2030. (2) Providing a database for the regional economic development planning. (3) Transferring new technologies for these provinces to create products and goods for the improvement of the economic efficiency and environmental protection. (4) Studying and warning of natural disasters, and building solutions to prevent associated damages. Therefore, building GIS database and Web Atlas for the Tay Nguyen region is one of the main sub-projects of the Program with the main objectives are: (1) to design and develop geographical database on natural conditions, resources,

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environment, socio-economic and humanities; (2) to construct the Atlas using Web GIS.

The database for the region is built based on the following source data: (1) The national digital topographic maps for the region, constructed from 2003 to 2008 at scales of 1: 25,000 (377 sheets), 1: 50,000 (105 sheets), 1: 100,000 (35 sheets), and 1: 250,000 (10 sheets); (2) The meteorological data over the 30 years of the Tay Nguyen; (3) Statistical Yearbooks of the five provinces for the period 2005 to 2014; (4) The population census data from 2005 to 2010; (5) The research studies and thematic maps results from this Program; (6) The available maps from the last two Tay Nguyen programs.

All the topographic maps were updated and converted from the DGN format to ArcGIS geodatabase using the ArcGIS Data Interoperability tools. The maps at scale of 1: 250,000 were merged to constructed the entire region map (5 provinces), whereas the maps with scale of 1: 100.000 and 1: 50.000 were compiled each entire map for each province. All map layers at scale 1: 25.000 and 1:10.000 are remained in form of the toposheet .

A total of 172 thematic maps were edited, converted in the standard format for storage. ArcMap software was used to separate, combine, and group the data layers. It is also used to transform the coordinate system, transfer the entire contents of the data for all region and provinces. For each province, these data was grouped by themes and spatial format. The thematic database are organized into four groups: Natural conditions with the maps of geology, mineral resources, climate, hydrology, soils, information on natural disasters and environment. Group of Sociology Humanities consists of the maps of history, administrative, urban space, population, labor, ethnic groups, healthcare and education. Economic and Infrastructure database comprises the maps of Industry, Agriculture - forestry – fishery; Commerce – tourism, Finance – insurance, Traffic – Telecommunications and Land use map. The theme" Spatial development planning into the year of 2025" includes the following map layers at scale of 1: 250,000, Tay Nguyen region land use planning; Industrial zones planning, Agricultural development planning, and map of Urban planning at scale 1: 50.000.

All the maps in Tay Nguyen geodatabse in Arc Server Manager are transformed in to web map and used to link to Web Atlas. Atlas construction toolkit includes Visual Studio 2010 software, ArcGIS Desktop, and ArcGIS Server. Atlas is designed to support three different users communities: *Internet Community Use, Provincial analytics, and Administrator.* Atlas has friendly, clear, easy to use interface with many functions for multimedia techniques.

The general functions for users are zoom in, zoom out, panorama, move, turn on, off the map layer content, search for attribute information, measure the distance, view slideshow media, chart and printing. Atlas also includes the advanced functions for professionals users from provincial departments and agencies. They are the tools of data processing, presentation, creating new maps, adding new feature, objects, editing and updating attribute data, exporting report for decisions making...

Atlas will be released on the Internet with high stability, security and information about Tay Nguyen region.

This work is fulfilled in the framework of the project code TN3/T22, supported by the Tay Nguyen 3 Program.

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Geospatial Project Management Portal

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Tugba Aydar

Proline Integrated Intelligence

Extended Abstract

Conventional project management has difficulties on usage which causes unproductive workforce especially if geospatial data relates with the project. Whilst Geographic Information Systems (GIS) provides convenient tools for geospatial data handling (analyzing methods, visualization opportunities, coordinate transformations etc.), existing GIS systems has lack of Project Management (PM) property. PM cycle without real time reports, work flows, task assignments (i.e. in emergencies, failures in electricity-water) and above all without effective communication tool between personnel in land and managers, it is difficult to constitute a rapid and successful management.

With intended Geospatial Project Management Portal - GPMP project, which will be developed on cloud technologies, time and spatial dimensions will be added to any task based area work. Consequently, GPMP will contribute a new approach both for GIS-geospatial users and project managers in terms of integration of GIS and PM methodologies by using cloud computing and open source coding advantages. Thus, team performance and completion of the task statistics reports will be available for the authorities who assign tasks to groups. *Figure-1* shows Workflow of GPMP.

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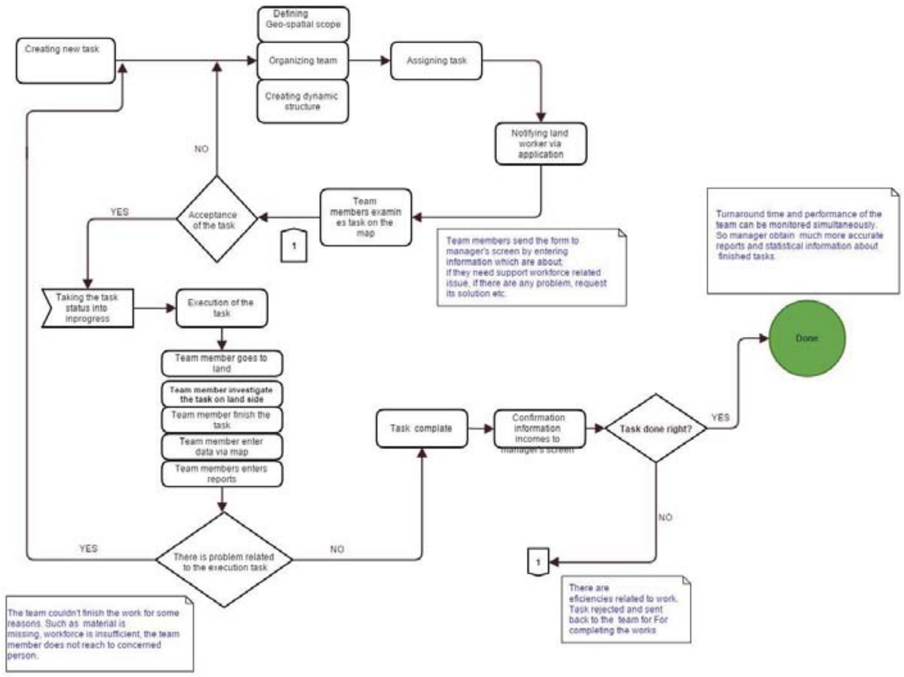

Figure 1. Workflow of GPMP.

Through GPMP, without any need for any modification of the user to the code blocks, the data -which corresponds about 80% of GIS and about 65% of budget- can be developed in shorter time periods and lower cost via pre-defined dynamic structures (web forms, data entry screens, process management etc.) by end-users.

Our main objective is to develop a GIS platform using SaaS (Software as a Service). This model will provide geospatial users a ready GIS platform including management and maintenance which requires specialized experience. Geospatial users will concentrate on data, data management and project management issues within this model. Moreover, SLA (Service Layer Agreement) will be provided which allow geospatial users to articulate their requirements and choose the appropriate services for their work. GPMP will be developed as platform independent GIS infrastructure which can run on any other products by using service-oriented architecture for any governmental authority/private sector or any foundation both for geospatial and project management requirements. We will also develop a mobile application which have capabilities to reach information on any geospatial project and allow structured data entry forms created by land teams. Furthermore, support to land works will be applied more effectively. Capabilities, such as task assignment to related personnel and data entry forms, will be prepared sector-based which is also the discriminative property of GPMP. Respectively, system, hardware, database, user interface, requirement analysis and project based requirements will be defined and GPMP will be coded to realize and pro-vide all these services. Users can choose optionally Google Maps, ArcGIS online, Bing (Virtual Earth), Open Street etc. as base maps within GPMP and can visualize vector and raster products of these services. JavaScript API, OGC, REST and SOAP will be used as services within GPMP. Maps produced by portal users will be visualized within a map viewer which will be developed both for map visualization and analysis. Task assignments (creating data entry forms- dynamic structures etc.) will be a part of geospatial project management regarding any geospatial related sector and will be developed by considering Project Management Institute (PMI) standards. GIS development and management also require crucial worldwide standards. We will consider; Open Geospatial Consortium(OGC), International Organization for Standardization(ISO), Republic of Turkey Ministry of Environment and Urbanization – Turkey National Geographic Information Systems(TUCBS), Infrastructure for Spatial Information in the European Community (INSPIRE), and Turkish Standards Institution(TSE), national and international geospatial standards in our project.

Technology behind our project will give us a more scalable and flexible base according to the traditional methods. As SaaS is a software service modal which is provided from a centralized server system, it will allow us to give credentials to private and public sector user groups who are working in different disciplines and concepts. Thus, user accounts will be priced instead of huge licensing costs. The project management programs based on cloud system will provide rich set of selective project management functions to users with monthly or yearly calculated costs.

Concerning our work flow, we have four main work packages: *1. Analysis, 2. Design, 3. Application Development, and 4. Pilot Implementation*. Analysis includes literature, feasibility, SWOT-requirement analysis, test plan-test tools; Design covers system architecture, database design, hardware infrastructure-scenarios design, GPMP interface design; User management, output applications, responsive web applications are the main developments in work package Application Development; and the last work package, Pilot Implementation includes system integration tests, infrastructure, interface tests, based on cloud approach, integration with other systems will be implemented.

We have acquired well defined Implementation of Requirements Analysis as a results of WP Analysis. Required modules are defined after analysis work-packet. General pieces of the system are defined as shown below:

- Portal Infrastructure
- Project Management
- User Management Module
- Geographical Data Management Module
- Map Viewer
- Map Editor
- Map Gallery
- Data Collector

Portal Infrastructure: The Portal is composed of five components that are Project Management, GIS, Cloud Computing, Open Source Code and Big Data.

Project Management: Project management programs based on cloud system will provide rich set of selective as mentioned above.

User Management Module: An application to allow users from an organization or public authority to assign roles to users and define groups for their own organization. Authentication management for single sign-on enabled modules. It will also support LDAP integration.

Geographical Data Management Module: Allows users to upload, edit and share GIS data with support for various kinds of file format via portal. Users will have the ability to define databases via portal or allow other user groups to collect data to be merged. Provides data usage statistics stored on the portal according to the users, groups and organizations.

Map Viewer : Allows view and other detailed query requests to be run on the user maps on various platforms. It will have ability to import/embed maps on web and mobile devices via Portal MAP API.

Map Editor : Application will have create, edit and share functions on service based or user collected data to optimize GIS data on related data schema. Allows multiple users to work on the same map data.

Map Gallery : A pool of maps which uses the maps on the portal and each map can be shared with visitor users or other user groups with the permission of the creator. Maps can be filtered with usage ratio, to be up-to-date and voting rates.

Data Collector : A mobile platform application to allow users to collect data with dynamic forms to fill user-defined new layers on maps. According to the mobile device offline data collection, GPS and photos can be collected if dynamic form is designed to use these capabilities.

Requirements and use-cases according to these requirements are defined for each part of the system. *Figure-2* shows general parts of the system.

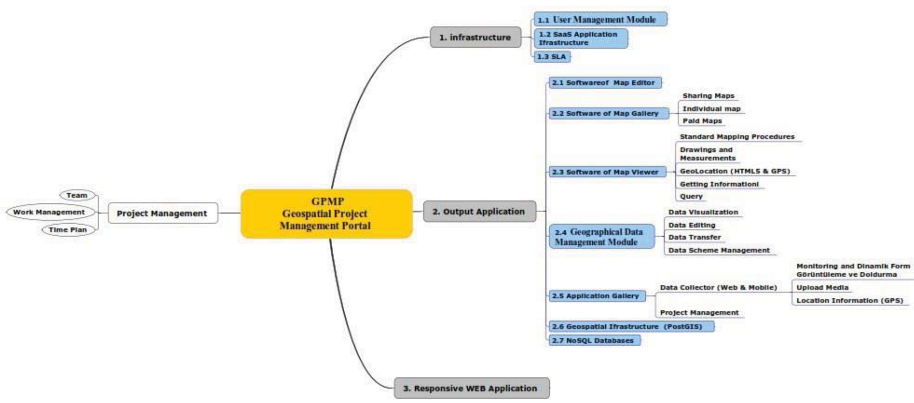

Figure 2. General parts of the system of GPMP.

Hence system services will be provided by our company-Proline, targeted results of system are respectively; ease of use (even non-GIS users will create, publish and share maps, charts, reports easily), open source and cloud computing allows reduced IT operational costs by outsourcing hardware and software, real time update, improved performance, unlimited storage, improved data security-project management, improved compromise between operating systems, enhanced file format compatibility will be a significant advantage to any geospatial user group. Our project was also received sup-port by The Scientific and Technological Research Council of Turkey (TUBITAK) with project no 3140923.

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Where have all the atlases gone? Developing data structures for a virtual research environment.

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Extended Abstract

Please Many atlas projects have been facing serious threats over the last decade. Not only that technological progress challenges traditional atlas forms and can lead to financial difficulties in realizing new editions of atlases currently in circulation. Moreover, changes in the founding of atlas projects, new scientific approaches to fundamental spatial issues and a transformation of user requirements are setting the new stage. Not to mention the innumerable atlases that were published on the internet but subsequently disappeared because of funding shortages/cuts, changes in staff, or technical and maintenance issues. The current challenges facing atlas projects bring into focus the problems for future investigations of historical atlases. In general the research on a specific atlas project or a single edition faces two fundamental questions, namely, where can I find a copy to work with and where can I find in-depth information on the respective subject. Today, we normally consult (online) public access catalogs ((O)PACs) which are nowadays often included within the scope of multi-institutional search engines or are thoroughly checked by googlebots. Although providing basic information on library holdings necessitates a visit to the physical archive, these search engines are often inadequate when it comes to serious research on atlases for two reasons:

First, a large number of Atlases are yet to be indexed in online search machines since cataloging atlases is often a pain in the librarians back - not only for weight reasons. Therefore, libraries tend to keep their own individual printed records of more exotic holdings like atlas collections, which causes problems for researchers.

Second, when available, the records often contain only basic bibliographic information following the bibliographic standards of MARC21 (MAchine Readable Cataloging) or cataloging standards such as the AACR (Anglo-

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American Cataloging Rules). Although these standards are of great importance for sustainable development and maintenance of the aforementioned archival and bibliographical search engines and have been developed over decades, they still lack vital description categories for atlaslike items.

This paper reports on a project to build up a comprehensive archive of information on national atlases and national atlas projects since 2013. By analyzing the records of a selection of national atlases in the most common "entry" search engines (e.g. WorldCat, AMICUS, David Rumsey Map Collection Database, IKAR), an average topic density has been defined and taken as an index for a second round of search in map/atlas related OPACs and specialized Archive/Library Databases (e.g. Newberry Library, Perry Castaneda Library Map Collection, Central Geographic Library). The overall results can be described as "unpretentious", since they essentially reflect the bibliographic standards implemented by the respective libraries.

To identify the information density provided by the OPACs and the search engines mentioned above a student experiment was launched as part of several seminars on the history of cartography held at the Global Studies Institute (University of Leipzig). Part of the seminar task was to collect as much information as possible on a specific national atlas/national atlas projects by using all possible sources. The goal was a comprehensive documentation of the respective atlas. The final papers revealed a low density of research related information in the aforementioned OPACs and databases. Instead, other sources such as JSTOR.org and archive.org provided substantial information by simply recording articles, reviews and research reports on the atlases/atlas projects.

With regards to the ongoing introduction of the new unified cataloging standard RDA (Research Description and Access) it might be now possible to considerate cartographic research demands. Considering some of the results of the aforementioned investigations may provide indispensable input to accomplish an archival/bibliographical Metadata set that meets international standards as well as the research requirements of a self-reflexive cartographic community.

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Use of paid Crowdsourcing for the Collection of Geodata

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Extended Abstract

Introduction

Crowdsourcing is a new technology and a new business model that will change the way in which we work in many fields in the future. Employers divide and source out their work to a huge number of anonymous workers on the Internet. The division and outsourcing is not a trivial process but requires the definition of complete new workflows – from the definition of subtasks, to the execution and quality control. A popular crowdsourcing project in the field of collection of geodata is OpenStreetMap, which is based on the work of unpaid volunteers. Crowdsourcing projects that are based on the work of unpaid volunteers need an active community whose members are convinced about the importance of the project and who have fun to collaborate. This can only be realized for some tasks. In the field of geodata collection many other tasks exist which can in principle be solved with crowdsourcing but where it is difficult to find a sufficient large number of volunteers. Other incentives must be provided in these cases, which can be monetary payments.

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Project

The majority of projects in the field of crowd-based geodata collection are based on the work of volunteers (VGI – Volunteered Geographic Information). In contrast to these kind of approaches, the project described in this paper has been realized with paid crowdsourcing, which means that the crowd-workers are paid for their work. We want to identify and quantify the parameters (e.g. amount of salary, size of working tiles or object types) which influence the quality of the results (especially: correctness, geometric accuracy and collection time).

We developed a web-based program for the collection of geodata and integrated it into the commercial crowdsourcing platform microWorkers (www.microWorkers.com), which takes over the recruitment and the payment. The platform has access to more than 600.000 registered crowd-workers. The workers are informed automatically when a new job is offered by an employer on the platform. The employers can restrict the jobs to specific groups of workers. For example, it is possible to offer the jobs only to workers that are living in a specific country or to workers that have already successfully worked on a particular number of other jobs. Further qualifications are possible with own developed tests, which must be solved before the job. After the job has been completed, the results are submitted to the employer who checks the quality of the results. The final payment is handled by the crowdsourcing platform.

Graphical User Interface

Figure 1 shows the Graphical User Interface of the program. The program was developed with JavaScript. The central element is an orthophoto with the size of 500 * 450m² from which the data has to be collected. The object classes that have to be collected are: forests (with polygons), streets (with lines) and buildings (with points). Wrong collected objects can be deleted. The workers have the possibility to make additional comments on their work and submit them together with the collected data.

First results

A RGB orthophoto with a ground sampling distance (GSD) of 1m and a size of approximately 5 * 4km² was subdivided into 88 patches with the size of 500 * 450m². Several campaigns with different parameters were launched on the microWorkers platform to evaluate the quality of the crowd-based data collection. The results are very promising and the quality of the data was even outperforming our expectations in many cases. However, the tests showed also that the quality of the collected data varies significantly. Some crowd-workers collected the data with very high quality (see *Figure 2a*) whereas other crowd-workers collected completely wrong data (see *Figure 2b*). Interestingly, we observed that there is no direct connection between the amount of salary and the quality of the results. An increase of the salaries did not lead to a better quality but only to a faster completion of the campaigns.

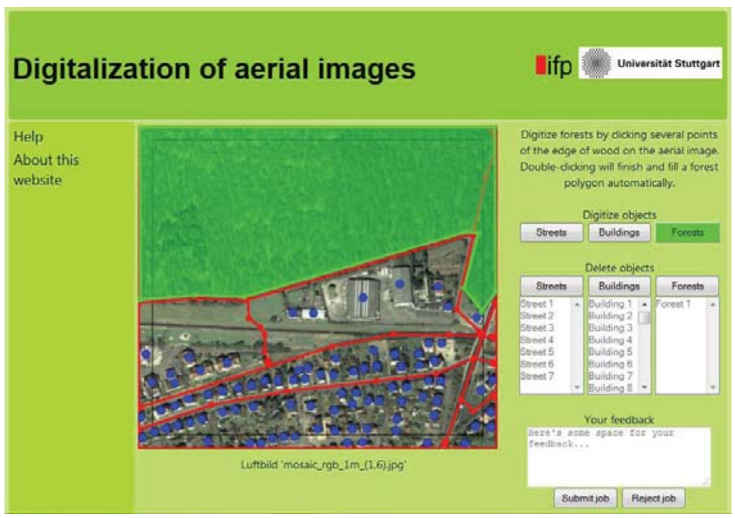

Figure 1. Graphical User Interface of the program for crowd-based data collection.

Figure 2. Two examples of crowd-based spatial data collection: a) data with high quality b) useless data

Outlook

The test showed that in principle it is possible to produce high quality spatial datasets with paid crowdsourcing. The main problem is that the quality of the data is extremely heterogeneous. Therefore, it is necessary to find control mechanisms that evaluate the quality of the data. This either must be done automatically or again sourced out to the crowd. Furthermore, selection procedures are needed, which can automatically select crowdworkers who collect data with high quality. This can be realized for example with user profiles. Finally, algorithms are needed which integrate the individual results into an overall result. Spatial inconsistent datasets, which overlap multiply, have to be integrated into a consistent, uniform dataset. All these aspects will be investigated in our ongoing research.

INSPIRE and VGI: Species Distribution in Europe

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Abstract. The growth of the Internet broadband has modified our needs, rising new types of stakeholders, markets and opportunities, especially in the mobile field.

Nowadays, national environmental agencies can share their own data between each other, governments can better monitor their country and civil protection can operate its action plans in a more efficient and quick way.

However, what happens if geographical data have to be used in operational activities, between European Member States? To answer this question, starting from the 2007, the INSPIRE directive tries to address this issue, with the build of 34 spatial data themes for environmental spatial information and, in general, a directive to set up the European Spatial Data Infrastructure. Thanks to this directive, member states have the instruments to exchange and use huge amount of environmental data between each other but, what happens if, following the new social trends of crowdsourcing, we put another variable constituted by normal citizens in the loop?

The creation of new INSPIRE compliant spatial datasets requires specific technical and methodological skills as well as a deep understanding of the directive. On the other hand, nowadays citizens can be seen as mobile sensors (Goodchild, M. F. 2007), and their contribution in the creation of spatial data can be fundamental.

The aim of this paper is to offer a possible solution tuned on the INSPIRE Specie Distribution data theme but applicable on all the others environmental datasets involved in the European directive, to create high quality INSPIRE compliant data, exploiting the users contributions through collaborative information collections (VGI).

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Keywords. INSPIRE, crowdsourcing, specie distribution, mobile devices, European SDI, eENVPlus, VGI.

1. Introduction

The eENVplus[1] project (Attardo C, Saio G. 2013) aims to unlock huge amounts of environmental data, managed by the involved national and regional environment agencies and other public and private environmental stakeholders, through the integration and harmonisation of existing services. These data are not only collected to answer reporting obligations on the environment to the European Union, but also to support national and local policies and actions.

The project does not design new services but rather, starting from the results of previous European experiences (funded projects, best practices, EU and national and local experiences), it integrates existing infrastructures into an operational framework able to overcome cross-border and language barriers.

eENVplus provides not only the ICT infrastructure but also the description and the support to make this infrastructure operational and profitable through the provision of an organisational model and a tutored training framework.

Figure 1 represents the ICT infrastructure provided within the eENVplus project: how it is possible to see, it is composed by a set of individual components, based mainly on free and open source software, but also new components developed from scratch, that are able to talk each other taking the advantages of the use of standard protocol for data exchange, download and process.

Services involved in the eENVplus infrastructure can be grouped in four main categories:

- Services for data ingestion dissemination [Figure 1 – orange blocks];
- Services for data processing [Figure 1 – purple blocks];
- Services for data cataloguing [Figure 1 – green blocks];
- Services for crowdsourcing [Figure 1 – blue blocks].

In order to unlock the mentioned huge amount of data, the ICT infrastructure provided contains a specific module, designed from scratch, whose role

[1] www.eenvplus.eu

is to acquire, store and disseminate observations collected by users about different environmental topics:

- Specie distributions;
- Protected sites;
- Damage to the environment.

This paper focuses on the topic of species distribution in Europe.

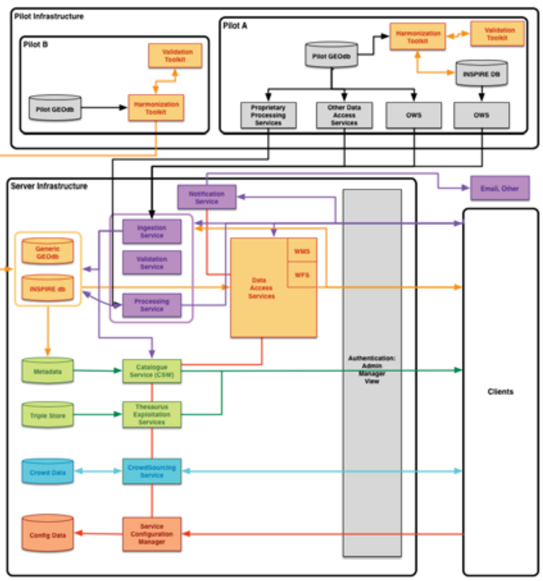

Figure 1 - The eENVplus Spatial Data Infrastructure.

The aim of this paper is to offer a possible solution, tuned on the INSPIRE Specie Distribution data theme but applicable for all the others environmental datasets involved in the European directive, to create high quality INSPIRE compliant data, exploiting the users contributions through collaborative information collections.

2. The Impact of INSPIRE

As (Masser 2015) reports, INSPIRE is *well transposed* by European member states, but a *gap* still exists to put the directive into operational environmental activities.

One of the main implementation barriers that are currently influencing the effectiveness of the directive is the data harmonization process.

The data harmonization process is a very time-consuming operation, directly influenced by the poor availability of personnel who has technical and legislative skills in order to produce INSPIRE-compliant datasets.

For the very specific requirements listed in the previous paragraph, from a study performed in the 2014, only the 20% of the geo-ICT companies have the skills required to work within INSPIRE (Vancauwenberghe, G., Cipriano, P., & Craglia, M. 2014).

The production of harmonized datasets is normally performed starting from existing datasets and using the so-called mapping tools, for exam- ple HALE[2] (Fichtinger, A., Rix, J., Schäffler, U., Michi, I., Gone, M., & Reitz, T. 2011).

As (Otakar Čerba, Karel Charvát, Karel Janečka, Karel Jedlička, Jan Ježek, Tomáš Mildorf 2012) reports, the harmonization process is composed by five actions, where first four of five are manually performed:

1. Theory of spatial data harmonization;
2. Source data understanding;
3. Target data understanding;
4. Definition of the necessary harmonization steps;
5. Practical realization.

The poor availability of professional users with the aforementioned technical skills may influence the production of harmonized datasets.

3. INSPIRE and VGI

The approach described in this paper enables the possibility to generate new harmonized datasets from non-professional users, taking advantages from the enormous resource of volunteered geographic information (VGI) (Flanagin, A.J.; Metzger, M.J 2008) (Fritz, S., McCallum, I., Schill, C., Perger, C., Grillmayer, R., Achard, F. and Obersteiner, M. 2009), and the diffusion of INSPIRE into operative activities can be encouraged.

Although previous approach described in the literature (Wieldmann & Bernard 2014) mainly considers crowd sourced data as an improvement of already existing INSPIRE datasets through data fusion techniques, in this

[2] http://www.dhpanel.eu/humboldt-framework/hale.html

paper we focalize our attention in generating completely new INSPIRE compliant datasets starting from the same type of source.

A mobile application, designed and developed from scratch, shown in Figure 2, is the instrument designed in order to acquire and send information from users to the central infrastructure.

Figure 2 - Mobile application for Species Distribution crowdsourcing

The eENVplus mobile application for species distribution allows users to collect, visualize and upload observations through the use of an interactive 2D map. Observations will be displayed as point of interests over publicly available thematic layers.

The data model for Species Distribution collection is represented in the following class diagram, Figure 3. Taking into account the issue related to the amount of information exchanged between mobile devices, the Species Distribution data model was designed in order to be as light as possible.

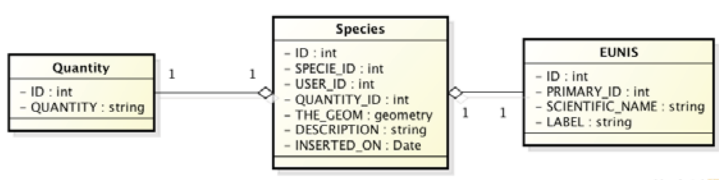

Figure 3 - Species class diagram for crowd-based observations collection

The aforementioned data model was designed considering as main requirement the lightness of the entire package representing each single observation. More in details:

- Species: represents the main table where observations about species are physically stored;
- EUNIS[3]: represents a dump of the EUNIS "Species" database, containing the scientific name of each element and an unique identification number, used also as primary key, for each of them. The EUNIS "Species" database is one of the three databases allowed by the Species Distribution technical guidelines[4];
- Quantity: support table which role is to allow users to specify a quantity of reported elements for each observation.

The observations collected within the use of the mobile application can be assessed also by the use of a HTML 5-based web portal. The aim of this portal, excluding the common point of interests visualization, is to allow the system administrator to approve or reject unpublished observations, enable or disable users and, most importantly, export observations by a comma separated value file (CSV) or within a fully INSPIRE-compliant Species Distribution GML.

3 http://eunis.eea.europa.eu

4 http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_SD_v3.0.pdf

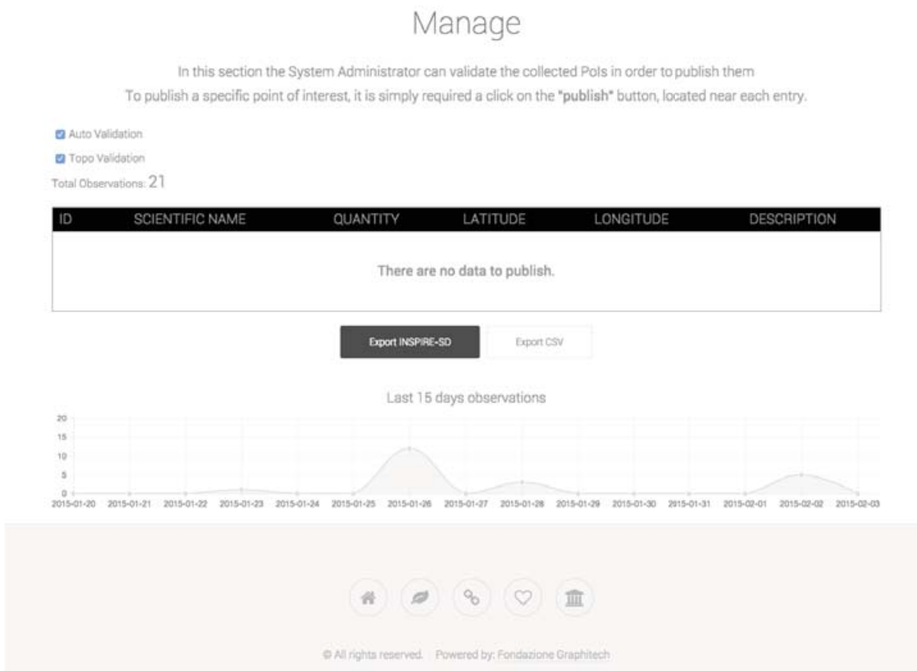

Figure 4 – eENVplus CrowdSourcing Service Administrator management portal

3.1. From CrowdSourced data to INSPIRE SD GML

Taking advantages of the Crowdsourcing service developed within the eENVplus project and described in the previous chapter, our effort has been focused into automatic procedure generation to create, starting from a lightweight data model optimized for mobile devices data exchange, into a complex GML INSPIRE compliant data theme with Species Distribution.

This procedure was designed in order to be applicable on others INSPIRE data themes.

The following figure represents the version 3.0 of the INSPIRE Species Distribution class diagram that has to be replicated from the developed procedure starting from the input data model.

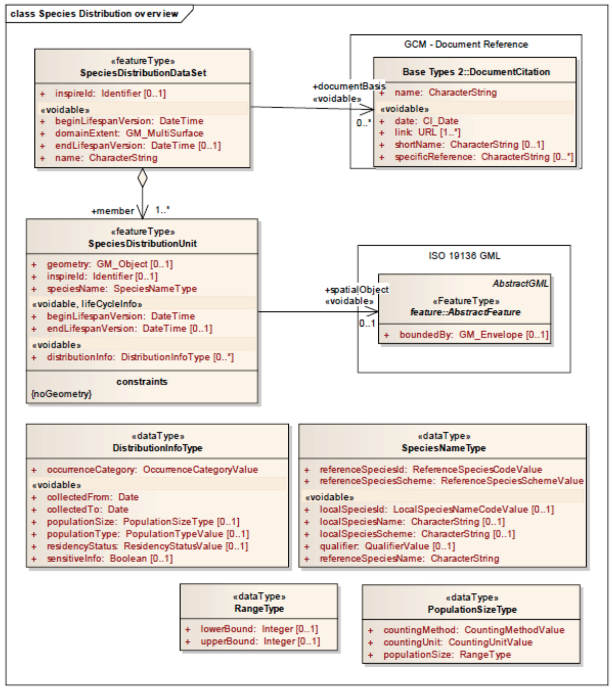

Figure 5 - INSPIRE Species Distribution class diagram v3[5]

Due to the complexity of the schema reported in Figure 5, and the need to minimize the quantity of data collected through a mobile device, our decision was to concentrate our attention mainly, but not only, on the mandatory field of the schema: in this manner we ensured that the compliance with the reference schema is maintained.

Starting from the eENVplus Crowdsourcing service data model for species distribution reported in the previous chapter, the following figure shows the mapping between source and target schemas.

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[5] http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_SD_v3.0.pdf

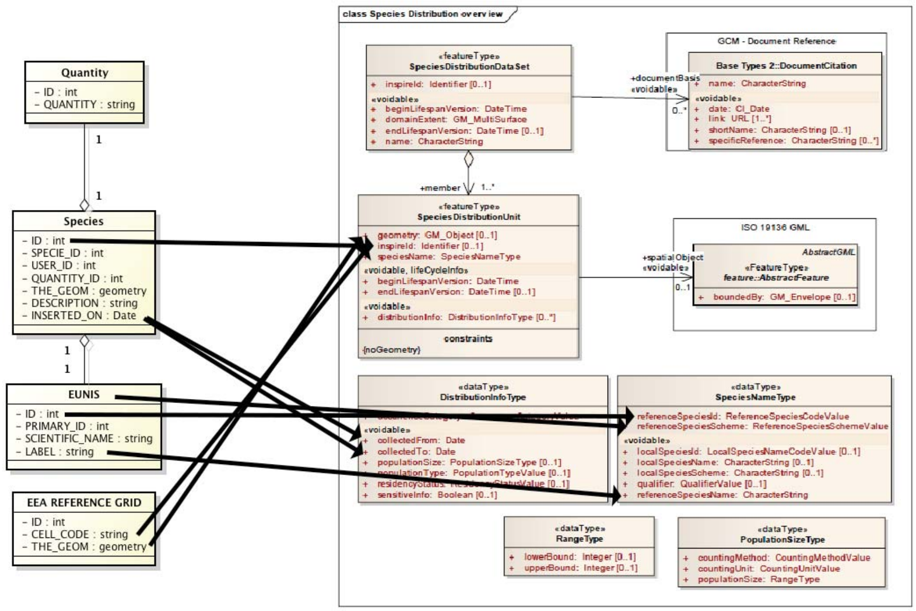

Figure 6 – Mapping between elements in order to generate a SD v3 INSPIRE compliant dataset

In order to generate a fully compliant INSPIRE SD v3 GML a support table is needed in addition to the ones involved in the process of storing data coming from the eENVplus CrowdSourcing Service.

The aforementioned table, represented in Figure 6 named as "EEA reference grid[6]", contains the **1km** grid for the area of interest needed in order to map species distribution according to the data theme technical guidelines.

The following table represents the mapping between source and destination elements in order to obtain a fully compliant INSPIRE SD v3 GML file.

Source	Destination
Species.ID	SpecieDistributionUnit.inspireId
EEA.CELL_CODE	SpecieDistributionUnit.inspireId
EEA.THE_GEOM	SpecieDistributionUnit.geometry
EUNIS.ID	SpeciesNameType.referenceSpecieId
http://inspire.ec.europa.eu/codelist/ReferenceSpeciesSchemeValue/eunis	SpeciesNameType.referenceSpeciesScheme

[6] http://www.eea.europa.eu/data-and-maps/data/eea-reference-grids-1

EUNIS.LABEL	SpeciesNameType.referenceSpeciesName
MIN(Species.INSERTER_ON)	DistributionInfoType.collectedFrom
MAX(Species.INSERTER_ON)	DistributionInfoType.collectedTo

Table 1. Mapping between source and destination data model

Figure 7 represents how the reference grid is composed for the observations collected in France.

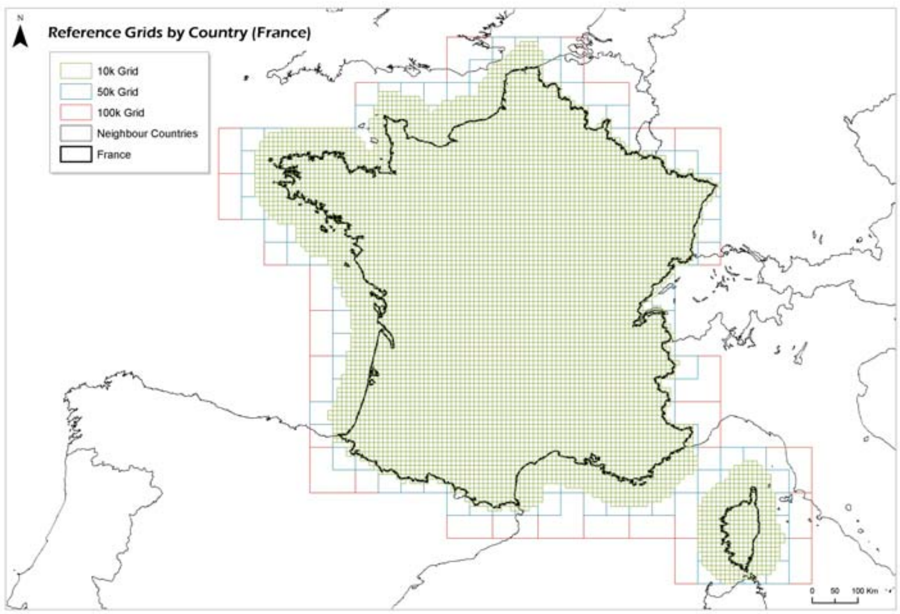

Figure 7 - EEA France[7] reference grid, EPSG:3035

The automatic procedure for data translation is developed by the use of the Java Servlet technology: following the mapping described in Figure 6, the produced output GML is a concatenation of the following INSPIRE Compliant Species Distribution elements, visible in Figure 8.

---

7 http://www.eea.europa.eu/data-and-maps/data/eea-reference-grids-2#tab-gis-data

```xml
<base:member>
    <sd:SpeciesDistributionUnit gml:id="eenvplus_SD_export_0_53">
        <sd:inspireId>
            <base:Identifier>
                <base:localId>0</base:localId>
                <base:namespace>SD.EENVPLUS.Unit</base:namespace>
                <base:versionId>1.0</base:versionId>
            </base:Identifier>
        </sd:inspireId>
        <sd:geometry>
            <gml:Polygon gml:id="0_53" srsName="urn:ogc:def:crs:EPSG::3035">
                <gml:exterior>
                    <gml:LinearRing>
                        <gml:posList>2888000.000125 3760999.99984 2888000.000125 3760000 2888999.999965 [...]</gml:posList>
                    </gml:LinearRing>
                </gml:exterior>
            </gml:Polygon>
        </sd:geometry>
        <sd:speciesName>
            <sd:SpeciesNameType>
                <sd:referenceSpeciesId xlink:href="http://eunis.eea.europa.eu/species/53"/>
                <sd:referenceSpeciesScheme xlink:href="http://inspire.ec.europa.eu/codelist/ReferenceSpeciesSchemeValue/eunis"/>
                <sd:referenceSpeciesName>Callimorpha hera Linnaeus, 1767</sd:referenceSpeciesName>
            </sd:SpeciesNameType>
        </sd:speciesName>
        <sd:distributionInfo>
            <sd:DistributionInfoType>
                <sd:occurrenceCategory xlink:href="http://inspire.ec.europa.eu/codelist/OccurrenceCategoryValue/present"/>
                <sd:populationSize>
                    <sd:PopulationSizeType>
                        <sd:countingMethod xlink:href="http://inspire.ec.europa.eu/codelist/CountingMethodValue/counted"/>
                        <sd:countingUnit xlink:href="individuals"/>
                        <sd:populationSize>
                            <sd:RangeType>
                                <sd:upperBound>1</sd:upperBound>
                                <sd:lowerBound>1</sd:lowerBound>
                            </sd:RangeType>
                        </sd:populationSize>
                    </sd:PopulationSizeType>
                </sd:populationSize>
                    <sd:sensitiveInfo>false</sd:sensitiveInfo>
                    <sd:collectedFrom>2015-05-06</sd:collectedFrom>
                    <sd:collectedTo>2015-05-06</sd:collectedTo>
            </sd:DistributionInfoType>
        </sd:distributionInfo>
        <sd:beginLifespanVersion xsi:nil="true"/>
    </sd:SpeciesDistributionUnit>
</base:member>
```


Figure 8 - Portion of the generated GML file SD v3 INSPIRE Compliant

In order to have a visual validation of the produced GML file, the following figure represents:

- On the left, the source dataset, composed by a set of point of interest. Each POIs contains the information acquired by users related to a specific specie. The reference data model for each point of interest is the one reported in Figure 3;
- On the right side of the figure, the generated INSPIRE compliant Species Distribution GML file. The GML file is obtained applying automatically the mapping described in **Figure 6** from the source data model to the target data model.

Figure 9 - Comparison with the source dataset and final GML file

3.2. Publish INSPIRE SD through INSPIRE network services

Although in the previous section the obtained output was a fully INSPIRE-compliant GML datasets according with the Species Distribution technical guidelines, the main limitation at this stage is due to the fact that no standard services to exploit the produced dataset was part of the loop.

The eENVplus infrastructure, mentioned in the first chapter of this paper, has a specific module to ingest, process and distribute INSPIRE- compliant datasets through the use of a network service based on the Web Feature Service (WFS) protocol[9] (Vretanos, P. A. 2005).

The aforementioned component was not built from scratch, but constructed on top of an open source software for spatial data infrastructure (Groot, R., & McLaughlin, J. D. 2000) and geospatial web. This software, called deegree[10] (Fitzke, J., Greve, K., Müller, M., & Poth, A. 2004), includes a specific module to create, starting from any XML Schema Definition, XSD, file, specific mapping between relational databases that will contain the representation of the XSD file taken as input, and a WFS service.

In this way the generation of the INSPIRE-like database to allow the storage of data coming from INSPIRE-compliant datasets in accordance with Annex I, II and III, can be easily managed.

The adoption of degree introduces many advantages summarized below:

- The use of a standard protocol for geographical data exchange: the use of a standard protocol for data exchange, the Web Feature Service in this context, allows the possibility to exploit the result dataset in other Spatial data infrastructure and in other applications.

- The possibility to store data in a relational database: files will be moved from a GML-based format into a more flexible relational database.
- The reasoning enabled through the use of the supported ISO 19143[8] Filter Encoding (Vretanos, P. A. 2005) query language: WFS 2.0 allows users to perform filters over the result dataset. For example, it is possible to ask for a element that contains a specific attribute value, or it is possible to perform spatial and logical operations:
    - **Logical** operations: *and, or and not*;
    - **Comparison** operations: *equal to, not equal to, less than, less than or equal to, greater than, greater than or equal to, like, is null and between*;
    - **Spatial** operations: *equal, disjoint, touches, within, overlaps, crosses, intersects, contains, within a specified distance, beyond a specified distance and BBOX*;
    - **Temporal** operations: *after, before, begins, begun by, contains, during, ends, equals, meets, met by, overlaps and overlapped by*;
    - **Equal** operation: to test whether the identifier of an object *matches* the specified value.

In this regard, the publication action is completed performing a transactional WFS call from the eENVplus Crowdsourcing Service to the spatial data infrastructure able to manage these commands.

The following sequence diagram shows how the system reacts to a publication request performed by the moderator.

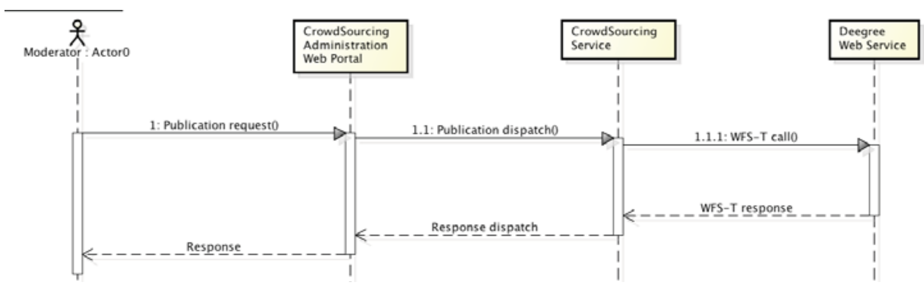

Figure 10 - GML publication Sequence Diagram

The entire overview of the workflow is visible in the following schema.

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[8] https://portal.opengeospatial.org/files/?artifact_id=39968

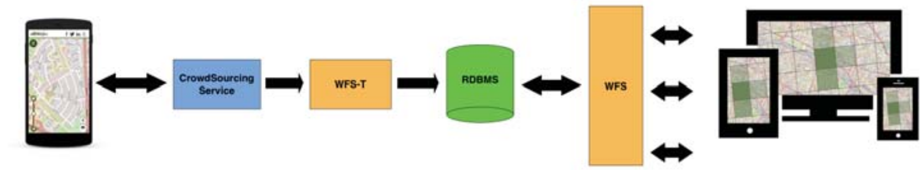

Figure 11 - Data generation, ingestion, harmonization and publication

4. Future Work

There are three main areas that will be influenced by the future work plan:

1. **Replacement** of the current data collection method, developed from scratch, taking the advantages of the WFS-T functionality provided by the deegree web service: The choice to develop the eENVplus CrowdSourcing service from scratch was due to the fact that the aforementioned service was designed to acquire different data models, sometimes containing pictures. The focus of this paper was related to a small part of the functionalities developed within the context of the eENVplus CrowdSourcing service. The use of the WFS-T for data ingestion also enables the use of the WFS protocol for data exchange between mobile apps.
2. **Increasing** the number of INSPIRE data theme produced by the system. Taking advantage of the WFS-T based version of the eENVplus CrowdSourcing Service, the objective in this context is to increase the number of INSPIRE data themes supported by the application. In this way, future version of the developed service can produce different INSPIRE-compliant datasets according with different data theme specifications.
3. **Updating** the procedure for INSPIRE-compliant Species Distribution GML creation and publication, producing a WPS (Schut, P., & Whiteside, A. 2007) based version of the tools. The process of “standardization” of the procedure aimed at data collection (the use of the WFS-T for data ingestion, and WFS for data dissemination) will influence also the automatic procedure for data harmonization. By the use of the WPS protocol, the developed processing services (one for INSPIRE data theme compatible with the system) will be also re-usable in other Spatial Data Infrastructures.

5. Conclusions

The aim of this paper is to offer a possible solution, different from the previous approach, in order to put non-professional users in the loop of generating spatial data compliant within the INSPIRE directive.

For the first version of the system we concentrate our attention on the use case of the species distribution in Europe, designing and developing a crowdsourcing mobile application to collect data from users according to a lightweight data model and, on the server side, a set of APIs to manage the incoming data, harmonizing, on the fly, information from the source to the destination (INSPIRE SD v3) data theme.

Through the use of a spatial data infrastructure, based on deegree web service, able to ingest, process and disseminate INSPIRE-compliant GMLs, a specific Crowdsourcing Service module was designed in order to automatically perform transactional WFS calls in order to store harmonized information in a more complex SDI.

Information stored and disseminated by deegree can now be accessed through external SDI, encouraging the diffusion of INSPIRE into operative activities of Member States.

Acknowledgments

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SDI4apps Points of Interest Knowledge Base

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Extended Abstract

SDI4Apps – Uptake of Open Geographic Information through Innovative Services Based on Linked Data[1] is an EU-funded project (European Union's ICT Policy Support Programme as part of the Competitiveness and Innovation Framework Programme) coordinated by the University of West Bohemia[2] (link) in Plzen, Czech Republic. The project is being implemented with the concerted effort of 18 organizations (universities, research institutes, private companies, regional authorities, non-governmental organizations) across Europe. SDI4Apps seeks to build a cloud-based framework with open application programming interfaces (APIs) for data integration and sharing focusing on the development of six pilot applications. The project draws along the lines of INSPIRE (INfrastructure for SPatial InfoRmation in Europe), Copernicus and GEOSS (Global Earth Observation System of Systems) and aspires to build a WIN-WIN strategy for building a successful business for SMEs (small and medium enterprises) on the basis of European spatial data infrastructures.

The SDI4apps solution is applied in six pilot applications. One of the pilot applications, the Open Smart Tourist Data pilot, focuses primarily on cycle tourism. In addition to the cycle routes dataset, another crucial knowledge base including points of interest (POI) is being created.

The contemporary version of the SPOI (SDI4Apps Points of Interest) knowledge base (October 2015) contains more than 4,100,000 POI cover-

[1]http://www.sdi4apps.eu

[2]http://www.zcu.cz

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ing European and African countries. Data are kept as RDF triples in the Virtuoso database system. OpenStreetMap is the main data source of the POI knowledge base, but there are integrated other resources such as points from GeoNames.org, experimental ontologies developed at the University of the West Bohemia (European ski resorts and Christian monuments in Rome) or data from the Posumavi region (south-west Bohemia). The original data are transformed to an RDF file through XSLT styles and Saxon XSLT processor. These XSLT styles process structured and valid information such as ontologies as well as non-valid data such as particular web pages of Posumavi region. The data are published via SPARQL endpoint[3] and the SDI4apps geoportal (map application Smart Tourist Data). There is also a web page[4] presenting SPOI data.

The data model follows recommendations for RDF data sets, semantic data, Linked Data as well as the data model published in Points of Interest Core (W3C Editor's Draft published in 2012; this model is used for OGC OpenPOIs.net dataset).

SPOI knowledge base complies with 5-star rating system of Linked Open Data. The data model re-uses several important, respected and standardized formats and vocabularies such as XML, XML Schema, RDF, RDFS, SKOS (Simple Knowledge Organization System), GeoSPARQL or FOAF (Friend of a Friend).

There is a huge space for further development. The next steps will focus on collection and harmonization of new data, solving open questions related to licenses, advanced visualization, modification of IDs to more readable form, interconnection to the INSPIRE specifications (for example addresses), providing data in other formats such as GPX or KML and implementation of new properties of POIs (metadata, spatial relationships or keywords).

[3]http://ha.isaf2014.info:8890/sparql

[4]http://sdi4apps.eu/spoi/

Data Quality Control for Topographic Mapping Production

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Extended Abstract

This paper describes a part of a project that aims to perform the spatial data quality control and the evaluation of intermediate and final products generated throughout the topographic mapping of the city of Porto Alegre, State of Rio Grande do Sul, in the south of Brazil. Considering that mapping quality is directly related to the quality of data handled at each stage of cartographic production, methodologies and criteria were defined for each one of the process steps. Quality is a complex issue in the cartographic products analysis, once it comprises a set of qualitative and quantitative parameters.

In Brazil, only the National Map Accuracy Standards (PEC) defines the quality of cartographic products. PEC is an important classification parameter, but it just considers the positional accuracy of the mapped features.

The present study shows the methodology and the results achieved by the quality control of the photogrammetric restitution stage, for planimetric features, at 1:1.000 scale, covering an area of 545 km². The methodology was developed considering the technical specification of the bidding process, the Brazilian cartographic legislation and the international standards related to spatial data quality (ISO).

In order to perform the intended analysis the area was divided into 71 sectors. The set of parameters considered in the quality evaluation were: positional accuracy, completeness, logical consistency, semantic quality and attribute precision.

The criterion adopted for positional accuracy was the horizontal PEC, that sets that 90% of the horizontal coordinates of points in the map when compared to the coordinates of the same points in the ground should not exceed

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0.5 mm x map scale, and limits the RMS errors in 0,3 mm x map scale. The other parameters were analyzed in random samples of 10% of the mapped features, for each sector, with the support of a photogrammetric system. Any nonconformity found in these samples resulted in rejection of the product.

For accuracy evaluation the horizontal coordinates of 180 well-defined points in the map were compared to the coordinates of the corresponding points in the ground. These ground points were determined by a horizontal check survey of higher accuracy. Lack of features (features that should be mapped and were not), features that do not exist (do not appear on the images) and features with incorrect shapes were searched in the completeness analysis. The logical consistency covered the computational representation structure and storage, the topological relationship and the simbology analyses. Description, classification and geographical names were verified on the semantic quality analysis. And the attribute precision considered the correct association of attributes for each feature or set of features.

The results showed that positional accuracy was in accordance with PEC for topographic map class A at 1:1.000 scale. On the other hand, completeness, logical consistency and semantic quality presented an amount of errors that exceeded the maximum number of errors previously defined. Therefore, the products were rejected and sent back to the producer company for correction.

Because of the large number of rejections some adjustments were necessary throughout the control process, concerning the level of acceptance and the sample. So the level of acceptance increased from 0% to 2.5% of nonconformities. The random sample of 10% of mapped features for the sectors that were not analyzed before remained the same. But for the second evaluation of the rejected sectors, the random sample was split into two samples of 5%. One of them with the same sampled features of the first analysis and the other one with different ones.

In conclusion, the methodology and the parameters used were suitable to improve the quality of the products generated in the photogrammetric restitution stage. And the quality control for each stage of the cartographic production process is important since it has an impact on the quality of the final products.

Licenses and Open Data in Cartography

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Extended Abstract

Open Data is one of the phenomena of contemporary Geoinformatics and Cartography. Development and expansion of cartography is clearly linked to the availability of spatial data that can be visualized. That is why the Open Data became a boom that approximately 15 years after the formation of “information society” begins to form “geoinformation society” – society dependent on the applications working with spatial data.

At the beginning of the 21st century, data was the main "assets" of each cartographic publishing house. However, now it is not difficult to obtain any data and it was clearly shown that free availability of the spatial data causes the development of other spatial-based applications. **Open data** mean that data are freely available to everyone to use and republish as they wish, without restrictions. There are various “openness level” of data – from the situation when data is available only in a particular format, and for non-commercial use only, to “really open data”, which are freely available to anyone, without any restrictions from copyright, patents or other mechanisms of control. In fact, open data complement the existing range of open source, open hardware, open content and open access. Together with these other tools open data creates enormous opportunities in the field of Geoinformatics and Cartography – for any data processing, cartographic production and other applications. Open data has become an important tool for creating geoinformation policy states (Reichman, Jones, Schildhauer, 2011).

Intellectual property is very important in the time of information society (Peterson, 1999). Unfortunately, the debate over the appropriate scope of intellectual property protection for GIS and geodatabases largely ignores the role of cartography and spatial-data uniqueness in setting rights. An important part of copyright law is the definition that for each use of the work there is essentially required consent of the author. The law essentially

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requires the authorization to exercise the right to use the work (license) to another person. There are also possible contracts and licensing agreement with the fact that no such authorization is needed, in other cases possible use of the work is prescribed by law (Vondrakova, 2013). In the field of information technology there are very often used pre-defined licenses. **Licenses** linked to software (including GIS) are: public domain, cardware, freeware, shareware, commercial software licensing, OEM (Original Equipment Manufacturer), open source etc. Usually in non-technological field of geographic information systems and in cartography are used licenses for no-software products – copyright as all rights reserved and Creative Commons licenses as some rights reserved.

Digital data are often under copyright protection as geodatabases. Due to the territoriality of copyright protection it very important to know the specific license terms and conditions. The uniqueness of spatial data and services deals with fact, that special data are combined together. And it is the combination of different data sources, where it is really important to follow licenses and copyright issues.

There was implemented a study on copyright issues in cartography and geoinformatics in cooperation with experts in law and in the fields of Geoinformatics and Cartography. The contribution includes specific illustrative examples in which there is a conflict with the legal protection of copyright works. Based on the definition of state matters a brief analysis of where there are gaps in the protection of copyright in the field of GIS and cartography.

This contribution was implemented within project "Increasing of effectiveness of copyright protection in cartography and geoinformatics" TD020320, co-financed by Technology Agency of the Czech Republic.

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New Approach to Experimental Testing in Cartography

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Extended Abstract

In recent years, cartographic research has placed increasing emphasis on the study and evaluation of the process of communication of information between the map and the user. Increasingly, cartographers deeply consider the practical usability of their products, the target group of users, and possibly the methods by which these aspects can be monitored and evaluated. This interest in the professional cartographic community has been also emphasized thanks to numerous activities of the International Cartographic Association, which established aspects of user research in cartography as one of its action goals.

One of the specific aspects of user studies in cartography is its interdisciplinary nature, which uses a large number of methods and techniques known, for example, from psychology, and the relatively young field of cognitive psychology. This contribution summarizes selected topics related to experimental testing of cartographic visualizations. In addition to selected methodological aspects of experimental research in cartography, it outlines possibilities of using knowledge and research practices in cognitive psychology, which can help in interpreting the evaluation of some aspects of cartographic products' usability.

The methodological part of the contribution deals with theoretical aspects of the evaluation of cartographic products. Existing evaluation approaches of cartographic products are briefly described, from strictly subjective evaluation methods (e.g. Martin 2007, Hartson & Pyla 2012, Johansen 1991 etc.) to objective methods (e.g. Konečný et al. 2011, Štěrba & Šašinka 2012

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etc.) focusing on the applicability of the cartographic visualizations. The emphasis is put on psychological aspects, which can have a significant effect on the communication of information between the map and the user (Koláčný, 1977). The phenomenon of cognitive style is described, which brings the possibility of studying individual differences among users of cartographic products. Options for testing cognitive styles among users are then presented in this sense.

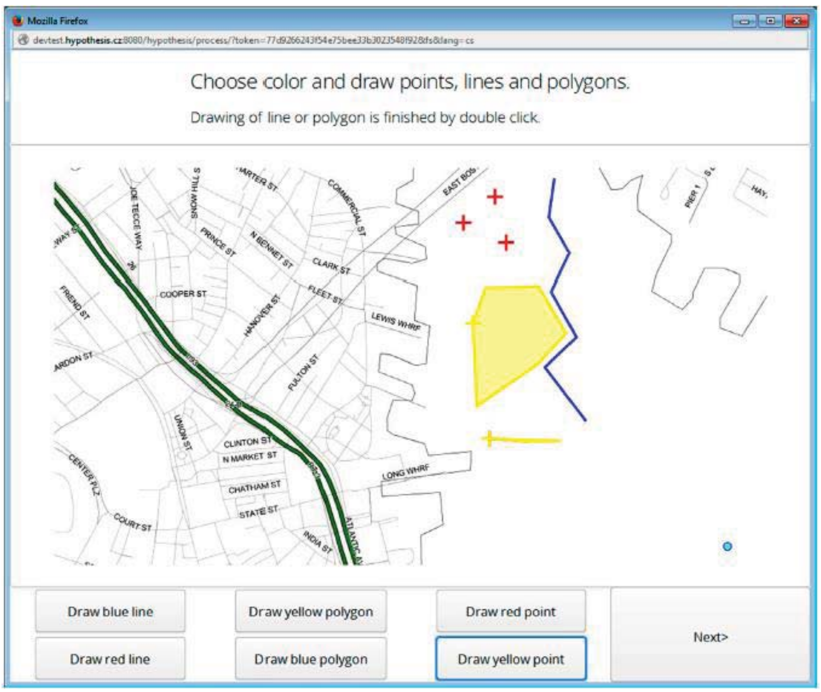

Figure 1. An example of slide from Hypothesis software designed for testing of drawing points, lines, and polygons into the map (Štěrba et al., 2015).

The final part of this contribution is focused on the practical use of newly developed interactive testing software Hypothesis, which was used in experimental research in cartography. Simple examples (*Figure 1*) present the rich functionality of this tool, which enables the implementation of objective and subjective evaluation methods and testing the user's performance on the map, according to the requirements of the specific research project. Finally the summarizing publication (Štěrba et al., 2015) will be introduced.

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Impact of attentional issues on map use performance

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Keywords. ASRS, attention, map, performance

Extended abstract

Background. Differences in attention properties might have a major impact on the performance related with map use. Cognitive processes related with attention properties are crucial in the interpretation of maps (Wolbers and Hegarty, 2010; Griffin and Fabrikant, 2012). There are important differences in the cognitive interpretation between 2-dimensional and 3-dimensional maps. Edler et al found that spatial visual memory is affected according to 2- and 3- dimensional representations (Edler et al, 2015). The aim of the present work was to study the link between self-reported attentional problems and map use performance. Both 2-dimensional and 3-dimensional maps were used.

Methods. Twenty-four students (Land Surveying B.Sc., 21-26 years; mean: 22.7, SEM: 0.3) participated in the study after informed consent. The Adult ADHD Self-Report Scale (ASRS) Symptom Checklist was used to evaluate attention-related problems (Kessler et al, 2005; Kessler et al, 2007). This self-reported checklist consists of 18 items, 9 related to attention problems, and 9 related to hyperactivity/impulsivity problems. The Hungarian version was also validated (van de Glind et al, 2013). Only the number of attention problems was considered. The data source of the maps was the Hungarian Earthquake Catalogue with information about location, magnitude, and energy of earthquakes from 456 B.C till present days (Pődör and Kiszely,

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2014). Sample maps were presented in Fig. 1 and 2, respectively. The participants conducted the tasks in a computer lab. The maps were prepared in ArcGIS at 1 : 2 million scale.

Statistica 7.0 program package was used to analyze the link between map performance and the number attention problems. Spearman's correlations were run between symptom checklist and map performance variables. The level of significance was set at $p=0.05$.

Results. In the overall map performance, the maximum score was 40 out of 48 points, the minimum was 24, the mean was 34.9 points. From the maximum scores, students reached 76.0 ± 2.4 percent on the 2-dimensional maps, while 68.1 ± 2.9 percent on the 3-dimensional maps. In the population studied, the number of attention problems was 3.3 ± 0.4 (mean±SEM).

The number of attention problems showed a significant inverse correlation with the map performance in the case of 2-dimensional maps (Spearman $R=-0.60$, $p=0.002$), but not in the case of 3-dimensional maps (Spearman $R=-0.03$, $p=0.9$).

Conclusions. In our setting, the number of self-reported inattention symptoms was inversely correlated with the test performance in 2-dimensional maps, while this effect was not observed in the map performance related to 3-dimensional maps. Our preliminary results indicate that this effect might have a major importance in the interpretation of different map types.

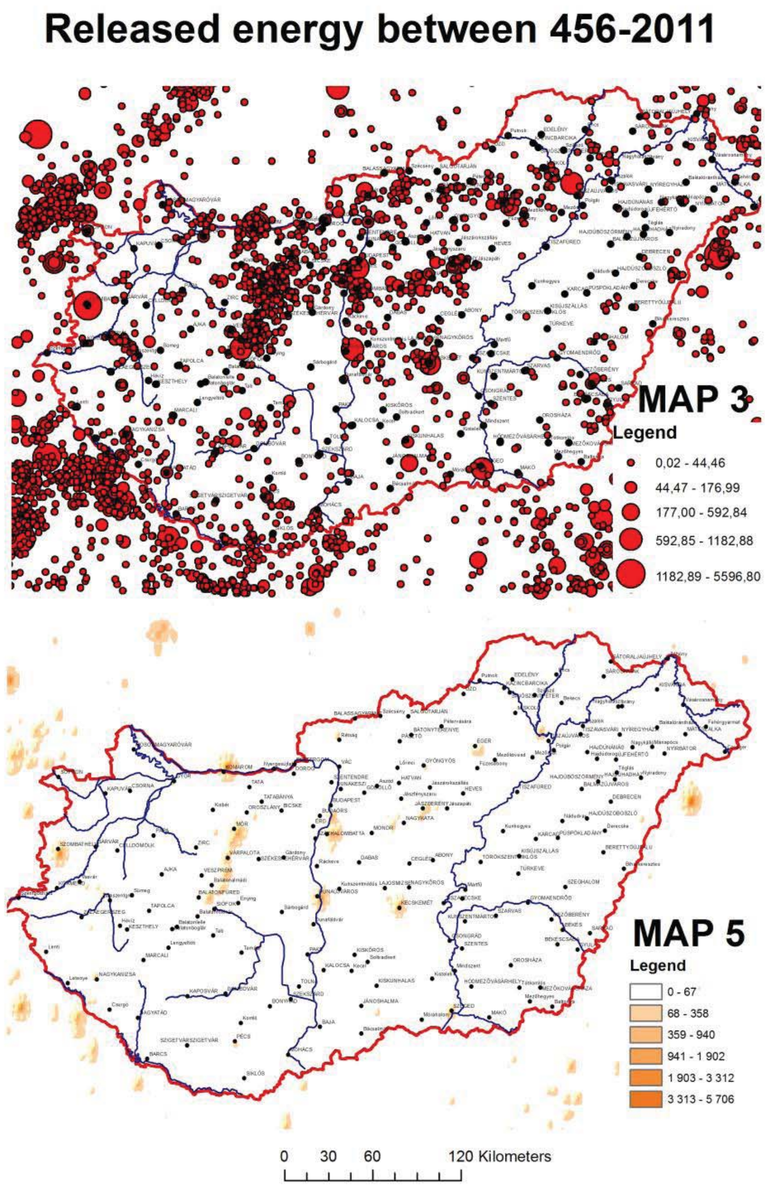

Figure 1. Maps used in the present study - 2-dimensional test maps

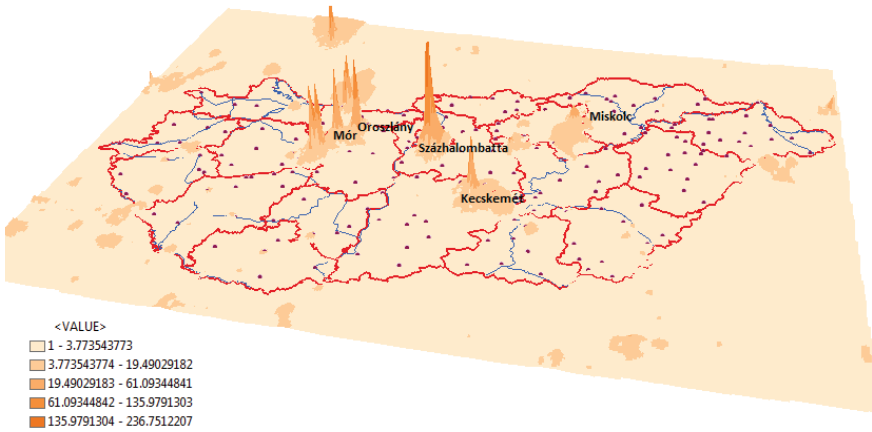

Figure 2. Map used in the present study -3-dimensional test maps.

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RESEARCH INVESTIGATIONS RELATED TO USER CENTERED DESIGN FOR GEOINFORMATION PRODUCTS

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Extended Abstract

This paper aims to present the results of our projects that the main goal is to develop investigations from research problems that are defined based on the relationship between geoinformation solutions and knowledge in Cartography and GIScience. Those projects are being developed over the last 10 years, and here we describe six of them: two at doctoral level and four at master level. For those doctoral dissertations, we relate the research problems to human perception and cognition. Their results discussion aimed to provide improvements in cartographic design solutions. Santil (2008) proposed the following research problem: "when the point and line symbols are designed from visual variables that stimulate the perceptual property called selectivity, what is the visual perception result?" He has applied a set of experiments to verify if the Gestalt laws (Köhler, 1947; Sternberg & Sternberg, 2012) - proximity, similarity, and *Prägnanz* – might help us to understand how we see those groups of symbols. From his experiments, we may conclude that proximity is a key element in seeing groups of symbols, but similarity is the factor that imposes the unity of symbols. Andrade (2014) investigated how visual perception of pictorial symbols can stimulate the acquisition of spatial knowledge by users of tourist maps. In this investigation, the results were discussed in accordance with the Gestalt laws — figure-ground, *Prägnanz*, proximity & similarity, and visual unification— to figure out how much the Gestalt laws influence the map reading process (Köhler, 1947; Sternberg & Sternberg, 2012).

One of the master investigations (Bravo, 2015) was developed from a research problem related to spatial cognition issues and VGI (Goodchild, 2007). The research problem is how the mental processes of knowledge

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organization affect the reliability of VGI semantic content. Bravo (2015) has found that the reasoning of individuals depends on their cognitive skills of knowledge organization. The results pointed out that the participants understand geoinformation on a VGI system in accordance with the basic level categories (Rosch, 1973). The results also showed us that the participants organize their geographic knowledge through partonomy and taxonomy relations (Tversky & Hemenway, 1984; Bravo, Santil & Sluter, 2011). At the end, we concluded that mental processes of knowledge organization influence the judgement on VGI reliability.

For Ramos (2015) master thesis, the research problem is defined as how to improve the automation of geoinformation processes based on urban planners requirements for a geoinformation system. The hypothesis lies on two primary conditions that are the users' requirements must be elicited in accordance with the techniques and methods of the requirements engineering (Kotonya and Sommerville, 1998; Sluter et al., 2014); and the geodata queries and processing must be accomplished by an expert system that replaces some of the user spatial analyses tasks.

Finally, there are two works at master level (Prado, 2007; Yamada, 2015) with the research problems related to visual perception and cognition and, the results are verified in accordance with map use context. Prado (2007) defined his research problem as how 2D and 3D geovisualization can stimulate the spatial knowledge acquisition of soil scientists when they have to understand the landscape properties in order to define the soil samples locations. The hypothesis was that the 3D cartographic representations are more effective because they release our mind from creating mental images of the relief from 2D representation by contour lines. Consequently, the soil scientists need less cognitive effort to understand the landscape from cartographic representations, and they can focus their attentive cognition in the relationship between the landscape variables and the landscape patterns that influences the soil formations.

The last of these works was developed by Yamada (2015), and her research problem is proposed as "how are the mental schemata of urban planners when they define and represent urban public spaces?" The solution of this problem is obtained through discussing the results of identifying the components of propositional schemata (Rumelhart e Norman, 1985) of urban planners; identifying how their image schemata is used when they delineate public spaces; and understanding the relations between urban planners propositional and image schemata (Lakoff, 1987).

One of our premises for every research project we develop is that the success of a geoinformation product is dependent on the abilities of the cartographer, or geoinformation expert, to take into account the needs of the users in each product design decision. The systematic structure of cartographic product design and production makes clear to us, cartographers, some lack of scientific and technological knowledge. A systematic understanding of human abilities, design decisions and map use context can be built from a point of view that is that the design of a geoinformation product can be developed in accordance with the UCD approach.

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Methodology for Automating Cartometric Evaluation of Urban Topographic Maps in Brazil

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Extended Abstract

Brazilian official maps for the urban areas must be at 1:2,000 scale and maps at smaller scales are no produce by cartographic generalization. This requires a methodology for producing maps at different scales by cartographic generalization that can be appropriate for the Brazilian landscape. The cartographic generalization process can include cartometric evaluation. This evaluation can be helpful to define which features should be generalized and which operators should be applied (McMaster & Shea 1992).This paper presents a method for developing cartometric evaluation for an urban topographic map at 1:5,000, derived from a 1:2,000 scale.

Some of the cartometric evaluation components are the geometric conditions, the spatial and holistic measures. Nowadays these aspects are understood as constraints, restrictions, map specifications, generalization guidelines, tolerance values, cartographic rules, representation problems and graphic parameters (Mustiere 2005, Stoter et al. 2009, Tailender 2011). In addition, constraints are used to evaluate the generalization process quality and may indicate is the generalized features (Stoter et al. 2009). The following aspects must be considered when a map is produced by generalization: the features characteristics and the relationships between them, the representation problems, the graphic parameters for each problem and the order for applying the generalization operators.

The cartometric evaluation is automatically performed with the support of an expert system. The first results were achieved with a system that was developed using the ModelBuilder application and the ArcGIS software and are related to evaluation of buildings, parcel limits, streets and roads. This system detects representation problems by performing geometric measures on some features with the aid of spatial analysis tools of this GIS software. As a result, new data layers are generated and they store the features that show

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the representation problems. For example, the system measures the distance between buildings. The new layer shows which buildings, and what part of those buildings, do not fit the distance constraint, in accordance with the generalization conditions.

Our goal at the moment is to develop an expert system to perform the cartometric evaluation and the spatial transformations on QGIS. The proposed method includes six steps: (1) identification of the representation problems on the map when its scale is reduced, (2) formalization of those problems, (3) definition of the graphics parameters related with each representation problem, (4) definition of the generalization operators, (5) formalization of the rules that describe each problem and operator, (6) design and implementation of the expert system.

The system generates a new data layer that contains the features that have representation problems. The system indicates which generalization operator must be applied based on the cartometric evaluation results. Another data layer stores the features already generalized. The new layers are automatically added to the screen viewer.

The automation of cartographic generalization is a challenge, partly due to the subjective decisions taken during the process. The cartometric evaluation clearly shows this subjectivity. Two cartographers can identified different representation problems in the same map and this will lead to two different generalized maps. The formalization of the components of this evaluation can make this process more holistic and less dependent of human control and influence, and thus more efficient.

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Lexical knowledge sources for cartography and GIS – development, current status and outlook

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Extended Abstract

The aim of scientific research is *to acquire new knowledge*. It should always be in touch with current knowledge and has no chance of success without an awareness and evaluation of the available knowledge. The same applies to the disciplines of cartography and geoinformatics. As in other sciences, current expert knowledge is documented and published in various forms: as individual articles (papers) about often narrowly defined subjects in periodicals, scientific publication series or other compilations, as independent monographs, systematically subdivided into textbooks for educational purposes and finally also in specialised encyclopaedias. These in turn are especially useful for cartography teachers and students as well as for laypeople who quickly need to look up technical terms.

In response to the publication of the "Encyclopaedia of Cartography and Geomatics" (*Lexikon der Kartographie und Geomatik,* 2001/2002), Stams compiled in 2003 a comprehensive "Review and Comparison" (*Rückblick und Vergleich*) of cartographic encyclopaedias. In the intervening 12 years, we have witnessed developments in lexical knowledge sources that far surpass those of the past century. *The transition to the digital world has been a gradual one*. The great universal encyclopaedias, which contain a selection of the main terms from subject areas that include cartography and GIS, have been no exception. For example, the Encyclopaedia Britannica, which was available on CD-ROM as early as 1994, transitioned to an online edition in 2008/09 and gradually opened the door for anyone to participate in composing keyword articles. In so doing, it hoped to adopt the approach first taken with the launch of WIKIPEDIA in 2001.

Steps in the development of lexical knowledge sources for cartography and GIS since 1990:

- Printed version (available to purchase)
- Printed version and eBook (available to purchase), pdf file (free)

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- Offline versions: CD-ROM or DVD-ROM versions and USB stick (avail able to purchase)
- Online version, fee-based
- Online version, free
- Online version with possible user participation (desirable), free

It should be noted that not all cartographic encyclopaedias have taken the final step (online, free, participation possible) and are available as combination sales (primarily printed+online).

The actual revolution in specialised encyclopaedias for cartography and GIS *began in 2001/02*. Whilst the three large encyclopaedias of the late 20th century, including the Encyclopaedic Dictionary of the ICA Commission II, were still only published in print, the two-volume edition of the “Encyclopaedia of Cartography and Geomatics” was immediately followed by a CD-ROM edition with identical contents, and the “Encyclopaedia of Geoinformatics” (*Lexikon der Geoinformatik,* Bill and Zehner, ed., 2001) was available online shortly after its publication as a printed book (Geoinformatics Service of the University of Rostock). No new edition of either encyclopaedia has since been published, despite the fact that they have long been out of print. On the one hand, this would seem to indicate that a substantial part of the contents remains valid despite the lack of updating and on the other, that the transition to the digital world is finally complete.

The previously mentioned *“Encyclopaedia of Cartography and Geomatics”* (Bollmann and Koch, eds., 2001/02) *provides a typical example* of the gradual progression of lexical versions. After sales of the printed and CD-ROM version were suspended, a fee-based online version followed. For the past few years, the encyclopaedia has been available free of charge on the Internet. The publisher has no current plans to update or further develop the encyclopaedia, such as by adding dynamic cartographic illustrations, real 3D maps, etc. Thus the opportunity for development is unfortunately not being exploited. Among the (few) more recent global encyclopaedias, the *“Encyclopedia of GIS”* from US publisher Shekar and Xion has an entirely different style to that of the *Rostock Encyclopaedia of Geoinformatics*, even though both are available digitally as well as in print. Here, an international team of authors composed detailed essays on 41 problem areas and provided extensive literary references, giving the impression of an alphabetically structured manual. Similar characteristics can be found in Volume 6 of the compiled *“History of Cartography”* (“Cartography in the 20th Century”, Monmonier, ed., 2015), published in 2015, currently unavailable online, but available to purchase as an eBook.

For both printed as well as online encyclopedias is to convey the scientific and conceptional structure of meaning. It goes without saying that as a *unified scientific concept* is applied. This should be based on the foundation of modern science. A largely uniform structure of the texts of keywords facilitates knowledge discovery from the lexicon. In clear and concise definitions to look for. The *knowledge* of encyclopedia should be *reliable, quotable and currently*, access to knowledge and its exploitation as quickly and uncomplicated. In addition, ways must be shown to the broadening and deepening of the limited lexicon knowledge.

In the end, the question remains: does the existence of the *"free encyclopaedia" WIKIPEDIA*, which has been collectively maintained by volunteer authors since 2001 and contains ever increasing numbers of keyword texts on cartography and GIS, make the maintenance, further development and new development of all types of independent specialised encyclopaedia redundant? Currently and in the near future *they are not yet obsolete!* The ideal version of an encyclopaedia for cartography and GI sciences should be dynamic, interactive and optimally adapted to users, thereby facilitating their work in conjunction with a modern editorial environment (content management system). Main contents should be still developed collaboratively by experts.

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The GEOTHNK Approach to Spatial Thinking

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Extended Abstract

Spatial thinking uses the properties of space as a means of solving problems, finding answers, and expressing solutions (NRC, 2006). In other words, it uses space for structuring problems, seeking answers, and formulating possible solutions associated with space in science, workplace and everyday life, including the ability to review and analyse space, essential to educated citizens for decision making. The NRC Report marked the need for a major turn in education towards the enhancement of spatial thinking. In Europe, however, there is not a declared official priority yet. In this context, GEOTHNK is a European effort for a scientifically grounded, technologically sustainable framework for the development of learning pathways for enhancing spatial thinking across education sectors and learning environments.

The GEOTHNK approach goes beyond the provision and organization of resources. An innovative learning and teaching environment has been developed[1] for the semantic linkage of geospatial concepts, representation tools, and reasoning processes in between and across domains and educational contexts. To accomplish the project's objectives, the adopted pedagogical methodology follows the Inquiry Based Learning Model as formulated by various researchers and perspectives (such as DeBoer, 1991) and officially promoted to pedagogy for improving science learning in many countries (Rocard et al., 2007).

Spatial thinking is defined as a constructive synthesis of three components: (a) concepts of space, (b) tools of representation, and (c) processes of reasoning. The geospatial domain presents an excellent opportunity towards achieving a meaningful connection between theoretical, higher-

[1] http://portal.opendiscoveryspace.eu/community/geothink-community-400866

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level concepts and tools of representation and their application in everyday life. These components are also helpful in understanding many other georeferrenced phenomena, such as the spatio-temporal change of countries and their boundaries due to historical events.

The set of GEOTHNK concepts is formulated based on a thorough analysis of existing vocabularies, such as TeachSpatial (2011) and Schools Online Thesaurus website – ScOT (2014) and was developed according to the principles of interdisciplinarity, transversality and, semantic linkage. GEOTHNK includes more than 250 concepts, both spatial and non-spatial, concepts referring to tangible objects and abstract notions. Each concept is described by three elements: (a) a term, (b) a definition, and (c) links to useful resources. To support the development of multifarious pathways, GEOTHNK provides links to various categories of representation tools such as maps, map viewers, and map making applications, historical maps, virtual globes, satellite and aerial imagery, tools and resources for exploring and creating visualizations and 2D/3D geometrical models. Finally, reasoning tools are classified into two types; those for: 1) grasping a specific concept and 2) understanding or implementing an educational pathway.

Our experience from the GEOTHNK Community thus far has shown that there is more to spatial thinking than meets the eye; teachers in the community vary in terms of the discipline they practice, constituting a multifarious audience that blends with geography teachers and give strong evidence that spatial thinking cross-cuts the curriculum and should be dealt with accordingly.

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Thematic Cartography: a Key Course in Geospatial Engineering

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Abstract. In this paper a new revised undergraduate course on Thematic Cartography is presented as a 5 ECTS integral compulsory core course of the undergraduate curriculum of the School of Rural and Surveying Engineering at the Aristotle University of Thessaloniki, which leads to the homonymous five years engineering degree, after the submission of the diploma dissertation. The paper is focused mainly on the exercise and implementation part of the web-based course targeted to the familiarization of the students with a series of relevant software applications in relation to the data mining from the EUROSTAT provider. It is shown how this key course covers the educational and student needs of a spectrum of other courses in the engineering curriculum and raises the overall interest of engineering students for cartography.

Keywords. Thematic Cartography, University Education, Engineering Curriculum

1. Introduction

The School of Rural and Surveying Engineering (SRSE) at the Aristotle University of Thessaloniki (AUTH) is one of the seven independent Schools of the Engineering Faculty, providing engineering degrees. It was established third in 1962, after the School of Civil Engineering (1955) and the School of Architecture (1957),[1] consisting now of three Departments: Geod-

[1] The other AUTH Engineering Faculty Schools are: Mechanical Engineering (1973), Electrical and Computer Engineering (1973), Chemical Engineering (1973) and Spatial Planning and Development (2004)

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esy and Surveying (DGS), Cadastre, Photogrammetry and Cartography (DCPC) and Transportation and Hydraulic Engineering (DTHE), all dealing with the teaching and research in the relevant fields of engineering sciences and technologies. The five years/ten semesters curriculum of studies in SRSE,[2] which is the second School in Greece offering this field of engineering, together with the counterpart at the National Technical University of Athens (NTUA), leads to the homonymous engineering degree at a Master of Engineering level and to the professional engineering license after a legal examination at the Technical Chamber of Greece. The engineering degree in this field defines a historical track of studies and profession in the country with solid roots in the early 20th century Greek higher education system and even older, as the first relevant studies offered at the military academy and established in the 1830s after the foundation of the modern Greek state, were affined to subjects now under the SRSE concern.

Cartography in Greece is traditionally treated among the core subjects of the studies and research in the two SRSE in Athens and Thessaloniki, covering the whole spectrum of the field in the sense of ICA; both as a discrete scientific field and as a field having strong relevance and ties with geodetic, surveying, photogrammetry, remote sensing, cadastral and geoinformation matters focused on the engineering points of view. Cartography in Greece is definitely engineering-born and historically related to engineering education development (Livieratos 1993), also because, in contrast to other European countries (including the neighbouring countries), the geography high education studies started very late in this country, only in the 1990s. The AUTH-SRSE treated Cartography at a privileged level, mainly since the early 1980s after the relevant Chair of *Higher Geodesy and Cartography* was first established in 1979, headed by Prof. Evangelos Livieratos, who since then and for the next 36 entire years dedicated efforts, energies and resources in developing cartographic teaching and research in Thessaloniki.[3] From the first three cartographic courses introduced in 1979: *General Cartography, Thematic Cartography* and *Mathematical Cartography* -all three backed by relevant lecture-notes, the 2014-15 curriculum of the AUTH-SRSE counts seven "pure" cartography-based undergraduate compulsory and elective courses for a total of 38 ECTS, to which a number of cartography and mapping relevant courses should be also considered, of-

[2] For the AUTH-SRSE undergraduate curriculum of studies, see: http://www.topo.auth.gr/main/index.php/en/studies-atm-2/undergraduate-studies

[3] Thematic Cartography was taught for the first time in Greece by E. Livieratos, at the NTUA in 1978; his book *General Cartography and introduction to Thematic Cartography*, Ziti Editions, Thessaloniki (2nd ed, 1989), is a basic reference in Greek for teaching introductory courses in cartography

fered in association with subjects of geodesy, surveying, photogrammetry and remote sensing, cadastre and geoinformation as well as the post-graduate courses of the programme offered in map production and geographic analysis.

It is no coincidence that a number of institutional cartographic structures dedicated to cartography were founded there: the *Hellenic Cartographic Society* (HCS), representing Greece since 1995 in the International Cartographic Association,[4] the *National Centre for Maps and Cartographic Heritage* established as independent legal entity in 1997, which since 2013 operates as the *Archives of Cartographic Heritage*, section of the General State Archives of Greece, always housed at Thessaloniki, together with other international cartographic activities as it is e.g. the ICA Commission on *Digital Technologies in Cartographic Heritage* and the international web journal *e-Perimetron* on sciences and technologies affined to the history of cartography and maps, both operating since 2006.

Having such a background, the approach to the Thematic Cartography (Imhof 1972, Dent 1996, Slocum et al 2005) key undergraduate compulsory course is a highly demanding and challenging issue for the overall educational and training process in the SRSE, taking into account the synthetic and multidisciplinary profile of this unique engineering degree which combines a very strong geodetic-geospatial engineering component with a component related to the engineering of infrastructures.

2. Thematic Cartography in AUTH-SRSE

2.1. Theory and practice

Thematic Cartography (TC) is a basic course in all geospatial engineering related curricula of the university engineering and geography and of the technological institutions Schools of tertiary education in Greece. The AUTH-SRSE core course on TC (Course ID 20052253) is compulsory in the list offered at the 4th semester programme of studies under the general-synthetic course description, reading as: "The object and history of TC; thematic data and classification; the issue of scale and projection in thematic maps; standards, rules and practices in the graphic and image representation of thematic information; acquisition, process and representation of thematic data; symbolism of qualitative and quantitative information; the issue of ordering information; classes of thematic maps (choropleths, isarithmic contouring, topologic maps, atlases); statistics in TC; graphics

[4] Before the establishment of the HCS, the AUTH SRSE-DCPC was an affiliate member of the ICA.

and design in TC”. This general description is associated with relevant cartography, in the curriculum courses offered, in consequential logic in higher semesters, i.e. the courses of map use, map production, cartographic visualisation and non-conventional cartography.

But, as required and expected in an educational process, the main didactic effort for the consolidation of knowledge in a complex field like TC, which apart from its imposing theoretical background, requires implementation strategies and practical experience, is to focus on a efficient plan of exercises targeted at the advancement of the students efficacy in approaching integrally a TC project. Following this principle, we preformed recently a reform in the TC exercise–practical work of the students, focusing on the gaining on-line experience in the chain of data acquisition, processing and cartographic representation. The basic idea is the in-situ implementation of an integrated project by the students, using on-line an institutional web provider of thematic data familiarizing themselves with a series of software applications for data analysis, vector- and raster-wise graphic design, image processing etc, which are assembled in a working flow.

A team of three academic staff members,[5] assisted by two volunteers,[6] and a senior student,[7] guides the class, supported remotely, by a networked researcher, who contributed in the initial development of the project and now is based abroad.[8]

The TC course is backed by a dedicated web page,[9] which is the on-line reference of the students for downloading the exercises and get general and targeted information on the course and relevant student activities, also with links to relevant sites.

2.2. Steps and targets – The data provider

The main concern of this plan in the teaching strategy of TC for engineering students is to make them aware of the great importance of the linking with the underlying geospace of the ordered data coming either from the physical (natural) world or/and from the human world; all data requiring a TC

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[5] Profs Chrysoula Boutoura, Alexandra Kousoulakou and Evangelos Livieratos, AUTH-SRSE academic staff

[6] Dr. Maria Pazarli and Cand. Dr. Nopi Ploutoglou, Archives of Cartographic Heritage, by the General State Archives of Greece, Thessaloniki

[7] Dipl. Math. Filippos Makris, SRSE student

[8] Dr. Angeliki Tsorlini, Post-doc fellow at IKG-ETH Zurich

[9] The TC course web site: http://cartography.web.auth.gr/Thema_Carto

referenced mapping and visual monitoring. This is achieved perfectly using e.g. a valid institutional data provider as it is the EUROSTAT (2015a), selected for our project among other arguments due to the prestige and authority of this institution, which also attracts the interest and the attention of the students from the very beginning of the process *(Figure 1)*.

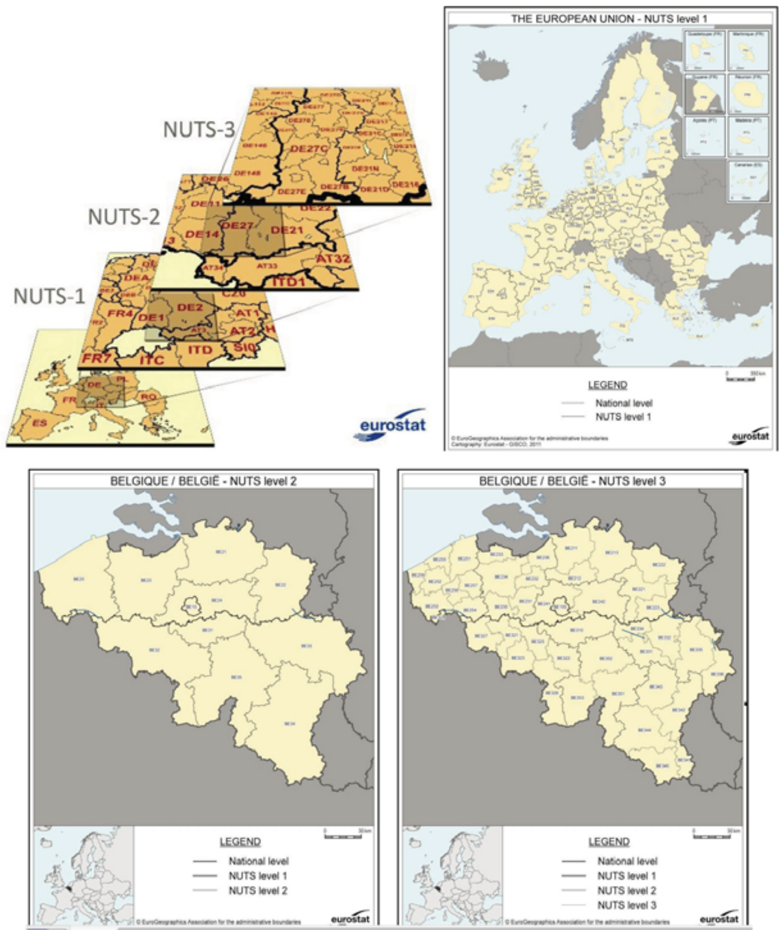

Figure 1. The NUTS classification (Nomenclature of territorial units for statistics) as a hierarchical system for dividing up the economic territory of the EU (Source: EUROSTAT portal)

The EUROSTAT (2015b) website gives the possibility to students to meet and browse the huge crowd of geospatial information collected over time and to familiarize themselves with the ordering of spatial units, which is a basic concept in TC *(Figure 2)*. This gives the students the direct view and understanding about the European geospatial arrangement in areal units for the better classification and management of information. The examples of good practices, including proper cartographic visualisation and the contexts of thematic issues treated, concerning the demographic, social, political, cultural and economic situation in Europe, easily retrievable and downloadable from the EUROSTAT (2015c) provider, familiarise students with the themes and show them the importance of organising properly the geospatial data in tabular and/or pictorial media the latter in terms of diagrams, cartograms and maps helping the students to consolidate the theoretical teaching and to draw "real life" conclusions on the spatial distribution of phenomena.

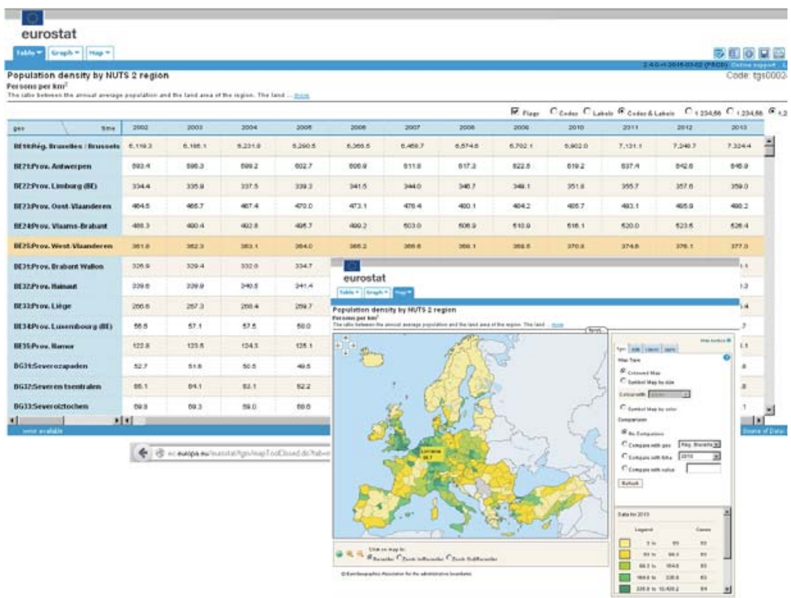

Figure 2. On-line thematic map directly associated with the database (Source: EUROSTAT portal).

The use of the EUROSTAT portal as the basic on-line provider of real and updated spatial thematic data, which are already represented on existing maps (used thus in the teaching process as examples of good or bad cartographic practice, if it is the case) or suitable to be represented in a new TC project carried out by the students, satisfies in a multipurpose ways the teaching strategy and work in the class, helping the in-situ concentration of the students' interest and self-acting but also the group work in testing and discussing alternatives. More, the students are encouraged to think different approaches for the treatment and representation of the available data and to learn to criticise constructively the solutions adopted by the EUROSTAT staff by elaborating and depicting the relevant data and the associated spatial distribution in their own alternative way, enriching this way their knowledge and training impact.

2.3. The cartographic implementation

The next step in the student work and the interaction with the tutor is the use and proper implementation of the rules of TC for the preparation of own thematic maps using the available basic software applications.

Thanks to the plan and the integrated approach, students are trained in the use of a range of software application for the mathematical and graphical management of spatially related information. The applications are used in a combined mode, following the combined use and learning procedure in order to prepare thematic maps properly representing point, linear, surface and volumetric data. Applications like Jasc PaintShop Pro, MicroSoft Office Excel, ColorBrewer, GoldenSoftware Surfer and other less known supportive software are used in a chain-wise flow for a "best" thematic mapping of data downloaded from the EUROSTAT portal in the EU regional spatial level according to the EU countries administrative division *(Figures 3 – 6)*.

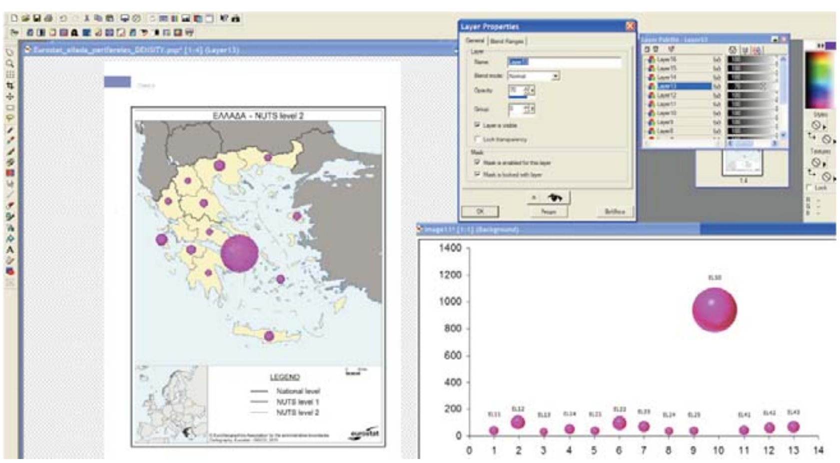

Figure 3. Preparing a thematic map with proportional point symbol using MS Office Excel and Corel PaintShop Pro.

Following this logic, the students are not stream-users of just one dedicated software application for the construction of a thematic map constrained upon a predefined typology from those taken among the very few existing for this purpose or as those in GIS applications.

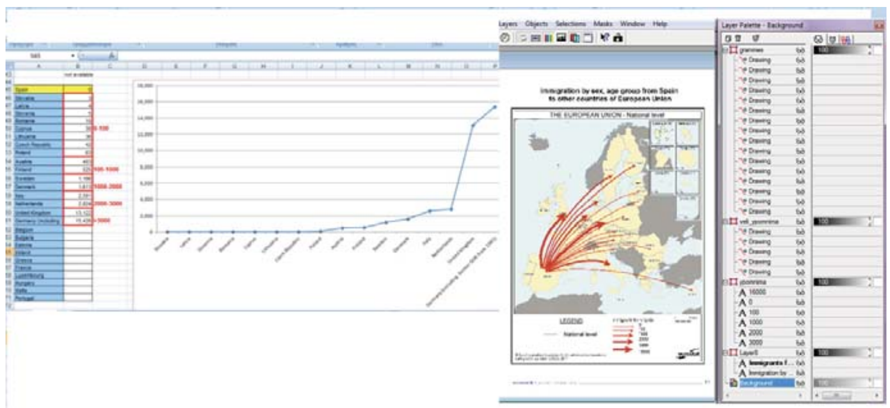

Figure 4. Preparing a thematic map with linear data depiction. The choice of optimal breaks classification using MS Office Excel and Corel PaintShop Pro.

On the contrary the students learn how to be unconstrained to just one possibility and constructive in combining a number of relevant software applications (usually easily available) becoming thus flexible *smart-users* having understood first the procedures and the rules for the best possible solution, according to the problem and the effective ways to its implementation.

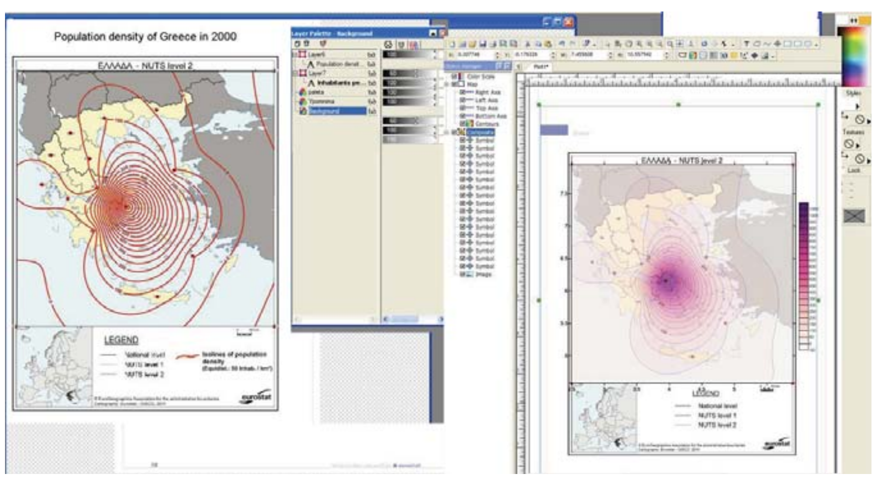

Figure 5. Compiling an isarithmic thematic map using MS Office Excel, Corel PaintShop Pro and GoldenSoftware Surfer.

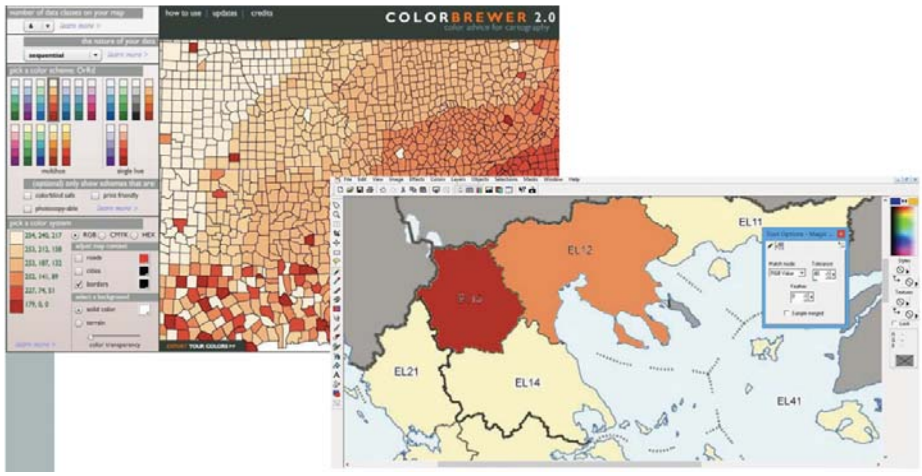

Figure 6. The production of a thematic choropleth map using the ColorBrewer utility.

2.4. The final project

The project on thematic mapping followed in the AUTH-SRSE TC class is using free online software, namely Indiemapper (2010), one of the few available for free, fuelled by data downloaded (equally for free) from the EUROSTAT portal *(Figure 7)*. After the experience gained with the use of a number of supportive software applications, the students are using an on-line available main application to construct a series of thematic maps. Having now the gained experience they can judge and face any gaps and imperfections to fill in the automation of such complex and multifaceted process, as it is the preparation of a thematic map, in order to satisfy the preset objectives i.e. the effective visualization and transmission of geospatial information, concerning especially issues like a properly designed title, legend, scale bar etc. which complete and enable the reading of the map. Almost always the map is further elaborated in other image processing or graphics editor software such as Paintshop Pro mentioned before, Adobe Illustrator or Adobe Photoshop.

The concept of this practical work is to make the students thinking and acting in preparing a thematic map, not only as simple users having got a surface contact on what TC is all about from the lectures-part of the course, but also as “first step cartographers”. This means that the students should be capable enough to decide, e.g. on the choice of the adequate map projection system, the selection and implementation of classification (optimal breaks, quantiles, equal intervals, manual classification etc) as well as on the design of a complete and functional legend. Considering in addition, that the students are in an engineering curriculum, they should be able to conceive, plan, organise, install and apply integrated processes for the production of a specific product output, in this case a thematic mapping project.

Figure 7. On line thematic mapping using the free software Indiemapper.

This approach concerns especially the engineering perspective since, by definition, the students are dealing with multitasking thematic data dealing with a variety of geo-related issues such as the environment, the transportation, and infrastructures, the cadastre and land registry, the geo-positioning of natural resources and other affine themes from the worlds of physical and human activities and interactions.

Some examples *(Figures 8 – 10)* of student-exercises, following the chain flow presented in this paper, illustrate the result of the process and the work done in the AUTH-SRSE TC class. The maps prepared using the on-line free software and finalised using additional image and graphics processing software.

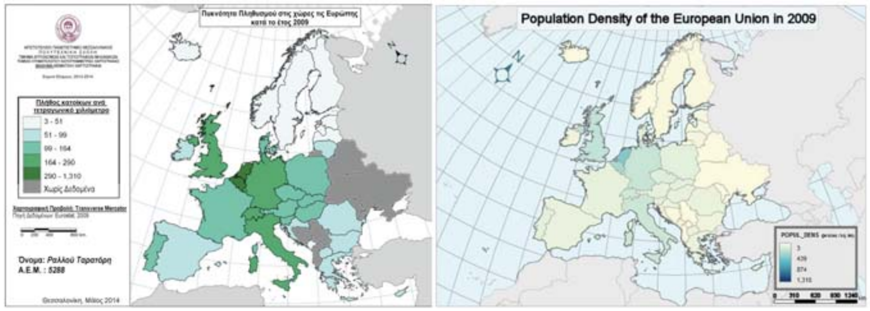

Figure 8. Student exercise: two graphic approaches to European population density

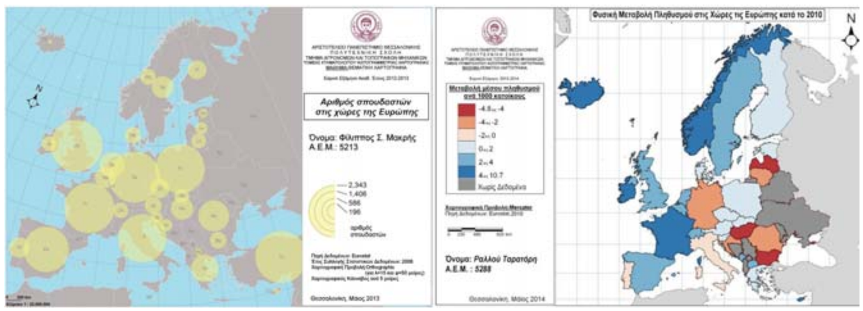

Figure 9. Student exercise: student population (left); population variation (right)

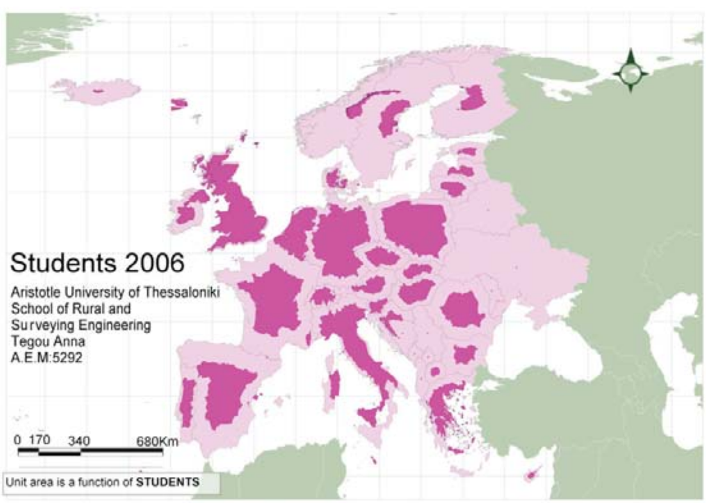

Figure 10. Student exercise: European countries according to student population; a "cartogram" onto a map.

2.5. Evaluation

The new revised teaching strategy in teaching TC in the AUTH-SRSE is developing since the academic year 2012-2013. The results are spectacular for an engineering class of a hundred students, all attending the course in-situ, each with a laptop or serviced by the SRSE desktop computer facilities, all in a wi-fi environment, for developing their own project.

Other benefits for the students were the rapid familiarization with all software available (the tendency to learn many software applications is popular among engineering students, especially when this is done in an real-life application environment, as it is the TC project), the consolidation and digest of the theoretical teaching given almost simultaneously with the preparation and guidance of any new step of the practical work, the understanding of TC as a key issue in a variety of many other study courses in all the three SRSE Departments and last but not least students look to appreciate to get direct free access to the numerical, textual, pictorial and map data base of a major European institution, as it is the EUROSTAT, portraying all data referred to the real social, political, economic and cultural life of the EU members states.

Figure 8. AUTH-SRSE students, mainly following the TC course, participated in the ICA 10th International Conference on *Digital Approaches to Cartographic Heritage* Corfu 27-29 May 2015. Here the students in educational visit in the Historical Archives of Corfu

It is especially visible the active interest and involvement of all students concerning both the class labour and the homework. In this field of students raised interest for cartography with TC as the vehicle, some other results have been observed in students behaviour towards Cartography, in general *(Figure 8)*: their dense participation in recent cartographic Conferences held in Greece, the 13th National Cartographic Conference Patras 22-24 October 2014, organised by the Hellenic Cartographic Society and the even denser participation in the 10th International Conference on Digital Approaches to Cartographic Heritage, Corfu 27-29 May 2015 organised by the ICA Commission on Digital Technologies in Cartographic Heritage.

3. Conclusion

Having implemented the re-designed TC course for four academic years now, it seems that the originally planned modifications and improvements to it, as described above, have so far been justified. This is manifested first of all in the results of the students' projects, compared to previous ones. Furthermore, the students themselves seem to appreciate the fact that they are provided with a multitude of tools in order to carry out their exercises, despite some inevitable initial complaints, they seem to quickly realise that the variety of tools they have to use for their exercises reflects a real-world situation and they rapidly appreciate and master the different software packages they are faced with.

Additionally, some feedback from students of the first academic year that the new TC course was implemented (and who are now almost at the end of their studies) seems to enhance this point; not only they appreciate in retrospect, but they also seem to develop an increased interest for cartographic and geographic topics, as compared to previous years. This is manifested not only in the dense and enthusiastic participation to national and international Cartography Conferences mentioned previously, but also in the increasing (compared to previous years) number of students who in the last two years follow the SRSE-DCPC elective courses, from the seven semester onwards. Hopefully this will set a trend for the future; in this context the TC course already is an example of good practice.

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Toponymy of Rio de Janeiro State, Brazil: From Historical to Current Maps – Research and State of Art

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Extended Abstract

This paper, developed by the Laboratory of Cartography´s team, from the Department of Geography of the Federal University of Rio de Janeiro, aims to present the research project on Toponymy of the State of Rio de Janeiro, Brazil, and spans from the beginning of its territory nomination to the current days.

The State of Rio de Janeiro is one of the 26 States of the Federative Republic of Brazil and currently has 92 (ninety two) installed municipalities and 188 districts. Distributed among those municipal districts there are approximately hundreds of villages or settlement nuclei and thousands of others place names, such as farms, rivers, mountains, beaches, lakes and lagoons, roads, natural parks. The study of this toponymy presents a portrait of the occupation of the state, from the early times of the 16^{th} Century to the currents days, allowing important cultural, linguistics and anthropological aspects on a geographical and historical approach.

The research is covered by a multi and interdisciplinary structure in which some areas are continuously intertwined, such as cartography, historical cartography, linguistics, anthropology, GIS, spatial data infrastructure, geography, history and toponymy evidently.

The applied methodology consists in structuring distinct phases, allowing the construction of a toponymic spatial-time database, where the toponyms are extracted from historical and current maps. From this database, the following information is defined for each toponymy: spatial positioning,

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linguistic study, toponymic motivation, toponymic evolution and its genealogy, as well as the socio-anthropological and cultural factors.

The project has the support of a vast historical and current cartographic documentation, written documents and field works, in which were created different methods for the extraction of place names. The cabinet works include the historical-geographical study, anthropological and cultural aspects and genealogy of place names, seeking the approval and certification to be included into the database called Geographical Names Database of the State of Rio de Janeiro (BNGERJ).

In order to picture the magnitude of the project relating to the worked volume of the handled information, so far have been cataloged and worked 57 historical maps on different scales ranging from 1: 150,000 to 1: 1,000,000; 387 sheets of topographical and municipal maps, ranging from 1: 50000 to 1: 2000 scale. There were extracted approximately 90,000 place names, of which 40,000 are in the classification process.

In addition to the field works that allow doubts clarification and certification of all place names, one municipality will be chosen from the current 92 of the State, which will enable to develop a deep toponymy collection process, in situ, within its limit. This procedure will allow comparative studies mainly on the social and cultural aspects of the area.

The research started in 2011 and still in the process due the large volume of information to be handled, as well as some financial support difficulties. Since every time it turns out an expansion of study possibilities and applications, the research is still on its way and there is no set deadline. In this aspect, is intended to suggest the creation of toponymic nucleus on each of the State municipalities.

In parallel with the research work, the metadata for place names and spatial data infrastructure that will be applied to the project is in its final phase of development.

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Some remarks on the question of pseudocylindrical projections with minimum distortions for world maps

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Extended Abstract

Atlases for the general public and for schools cannot miss chorographic world maps. The traditional expectations made on the planar representations of the known world – the symmetry, the scale invariance and the similarity – also apply to them. The latter two requirements should imply the smallest possible map distortions (the changes of lengths, angles and areas, which emerge during mapping) and on the other hand, the similarity of the outline of the mapped Earth.

In the aphylactic (neither conformal nor equal-area) projections both the angular and area distortions can be reduced by the principle of „balance of errors", using the Airy-Kavrayskiy criterion. This favourable index number gives the aggregated measure of the sum of angular and area distortions for the territory of the World. The pseudocylindrical map projections are often used in the field of representation of the Earth. The purpose of this paper is to construct some of such map projections which minimze this criterion, while the outline of the mapped Earth keeps an oval shape.

This task demands the determination of the appropriate „projection equations" $x(\varphi,\lambda)$ and $y(\varphi)$, which carry out the mapping of the curved Earth surface (parametrized by the geographic latitude φ and longitude λ) to the map plane (parametrized by the rectangular coordinates x and y). The minimization of the Airy-Kavrayskiy criterion is a mathematical problem known from the calculus of variations. The task was solved in two steps. The first one was directed to the function $y(\varphi)$, and the result was that the fairly good projection has to have true scale midmeridian without respect to the function $x(\varphi,\lambda)$ and the territory to be represented. The second step results in the right function $x(\varphi,\lambda)$ by the direct minimization of the above

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mentioned criterion, and the calculations used some different kinds of non-linear functions. The numerical values for the coefficients c_i of $x(\varphi,\lambda)$ were obtained with the help of the downhill simplex method.

The outline of the mapped Earth is favourable from the aspect of similarity, if the poles are represented as single points instead of lines, moreover, the curvature of the outline does not vary extremely in the environment of the poles. If we take into consideration both the value of the Airy-Kavrayskiy criterion and the change of the value of the curvature κ along the outline, we get some favourable projection solutions depending on the kind of the approximating function. These projections were introduced in this paper.

One of the preferred versions is the following:

The projection equations:

$$x = c_1 \cdot \left(1 + c_2 \cdot \varphi^2\right) \cdot \sqrt{1 - \left(\frac{2 \cdot \varphi}{\pi}\right)^2} \cdot \lambda$$

$$y = \varphi$$

where c_1=0.768, c_2=0.170; the parallels are equidistant.

The value of the Airy-Kavrayskiy criterion: 0.13522;

$\kappa_{\pm 90°}$=0.134 $\kappa_{\pm 85°}$=0.221

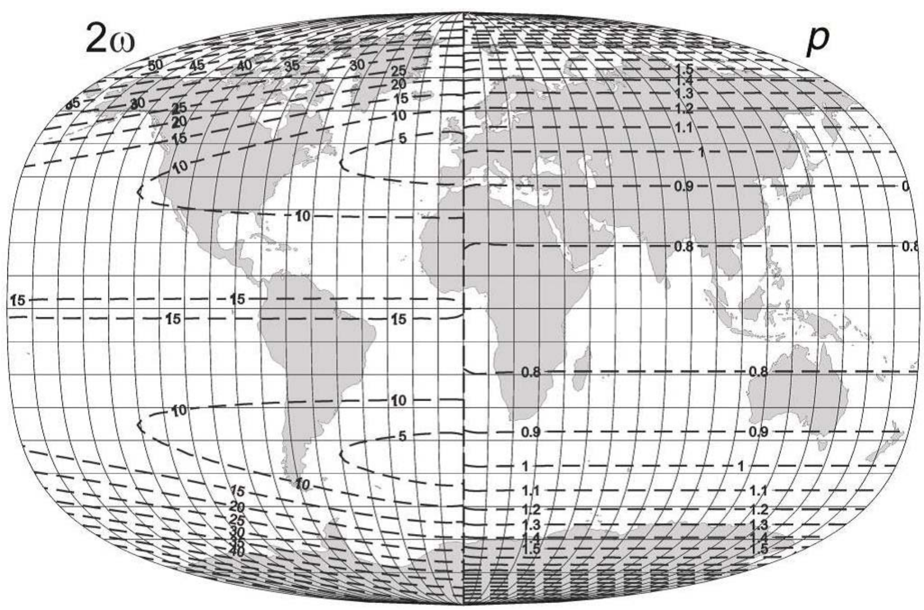

Figure 1 shows the isolines of the maximum angular deformation 2ω and the area scale p.

Map Projection Aspects

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Extended Abstract

A projection can have various aspects. What do projections in different aspects have in common? The answer is a mapping principle depicted by, for example, the representation of main and collateral circles and distortion distribution. How do aspects of the same projection differ? They differ according to the representation of contents, for example graticule form and position or orientation of represented elements (land, borders, etc.).

In this paper, we define projection aspects without referring to auxiliary surfaces and their axes. In fact, it is well known that mapping to auxiliary surfaces (cylinder or cone) which are to be developed onto a plane is only the case with a small group of map projections, e.g. perspective projections. All other projections map directly to the projection plane. Therefore, using terms which only refer to some cases in general definitions should be avoided.

Thus, the issue of map projection aspects is not only a linguistic issue, but relates primarily to the definition of the term. How can a map projection aspect be defined unambiguously? Is it even possible?

If we want to understand the concept of aspects in map projection theory, we first have to define the standard geographic coordinate system using geographic parameterization of a sphere. Analogously, we have to define the generalized or pseudogeographic coordinate system using pseudogeographic parameterization of a sphere. Then, we can establish the relation between the two spherical coordinate systems. It is possible to obtain each one from the other by rotating around the centre of a sphere, and each rotation in space is defined by three parameters.

Subsequently, the basic equations of map projection or an equivalent representation of map projection must be defined and that is a matter of convention. The map projection aspect can now be defined as the position of the

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projection axis in relation to the axis of geographic sphere parameterization.

At first, this may seem to provide a solution to the aspect problem, but this is not the case. The equations of a certain projection in a pseudogeographic system must still be formulated.

If we want to refer to the aspect of any other map projection, we must provide a definition in a pseudogeographic system in a similar way. In fact, projection categorization according to the shape of the normal cartographic network (cylindrical, conic, azimuthal, pseudocylindrical, etc.) is not unique, because, for example, an orthographic projection is both azimuthal and pseudocylindrical. Therefore, additional sorting criteria are required. We suggest the following additional criteria:

- author's definition of basic equations of map projection or an equivalent representation of map projection
- compatibility of the graticule's appearance with projection distortion distribution
- simpler appearance of the graticule
- simpler mathematical expressions

We propose the following definitions.

Basic equations of map projection are map projection equations which define a map projection in a pseudogeographic system.

The *projection axis* is the axis of pseudogeographic parameterization of a sphere, based on which the basic equations of map projection are defined.

The *projection aspect* is the position of the projection axis in relation to the geographic sphere parameterization axis. The aspect can be normal, transverse or oblique.

The *normal aspect* is the aspect in which the projection axis coincides with the geographic parameterization sphere's axis.

The *transverse aspect* is the aspect in which the projection axis is perpendicular to the geographic parameterization sphere' axis.

The *oblique aspect* is neither normal nor transverse.

Finally, we show that the definitions of the polar and equatorial aspects are imprecise and ambiguous, and should be avoided.

The Web Mercator Projection: A Cartographic Analysis

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Abstract. The well-known Mercator projection is widely used by web-based mapping services such as Google Maps, Bing Maps, in a modified version, which is called Web Mercator. This is the simplified version of the ellipsoidal projection, which is no more conformal. In this paper the properties of this projection, especially its deviation from conformality, is focused on. Additionally web-based 3D globe visualization is suggested as a possible alternative for online mapping.

Keywords. Map projections, Web Mercator, online mapping, GI Science, virtual globes

1. Introduction

Web-based mapping services are using a new type of cylindrical map projection adapted from well-known Mercator projection that is called Web Mercator. In this projection the geographic data based on WGS84 datum is transformed to the map by using spherical projection equations. The resulting projection is no more conformal. This adaptation is only beneficial in terms of computer graphics and tiling system that makes possible to publish maps at different zoom levels. Both the ellipsoidal Mercator and the Web Mercator projections are not suitable for the representation of the whole world or large parts of the world due to high scale changes towards poles.

Buttersby et al (2014) comprehensively analyzed the Web Mercator projection. They also give numerical and visual comparisons between ellipsoidal Mercator and Web Mercator. A similar analysis is given by NGA (2014).

Adaptive composite projections can be an alternative to Web Mercator projection (Savric & Jenny 2014, Jenny 2012).

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In this paper, the non-conformality of Web Mercator is mathematically shown and a numerical distortion analysis is given. The Web Mercator and the ellipsoidal Mercator projections are compared. As an alternative solution 3D virtual globe representation is suggested. Google provided such an opportunity that is deprecated lately. This was a good opportunity together with a web-based map that helps inexperienced users to understand shape changes caused by map projections.

In the following sections the basic problem of map projections is introduced. Mercator projection and Web Mercator adaptation is mathematically explained and compared. The difference between spherical and ellipsoidal latitudes is explained. Then virtual globe representation possibility is discussed. At the end some conclusions are given.

2. The Map Projection Problem

The earth's surface is represented by maps. Since the surface is curvilinear it must be transformed to the plane. The term map projection refers to this transformation process, and defined by two functions that relate geographical coordinates on the reference surface to the coordinates on the map plane.

2.1. Reference Surface

The surface of the earth is represented either by a sphere or by an ellipsoid for mapping purposes. The geometry of the sphere is rather simple. It has only one parameter, the radius. Spherical earth radius is determined by using ellipsoid dimensions. Mostly an authalic sphere is used of which surface area equals to the surface area of the ellipsoid. For each ellipsoid an authalic sphere can be defined. For WGS84 ellipsoid the authalic sphere radius is approximately 6371km.

The earth can be represented by an ellipsoid of rotation, also called spheroid, depending on two parameters, the equatorial radius (a), and the polar radius (b). The flattening, first and second eccentricity are given by the following equations.

$$
\begin{aligned}
f &= \frac{a-b}{a} \\
e &= \sqrt{\frac{a^2-b^2}{a^2}} \\
e' &= \sqrt{\frac{a^2-b^2}{b^2}}
\end{aligned}
\tag{1}
$$

Since the curvature is not constant on the surface, the radius along meridians (M) and perpendicular to meridians (N) are used in calculations, both depend on the latitude.

$$M = \frac{a\left(1-e^2\right)}{\left(1-e^2\sin^2\varphi\right)^{\frac{3}{2}}} \qquad N = \frac{a}{\sqrt{1-e^2\sin^2\varphi}} \tag{2}$$

2.2. Map Projection

A map projection is defined by two functions.

$$x = x(\varphi,\lambda) \qquad y = y(\varphi,\lambda) \tag{3}$$

These functions define a transformation from the reference surface to the map plane, which is also called forward transformation. An inverse transformation is also needed, accordingly.

$$\varphi = \varphi(x,y) \qquad \lambda = \lambda(x,y) \tag{4}$$

The reference surface is undevelopable to the plane. Therefore the original surface is distorted after map projection transformation. The differential scale changes around a point that are called distortions are investigated by using a differential circle on the original surface and its projection that is an ellipse in general. According to Tissot semi-axes of this ellipse are perpendicular both on the original and projection surface. At the same time the semi-axes (m_1, m_2) correspond to the principal directions where the linear differential scale or linear distortion maximum and minimum (Richardus & Adler 1972). They are derived from partial derivatives of forward transformation equations (m_1: maximum, m_2: minimum). The formulae for unit sphere:

$$(m_1+m_2)^2 = \left(\frac{\partial y}{\partial\varphi}+\frac{1}{\cos\varphi}\frac{\partial x}{\partial\lambda}\right)^2+\left(\frac{\partial x}{\partial\varphi}-\frac{1}{\cos\varphi}\frac{\partial y}{\partial\lambda}\right)^2$$
$$(m_1-m_2)^2 = \left(\frac{\partial y}{\partial\varphi}-\frac{1}{\cos\varphi}\frac{\partial x}{\partial\lambda}\right)^2+\left(\frac{\partial x}{\partial\varphi}+\frac{1}{\cos\varphi}\frac{\partial y}{\partial\lambda}\right)^2 \tag{5}$$

Linear distortions along meridians (h) and parallels (k) (unit sphere):

$$h = \sqrt{\left(\frac{\partial x}{\partial \varphi}\right)^2 + \left(\frac{\partial y}{\partial \varphi}\right)^2}$$
$$k = \frac{1}{\cos\varphi}\sqrt{\left(\frac{\partial x}{\partial \lambda}\right)^2 + \left(\frac{\partial y}{\partial \lambda}\right)^2} \tag{6}$$

Maximum direction distortion (ω) and area distortion (p):

$$\sin\omega = \frac{m_1 - m_2}{m_1 + m_2}$$
$$p = m_1 m_2 \tag{7}$$

3. Mercator and Web Mercator projections

The term Web Mercator is used to define a modified variant of Mercator projection used by web based mapping services such as Google Maps, Bing Maps, Open Street Map and etc.

3.1. Mercator projection

Mercator projection is one of the well-known projections, which is classed as cylindrical and conformal. The most known property of this projection is that the rhumb lines are depicted as straight lines. The length of the equator is preserved in the projection, which is also termed projection with one standard parallel. It is conformal, but distorts the areas towards poles too much. At 60° latitude areas are 4 times exaggerated. Since the poles go to the infinity in the projection plane, polar areas can not be shown. Despite not being suitable, it has been widely used for world maps.

The spherical Mercator projection is defined with the functions below.

$$x = R\lambda$$
$$y = R \ln \tan\left(\frac{\pi}{4} + \frac{\varphi}{2}\right) \tag{8}$$

Since the projection is conformal, linear distortion (differential linear scale) is constant around a point.

$$m = \frac{1}{\cos\varphi} \tag{9}$$

If the projection is implemented with two standard parallels, area and distance distortions can be diminished in some extent. The projection equations and linear distortion are as follows (φ_0 being the latitude of the standard parallels in north and south).

$$x = R\cos\varphi_0 \lambda$$
$$y = R\cos\varphi_0 \ln\tan\left(\frac{\pi}{4}+\frac{\varphi}{2}\right) \qquad (10)$$
$$m = \frac{\cos\varphi_0}{\cos\varphi}$$

The ellipsoidal Mercator projection equations with one standard parallel are below (Richardus & Adler 1972, Battersby 2014, NGA 2014):

$$x = a\lambda$$
$$y = a\ln\tan\left(\frac{\pi}{4}+\frac{\varphi}{2}\right)\left(\frac{1-e\sin\varphi}{1+e\sin\varphi}\right)^{\frac{e}{2}} \qquad (11)$$

Linear distortion is constant in any direction around a point.

$$m = \frac{a}{N\cos\varphi} \qquad (12)$$

The ellipsoidal projection can also be implemented with two standard parallels.

3.2. Web Mercator

The Web Mercator projection is a modified version of the Mercator projection, in which the WGS84 Ellipsoid (a=6378137.0 m, e^2= 0.00669438) is projected to the plane as if it were a sphere. The Cartesian coordinate system in the projection plane is arranged to meet the conventions in computer graphics, x right, y down (Fig.1). Because the poles can not be shown, the map at the smallest scale is arranged to be a square of 256x256 pixels. This map is assumed at the zoom level 0. The map size increases with the zoom level (n) (Google 2015a, Microsoft 2015).

$$x = \frac{128}{\pi}2^n(\lambda+\pi)$$
$$y = \frac{128}{\pi}2^n\left(\pi-\ln\tan\left(\frac{\pi}{4}+\frac{\varphi}{2}\right)\right) \qquad (13)$$

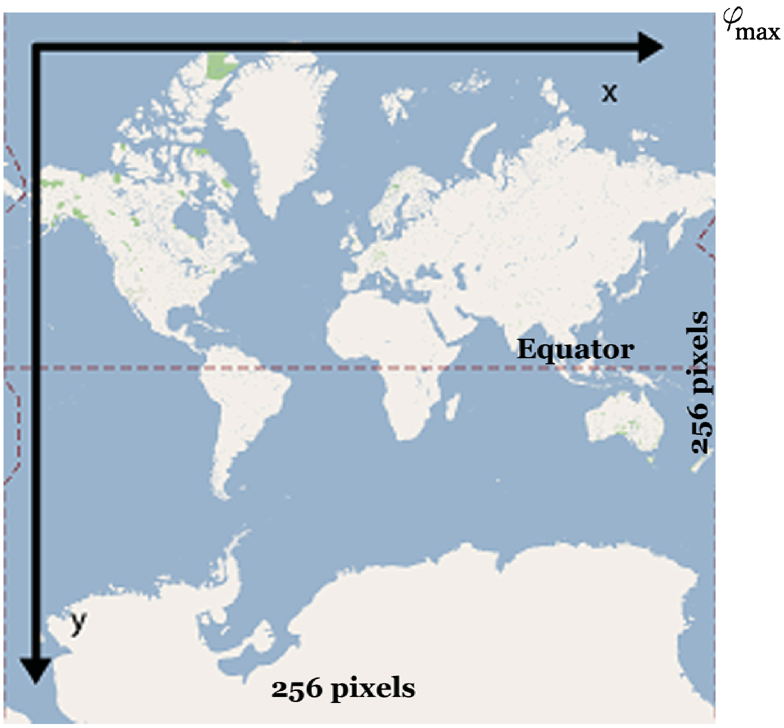

Figure 1. The Cartesian coordinate system in Web Mercator

Here the distance unit is pixel, of which physical size depends on the monitoring device. The maximum latitude can be obtained by setting y=0.

$$\ln\tan\left(\frac{\pi}{4}+\frac{\varphi_{\max}}{2}\right)=\pi$$
$$\varphi_{\max}=2\arctan e^{\pi}-\frac{\pi}{2} \qquad (14)$$

The numerical value is ±85.05129°, which is the north-most and south-most latitude of the map.

The spatial resolution of 1 pixel:

$$1\,pixel=\frac{\pi a}{2^{n+7}}\,meters \qquad (15)$$

The web mapping services use zoom levels up to 18, in general (e.g. Google Maps). The spatial resolution of 1 pixel ranges from 156 km at zoom level 0 to 0.60 m at zoom level 18.

Inverse projection:

$$\varphi = 2\arctan e^{\pi - \frac{\pi y}{2^{n+7}}} - \frac{\pi}{2}$$
$$\lambda = \frac{\pi x}{2^{n+7}} - \pi \tag{16}$$

Since the ellipsoid surface is projected onto the plane with spherical projection equations, Web Mercator projection is no more conformal. To evaluate the distortions occurred in this projection a metric Cartesian coordinate system is necessary. If we use a north-east xy system, where x corresponds to the zero-meridian and y to the equator, projection equations become as follows.

$$x = a\lambda$$
$$y = a \ln \tan\left(\frac{\pi}{4} + \frac{\varphi}{2}\right) \tag{17}$$

The principal directions at which linear distortion is maximum and minimum are coincident with the projected meridians and parallels.

$$h = \frac{1}{M}\frac{dy}{d\varphi} = \frac{a}{M\cos\varphi}$$
$$k = \frac{1}{N\cos\varphi}\frac{dx}{d\lambda} = \frac{a}{N\cos\varphi} \tag{18}$$

As seen from Eq. 18, the linear distortion is not constant which means that the projection is not conformal. Since $h > k$, linear distortion is maximum along meridians. Table 1 shows the projection distortions at certain latitudes. It is seen that the deviation from conformality decreases towards poles. The maximum direction distortion is maximal at the equator. The area distortion (p) is too high above 60°. In table 2, one degree meridian arc length in WGS84, Web Mercator and ellipsoidal Mercator are shown. The modification of the projection causes differences in Northing up to 9751 m, which is actually not a negligible value.

φ	h	k	p	ω
0°	1.006739	1.000000	1.006739	11' 32.7"
10°	1.021961	1.015324	1.037621	11' 11.9"
20°	1.070092	1.063761	1.138322	10' 11.9"
30°	1.159566	1.153734	1.337830	8' 40.0"
40°	1.308756	1.303601	1.706096	6' 47.1"
50°	1.556989	1.552665	2.417482	4' 46.8"
60°	1.998334	1.994973	3.986623	2' 53.6"
70°	2.917448	2.915150	8.504798	1' 21.3"
80°	5.741212	5.740046	32.95482	0' 21.0"
85°	11.43612	11.43554	130.7782	0' 5.3"

Table 1. Distortions in Web Mercator projection

φ	WGS84	Web M.	Mercator	Difference (WM-M)
0°	110574.389	111325.1	111312.0	13.1
10°	110611.187	113216.8	112942.0	274.8
20°	110710.615	118847.7	118310.8	536.8
30°	110860.926	129199.3	128396.9	802.4
40°	111044.261	146399.4	145318.3	1081.1
50°	111238.681	175017.9	173620.6	1397.2
60°	111420.728	226085.3	224268.1	1817.2
70°	111568.259	333556.5	330999.0	2557.5
80°	111663.201	675090.0	670299.7	4790.3
85°	111687.001	1424698.4	1414946.5	9751.9

Table 2. 1° meridian arc length on WGS 84, Web Mercator and Ellipsoidal Mercator and differences between Web Mercator and ellipsoidal Mercator (length unit: meters)

3.3. Latitude difference

One drawback of the Web Mercator implementation is the assumption of ellipsoidal latitude as if it were spherical. There is a difference between ellipsoidal and spherical latitudes. Web Mercator projection uses a sphere of which radius equals the equatorial radius of WGS84 (a). The spherical latitude, where $R=a$, is approximately equals to the central latitude of the ellipsoid (Figure 2).

$$\tan\gamma \cong \left(1-e^2\right)\tan\varphi \quad (19)$$

If spherical calculations are performed with latitudes taken from a web mapping service such as Google Maps, the differences should be taken into account.

The geometry library of the Google Maps API ignores this difference in latitude, and performs the spherical calculations with ellipsoidal latitude as if it were spherical (Google 2015c).

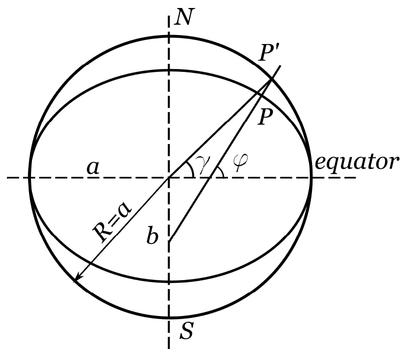

Figure 2. Ellipsoidal and spherical latitude

If the central latitude was used in the Web Mercator projection, the resulting projection would be conformal.

4. An Alternative solution: virtual globe representation

It is obvious that either Web Mercator or ellipsoidal Mercator is not a good choice for web mapping, because of high scale changes towards poles. The geodesic lines are too distorted in long distances. People who are aware of projection distortions can easily understand why geodesic lines are longer than the straight line connecting points of interest. Figure 3 shows a geodesic line connecting Istanbul and New York in Goggle Maps and Google Earth. The appearance is too different in map and virtual globe.

Virtual globe view is a good alternative to Web Mercator. In Google Maps API v2, now deprecated, switching to Google Earth View was possible. This option is no more supported in the current version (v.3). Google launched Google Earth API that make possible to have Google Earth within a web site, as a mashup. This API was functional under certain platforms with a plug-in. It is deprecated lately (Google 2015b). Bildirici et al. (2014) combined Google Maps API and Google Earth API for educational purposes within a single map mashup. Their mashup made possible to compare rhumb-lines and great circles on the map and on the globe.

By using virtual globe representation the Polar Regions are shown, which is not possible in Web Mercator. Web mapping services should make possible globe views with map and satellite options to avoid misunderstandings caused by Web Mercator. It would be a good opportunity for inexperienced users in terms of map projections.

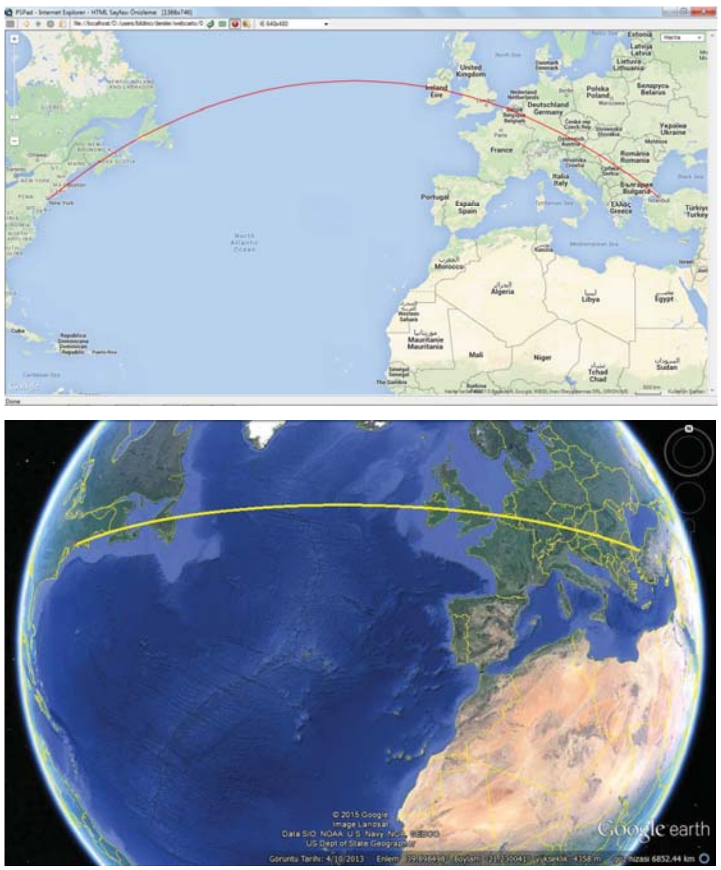

Figure 3. A geodesic line connecting Istanbul and New York in Google Maps and Google Earth (8072 km)

5. Conclusion

Web Mercator projection as a variant of well-known Mercator projection becomes a de facto standard widely used by online mapping services such as Google Maps, Bing Maps etc. Despite being unsuitable in terms of map projection distortions, it is beneficial in terms of computer graphics and tile system that makes possible to realize different zoom levels of map data. It is especially important that the graticule appears rectangular that matches the Cartesian coordinates on the map plane. Only cylindrical projections enable such an opportunity. Virtual globe representations are another way of web-based visualization. Google supported earth view in the previous version of Google Maps API, and later launched Google Earth API. Both are deprecated now. Since globe representation is a 3D visualization not affected by map projection distortions, their use is beneficial together with 2D map. Such possibilities can help map users to understand changes in geometry caused by map projection.

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A Semi-automatic Approach for Determining the Projection of Small Scale Maps Based on the Shape of Graticule Lines

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Extended Abstract

Knowing a map's projection is of essential importance. This is particularly true when using them as a source for creating derivative works, dealing with them in a GIS environment or when meta-data is assigned to these maps during the process of cataloguing in a library. However (especially on older maps), projection information is often absent or partially present. This problem is dealt with in a number of different ways in contemporary cartographic practice. The most common is to ignore the question of projections and use ground control points (with known geographic and image coordinates) to associate the image with its location in geographic space. This method is called georeferencing and is very broadly used. Georeferencing however, if used improperly, can introduce transformation errors that make these maps unsuitable for further use.

The related problem of determining the projection of maps, then using the resulting information for the purposes of georeferencing has not been studied in great depth historically. This is mainly due to the fact that such analysis would have required abundant computing resources that were unavaliable even a couple of decades ago. In the recent years however, several approaches were developed that allow us to make educated guesses about unknown cartographic projections. (Bernhard & Lorenz 2011), (Bayer 2014).

Our objective is to develop a semi-automated approach for determining the projection and projection parameters of a small-scale map. This both provides the meta-data needed for cataloguing and also serves as an aid for more precise georeferencing. Our method is based on the shape and secondary properties of a map's graticule lines. The method was first outlined in a study by György Érdi-Krausz (1958) then later refined by János Györffy (2012). Érdi-Krausz's study is concerned with the analysis of

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cartographic projections and describes a hierarchy for determining an unknown projection. The hierarchy is formulated as a decision tree with a set of questions. These can be answered by calculating different properties (primarily the shape) of graticule lines found on the map in question. While Érdi-Krausz provides methods for assessing these properties on printed maps using cartometric analysis (manual measurements), our approach automates these calculations using different algorithms and makes Érdi-Krausz's method work on maps that are given as digital raster images.

To this end, a web-based application is created. Its user interface is explicitly designed to be usable by a non-professional audience. Drawing tools are provided for manually tracing graticule lines and poles on raster maps uploaded by the user. Given the approximate traces of these lines, we run a three-stage analysis on them to determine the shape and secondary properties of graticule lines, then the exact parameters of the projection. In the first step, we employ a complex curve fitting algorithm to determine the primary shape of graticule lines. We are able to distinguish between a number of different curve types (non-degenerate conic sections circles, ellipses, parabolae and hyperbolae using the conic fitting algorithm by Wijewickrema et al. (2010) and straight lines). Recognition of the curve type allow us to ascertain the approximate category our projection fits into. However, to determine the exact type of the projection, we also need to compute other properties, such as the spacing between graticule lines, their angles and coordinates of intersections, their concentricity and parallelism. Having computed these properties, one can fit the projection into Érdi-Krausz's system. In a third step, further (projection-specific) computations allow us to ascertain the exact parameters of the projection, thus emitting georeferencing meta-data associated with the raster map in question. The algorithms we use are cheap in terms of computational resources and fast enough to allow semi-realtime processing.

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A Forgotten Atlas of Erwin Raisz: "Atlas de Cuba"

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Extended Abstract

The "Atlas de Cuba" was published in 1949 by the Institute of Geographical Exploration at Harvard University. This atlas is result of collaboration between Erwin Raisz (1893–1968), the American cartographer born in the former Austro-Hungarian Monarchy and a Cuban geographer and cartographer, Gerardo Canet (1911–2011), who spent a grant obtained from the Guggenheim Foundation to work as assistant professor under the tutelage of Erwin Raisz in the Department of Cartography of the Institute of Geographic Explorations at Harvard University between 1945 and 1949.

Using Canet's words in the Introduction, the atlas is "*a living picture of Cuban Geography as far as possible in 64 pages*". A total of 34 themes were represented by maps and graphics:

- Introduction: Cuba, center of the Americas; The world around Cuba
- History of the country: Discovery, conquest and colonization; Colonial Cuba; Revolutionary Cuba
- Physical geographical characteristics: Climate; Hurricanes; Magnetism, gravity and earthquakes; Oceanography; Geology; Geomorphology; Soils; Forestry; Fisheries; Vegetation
- Major parameters to describe the society: Population; Standard of living; Health; Social composition; Government; Tourist trade; Education
- National economy: Agriculture; Sugar; Minerals; Tobacco; Coffee; Winter vegetables; Fruits; Other crops; Livestock; Industries; Communications; Import and Export

The atlas is the rich combination of maps with pictures, charts and short explanatory texts written in Spanish and English. The authors not only

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wanted to create an atlas for scientists and specialists with the different topics represented in the maps: their intention was to make all this information available and easily understandable for the public in general (*Figure 1*).

Figure 1. Examples of flow map (Canet & Raisz 1949: 49) and dot map completed with the isotypes of Neurath (Canet & Raisz 1949: 54)

The atlas joined two peculiar cartographic styles: the delicacy of the drawing ability of Erwin Raisz and Canet's interest to represent the broader spectrum of data collected by him with the collaboration of Cuban scientific personalities and governmental institutions, using all the graphic tools at their disposal to make the atlas more attractive.

Considering that the Academies of Sciences of then Soviet Union and of Cuba (founded in 1962) published the National Atlas of Cuba only in 1969, it is undeniable that the atlas of Canet and Raisz was worthy of being recognized as a meritorious work of the Cuban cartography in the period 1949–1969. It was the only atlas summarizing the most characteristic aspects of the country with a degree of detail and scientific rigor according to the level of the Cuban scientific development at that time.

Since 1961 this place was and even today, 15 years after having begun the 21st century, is denied by Cuban scientific and politic authorities with the deliberate official ignorance of its existence, causing that it is an unknown work for the new generations of Cubans.

Paradoxically the international valuation of the atlas has grown over the years. Currently, it constitutes an extremely valuable and rare piece of universal cartography, because of the participation of Erwin Raisz in its creation and the small number of copies that have stood the test of time.

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The Matteo Ricci 1602 Chinese World Map: the Ptolemaean Echoes

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Extended Abstract

The Matteo Ricci's (1552-1610) World Map (WM) made in 1602 is the third, more advanced, after his two earlier maps made in 1584 and in 1600. It is of main importance for the cartographic heritage of both China and Europe, printed in Chinese by this emblematic Jesuit missionary, during the very late period of the Ming Dynasty. The Ricci's 1602 WM entitled *Kunyu Wanguo Quantu (A Map of the Myriad Countries of the World* or *Complete Geographical Map of all the Kingdoms of the World)* was printed in several copies most now lost and it is the advanced version of the earlier Ricci's map entitled *Complete Map of the World's Mountains and Rivers* with rough depictions of the continents. In the paper, the test-approach to Matteo Ricci WM is following, in general, Bertin's (1967) analysis concerning the *external* and *internal recognition* theory for the map reading and evaluation.

From the analysis of some selected cartographic recognition items of this map, following Bertin's *external* and *internal recognition* theory for the map reading and evaluation, some conclusions are drawn that either confirm or contrast some so far established stereotypes, especially on what European school of cartography models the map was presumed to refer. It is shown that the foundation of Ricci's geographic and cartographic thinking was of Ptolemaean descent and that for the positioning of places, with respect to the graticule of meridians and parallels, Ricci follows the Ruscelli's Italian version of Ptolemaean *Geographia*, which is evidently a derivative of Gastaldi's counterpart, using an oval map projection variant. This projection is clearly a derivative of previous Italian models, mainly Venetian, and not of models used by the Atlantic schools of European cartography. It is also shown that the oval projection, popular in 16th century, is nothing but a derivative of Ptolemy's second projection, under a fourth order polynomial transformation.

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Concerning the placement of the Americas eastwards, the *flattery scenario,* popular in the so far encountering with the issue, is critically discussed in terms of two other legitimately possibilities: the *technical scenario,* related to the practical drawing issues requesting spatial commodity for a comfortable representation of China in detail, and the *cultural scenario,* which is discussed in depth, based on Ricci's classical educational background and of his technical geographical preparation at the Collegio Romano under Clavius, embedded this preparation into the very specific spiritual environment of the Roman Church, the Jesuit missionary was strongly linked with. If the *cultural scenario* is valid, fuelled with existing relevant evidences, then the Ptolemaean echoes in Ricci's Chinese map, already sound in his representation of the *Œecumene*, become even stronger.

The paper shows further how the research on Matteo Ricci's WM is today boosted thanks to digital technologies used for the analysis and interpretation of relevant cartographic heritage issues, offering valuable insights for the understanding of the cultural dimension of Chinese cartographic legacy. There is no doubt that comparative analyses of the geometric content of this unique map could also open more space for additional reading and evaluation. Finally, it is also stressed that a proper global approach to this map should be attempted, not only concerning Ricci's missionary priorities in China, but also his cultural and intellectual environment of his original education, in the context of the geographic ideas and skills he gained in Rome.

In conclusion, the paper shows that the presumed influence of the Atlantic school of European cartography on Ricci's map, as proposed sometimes, seems to be a rather weak consideration. On the contrary, a multichannel echoing of Ptolemaean cartography is more than evident in Ricci's map, as the analysis of fundamental map-elements can demonstrate. The Ptolemy's echoing and the meta-Ptolemy advances in the Mediterranean school of European cartography, of Italian origins, obviously embrace the Matteo Ricci's Chinese WM in its legacy.

The Eurocarto heritage

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In 1970's a group of scientists in the fields of cartography and geo sciences research, as well as practitioners in the USA and Canada decided to initiate a series of conferences named Auto Carto. Some years latter one of European Fathers of GIS and automated cartography – David Bickmore of the UK proposed to the European cartographic community another conference focused on same scope of investigations like North American colleagues. He invented a name of the conference Eurocarto.

The first one has been held in December 1981 in Oxford, where in 1964 David Bickmore and Ray Boyle presented "The Oxford System of Automatic Cartography" to our community. At that conference there were discussed a key issues of the computer assisted, or computer aided, or automated cartography, like thematic mapping with the use of computers, automated name placement or generalisation algorithms.

There were present a number of outstanding British and non-British cartographers of that time. Namely, Joel Morrison (USA) – future ICA President, Stein Bie (Norway), Tom Waugh (UK) – an author of GIMMS system, Peter McMaster (UK) – future Ordnance Survey General Director, Mike Klein (UK) – an owner of the first GIS private company in UK, and many others. At the closing session we agreed that the conference should be repeated in other European countries.

The series of the conferences has been endorsed by the International Cartographic Association as an important contribution of European cartographers to the discussion on the modern cartography. In the next years 13 conferences, following the first one took place in many location in Europe (all together 14), namely:

- Eurocarto II in Bolkesjö – 1983,
- Eurocarto III in Graz – 1984,
- Eurocarto IV in Frankfurt am Main – 1985,

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- Eurocarto V in Paris – 1986,
- Eurocarto VI in Brno – 1987,
- Eurocarto VII in Enschede – 1989,
- Eurocarto VIII in Palma de Maiorca – 1990,
- Eurocarto IX in Pultusk – 1991,
- Eurocarto X in Oxford – 1992,
- Eurocarto XI in Kiruna – 1993,
- Eurocarto XII in Copenhagen – 1994,
- Eurocarto XIII in Ispra – 1995,
- Eurocarto XIV in Lyngby – 1997.

Main focus of the conferences has been initially directed to the digital cartography, evolving to GIS relevant topics. In 1990's some sessions have been devoted to the first attempts of establishing a spatial information infrastructure, namely by David Bickmore's idea of the World Digital Database for Environmental Science.

Each of the Eurocarto conferences has had its own character and own thematic scope. They varied from methodological approaches (like digital cartographic modelling) thru regional related issue (like *Mapping Technology for Societies in Transition*) to European level considerations (like *Pan-European Environmental Policy: some relevant GIS applications*).

Most of the issues presented and discussed during the Eurocarto meetings has been already solved and today seems so obvious. However, for a long time they provided a unique opportunity for European cartographers to meet and discuss the most essential issues of contemporary cartography and Geographic Information Science. Many of participants of those conferences are still active in our discipline and their experiences of the past scientific events can be used in the new series of conferences for European cartographers and GI scientists.

Iconographic Sources of Swedish Campaign in 1647 in Bohemia in Multidisciplinary Research

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Extended Abstract

Iconographic sources depicting Thirty Years' War battlefields in the Czech lands can be found in historical graphic works printed in the most comprehensive documentary publication of the 17th century, the Theatrum Europaeum. Swedish campaign of the year 1647 left behind the most numerous and best preserved traces in the landscape of the Czech lands. The paper focuses primarily on engravings related to war events at the locations of Cheb, Třebel and Teplá in western Bohemia. It presents interim results of interdisciplinary research the transformed landscape of the Thirty Years' War in today's Czech Republic using these iconographic sources (more to this in (Janata, Zimová 2013), which involves the combination of archaeology, history and art history with tools of spatial analyses, digital terrain modelling and new possibilities of airborne laser scanning data processing. This research is linked to the complex archaeological and historical research of the former Třebel battlefield from the year 1647 (Matoušek 2006; Grabolle et al. 2009), which emphasized the possibilities and significance of the specific and narrative value of iconographic sources.

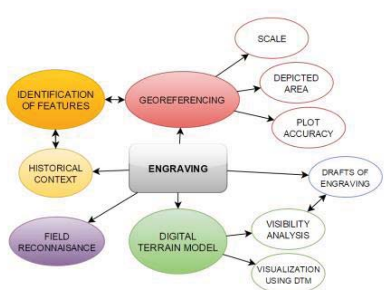

Figure 1. Research methods and their relations.

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The processing of engravings (as shown in Fig. 1) involves several individual activities slightly different for various engraving depending on their properties. The process methodology may involve following steps:

Identification of features in engravings and putting them into historical context, which is a connected process. To do so, descriptions linked to the image of the situation (e.g. legends, accompanying depictions, etc.) and, more importantly, documentary publications from the period can be used, which often describe the course of battles in sufficient detail. Elements of the image such as various settlements or individual buildings, bodies of water or roads networks can all be used to georeference the engraving to other cartographic sources, which is crucial for further analysis.

Further, visibility analyses are performed using the digital terrain model which serves to reconstruct height conditions of the depicted landscape and to identify the points from which the authors of the engravings may have created their source drawings. With the help of terrain models, we can verify the possibilities of visibility from individual elevated standpoints.

Using several methods, the scale number of engravings is estimated. Usually by establishing an approximate scale for various directions (two are sufficient in practice), in case of a sufficient amount of points a map of contour lines of the scale number may be constructed. The engravings primarily show a medium scale ranging from 1 : 8,000 to 1 : 25,000.

The engravings might have served not only as documentary images of the battle scene, but also as plans of the construction of fortification systems or tactical planning. The project is highly original in terms of Central European studies as it takes an interdisciplinary approach aiming to combine written, cartographic, archaeological, iconographic and environmental sources with systematic co-operation within a broad spectrum of research fields.

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Overview of the geological mapping in Transylvania in the 19th century

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Extended Abstract

In Transylvania (as part of the Habsburg Empire and later the Austro–Hungarian Monarchy), the systematic and detailed geological mapping was started in the mid-19th century. These were the times when the scientific conception of geology – as a separate branch of science – completed itself, and simultaneously it developed its own cartographic representation methods (which distinguish the geological formations according to their age, formation conditions and lithological compositions) most suitable for the purpose (Brezsnyánszky & Turczi 1998; Barczikayné Szeiler et al. 2009).

The first early geological maps (more precisely petrographic and geognostic maps) were plotted mostly by foreign travellers or naturalists (e.g. Townson 1797; Staszic 1815; Beudant 1822; Lill von Lilienbach 1833; Boué 1834) using the earlier mining maps as well as topographic maps showing the occurrences of some mineral resources, e.g. the map by Marsigli (1741); the map by Wappler (1780); the map by Korabinszky (1791) (Brezsnyánszky 1985, 1996, Brezsnyánszky & Turczi 1998, Brezsnyánszky & Síkhegyi 2007). The compilation of the latter was stimulated by the economic booming of the regions liberated from the Turkish rule, and also by the increasing economic importance of mining (Barczikayné Szeiler et al. 2009). Based on geological data and earlier maps from the first half of the 19th century, Wilhelm Haidinger (1845) plotted the first overall geological (geognostic) map showing the entire Austrian Empire, including also Transylvania (Brezsnyánszky 1996; Barczikayné Szeiler et al. 2009).

The systematic geological mapping of the Habsburg Empire was also favoured by the foundation of the Imperial Geological Institute (Vienna, 1849) and of the Royal Hungarian Geological Institute (1869), as the industrial revolution required science-based geological researches (Pentelényi & Síkhegyi 2012).

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The systematic geological mapping was based on the 1:28,000 map sheets of the 2nd Military Survey, however only the deduced 1:144,000 detailed maps ("*Spezialkarten*") were published (Jankó 2007); consequently the first systematic geological mapping was performed also on the scale of 1:144,000, representing mostly the areas of the Empire rich in raw materials (Barczikayné Szeiler et al. 2009). However only one sheet ("*Tasnád és Szilágy Somlyó*") related to Transylvania has been published. The compilation of this map series was interrupted after 1880, because meanwhile the surveying and publishing of the map series on the scale of 1:75,000 ("*Geologische Karte*") – based on the topographic map sheets of the 3rd Military Survey – had started (Barczikayné Szeiler et al. 2009).

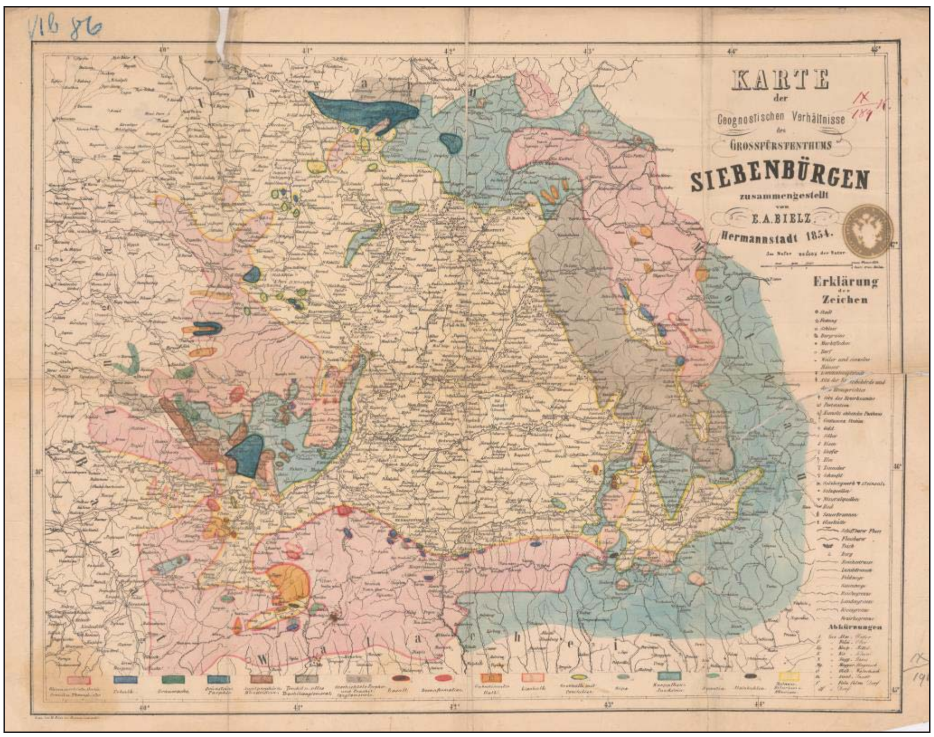

Figure 1. Karte der geognostischen Verhältnisse des Grossfürstenthums Siebenbürgen, 1:864,000 (Bielz 1854a) (Source: Collection of the Library of the Geological Survey of Austria).

In the mid-19th century, the topographic map sheets on the scale of 1:144,000 related to Transylvania were still not available (Brezsnyánszky 1996), because here the surveying activities started later, in 1853 (Jankó

2007). For this reason the geological mapping was based on the deduced general maps of the 2nd Military Survey on a scale of 1:288,000 and 1:576,000 („*Generalkarten*") (Jankó 2007, Brezsnyánszky 1996, Barczikayné Szeiler et al. 2009), and in the beginning even on the 1:864,000 overall maps of the 1st Military Survey. The geological researches as well as the mapping work were directed by Franz Ritter von Hauer (1822–1899) and Ferdinand Richthofen (1833–1905), with the participation of Eduard Albert Bielz (1827–1898), Karl Ferdinand Peters (1825–1881), Guido Stache (1833–1921), Dionys Štur (1827–1893) etc. (Brezsnyánszky 1996).

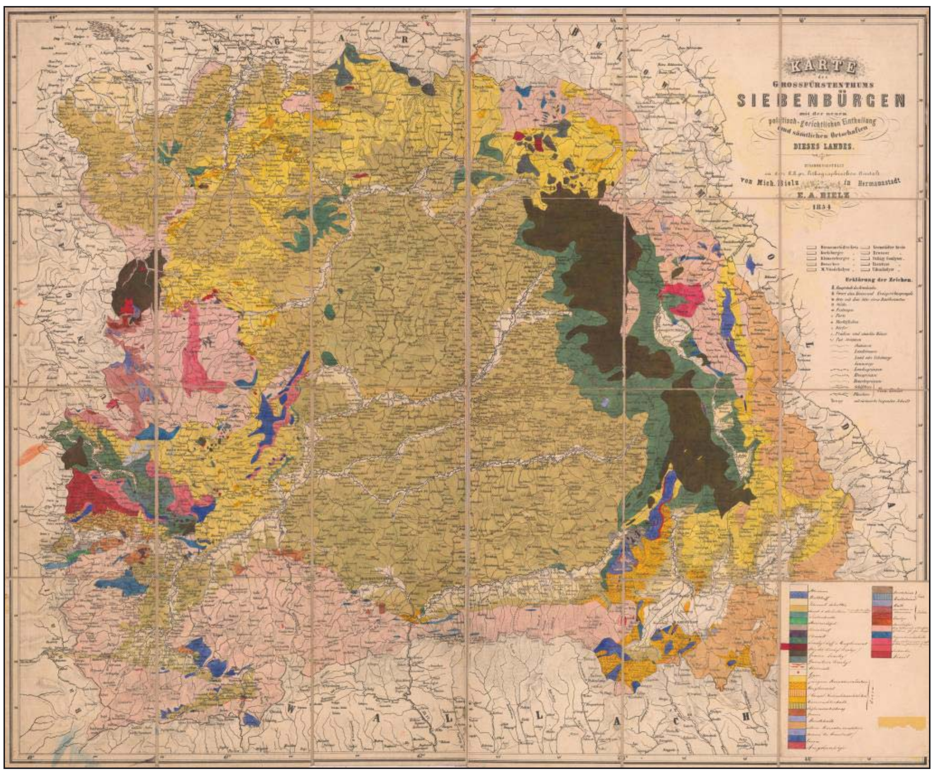

Figure 2. Karte des Grossfürstenthums Siebenbürgen mit der neuen politisch-gerichtlichen Eintheilung und sämtlichen Ortschaften dieses Landes (Geologische Übersichts-Karte von Siebenbürgen), 1:432,000? (Bielz 1854c) (Source: Collection of the Library of the Geological Survey of Austria).

Two maps compiled by Eduard Albert Bielz (Bielz 1854a,b) are rather geognostic maps and besides the distribution of the different rock types they show the occurrences of the most important mineral resources and other geographic data (*Figure 1*), or – in addition to these – also the location of salt occurrences and saline springs (Brezsnyánszky 1996, Barczikayné Szeiler et al. 2009).

In contrast, the map published by his father, Michael Bielz (1787–1866) also in Sibiu (Bielz 1854c) (*Figure 2*) reflects much better the cartographic representation methods of the second half of the 19th century, and contains geochronological data, just like the map plotted by Karl Ferdinand Peters (Peters 1858) (*Figure 3*), as a result of a scientific expedition in the Apuseni Mountains.

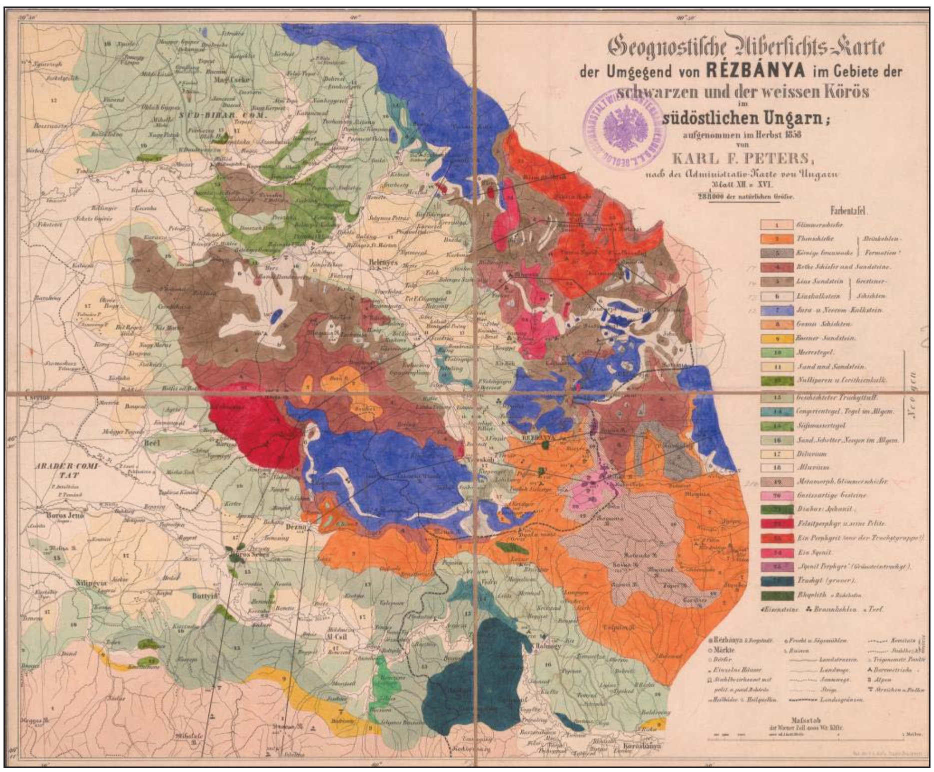

Figure 3. Geognostische Uibersichts-Karte der Umgegend von Rézbánya im Gebiete der schwarzen und der weissen Körös im südöstlichen Ungarn, 1:288,000 (Peters 1858) (Source: Collection of the Library of the Geological Survey of Austria).

In 1861, Franz Ritter von Hauer (with the participation of Eduard Albert Bielz, Ferdinand Richthofen, Guido Stache and Dionys Štur) published in Sibiu the overall geological map of Transylvania on a scale of 1:576,000

(Hauer 1861) (*Figure 4*); then in 1863, after the publication of the general map of Transylvania (MGI 1863), reedited it – with the involvement of co-authors – on a scale of 1:288,000 (Hauer et al. 1863) (*Figure 5*). The legend of this last map is based on the stratigraphic time scale classification system and distinguishes 43 different rock types and stratigraphic units using different colours, lines and surface signs. The map regarding its stratigraphic conception and up-to-date features exceeds considerably the level of the previous ones (Brezsnyánszky 1996).

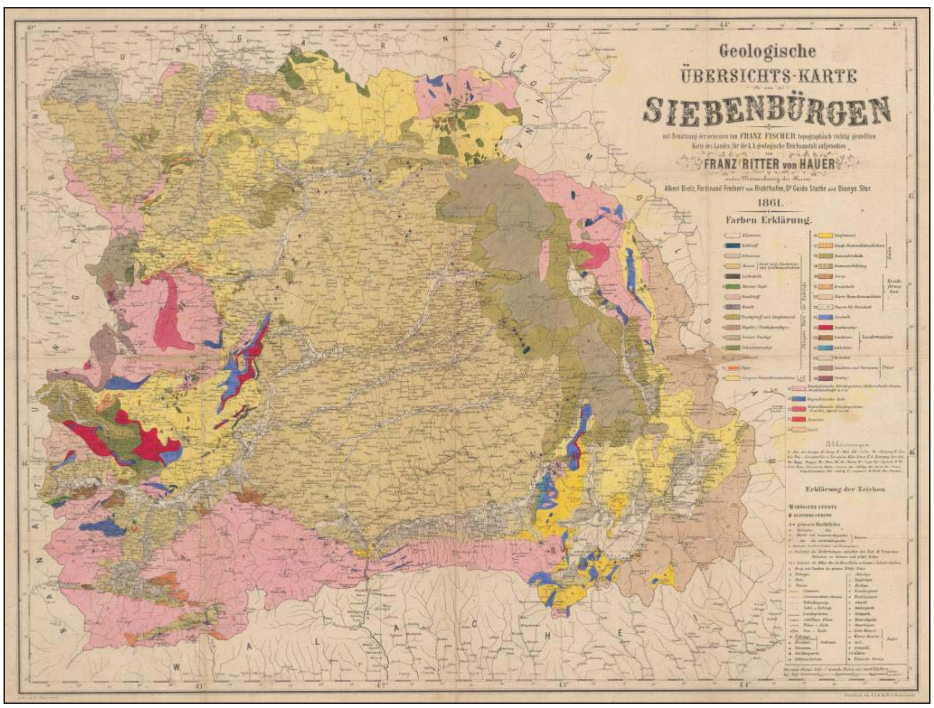

Figure 4. Geologische Uibersichts-Karte von Siebenbürgen, 1:576,000 (Hauer 1861) (Source: Collection of the Library of the Geological Survey of Austria).

Franz Ritter von Hauer also compiled an overall geological map showing the entire Austro–Hungarian Monarchy (Hauer 1867–1871) on a scale of 1:576,000, based on the previously presented maps and other local, as well as systematic, sheet-by sheet surveying results (Brezsnyánszky 1985, 1996, Brezsnyánszky & Síkhegyi 2007, Barczikayné Szeiler et al. 2009).

The geological map of the Szeklerland (*Figure 6*) by Ferencz Herbich (1821–1887) (Herbich 1878a) was published by the Royal Hungarian

Geological Institute, as an appendix to the author's monographic work (Herbich 1878b). The map has a scale of 1:288,000 and its topographic basis was derived from the map series based on the Second Military Survey (Galambos & Unger 2009).

Beside the study of the legend and nomenclature of the old geological maps the analysis and exploration of their topographic basis (projection, geodetic datum, prime meridian) is also extremely important because it is the key for georeferencing and thus for the GIS applications (Galambos 2009, 2010). Integration of the historical geological maps into a GIS database makes possible the analysis and comparison (both in quantitative and qualitative ways) of old geological data with modern ones, and consequently the tracking of the evolution of the geological knowledge.

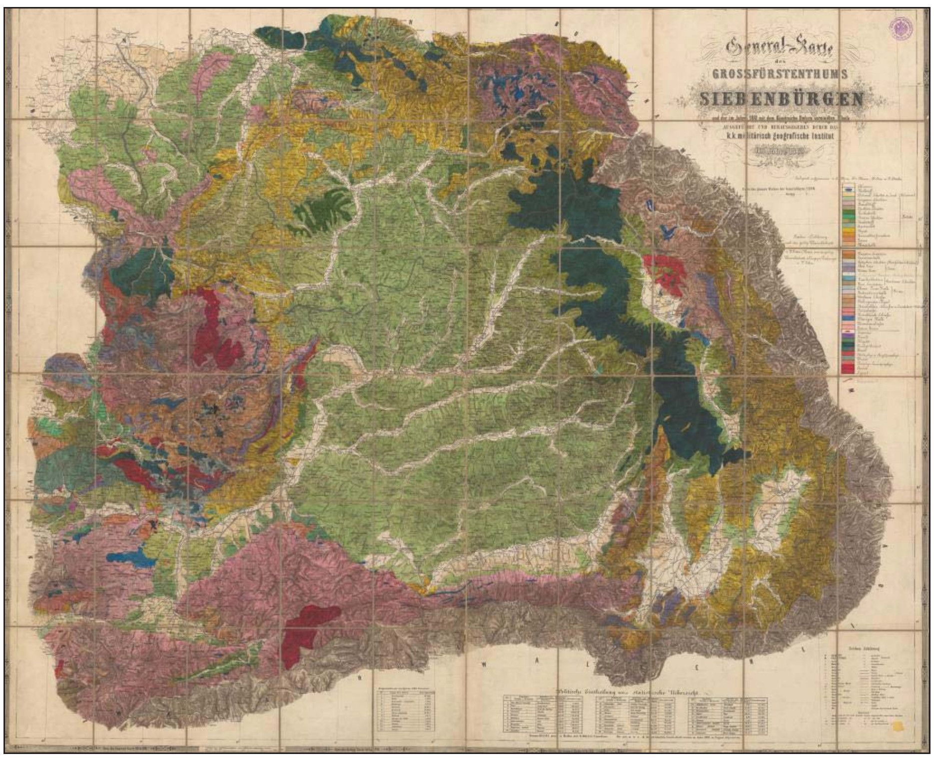

Figure 5. General-Karte des Grossfürstenthums Siebenbürgen und der im Jahre 1861 mit dem Königreiche Ungarn vereinigten Theile (Geologische Übersichts-Karte von Siebenbürgen), 1:288,000 (Hauer et al. 1863) (Hauer 1861) (Source: Collection of the Library of the Geological Survey of Austria).

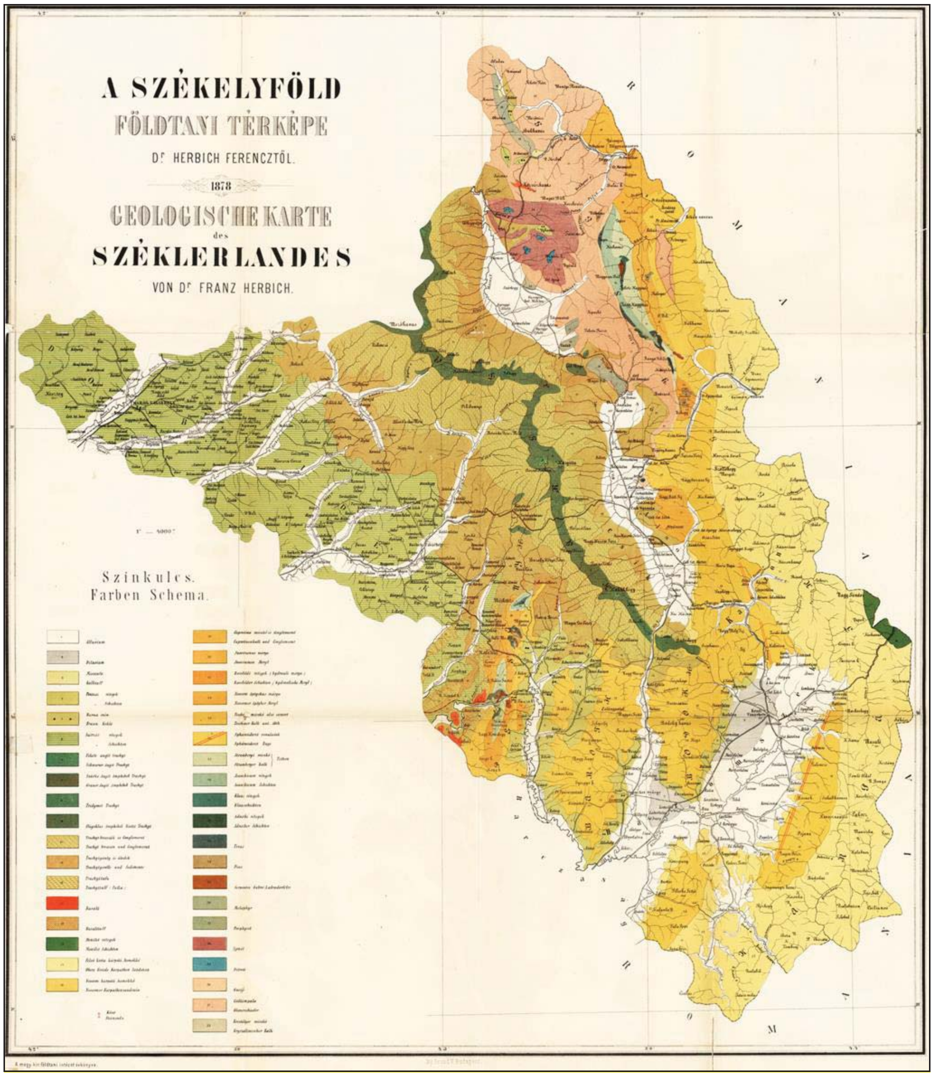

Figure 6. A Székelyföld földtani térképe, 1:288,000 (Herbich 1878a) (Source: Collection of the Library of the Geological and Geophysical Institute of Hungary).

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Bielz EA (1854b) Karte der Verbreitung der Salzquellen und des Steinsalzes in Siebenbürgen mit Rücksicht auf die geognostischen Verhältnisse dieses Landes. Map, scale: M=1:864,000, Hermannstadt (Sibiu)

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Hauer FR (1867–1871) Geologische Übersichts-Karte der Österreichisch–Ungarischen Monarchie nach den Aufnahmen der k. k. geologischen Reichsanstalt. Map, scale: M=1:576,000, Wien

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Touch the map and take a historic walk – Reviving cartographic heritage in the Danube Museum

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Abstract. This paper introduces the interactive cartographic interface developed specially for the presentation of an important cartographic heritage document on touch screen. The unique copy of the map, preserved in the Danube Museum (Esztergom, Hungary) can be explored by using a highly intuitive, graphic interface. To enhance user experience interaction allows the user to explore the map in an easy to use, informative context. Based on the 'walk' metaphor the user is allowed to navigate on the 19th century map in GE augmented environment.

Keywords. Cartographic heritage, Interactivity, Thematic map

1. Introduction

This paper introduces the novel application of touch-screen interactive cartographic interface in the presentation of cartographic heritage. The unique map, preserved in the Danube Museum (Esztergom, Hungary), is an important piece of cartographic heritage for several reasons (Török-Hillier, 2012). The 1833 map was constructed by an important hydrographic engineer working on the mapping of the river, was published by the society for a permanent bridge over the Danube, and the hand-coloured copy was most likely a presentation copy prepared by the author for his patron, count István Széchenyi. To make this piece accessible for the general public a special display was placed in the Danube Museum's new Showcase. When touching the screen the early map is not only presented for the visitor but the special applications give background information and invite for interactive exploration.

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2. An Important Historic Map

2.1. The first Hungarian 'Map'

The large size, detailed and elegant map, *'Ground and Hydrographic Map of the Free Cities of Buda and Pest'*, was lithographed by its author, László Vörös, and was published with the support of the Bridge Builder's Union in 1833 in the city of Pest, Hungary.

Figure 1. László Vörös' map of the Danube. '*Alap 's vízhelyzeti térképe Buda és Pest szabad királyi fő városainak*.' Pest, 1833. Litograph, handcoloured. Size: 1745 x 855 mm. (Courtesy Department of Cartography and Geoinformatics, Eötvös Loránd University, Budapest)

The building of a permanent bridge connecting Buda and Pest became part of the national development movement in Hungary, led by count István Széchenyi. The planning of *Chain Bridge* (1849), a symbol of the Hungarian capital, made mapping highly important for both the developers and supporters of the project. Engineer Vörös' rare thematic map is considered as a milestone in the history of Hungarian cartography, and is an important document of cartographic heritage.

This map of the Danube was the first cartographic work in Hungary which had the a newly coined Hungarian word, '*térkép*' (map), in its title. In other words, this was actually the first 'map' to be made in this country. The author included both '*ground plan*' and '*hydrographic*' as the subjects of his work, suggesting that he clearly realized his work is different from other urban plans or topographic maps of the city.

In 1832 it was apparently acceptable to both the maker and the public to include rich *hydrographic* content in a *general* or reference map. It should be observed that in the case of this map of Pest-Buda, the additional, special content, the representation of the Danube, did not cause many graphic problems. The thematic information appeared in the river, which could be left almost blank on contemporary urban maps. Vörös simply used this free graphic space to include the vast amount of hydrographic data he collected as a civilian engineer working on the Mapping of *the Danube (Danubius-Mappatio)*. The two content layers of the 1833 map were *spatially* separated, so visual hierarchy was not a design problem for the author

In the collection of the Danube Museum in Esztergom, Hungary there is a remarkably well preserved, original copy, It was acquired from the Hydrographical Institute in the 1860s, but its provenance is unknown. It is in the director’s office, because the large map is in a late 20th century frame. We could inspect the copy when it was removed from the frame and found evidence for its historical importance. The author’s blind stamp was discovered by Török and we have good reason to think it could be coloured by the map's author. Moreover, circumstantial evidence suggests, a letter in the Museum’s collection, that this map could be a presentation copy to count Széchenyi, the patron of the cartographer (Török-Hillier 2014)

2.2. The Map Maker

László Vörös studied at the *Institutum Geometricum et Hydrotechnicum*, the world first university level civil engineering institute founded in 1782. Already as a university student he worked as surveyor, engineer, engraver and map maker for the 'Danube Mapping Project' from 1828.

Systematic survey of the waters in Hungary started as a late *Enlightenment* project in the early 19th century, and hydrographic maps were produced by a generation of civil engineers, including Vörös. The mapping of the river's section between the cities of Buda and Pest (today Budapest) became a priority task for the regular floods, threatening the developing and expanding sister-cities. Vörös was commissioned to construct a detailed and accurate map from the available topographic and hydrographic data. For personal controversies, however, he left the project and in the end he drafted and published his map privately.

3. Cartographic Heritage: Protection and Presentation

At first sight the wall map looks like a city map, but a closer looks reveals the abundance of thematic cartographic information of the work. The interpretation of this rich data content is very difficult for the modern reader. This historical map produced by a specific, hydrographic mapping mode, which can not be fully understood in the customary topographic paradigm.

We put the map into its contemporary technical, cultural and social contexts to make its numeric data meaningful. The interactive exploration of the map, the visualization of the spatio-temporal database for the modern reader requires modern *geoinformation technology* **and** the *expertise of the historian of cartography*.

For museum pedagogical purposes interactive visualizations are especially important. But scholarly visualizations, developed for experts, can not be used directly for the general public, in our case groups of schoolchildren. This is why we developed a special, *touch screen-optimized* application interface for the expected visitors.

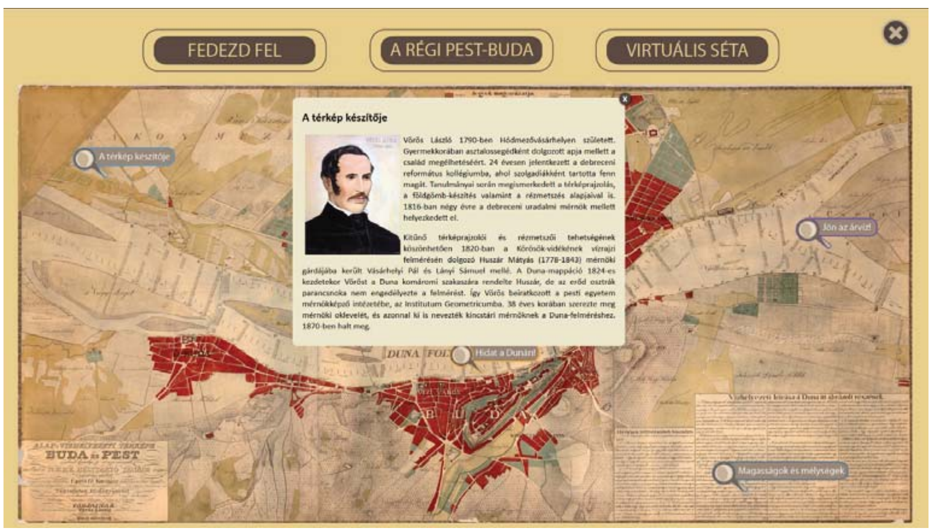

Figure 2 The historic map as graphic interface. The icons on the map surface are placed an significant content elements: e.g. the name of the map maker is linked to the thematic section on a short biography and a portrait. (Authors' image.)

The general overview of the historical map was used not only as background image, but it was actually developed a *graphic interface* for the 'Explore' function. We placed icons near to the most interesting features of the map. When clicking on them the visitor can read a short explanation and see additional textual, as well as pictorial information.

These thematic sections were selected:

- *The firs 'map' in Hungary*
- *The map maker: László Vörös*
- *Flood, flood!*
- *Heights and depths…*
- *Bridge over the Danube*
- *Key to the map's legend*

The short but informative text introduces 19th century hydrographic survey, the threat of icy floods, and explains the meaning of the numeric data on the map.

After the general introduction users may select among the menu items: *'Explore', 'Old Pest-Buda'* or *'Virtual Walk'* options.

Clicking on **'Explore'** opens a zoomable map in a new window, and make the visitor able to study its content in minute details. The Flash-based 'Old Pest Buda' application allows the user to compare the historic map image with a modern satellite image.

Figure 3 Screenshot from the application ‚Old Pest-Buda': the old map's content can be compared with the modern satellite image. (Authors' image.)

The third visualization option is based on the familiar *GoogleEarth* technology, and puts the three-dimensional historic map into the readers' modern world. By turning on the 'buildings' 3D layer on GE, visitors can easily recognize familiar buildings in Budapest. They may surprise to see how these are placed on the old map: e.g. the House of Parliament is under water, because the building is partly in the former river bed! The interactivity with this application's familiar interface may result in a memorable historic walk in Budapest and on an important 19th century map.

Figure 4 ‚**Take a historic walk'**: the interactive application shows 3D buildings of modern Budapest (*Google Earth*) on the base of the 1833 map. Note the *House of the Parliament* in the past riverbed. (Authors' image.)

As a future development of this project, one possibility is the inclusion of interactive educational games. This installation in the Danube Museum may give the authors also a possibility to extend their cognitive lab experiments and collect data about actual map use.

4. Conclusion

The presentation of a highly important and significant cartographic object with cultural values in the Danube Museum resulted in the interactive, virtual exhibition of a unique copy of the complex map of Pest and Buda from 1833. The special applications we developed for the touch screen make potential users able to explore the map's rich content, learn more about the past of hydrographical surveys and mapping, and take a historic walk in the early 19th century Pest and Buda.

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Conception of mini-atlas “Virtual museum of Leo Bagrow“

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Extended Abstract

The first project of museum of Leo Bagrow was proposed at the 13. Kartographiehistorisches Coloquium in Dresden on 20-23 September, 2006 (Wolodtschenko 2012).

The creation of any museum is a difficult and long work. The new project 2014-2016 includes a creation of mini-atlas “Virtual museum of Leo Bagrow“ for tablets and smartphones.

The author deals with conceptual-semiotic modelling (atlassing) and has created a small collection of thematic atlases (Bild/image atlases, event atlases, historical atlases etc.) for mobile devices with mono-display and double-displays (Wolodtschenko 2012). Three selected mini-atlases with historic-related themes are freely available from:
- http://rcswww.urz.tu-dresden.de/~wolodt/ATLAS/ICA_P-ATLAS-1ab.pdf
- http://rcswww.urz.tu-dresden.de/~wolodt/BILD-ATLAS/2015-PreMaps.pdf
- http://rcswww.urz.tu-dresden.de/~wolodt/ATLAS/2013-DoKarUk1.pdf

The conception of the mini-atlas "Virtual Museum of Leo Bagrow" is based on three time blocks or periods:
- Leo Bagrow in Russia/St.Petersburg (before 1918)
- Leo Bagrow in Berlin (1918- 1945)
- Leo Bagrow in Stockholm (1945- 1957).

The first part of this atlas entitled «Leo Bagrow in St.Petersburg» will be presented to the 135th anniversary of Leo Bagrow in the next year.

The nobleman Leo-Edward Semenovich Bagrow or Leo Bagrow (1881-1957) was lieutenant of the Russian Imperial Navy (1905-1917), hydrographer, collector of old maps, co-founder and editor of the international journal „Imago Mundi“ from 1935 till 1957 (Wolodtschenko 2010). He was an active promoter of the map, geography, and military-historical knowledge, author and publisher of books, entreprenuer, organizers and participants of exhibitions and special missions, a member of military and civilian circles and associations.

The talented Russian-Swedish scientist remains forgotten in Russia, Sweden and in the world. The short biographical information in English can be found in the obituary in journal „Imago Mundi“, vol.14/1959 (Skelton 1959) and in article by Heffernan and Delano-Smith (2014). In traditional and electronic encyclopaedia the biographical information about Leo Bagrow is very scarce and often contradictory. Also, there is no full biography of Leo Bagrow.

The atlas conception "Virtual Museum of Leo Bagrow" is a pilot project and includes selected facts, events, and documents of the life of Leo Bagrow (1881-1957) in thematic sections: a biographical sketch, publications, correspondence, photo -gallery (as Mini-Bildatlas) of individua-lists, and bibliography.

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Who needs *Mitteleuropa* old maps? Present-day applications of Habsburgic cartographic heritage

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Extended Abstract

The Cassini triangulation method from 18th cent. provided a mapped-Europe and, in a number of cases, "connected" through a triangle chain-network: a geometrical skeleton rather than a really map. Firstly, large basis triangulations (state survey for "national" geographies, to provide a meridian triangulation) were executed to furnish reference points for following detailed triangulation for mapmaking at large scale, earlier (after French) in Austrian Empire (Edney 1993). This was carried out, for French and Austria, at the same scale factor: the well-known 1:86.400 and its enlargements/reductions.

Historical habsburgic region of Tyrol (nowadays *Land* Tirol and, in Italy, Trentino-Südtirol Region) was extensively mapped from late 18th to early 20th cent., since it represented the "south of Mitteleuropa". These historical maps have their main *foci* on southern boundaries (security and fortifications) and rivers network (resources, transports). French scale for habsburgic mapping: measuring the Empires as a practical geopolitics throughout the direct state "sponsorship".

Our research group in historical geography at University of Trento are currently involved in two research projects on Trentino historical boundary line(s) and on Adige/*Etsch* river historical change detection (both funded by Trentino-Südtirol Region), dealing with a very large data-set of habsburgic cartographic heritage as a source for present-day issues (boundary disputes and river restoration).

In this paper, mainly methodological, we consider a part of data-set and cartographic time-series, that starts after the habsburgic First Military Survey (not including Tyrol): from *Kriegskarte* by von Zach (1798-1805, survey of venetian territories, but sharing commons boundary lines with Trentino);

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then with the Lutz map of Tyrol (1806) and its *Reambulierung* (updating) of Reininger-Geppert (1816-21), both included in the Second Military Survey (1806-69); toward the Third (1869-87) and the Fourth Military Survey (1896-1914, considering only the imperial period). Besides such a scales (1:28.800-25.000) there are hydrotopographical maps (1803-48) at very large scale (1:3.456). All maps are recovered from Vienna and Innsbruck archives and digitized in multi-resolution format; thus we are facing with cartographies composed by hundreds of map-sheets, with a good positional accuracy (after a planimetric analysis on sample sheets; and in general, Zentai 2013) and mainly (except specific case-studies, Dai Prà & Mastronunzio 2014) not georeferenced. But we need them with a common reference system (ETRF89), in order to compare with present-day reference maps (Google Map, Open Street Map and official topographic basemaps) for geospatial analysis and dissemination purposes. In other terms we need each of map-sheets "localizable", avoiding a massive previously georeferencing/mosaicking processing onto the whole data-set.

Thus, we are developing a multi-source, multi-scale and multi-temporal (but in progress) methodology for regional purposes, using map-sheets overview (index-map sheet; *Übersichtblatt, Skelett*) and, if present, overview triangulation sheet, provided along the maps and often neglected in a GIS-framework. Merging these data with archival documents and contemporary literature (e.g. von Zach 1803) we have investigated upon the original reference systems.

Although since the Second Survey a geodetic basis was used – Zach 1809 or Bessel 1841 ellipsoids[1], Vienna 1806 or Hermannskogel 1871 datums, Cassini or Gauss-Krüger projections (Mugnier 2004, Molnár & Timár 2009, Timár 2004) – other maps (*Kriegskarte* and hydrotopographical) have no fundamental geodetic survey, produced only using triangulation with plane tables and theodolites, starting from a central meridian (crossing astronomical observatories) with latitude/longitude (from Ferro prime meridian) of the survey points astronomically determined. That is: a topographic survey like the First Survey, whereas this used the Liesganig triangulation, the Kriegskarte used the "von Zach triangulation" centered on *Paduaner Meridian* (Rossi 2005).

The 4-steps map-to-map workflow is: a) assign to index-maps the original reference system; b) shift from Ferro to Greenwich with longitude rotation; c) perform the geographic datum transformation to WGS84; if parameters

[1] Original Bessel ellipsoid is in *Klafter* ("toise", but which one, *Wiener* or *Pariser Klafter*?) and, as other historical anthropometric measures, also the Bessel-toise is uncertain (US Army Map Service Technical Manual, 1943).

are not provided, notably for earlier Datum, we have calculated the roto-translation parameters using pairs of control points derived from “comparable” maps, e.g. habsburgic cadastre; d) reproject in ETRF89 UTM system. The results is a georeferenced index-map that readily provides the 4-corner coordinates of each single map-sheet for following georeferencing, only assigning the corner coordinates (from index-map) to corresponding corner-points (onto single sheets) without identifying landmark/control points on old and reference map. The positional accuracy is considerably better for maps with a geodetic basis and in flatlands, with increasing inaccuracy in relief areas (and without geodetic survey) and we need from 1 to 3 additional control points to align (zero-order transformation) the old map to the target one. Despite the inaccuracy (fairly suitable for dissemination purposes), we could use less control points of a standard rectification: 6 corner-points for 2-sheets, 10 for 4 and so on, and apply few additional points.

Finally, such a method has to be refined, but could provide a useful map-as-tool for not GIS-oriented fields and could be considered suitable for further research in spatial humanities.

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Selected Issues of Historical Spatial Datasets

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Extended Abstract

The importance of using technologies in historical sciences is growing. One of the possibilities for extending potential of historical research is using geographic information science (GIS). GIS is nowadays equivalent for both science and technology and comes with its own approaches and theories for processing and evaluating data. In this contribution we would like to introduce selected aspects we encountered when trying to apply cartographical methods and theories for handling historical spatio-temporal data. We described selected issues concerning quality of data, visualization potential or possible data sources. As this work is primary motivated and supported by the work on project GEHIR (A Generative Historiography of the Ancient Mediterranean, ID MUNI/M/1867/2014), we will focus mainly on the ancient Mediterranean.

There are various properties of historical data and simultaneously there are a lot of issues connected with using historical data for cartographic analyses. Most of them are connected with its source and the process of data collection. It involve theory of spatiotemporal data (types of spatiotemporal data, visualization of spatiotemporal data), consistency of historical data, interpretation of spatial related historical data, linking of data, sources and creating historical datasets, digitalization of existing maps, geocoding of catalogues etc.

Important issues represent uncertainty of historical datasets. As we noted before a crucial part of historical dataset is the quality. In every component (time, space, attributes) is the quality specific. Temporal component represented by time record is often the most problematic dimension when dealing with historical data. The basic idea is that we are not always able to de-

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fine exact temporal dimension but try to combine different attitudes to time record as post quem, ante quem dating, time cycles, description of precision of sources of temporal data etc. Also in case of spatial dimension it is important to focus on historical context of spatial information, new critical analysis of the source is the essential condition, stochastic approaches, be aware of possible errors in dataset and it´s nature.

For the purposes of the mentioned project, we were focused on the data describing the ancient Mediterranean. After consultation with relevant scientists and our own research we found few projects collecting data from ancient world, storing, visualizing and analysing them. The Stanford Geospatial Network Model of the Roman World (Orbis) can be mentioned, because that among others enables calculation of the cheapest and shortest path between places in ancient Rome. It also provides the possibility for choosing the mean of transport or a month of year. Maybe the most valuable thing is the network analytic algorithm behind the webpage that moves the point of this project from displaying and storing data to modelling on them.

As another example Pleiades can be mentioned. It consists of the database and historical gazetteer built by a community of users. It stores a lot of relevant types of (ancient) places and provides some additional information, connection on other places and also a geographic representation.

The aim of project Pelagios is to retrieve data from other sources and provide a framework for their visualization. Therefore the essential part is a web map and the ftp repository for those data.

Also modern datasets should be used to study the ancient world. For instance soils types are not changing radically through centuries and could say us something more about agriculture in historical regions. Elevation data are still actual for most of the Mediterranean region as well.

There are also datasets not so actual but still with a potential to help understand the spatial phenomenon. This way older demographic census from the beginning of the 20th century could help us reconstruct the population before social processes like emigration or urbanisation in last decades and understand and estimate the overall distribution.

For the purposes of storing and classification of relevant datasets we started to build a wiki project. Where we are trying to cover all described issues. For describing spatial and temporal distribution we plan to use a visual techniques - heatmap or histograms with timeline. To define the completeness, granularity or quality we started a discussion with relevant experts to create a classification scale. Our goal is to create an interface that informs about possibilities and issues of using spatial data in historical research and prepare a list of them. Pilot study was conducted on the Cyclades Islands. It consists of creation of the multidimensional model suitable for estimation of the risk potential of food self-sufficiency of the particular island. The first version of the model is presented below. In the next part of the mentioned project we would like to extend this model, build a simulation on top of its outputs and create an exploration tool to support our research work.

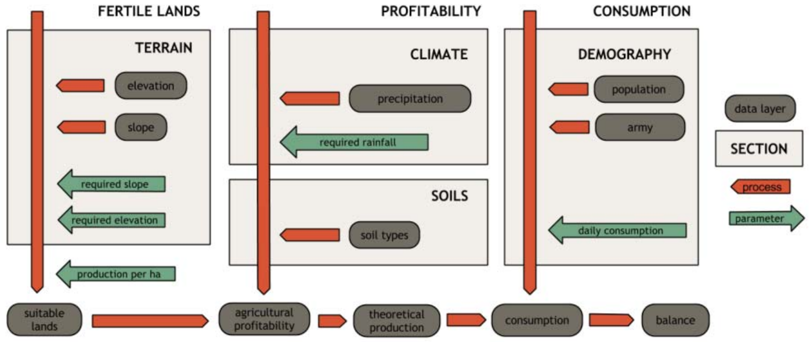

Figure 1. Model for calculating the theoretical food production/consumption balance of islands in Aegean Sea .

As we noted in this abstract, there is a lot of issues dealing with using geographical data connected with historical context for purposes of spatial analysis and visualization. As we are familiar with the theoretical concept of spatio-temporal data and approaches for handling them, our motivation were to define some problems occurred during our research and provide guidelines to support use of historical spatial datasets.

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Reconstructive 3D models of the Brno for the years 1400, 1645 and 1749 and their use in education

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Extended Abstract

Reconstructive virtual 3D models are very illustrative tool for presenting knowledge about the historical character and urban development of cities. Creation of 3D city models is available today for anyone, who would like to take this opportunity to present information, thanks to using high-quality free software. Probably the largest one - the model of ancient Rome - was open to the public in Google Earth software in 2008 (Rome Reborn, 2013). 3D city models have been made also for Koyto (Takase et al. 2004), historical area of Istanbul (Dursun et al. 2008), for Roman Cologne (Bauerlein et al. 2007) and many other cities. Reconstruction 3D models are also produced in the Czech Republic. For example Hájek et al. (2015) describes the process of 3D modelling of the Terezín fortress and Popelka & Brychtová (2012) created 3D models of fortifications of the Olomouc city.

Creation of a 3D model of the city Brno (Czech Republic) expressing its appearance at the time of Swedish siege in 1645 began in 2009. 3D models for two other periods, namely the years 1400 and 1749, have been processed subsequently (from 2011). All three models were made in connection with the project *Internet Encyclopaedia of History of Brno* (2004). The reason, why it was first processed the model for year 1645, was not only a historical significance but also the availability of suitable iconographic, cartographic and other relevant resources.

The availability of data for creation of 3D model is obviously different for particular period. While we have almost no contemporary cartography or iconographic sources for the year 1400, many detailed representations of the city as well as maps and plans are available for the 17th century. Ap-

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pearance of individual buildings is rather hypothetical in the case of a model for the earliest period and it is based both on archaeological investigations and on analogies with similar objects preserved in other locations. Because medieval allotment in Brno stayed largely unchanged until the 19th century, the most useful source of spatial information (for all three models) has been Stable cadastre from the beginning of the nineteenth century. Following maps and plans were used for creating 3D models:

- Map from book “Topographia Bohemiae, Moraviae et Silesiae” (author: Matheus Merian, 1650);
- Map from book “Relazione dell' assedio di Bruna e della fortezza di Spilberg” (author: N. H., 1672);
- Plans of fortifications from War Archive (Kriegsarchiv) in Vienna (1658-1749) – see figure 1;
- Plan of Brno (author: J. Anneis, 1784);
- Stable cadastre (1824);
- Old plans of particular buildings from National Heritage Institute, Moravian Archives and the Archives of the City of Brno.

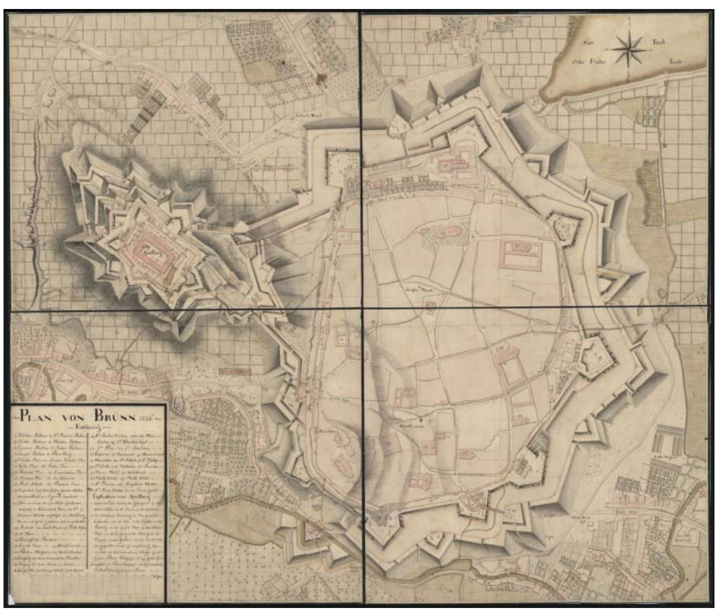

Figure 1. Comprehensive plan of fortification of Brno from 1749 (from Kriegsarchiv in Vienna).

Below mentioned vedute and old paintings were also used in the process of 3D modelling:

- Brno - panorama (author: Johann Willenberg, 1593);
- Brno - panorama (author: Joris Houfnagel, 1617);
- Brno – Orlí street (author: Max Groer, 1644);
- Brno from nordwest and from south (authors: H. B. Bayer & H. J. Zeiser, 1645) – see figure 2;
- Bird's-eye view of Brno (authors: H. B. Bayer & H. J. Zeiser, 1645);
- Brno - panorama (author: J. B. Speiss, 1675);
- Brno - panorama (author: Folpert van Ouden Allen, 1690);
- Paintings from second half of 18th century (author: Josef Masserle);
- Paintings from first half of 19th century (author: Franz Richter).

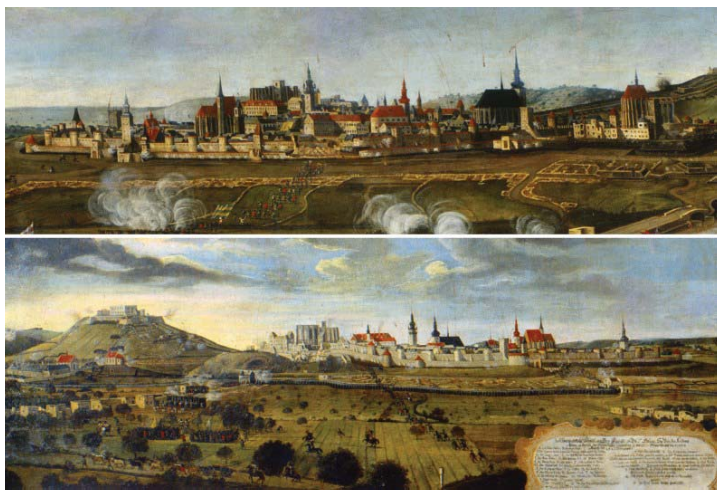

Figure 2. H. B. Bayer & H. J. Zeiser (1645): Brno from nordwest and from south.

Methodological approaches were used for consolidation and conversion of data from all mentioned sources into digital form. The Bentley Microstation software was used for vectorization building footprints from the maps of Stable cadastre (see figure 3). Resulting data were compared with data obtained during archaeological excavations in the historical centre of Brno. Historic building plans and surveys of selected buildings, primarily from the archives of the National Heritage Institute, Moravian Archives and the Brno city Archives, have been also used. Terrain model has been based on the present state and has been corrected according to the results of archaeological excavations.

City model has been finally created using the free software Google (today the Trimble) SketchUp. Complexity of the model can be demonstrated by fact, that the Brno inside the city walls has been formed from about 400 houses in the late medieval times. All of these are represented by simple models in the LoD2 (Level of Detail 2). Important objects such as churches, monasteries, fortifications and Špilberk Castle, whose historical form we know better, are modelled in more detail way (LoD3). 3D models were localized in the program SketchUp into coordinate system WGS-84 and exported to KML (*Keyhole Markup Language*) files that enable their subsequent display in Google Earth application.

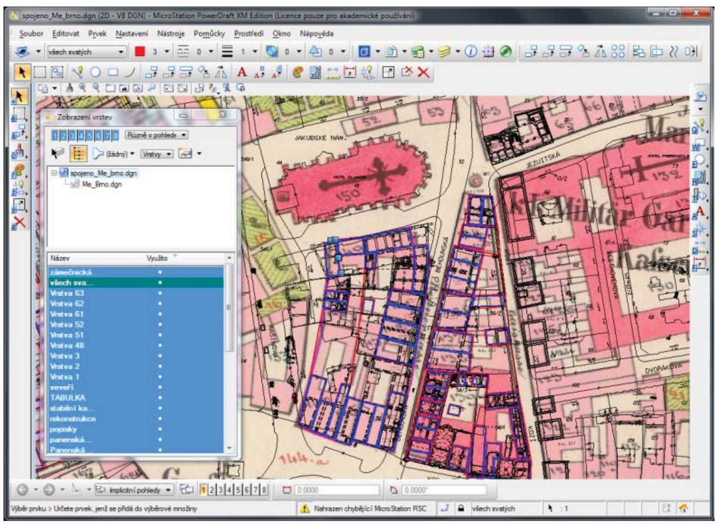

Figure 3. Vectorization building footprints from the maps of Stable cadastre in Bentley Microstation environment

All three virtual models are available on the website www.brno1645.cz (in Czech) City model from 1645 has been used for creation of the bronze sculpture in scale 1:1000, which is now located on the Moravian Square in the centre of Brno. Historical state of the city is presented to the general public by these ways. 3D models can be used also in school education in the curriculum of geography or history, where models can demonstrate the urban development. Example of the development of the selected area in Brno center is shown in figure 4.

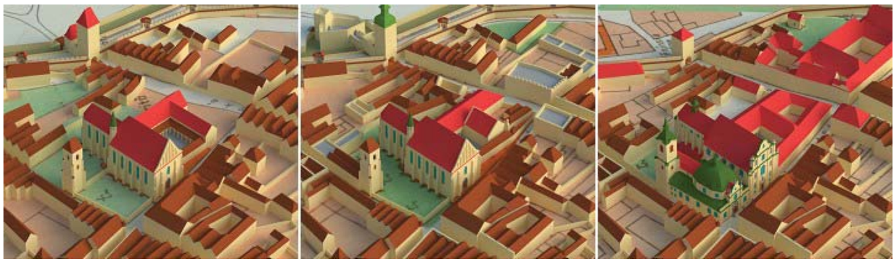

Figure 4. Urban development evolution of the Conventual Franciscans monastery neighbourhood area (years 1400, 1645 and 1749)

The models were thus presented to high school students, for example, during the GIS Day 2014, organized by the Department of Geography at Masaryk University in Brno. However, the models can be used in teaching at universities, whether in courses focused on local history of urbanism. Finally models serve as examples of the methodological approaches and technology available for creation of 3D models in GIS (Geographic information system), they were demonstrated during the lessons of the course *3D modelling and visualization* (code Z8311).

Figure 5. Superposition of 3D model of chapel of Virgin Mary on Žerotínovo Square on present buildings.

Continuous updating of 3D models and correction of errors (based on the new findings) as well as the gradual increase of the detail is ongoing. Aim is to replace the existing underlying reconstructive maps placed in 3D models and to add information attached to each captured objects. There are other ways of utilizing existing models, e.g. combination (superposition) of data from 3D models to the current situation (photos, video), or in real-time use of the augmented reality technology (an example of this superposition id shown in figure 5). Establishment of so-called serious game, where users went through virtual models, is also considered in terms of utilization of 3D models.

As it was mentioned, created reconstructive models of Brno have a wide range of applications. They are fully comparable from this point of view with other 3D city models that have been created in the Czech Republic or abroad. It is an indisputable fact that wide use balances the challenging process of creating 3D models.

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Cartographic visualization of historical source data on AtlasFontium.pl

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Extended Abstract

The scientific project in the form of a website "Atlas of Sources and Materials for History of Old Poland" also called the “AtlasFontium.pl” was created in order is to establish a platform aimed at collecting, disseminating and visualizing historical sources and materials, primarily those with spatial reference (Słoń 2015). The key objective of the project is to elaborate a consistent spatial and digital model of historical sources editions which combines several elements including: direct access to the scanned manuscript; ability to analyse the data within the spatial database and visualizing the outcomes in Web-GIS application as a digital map.

At this time (October 2015), AtlasFontium.pl includes 7 projects of historical sources editions, but three of them are the most important: Polish Territories of the Crown in the 16th century – database and digital map; Two digital editions of tax registers: Kalisz and Poznan Voivodeship 16th century tax registers – manuscript, database and digital map and the digital edition of the Court registers of Wschowa from 1495-1526 – manuscript, database and digital map.

Resources published on the website are available through a three-tier architecture which consists of a database, digital map and manuscript viewer. The modules are linked together and thusly all data can be accessed through either of these. Information about features’ geometry and attributes is stored in the spatio-relational database (PostgreSQL9.3 + PostGIS 2.0). The website supports two applications for content depiction. The first (PMapper 4.2) is a Web-GIS application used for cartographic visualization of spatial data, while the second (INDXR) allows to view scanned manuscripts on-line.

PMapper presents spatial data both in vector and raster formats, as well as allows to join external source layers through spatial data services such as WMS (Web Map Service). Application functionality also includes toggling layers visibility along with their descriptions, changing transparen-

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cy, identifying individual features, as well as performing search queries based on SQL syntax. The second application (INDXR) was created for the electronic edition of the Wschowa Court Book in 1495-1526 and serves as the browser for scanned manuscripts. Its main functionality involves not only scanned material visualizing, but also a capability of its indexing with the application of a database and visualizing the outcome on the digital map.

Source information acquired from 16^{th} century manuscripts are put into the database along with its geometry (point for settlements and polygon for boundaries) and attributes. The attribute table schema is derived from the specificity of each data source in order to maintain its structure but also allow it to be used in a statistical analyses. In general, there are two types of descriptive data – source and critical (Szady 2013). For tax registers which were created for each settlement in 16^{th} c. there are critical columns for settlements' name, size, and type. The source columns include data acquired directly from the manuscript: e.g. settlement name in the register, parochial affiliation, ownership, the date of tax payment, and the amount of tax paid, taxed acreage, economic facilities, professional groups, etc. If some information is missing or uncertain it is noted in "varia" column. In addition to the database form of tax registers, original manuscript is also provided in order to make it possible to verify data consistency and correctness by website users. Access to the manuscript is available either from the database or digital map. It is also possible to download all data in *.mdb file format (ArcGIS personal database).

Such an approach of historical sources publishing along with their cartographic visualization provides historical data in its original form. It allows users (historians, geographers, archaeologists) to work not only with the outcomes and results of historical-geographical research, but also to explore the potential of raw historical data either in the form of the geotagged manuscript or its database edition. In addition, all of the data is visualized on the digital map in order to provide spatial context.

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Geomatic Methods Supporting The Investigation Of Ancient History

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Extended Abstract

Nowadays working as an Archaeologist or an Ancient History Scientist also needs incorporating new methods from the Geomatics field. Only by using these methods an extension of the already realised findings could be reached. This could help the ancient scientist in getting more knowledge about living conditions and living ecology and interactions with environment or other humans of earlier times. This contribution will gives an overview of the state of the art methods applied in order to get new approaches by combining the geomatics technology with the knowledge of ancient history scientist. This will be realized for the example of two different projects in that field.

Regarding the method combination, among this spectrum of methods, one is the recording of high-resolution geodata by modern Laserscanning or other spatial data recording instruments. Also phtogrammetric survey, by drones (Unmanned Aerial Vehicles, UAV) will be included. On the other hand, it is also important to use geoprocessing methods by a GIS. With this tools, we might find a reconstruction of the former land surface in absolute heights as a product of accumulation or erosion, or the distribution of ancient land cover (hydrology, vegetation, soil etc.) by the analysis of old land use patterns. About the analysis of cost raster surfaces, deriving from Digital Elevation Models (DEM) or other attributes, a cost path analysis could be realized in order to get knowledge about accessibility or travel effort/time of the ancient inhabitants of former settlements (e.g. Vetter & Barnikel 2012). Another possibility is to provide the former geospatial data into a Web-GIS. Using the GIS Layer technologies, we can define layers for different purposes, e.g. different time periods (Hellenistic, roman, byzantine), former supposed land use scenarios, former simulated land surface situations, calculated runoff-scenarios etc (Vetter 2013). The novelty of this

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method is the holistic point of view by this approach: the first geodaetic survey of geo-data until the geodata storage, projection, adaption, mapping, visualisation and GIS-analysis could be carried out by one geomatic-specialist. For further analysis and interpretation, the expertise of an ancient historian is necessary.

In this contribution, the methodological approaches and first results of two projects will be presented. The first is the analysis of the Varus retreat of late summer AD 9. Here we will show an exemplary GIS-Workflow in order to reveal the marching routes which Varus possibly took, additionally possible places of combat and especially where Varus built his summer camp at the Weser. The significance of the assumptions will be discussed.

The second project refers the research on the site of the ancient city Metropolis (Ionia), today near Torbali, Turkey. In this area, we can find remains from Hellenistic, Roman and Byzantine epochs, lying on each other. For archeological understanding of former living conditions, it is necessary to separate the remains in different layers (in a GIS) and visualize the reconstructed ancient building structures in different thematic context (Zollhöfer et al. 2014). Moreover, in this area, possibly the remains of an ancient harbour could be assumed, which is attested in documents. Hence, a reconstruction of the hydrological catchment and water runoff path analysis have been carried out in order to find possible sites for the ancient harbour.

An open access web-based, map visualisation, realised with javascript based LEAFLET will be presented. Here we can find the important settlements, the relief situation, trade routes and river flows of the past. All this is in order to give scientists from other geographic regions or thematically other fields the opportunity to take advantage for own research or to give input for further examinations in a wider area of Ionia.

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The Integrative interpretation of old maps and other source of spatial information for researching and presenting phenomena from economic history

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Extended Abstract

The issues touched in the project are connected with an interdisciplinary approach to research about the changing development and management of space in Central Europe. This interdisciplinarity follows from the fact that the historical approach is intertwined with the geographical to research ancient reality written down on unique cartographic sources.

The research object is to elaborate a method of utilising cartographic sources and to adapt other sources of spatial information for researching and presenting phenomena from the economic history.

An image of pre-industrial Central Europe has been preserved in the folios of Prussian topographical maps *Urmesstischblätter*, which were published in the first half of the 19th century (Schroeder-Hohenwarth 1958). *Urmesstischblätter* were drawn up on a scale of 1:25,000. The folios for the analysed region were made circa 1822-33 on the basis of a table photograph taken after the first triangulation was performed (Jankowska 1993). *Urmesstischblätter* were drawn up only as manuscripts, which have survived

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in excellent condition to the present day in the collections of the State Library in Berlin (Engelmann 1968).

To capture changes in the studied area maps made after 1876 were issued. The second basic cartographic material is the *Messtischblätter* map. The folios constituting the basis of the comparative analysis were drawn up during the period of economic change (Krauss 1969). This work is excellent for a comparative analysis with *Urmesstischblätter* due to the conformity of scale and the division into folios. The *Messtischblätter* was made based on the corrected second triangulation, and lithography was used as the printing technology (Lindner 2003).

Other sources of spatial information are: descriptions of landscape and space, retained statistical data, documents, inventories, or public registers. Another, important group consists of photographs, postcards and other figures and drawings relating to the former economic space. In addition, an important material comprises data collected during field work: data from GPS and photographs taken in selected areas of research.

The value of the proposed research approach lies in the connection of the specificity of the aforementioned disciplines, their tools, approved theoretical foundations, and research methods. The common denominator is the period of history of economic development preceding the Industrial Revolution (Klemp 2000). We may consider the construction of railway lines as the primary spatial determinant (Shirley 2012).

Integrative interpretation of old maps and other source of spatial information was presented on examples of small town situated in the central part of Wielkopolska region. The developed method allows to interpret integrated topographic and economic elements. As a result of these actions it becomes possible to create a multimedia visualization with integrated sources of spatial information.

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Changes of landscape in the Sió-Sárvíz Valley (Transdanubia, Hungary) due to human activity. Analysis of old maps and historical data.

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Extended Abstract

1. Formation of the Sió-Sárvíz Valley, climatic fluctuations and human activity from the Palaeolithic period to the 18th century

Sió-Sárvíz Valley was formed at the end of Ice Age 11 000 years ago.

The climate was warm and wet between 6000 and 4500 BC, and the area of river-basins increased in the region. Huge areas of woods were cut, and farmers formed fields and meadows in the Bronze Age between 2700 and 1300 BC.

In the 1st and 2nd, century Romans settled down and created the province of Pannonia in the territory of Transdanubia. They built roads, towns, forts in the Sió-Sárvíz Valley.

Life continued calmly after the Roman occupation in smaller, native settlements of Celtic population. Some settlements near to Roman roads were more influenced by Roman trade and handicraft. The biggest palace of the province was built in **Sárszentmihály**. In the Roman towns and in rural estates the building of baths, aqueducts, damns, floodgates and fountains showed a high level of hydrological activity.

According to the latest data of climate history and dendrochronology, the neighbouring Lake Balaton region and Southern Transdanubia had a mild, almost Mediterranean climate. In the mild climate, a high level of agricultural activity is traceable: Romans planted vineyards and orchards. Near the Roman town Gorsium, in **Tác-Margittelep** (Sárvíz Valley) **peach** was planted in the 4th century AD.

In the Middle Ages the coronation town of **Székesfehérvár** became the centre of the Sió-Sárvíz Valley. In the 12th and 13th centuries, animal husbandry was the most significant branch of agriculture. Toponyms such as

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Bikád, Bikács, Tinód refer to this. **Szekszárd** had a Benedictine monastery, which has been a wine region even today. The market-town of **Ete** was ruined in Ottoman wars. The castles of **Ozora** and **Simontornya** remained local centres even in the period of Ottoman rule. By the end of 17th century the southern part of the Sió-Sárvíz Valley became one of the most ruined and deserted regions of the Hungarian Kingdom.

2. Transformation of landscape in the 18th and 19th centuries. Representation of the region on maps in the 16th and 19th centuries

Lazius's map of Hungary (published in 1552) represented **Sárvíz** as a river flowing from north-west to south-east.

On **John Speed**'s map of Hungary (published in 1626), the castles of **Ozora** and **Simontornya** were drawn as islands emerging from the marshland of river Sárvíz.

Johann Cristoph Müller represented Sió as a river flowing south-east of **Lake Balaton**, Sárvíz Valley as a marshy belt.

Ignác Müller, the military engineer, who was born in Székesfehérvár, created a map of Hungary in 1769 and represented a very detailed hydrology of the Sió-Sárvíz Valley.

1782-1785, First Military Survey of Hungary: marshlands before the drainage works.

János Lipszky published his famous and modern map of Hungary, which contained hydrological data characteristic of the Sió-Sárvíz Valley before the water-draining projects.

In 1762, **Ferenc Böhm** surveyed the Sárvíz Valley and he recommended an overall drainage of the region.

In 1811 and 1813 the southern section of Sió-Sárvíz between **Cece** and **Sióagárd** was regulated by the plans of **József Beszédes.**

In 1821-26, the northern section of the Sió-Sárvíz Valley was canalized. In the middle of the 19th century, the mouth of Sárvíz was transferred 33 km to the north.

After the water regulation projects, a new problem arose in the region: in 1854–55 the Danube's flood flowed back into the new artificial river bed and many shelves developed in it.

The upper section of the Sió river (Siófok-Simontornya) was also drained, and a floodgate was built in 1863 to control the water level of Lake Balaton

In 1833-36, the first map of Hungary of Lajos Scedius and Sámuel Blaschnek which was published with Hungarian title represented the upper section of Sárvíz as two parallel canals (**Nádor Canal**, **Malom Canal**).

József Homolka published the agricultural map of Hungary in 1895. Homolka represented meadows, flood areas and scattered dots of forests. The mouth of Sió-Sárvíz was covered by wet reedy areas.

3. Study of consequences of changes by the analysis of licences of drainage works and other hydrological activity

After draining, the land use and agriculture changed in the region. In the end of the 19th century, drained areas were involved into farming. Hydrological activity was administrated by the county administration. The process of canalization works were introduced into the **hydrological record**. They contained the process of canalization work, county permission of the process, locations, plans, implementation of the works, expert opinion.

The **hydrological permissions** were emitted by the sub-prefect of the county. The data were introduced into the hydrological record of the certain settlement by the archivist of the county. During my research of the region, I analysed sixty-two hydrological permissions of twenty- eight settlements. These records are complex sources of land use, the state of environment and changes of economic activity.

The artificial riverbed of the Sárvíz River was not deep enough, the canalization works were not executed perfectly.

Example one: in **Nádasdladány, Tallián ditch** running between two branches of Sárvíz was canalized in 1906. The ditch had to be deepened and maintained more carefully than earlier.

Example two: Near to the mouth of Sió-Sárvíz in **Szekszárd-Palánkpuszta** the ox-bow of **Kapszeg-tó** (a lake) was drained but enough water was left in it to provide water for the ox-bow in order to support reed cultivation.

In the beginning of the 20th century, irrigation canals were built in **Nádasdladány**, **Simontornya, Balatonszabadi**. Some rich landlords asked for permission to build fishpond systems in their estates: in **Simontornya, Somogyfok-puszta** (near Siófok), **Ádánd, Szabadhídvég-Pélpuszta.**

In the first decades of the 20th century, many industrial investments took place in the Sió-Sárvíz Valley: leather factory, mining of sand, distillery used the water of the two rivers. At present, the remnants of the old marshland **Rétszilas Lakes (Sáregres), Sárkány Lake (Sárkeresztúr), Sós Lake (Sárszentágota)** and **Kapszeg Lake (Mözs)** are the most precious areas of the Sárvíz ecological corridor.

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Digitising (Historical) Patterns of Power

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Extended Abstract

Perception, depiction and organisation of spaces and places in the Middle Ages encompass an interdisciplinary research field that helps to understand historical processes and relations within the medieval period.

The representation of space in medieval texts, the appropriation of land and the subsequent installation of new structures of power are central research topics of the project “Digitising Patterns of Power” (DPP). The focus on spatial phenomena prompts the use of spatial technology and geocommunication to analyse and represent these phenomena.

DPP is a multidisciplinary project, conducted by the Austrian Academy of Sciences the Institute for Medieval Research (IMAFO) in cooperation with the University of Vienna, Department of Geography and Regional Research. It is part of an initiative to promote digital humanities research in Austria. DPP will bring together expertise from historical and archaeological research as well as cartography and geocommunication to explore medieval geographies. Via regional case studies of comparable areas (i. e. Eastern Alps, Moravia-Thaya region, the historical region of Macedonia and historical Southern Armenia) with similar mountainous ecologies on the peripheries of historical empires, generalizable workflows and methodology will be developed.

By bringing together selected written sources as well as material evidence in a common spatial referenced database, further research-oriented analyses with digital tools become possible. Methods of geographical analyses like spatial statistics, network analyses, least cost calculations and view shed analyses (Breier 2013, Bodenhamer et al. 2010) can identify the patterns of influence, untangle and re-trace complex processes and make networks of power visible.

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By incorporating digital cartographic expertise, relevant facts can be depicted in a more effective visual form (Kriz 2013). The communication of space, time and spatial interconnectivity is an essential aspect of DPP. Optimal cartographic visualisation of base data as well as the historical and archaeological information are important features.

To provide a framework for these tasks, an interactive map-based online platform, based on open source technology, will be developed. Querying the database and overlaying various thematic layers will allow the user to explore the data and retrieve spatial relations, yet undiscovered. It will be a tool which can be used in the research process itself. Furthermore it will also be a platform to present and disseminate DPP's results in order to provide access to relevant data for fellow researchers and the general audience alike. "OpenATLAS", a database system established during previous research at the Institute for Medieval Research, will provide the backend for the application. Modular design, generalised workflow and compliance of data standards will guarantee sustainability.

Geocommuncation and cartography are important contributors for the historical research questions. Within DPP however, experts in cartography will not only provide technical know-how. The project offers opportunities to address research questions of these domains.

Data collected by archaeologists and historians is very inhomogeneous, and have various levels of accuracy, spatial as well as temporal. Specific entities as well as events can be located and dated precisely, whereas others can only be sited and assigned vaguely. These uncertainties and their representation have to be considered, if entities are to be displayed on a map. When showing the results of database queries, the quality of uncertainty will be reflected in the representation of the objects. Therefore, various methods of representing these uncertainties will be explored.

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The effect of the political transition of Hungary on map publishing

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Abstract. During the Cold War era, map publishing was a strictly controlled state activity in the socialist countries. As the traditional carto-graphic production was a very infrastructure-demanding process, only large institutions, such as civil or military national mapping agencies were able to afford it. This was the situation in Hungary too, where only two governmental NMAs and a few other professional institutions had the suitable infrastructure to manage the complete map production process. However, practically Cartographia Company (the Hungarian Company for surveying and mapping) was the only map production organization in Hungary: they produced all kinds of educational maps, and all other types of maps for civil use.

The political transition process in Hungary in 1989 luckily coincided with the technological transition process from the traditional to the digital map production. In a relatively short time (2-3 years), cartographers formed small firms (mostly based on digital technologies only) or started a 'one-man firm' (sole proprietorship).

This was also the time when GIS started to become more and more popular in the country. As governmental institutions were not really dealing with GIS, there was much more space for real private firms in this field, though there were also a lot of small private firms in map publishing.

Keywords. Hungarian cartography, digital cartography, Cold War

1. End of the Cold War era

In 1946 the former British Prime Minister Winston Churchill delivered his famous "Iron Curtain" speech in Fulton, Missouri. The speech called for an

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Anglo-American alliance against the Soviets, whom he accused of establishing an "iron curtain" separating the east part of Europe form the other parts of the continent. The answer of the Soviet Union was to establish Cominform (the Information Bureau of the Communist and Workers' Parties). Soviet leader Josef Stalin called the conference in response to divergences among communist governments on whether or not to attend the Paris Conference on Marshall Aid in July 1947.

The next decades were the time of Cold War (sometimes with real wars outside of Europe), where cartography had a specific role: there was an increasing need for larger scale and up-to-date maps. Finally, space technology and satellite images have totally changed the cartographic data collection methods, and these have contributed to the decline of secrecy in topographic mapping.

In the socialist countries, map publishing and map production was a strictly controlled state activity in the Cold War years. The traditional cartographic production was a very infrastructure-demanding process, therefore, only large institutions, such as civil or military national mapping agencies were able to afford. This was the situation in Hungary too, where only two governmental NMAs and a few other professional or educational institutions (e.g., the Geological Institute of Hungary and the Department of Cartography at Eötvös Loránd University) had the suitable infrastructure to manage the complete map production process. However, practically Cartographia Company (Kartográfiai Vállalat) was the only map production organization in Hungary: they produced all kinds of educational maps (school atlases, wall maps), city maps, tourist maps, country maps and globes for civil use. Thanks to Alexander Radó's (who died in 1981) professional-political background, his connections and international reputations, Cartographia Company had very good international relationships also with Western countries.

This paper focuses on the last years of the Cold War era, after 1985. Although Hungary was treated as the happiest barrack of the socialist countries ("Goulash Communism"), there was no liberalization in map production before 1985. Hungary launched a New Economic Mechanism in 1967, which gave producers the freedom to decide what and how much they produce and offer for sale, and also to establish commercial or co-operative relationships; however, most of the reform measures were cancelled or weakened due to Soviet pressure. This was the time when the recent civil NMA (Institute of Geodesy, Cartography and Remote Sensing = FÖMI) was established by re-organizing the old hierarchical structure, giving the supervision of civil cartography, especially the land cadastre to the newly named Ministry of Agriculture and Food.

The civil and military national mapping agencies had a stable structure until 1985, although the military mapping agency started to be re-structured continuously. We can state that there were no other map producers and map publishers in Hungary even in 1985. (As for orienteering map production, it was organized by the Hungarian Orienteering Federation in cooperation with the military mapping agency; however, these maps were only used for competitions and they were not for sale).

2. The time coincidence: start of the digital era in the Hungarian cartography and the era of political transition

2.1. Business in the last years of the Hungarian socialism

The economic difficulties, the slow growth of the economy, the decreasing level of the state investments forced the Hungarian governmental and political leadership to experiment with market reforms around 1980-1982. The experts not only suggested the improvements of state economy's efficiency, but were allowed to suggest changes on the property ownership, allowing private and partly private ownership for small firms (such ideas would not have been possible in the previous years).

The first Hungarian GIS company, Geometria Ltd. was established in 1986. Since its foundation, Geometria has had a determining role in network information and has been the leading service supplier of GIS applications in Hungary. The company developed alfaGrafik and topoLogic, their first basic GIS software, which reached significant success in various professional forums including the International Cartographic Conference in Budapest in 1989. This was the time when Geometria created the National GIS Basic Data-base (OTAB), which was the digital version of the 1:100 000 scale civil topographic map (all content except the relief). Completing the digital topographic map of the entire country constituted a very important step in the development of GIS in Hungary, although this database was yet not used for map production.

The Hungarian socialist system began transforming itself almost from its inception. After 1982, private entrepreneurs were permitted to cooperate in various forms of partnerships, and the formal private sector expanded dramatically. One of these forms was the so-called 'enterprise work team' (economic productive communities of the enterprise), which was in fact a private firm using the infrastructure and personnel of the company outside regular working hours. Cartographia Company also allowed such internal firms (after 1984), first of all with the purpose of giving their employees the opportunity to earn extra money and meet the large number of orders. One of the most prominent examples was preparing the *Multilingual map of Transylvania*. This was a relatively large-scale map (1:400 000) of Transylvania presenting all city names in three languages (Romanian, Hungarian and German), published by the enterprise work team not to harm the sensitivity of the Hungarian–Romanian political relationships. This map was published first in 1991 only. The first editions were made by using traditional map production technologies (Figure 1).

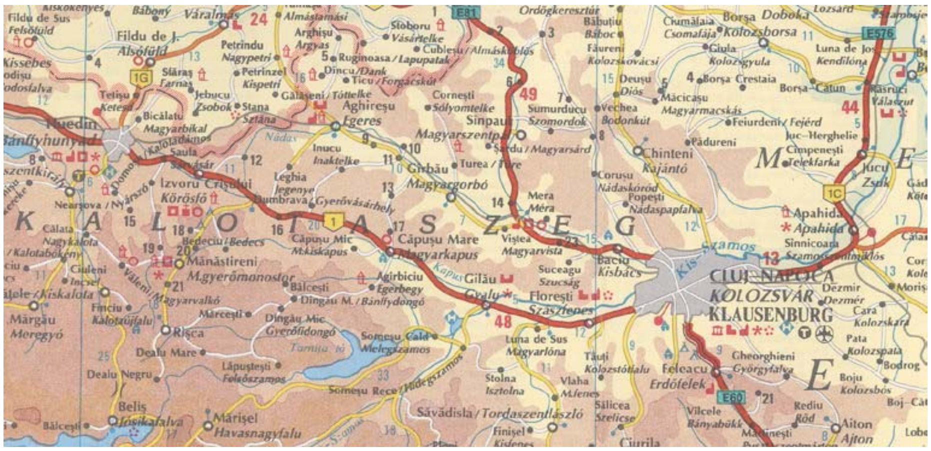

Figure 1. Multilingual map of Transylvania, first edition, 1991.

2.2. The beginning of digital cartography in Hungary

The first GIS software applications became available in Hungary in the middle and at the end of the 1980's. Although this was the last decade of the Cold War period in this part of Europe, the access to high tech devices (including computers) for the Soviet bloc countries was very much limited. The most developed Western countries formed the CoCom (Coordinating Committee for Multilateral Export Controls) to put an arms and different developed industrial technologies embargo on Soviet bloc countries.

One of the very first Hungarian cartographic/GIS software products was COMAPO, which was developed at the Department of Cartography, Eötvös Loránd University, Budapest, in 1972. The computational capabilities were good enough to manage analysis on different statistical data, but the main drawback was the lack of suitable output devices (printers). The COMAPO application was similar to the well-known SYMAP systems, which used line (dot-matrix) printers to produce thematic maps. Computer output, on monitors and printers, was limited to typical typewriter characters (letters, numbers, and simple ASCII symbols). These limited symbols could be used to create area patterns on maps. A modification of the line printer hardware and some programming allowed the overprinting of characters.

COMAPO was mainly the output system of an application which was developed by an institute of the National Planning Office (Országos Tervhivatal). This was a set of methods to print thematic maps which were created for analysing and researching regional planning data. The only method for producing such maps was the traditional (analogue) paper map production process, which was very time consuming. Although the digital method required very expensive infrastructure, on a state level they could afford for such equipment. Because these thematic maps were used for planning purposes and were not published in books or atlases, the low quality of visualization was not a problem (Figure 2).

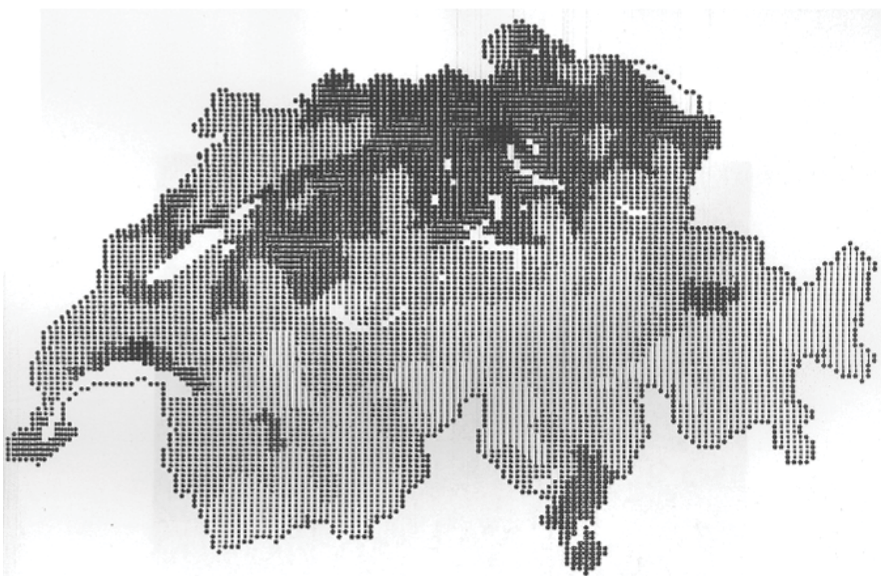

Figure 2. COMAPO thematic map (Switzerland).

To start modern map publishing, Hungary had to wait until the personal computer era arrived. As mentioned, due to the CoCom measures, Hungary was not allowed to have access to high technology IT devices quite until the political transition process. Thanks to the IBM strategy on personal computers, which allowed the cloning of hardware components, it was possible to import the components and assemble a PC and sell it on the Hungarian market. This was they that companies and institutes were able to buy personal computers since 1985.

Cartographia started to use PCs in its map production process in this time, but their usage was limited to certain phases of the production:

- Phototypesetting machines revolutionized the typesetting of cartographic products, but converting this process to the computer-based platform was another challenge. Phototypesetting was particularly important for book and daily newspaper production, so when such service became available in Budapest, Cartographia started to manage the phototypesetting of their maps in this way.
- Maps with lots of geographic names (like World Atlas, Road map of Hungary, Budapest map) set another important task: to compile the index section. If all the geographic names were digitally stored in a computer environment, it was also logical to manage the sorting of geographic names in alphabetic order. In the case of the large world atlas of Cartographia, this job required the sorting of about 100 000 names; this used to be an extremely time consuming process in the analogue era.
- Probably, the first elements of paper maps where IT methods were used to produce a part of the printed map were the title pages of city maps or tourist maps. Formerly, these maps were printed by limited spot colours, but in the digital era the printing technologies were improved considerably and CMYK printing became widely used. This method allowed using colour photographs on maps, which first appeared on the title pages of the Cartographia maps.

2.3. The role of secrecy

Secrecy has not really influenced negatively the map production process in Hungary in the mid or late 1980s. The topographic maps were classified, but soon after the political change both the civil and military maps became publicly available. In August 1989, I had the opportunity to visit Czechoslovakia together with the head of the Hungarian military mapping authority, who was very much surprised when we recognized that in Czechoslovakia the military topographic maps were already publicly available. This experience may have speeded up the process of the public availability of topographic maps in Hungary; even so, it took another year to complete this process.

3. Private firms in map publishing

The political transition process in Hungary in 1989 and the technological transition process from the traditional to the digital map production luckily coincided with each other. In a relatively short time (2-3 years), cartographers formed small firms (mostly based on digital technologies only) or started a ‘one-man firm’ (sole proprietorship). The digital technologies, however, were not yet suitable to manage the whole map production procedure of larger projects, like road maps or tourist maps. With a very limited IT experience and skills as well as with less powerful computers it was possible to produce only graphically very simple maps.

It is worth mentioning that some maps (large map projects) were produced by new companies and alternative map publishers (rather marketing firms) using exclusively traditional map production techniques. The Multilingual map of Transylvania was mentioned as an example.

One of the most prominent examples was the production of a 1:20 000 scale atlas of Budapest published by a newly formed marketing company, which collected enough advertisement to finance the whole project. The map part of the atlas was created by a small group of individuals, who had just left Cartographia, where they were employed as map editors or draughtsmen (Figure 3).

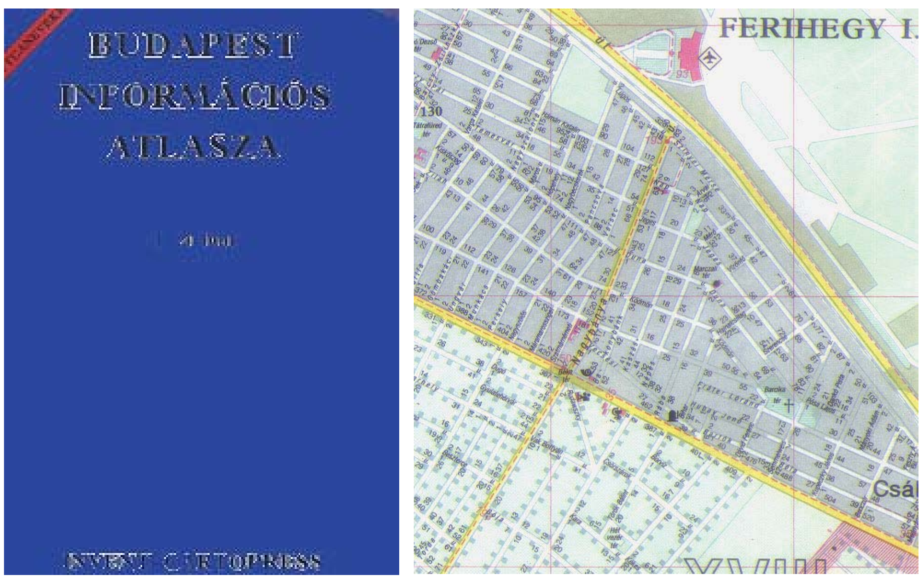

Figure 3. The title page and an example of an atlas page (Budapest Information Atlas, 1990), published by Invent Cartopress.

As Hungarians were not accustomed to having the opportunity of buying maps from various companies, it can be stated that the market was not prepared for such liberalization. However, these small or one-man firms were very flexible to start publishing maps if their income did not depend on selling maps only. The most typical products of this time (1990-1995) were city maps, where the production cost was covered by the income of advertising.

3.1. Legal issues

One of the most prominent manifestations of the political transition process was the nearly complete change of legal measures. As the laws and decrees focused on the political issues in the first years, Hungarian cartography had to wait for laws on cartographic and surveying activities. Establishing the legal background of the new economic system was a most prominent change. Various forms of enterprises were made available at that time, and all cartographic firms had to select one of these businesses (these forms were changed in 1997, when Hungary started the EU membership negotiations and started to harmonize the national measures to the EU regulations):

- Sole proprietorship (self-employment): this form of entrepreneurship was really suitable for individuals to test their skills. This is a type of business entity that is owned and run by one natural person and in which there is no legal distinction between the owner and the business. The owner is in direct control of all elements and is legally accountable for the finances of such business.
- Limited partnership firm: these firms were mostly family based small companies. If the entrepreneurs had very limited financial resources, they regularly choose this form, but their general partner's liability was unlimited for the partnership's obligations.
- Limited liability company: it can be established with a predetermined amount of initial capital provided by its founders. The liability of its members was limited to the provision of the company's initial capital. As a general rule, members are not otherwise responsible for the company's liabilities. Due to the very limited capital, only few companies (mostly owned by foreigners) were formed in cartography.

An interesting, though embarrassing part of the measures was the policy of using state cartographic data. All firms had to pay a fee after publishing maps based on state topographic and cadastre data, and a similar fee was to be paid where such data were used in GIS environment. The most important objection from the private firms was that actually the national mapping agencies formed the state cartography and they formulated the measures. The private firms had to prove that they had not used state cartographic or GIS data when they published their maps, although the national mapping agencies mostly focused only on detecting the illegal use of GIS data. The national mapping agencies were allowed to pay a discounted fee when they used state cartographic data (which was nevertheless created by them); this meant that one of the basic principles of the new political and economic system, the competitive neutrality, was damaged. However, the small firms had only limited opportunities to squeeze the measures, and even nowadays this principle is still valid in similar measures.

3.2. General observations

The most prominent observation on the Hungarian cartographic firms in these years is the **large number of firms**. It looks that the freedom given by the political transition was not just a feeling of the freedom in the private life, but also the freedom of enterprise. A lot of employees (mostly graduated cartographers, editors) felt that they had their own ideas which were worth dealing with in an independent company. Most generally, the majority of these early firms employed only one or two persons. These small firms or individual enterprises mainly concentrated only on a specific segment of map production and tried to guarantee their business share on that small area. Very few of these early firms existed for more than five years.

On the other hand, the number of published maps increased dramatically. Lots of city maps, recreation (biking, water sport) maps of smaller areas were published; the more experienced the map makers were, the most chance they had to publish the most profitable products: the road network of Hungary and the street map of Budapest. The firms soon realized and understood that the market was limited: no matter how many firms would publish new maps or atlases, the number of sold copies would be about the same. Another experience that they had to learn was that the selling of maps was a business different from map making, and that the income cannot be regularly realized by the map production company, but by the marketing firm.

The **first digital map** where the complete technological process was already digital was an orienteering map (Lajosforrás, 1990) drawn by the author, though it had only minor effect on other map publishers (Figure 4). A map drawing program developed especially for orienteering maps was released in 1989. Orienteering maps have a unified map specification all over the world, so this software was suitable for all countries. (First of all, because there are no texts on orienteering maps, so the software developer did not have to deal with handling text, which would have been a quite complicated task in those years). It is important to note that creators of orienteering maps switched to making their maps completely digitally in less than five years, although the number of orienteering maps published annually in those years was somewhat more than thirty. As soon as computer printers became more powerful and affordable, more and more orienteering maps were printed by computer printers instead of offset printing.

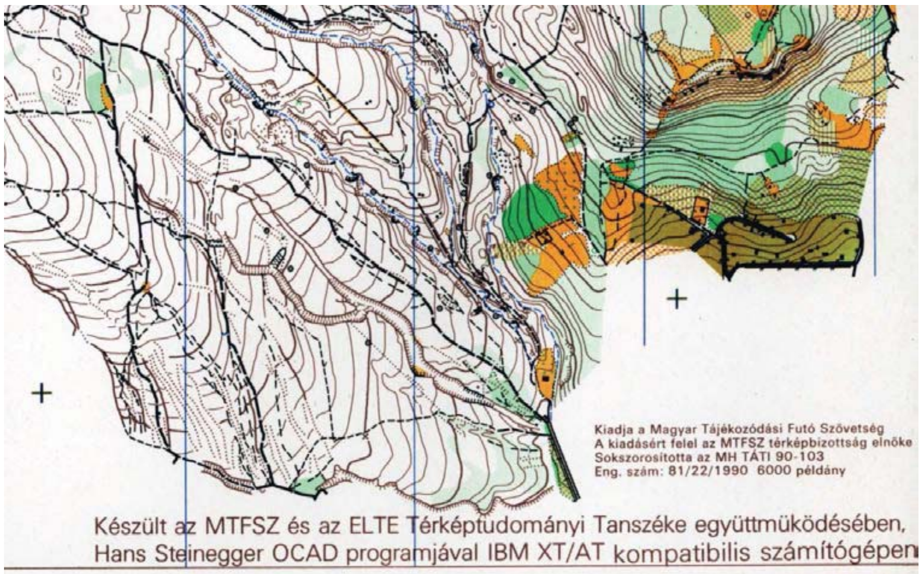

Figure 4. Part of the first Hungarian digital map (Lajosforrás orienteering map, 1990).

The **first digital city map** was produced by a German-owned company (Katicom Ltd.) in 1991. The company was not really present on the Hungarian market: they produced only German city maps (making use of the much lower salaries of the Hungarian employees). This city map represented Hévíz, a small Hungarian city, a famous spa. The company used Apple-McIntosh computers, which were not easily purchased in Hungary due to the constraints by the CoCom list. Probably, this was the first company in Hungary which used general graphic software for map production.

These small firms were much more flexible than the large Hungarian map producers. It took much longer time for Cartographia Ltd. and for the national mapping agencies to change their production line from analogue to digital. It is also true that some of these one or two-men private companies still focused on analogue maps. They were partly elderly people, who thought they would not want to invest in buying computers, or they simply thought that it would be to complicated for them to learn using computers. Even till the end of the 1990's, these very small firms were able to find analogue jobs, but doing this job was not enough for most of them for survival.

3.3. Major firms of the early digital years

Cartographia was still the dominant map production company of Hungary. For several years Cartographia had been a state-owned company, which was sold only after 2000. Cartographia produced its first totally digital map in 1992 (A Dunakanyar információs térképe). To convert their existing maps into digital from took several years. As tourists maps are complicated maps, both their digitizing and updating were very much time-consuming; this is why the production of tourist maps remained the ‘privilege’ of Cartographia Company for several years. There were, however, a few tourist maps produced by other companies (for example for Transylvanian areas).

- The first important private cartographic firm was **Agát-Topográf Ltd.** Most of the four founders of the company were former employees of Cartographia. They started to produce city maps in the first years: maps of smaller towns, especially places around Budapest, like Törökbálint, Herceghalom, Budaörs, which did not have maps in the previous times (Cartographia published maps for larger cities only). This was not only a map production job, because the firm also had to find enough advertisers to finance the publishing of maps. The map production in the firm was based on Apple-McIntosh computers.

- **Dimap** was founded in 1994, though the key person was already active as a sole proprietorship after 1990. It had only very few employees (former Cartographia employees, who initiated the publishing of the already mentioned Multilingual map of Transylvania) and produced mostly Hungarian city maps and maps of Transylvanian regions. This firm created the first digital map and atlas of Budapest (1995) and atlas of Hungary (1996), which were different from those of Cartographia. Their key software for these two atlases was AutoCAD; later, they began to use other graphic software to produce their city and tourist maps. From 1995 they began the collaboration with the Hiszi-Map (see below) to produce a series of county atlases of Hungary. The first one (Békés County atlas) was published in 1995.

- **Hiszi-Map** was also formed in 1994. They made county atlases, including maps of all villages and cities. In some years they produced the maps of all Hungarian villages. These maps were made mostly by non-cartographers, and their maps were not really suitable for GIS systems, although there was a need for such database.

- **András Szarvas** has been acting as a private cartographic publisher, map maker and map trader since 1991. He has more than 100 titles (Hungarian hiking maps, city maps, road maps and atlases of Eastern European countries, World atlases etc.). His maps were regularly reprinted, and by now his name is a kind of brand, mostly because his maps have been available in several shops. He formed one of the first webshops for map trade.

- There were few GIS companies which were interested in map production (not in the production of paper maps, but some other products). It is important to mention the **first Hungarian cartographic CD-ROM**, which was a vector-based World Atlas created by a GIS firm, Rudas&Karig Ltd., and the Department of Cartography, Eötvös Loránd University in 1994. This product preceded its age, because there were only few CD-ROM drives in Hungary; this explains why very few copies were sold (Figure 5).

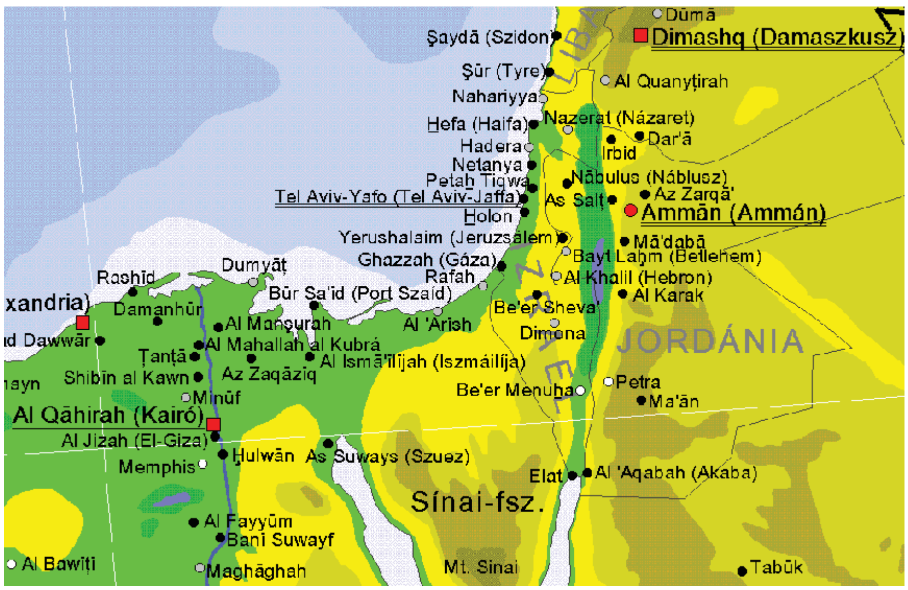

Figure 5. A screen shot of the CD-ROM World Atlas. It was a real challenge to represent all special characters in PC environment in 1994.

- Although maps are rightly considered culture-related products, only a few **foreign companies** tried to find a map production business in Hungary in the early years of digital map production. They soon recognized that the difference between the price levels of Hungary and the Western countries was too large at that time, so it was not profitable for them to “convert” their home (Western European) products and sell them in Hungary, because the prices would have been too high for the Hungarian market. Nevertheless, larger cartographic products, such as world atlases and hand books were translated into Hungarian. This was a kind of market for small Hungarian firms as all geographic names had to be translated or transformed into Hungarian. Such products were not quite successful at that time: they were published only once, and the foreign companies were not able to realize enough profit to re-publish the book or atlas. Their attempt rather turned out to be a financial loss. It took several years for the Hungarian market to be matured: such products (world atlases) became successful after 1999, but few atlases were already published in 1991-92. Exceptions were also the school atlases: the first foreign-based company school atlas was published in 1994.

4. Conclusion

It was a strange coincidence that the political transition process and the process of changing the analogue map production technique into digital happened at the same time, around 1985-1992. The political transition process made the establishing of private companies available, but without the technical opportunities of desktop map production even the most experienced individuals would have not been able to manage the whole process.

One of the most important reasons of writing this paper is to have a written documentation of this era from the eyewitnesses. Most of the information in this paper were collected in interviews (oral history). The private firms were not interested in writing a scientific paper: they were busy to learn how to survive in the business environment, where most of them had no practice at all (maybe they did not even want to share their business experience with their rivals).

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Interoperable Volunteered Geographic Information empowering e-governance processes: Case study for Land Use Dataset in the City of Zagreb

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Extended Abstract

Today, urbanisation is a major change taking place globally. It can be seen as a gift to the human society if it is controlled, coordinated and planed. However this development causes a lot of ecological, economic and social problems (Mohan et al. 2011). Cities are complex, networked and continuously changing social ecosystems, shaped and transformed through the interaction of different interests and ambitions. Ensuring employment, sustainable development, inclusion and quality of life are important concerns. There is no doubt that in these challenges, spatial data plays a crucial role. In order to manage sustainable development and support e-governance processes, integration of spatial data is needed in an efficient way.

Management of spatial data in local administrative units (municipalities and cities) is under the local spatial data infrastructures (LSDI). One of the most important areas of the LSDI is urban planning where Land Cover (LC) and Land Use (LU) are core information layers for a variety of scientific activities as well as administrative tasks.

This work presents the methodology to collect VGI observations for land use areas definition based on the LUCAS fieldwork methodology, and HILUCS (Hierarchical INSPIRE Land Use Classification System), and reference topological layer. The practical research work was performed during the GIS summer School in the city of Zagreb (Figure 1) in dual collaboration by Faculty of Geodesy, University of Zagreb and Faculty of Horticulture and Landscape Engineering, Slovak University of Agriculture in Nitra.

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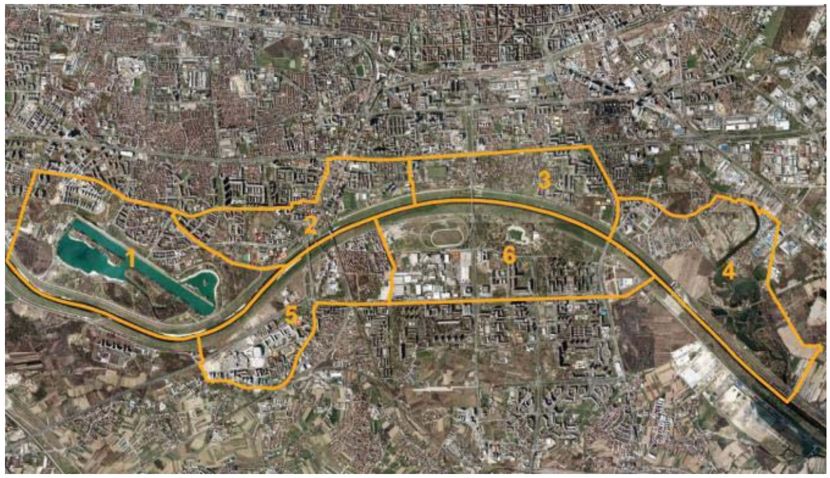

Figure 1. Study area - digital orthophoto with surveying zones boundary definition.

The reference spatial data was topographical dataset in national topographic model provided by the city of Zagreb. Mobile GIS devices Trimble Juno 3B were used for the field works. Attributes as HILUCS (Benner et al. 2013) LU and LUCAS LC codes (Gallego et al. 2008) together with cardinal direction photographs were implemented into the data model.

The fieldwork lasted four days and resulted in total number of 1755 observation points collected by six working groups. Point features were collected with the following data type attributes: LU codes defined by HILUCS and optional LC codes defined by LUCAS classification. The results presented provide suitable proposal for fieldworks methodology and updates of a land use database in line with the INSPIRE directive applicable at a LSDI level anywhere.

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Sample of map representation of land cover changes in two and three time horizons

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Extended Abstract

Land cover (LC) is considered one of the most dynamic phenomena of landscape. Changes can be expressed by statistics: tables and graphs which demonstrate enlargement or diminishment of individual LC classes. As these changes take place in space, the most appropriate means of their representation is a map which complements the statistics.

Map representation of LC is accomplished in two ways:

- A single map representing changes between two or more time horizons;
- Small multiple maps also representing changes between two or more time horizons.

Animation, which is a process of creating images simulating the movement first of all for temporal changes of objects and their properties, should be also mentioned here. Animation helps cartography to enlighten spatial relationships in landscape and processes taking place in it (Kraak 2014).

Representation of LC changes by small multiple maps is the most frequently used way. Each map represents the state of LC in the corresponding time horizon and the change becomes obvious from comparison of maps.

Representation of changes by means of a single map is not so frequent (see *Figure 1*). The aim of this paper is to show two options of LC change representation in two and three time horizons on a single map applying the CORINE land cover (CLC) data in order to highlight the trends.

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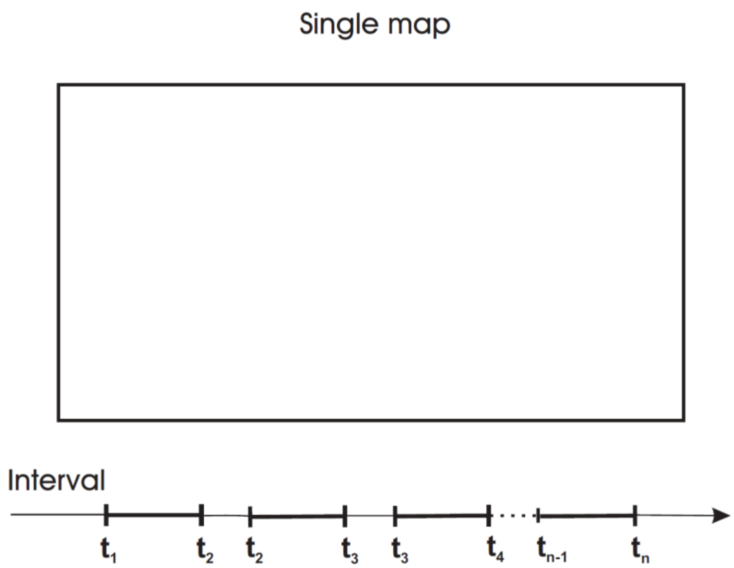

Figure 1. Mapping time intervals in a single map.

The first option demonstrates representation of changes in 1990-2000 and 2000-2006. It is based on comparison of computed mean value of changes (mean LC value in % is a ratio of the area of LC changes standing for the corresponding type of LC change to the area of all 1 × 1 km squares in which changes took place) of a particular LC type with the real value of the given type of change in a particular square. The result is spatial representation of nine possible types of LC changes distinguished by colour: hues of red (enlargement) and hues of blue (decrease) in two time horizons (Feranec et al. 2010). This approach is only suitable for map representation of changes in two time horizons (if used for, e.g., three horizons, the result will be 27 possible types of LC changes). It was used for the map representation of Czechia's and Slovakia's artificial surfaces (1990-2000 and 2000-2006, *Figure 2*) and for the European LC changes (1990-2000 and 2000-2006).

The second way demonstrates representation of LC changes in 1990-2000, 2000-2006 and 2006-2012. It is based on the comparison of sizes of real values (yearly change areas) of the appurtenant LC change type (in ha) in a 3 × 3 km square in three time horizons. The referential value is the LC change in 1990-2000. The result is spatial representation of squares where LC changes:

- enlarged (reaching greater value compared to referential value. They are represented in red);

- diminished (reaching always smaller value compared to referential value. They are represented in blue);

- reached alternating values (enlargement, diminishment and the same value compared to referential value or the change was not identified in the referred time horizon and took place in the following time horizons; such changes are represented in magenta, *Figure 3*).

This type of map representation also makes it possible to represent – illustrate changes in more than three time horizons in a single map contributing to the identification of trends in landscape dynamics.

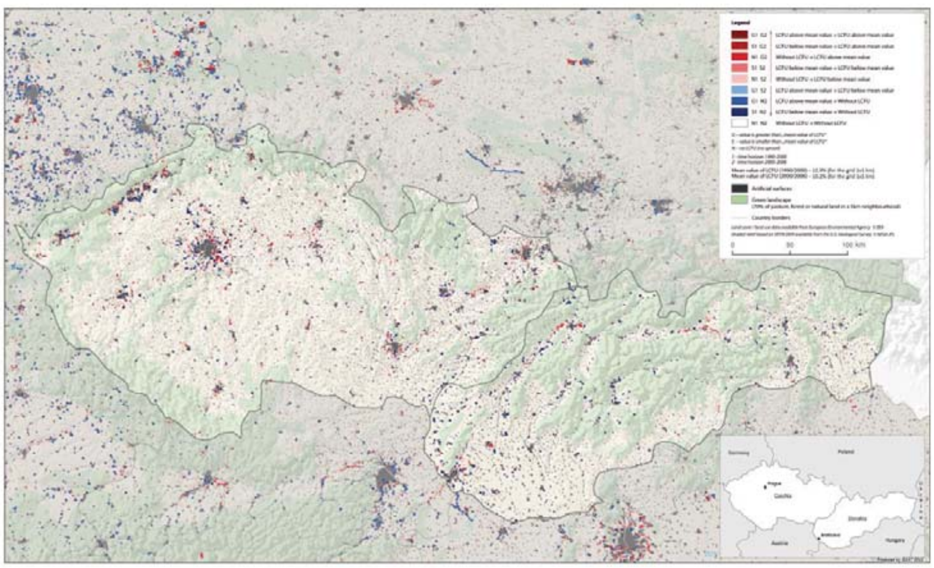

Figure 2. Changes of LCFU in Czechia and Slovakia in 1990-2000-2006 (Feranec & Soukup 2012).

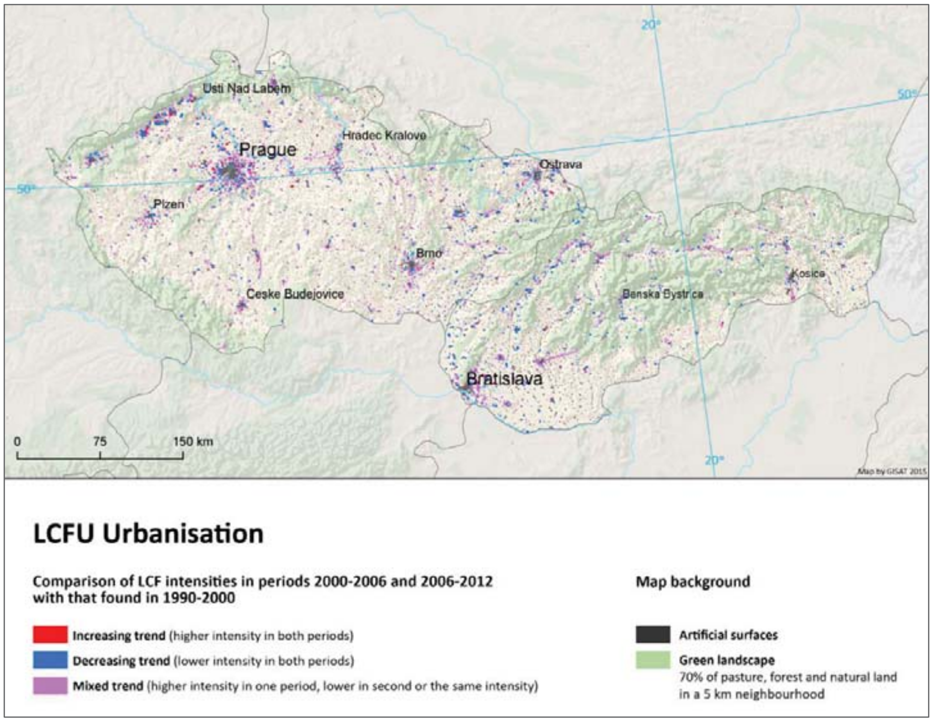

Figure 3. Changes of LCFU in Czechia and Slovakia in 1990-2000, 2000-2006, and 2006-2012.

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Land Cover Mapping for Subcarpathian Area (Romania) at Different Scales Using Currently Available Data Models

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Abstract

Land cover represents an important factor for different geographic analysis, from physical geography studies to environmental analysis and spatial planning. Land cover is a dynamic variable, because it reflects the interaction between socio-economic activities and regional environmental changes. For this reason it is necessary to update frequently this dataset.

Currently, there are many models of land cover or land use available, produced at global, continental or regional scales, but they are not every time accurate at detailed scales.

Subcarpathian regions are characterized by complex land cover features as an effect of the increasing anthropogenic pressure by settlements, land uses and mining/quarrying during the last 200-300 years. For this reason mapping land cover was a difficult task, and a time consuming one, as the manual classification of land cover classes was for the long time the only one technique.

The study area is located in Prahova County, Romania, between Prahova Valley and Teleajen Valley, and it is characterized of a variety of morphostructures. The typical landscape features include hills superposed on anticlines, depressions on synclines, relief inversions and geomorphic processes (landslides and selective erosion). In this context, the land cover is an important morphodynamic driving factor for a lot of processes.

Our paper proposes a combined GIS, Remote Sensing and cartographic approach in order to produce an accurate land cover data layer for a selected Subcarpathian region where land cover classes are various and com-

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plicated in configuration. The methodology includes some important steps: data processing, data filtering, landscape analysis, validation and correction and land cover mapping.

This paper focuses on the integration of data from existing land cover models with remotely sensed data (processed by thematic classification, modelling and image interpretation) as well as from thematic maps and research studies.

There are some available land cover models which differ in their spatial or temporal resolution and spatial coverage. Corine Land Cover is one of them, produced by European Environment Agency with a temporal resolution of 6 years (datasets available from 2000, 2006, 2012). Another available land cover model used in this analysis was Global Land Cover 30, produced by National Geomatics Centre of China at 30 m spatial resolution (Yu et al. 2014).

Also, we used some vector data to create masks for the remotely sensed images classifications (such as soil data, extracted from Romania Soil Map 1:200.000).

By integrating the processed satellite data, the available models of land cover and ancillary vector and raster data (Ran et al. 2012), the final results were obtained, which contains various classes, as follows: forest, grassland, orchards, settlements, water, degraded lands and transport network (Farmer et al. 2012). This result was confronted and validated with the latest orthophotos, remote sensing imagery at medium and high spatial resolution and in the terrain. A statistic approach was used in order to test the spatial accuracy of the land cover model.

The final step was to map the land cover for sample areas at different scale, such as for example: 1:25.000 for the entire study area or 1:10.000 for a selected geomorphic unit. This allowed the production of land cover maps for different applications like thematic mapping, natural hazards analysis and spatial planning (examples).

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Joint Information System (JIS) as Unique Land Register and Cadastral Information Systems

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Extended Abstract

In 2015 cadastral office in Varaždin started production of Joint information system (JIS) land register and cadastral information systems as integrated spatial information system. Land cadastre is in jurisdiction of State Geodetic Administration (SGA). Land register is ownership database in jurisdiction of Ministry of justice (MJ). This unique system is an Internet application that includes all business procedures that covers land cadastre (SGA) and ownership (MJ) procedures including cartographic part of the system web GUI (Graphical User Interface) for maintaining cadastral maps.

There are presented some initial experiences of using the JIS geographic information system for land cadastre and ownership register. Joint information system (JIS) includes: file management system for acquiring files, surveyor's projects controlling and registration in book-keeping part of land cadaster and cadastral map maintenance and ownership record maintenance. Formal control of surveyor's projects includes: book-keeping part of land cadaster and ownership record maintenance, cadastral map maintained control. In Republic of Croatia the land cadaster and ownership registration projects do licensed surveyors.

JIS (Joint information system) is big step in maintaining land management registration. SGA implements JIS county by county since several years ago. Web-based Geographic information system (GIS) for cadastral map maintaining has not final functionality. Tools for big land management registration transactions in JIS are missing. Users of standard CAD (computer aided design) based maintaining tools for cadastral maps are mostly disappointed using JIS because this web GUI has lack of full CAD functionality. JIS is not CAD, but it should spread its cadastral map maintaining functionality for the missing part for big land management registration transactions.

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Mapping abandoned Industrial Buildings: the territory from Land use to Reuse

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Keywords. Map, Industrial building, Abandonment

1. Introduction

The phenomenon of the abandonment of industrial sites is one of the most important events in the contemporary socio-economic dynamics, both in America and in Europe but especially in Italy. Nowadays the industrial area, on which a series of manufacturing building have developed over time, has lost contact with the surrounding environment and it has been deprived of its original function without acquiring a new one.

There is no a characterization of that areas: the brownfields or underutilized areas can be defined ad 'resilient areas' to be given new value, or areas that need to find new uses, through the recovery and the assignment of an active function, according to new policies acting on the whole territory (proposing them as potentially reusable).

Brownfield sites, meant as signs of the past but also of a recent abandonment, can be interpreted in a dynamic perspective, favouring their role of resource as an opportunity for the local development.

The prospective of re-use allows to minimize the consumption of new territory, through the knowledge and recycle of abandoned areas and buildings, as provided by some Italian Regional Plans. Indeed for planners and policy makers recycling of industrial abandoned areas is the best smart grow option.

In this context, through the interpretation of the industrial sites as elements of resilience for the territory, is possible to identify the most appropriate strategies for areas in crisis, in which intervention is a priority.

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The extent of industrial abandoned buildings is unknown in many cities and only few research identify these areas.

A case study limited to the municipal level can guide the process of interpretation and formulation of proposals for a more efficient territory in transformation.

The purpose of this research is an evaluation of the abandonment of industrial sites in a municipality of Friuli Venezia Giulia, in Italy, through the identification and the assessment of the current condition of the industrial buildings in the area.

The case-study territory is analysed through the processing of databases imported in a GIS, followed by observations on the field.

2. Method

The phase of data collection has entailed the acquisition of the cartography of the municipality of Tavagnacco (CTR) and the use of open-source tools like Open Street Map, to import the data into the GIS software (Quantum GIS 2.10).

The overlapping of maps implies a first confirmation of the position and dimension of industrial building in the area. By direct investigation (surveys, interviews...) it has been possible to categorise the status of activities or disposal of each production facility.

The work of survey and mapping takes into account both the 'disused' building, meant as completely abandoned, that the 'underused' ones, interpreted as a percentage of abandonment.

The direct survey, to detect the characteristics of buildings and areas, allows an evaluation of the potential reuse also based on the typologies of buildings and infrastructures of the analysed district in order to promote sustainable urban development, sustainable placemaking and revitalization.

3. Results

GIS results provide a quantification and a localization of the industrial abandonment in the territory: the presence of abandoned or underutilised buildings is homogeneous in the entire district. In addition, data and maps show the abandoned industrial sites, also in their future perspective, and the possibilities of regeneration through the reuse, even partial, of the buildings.

The analysis highlights how the built environment to recycle is remarkable both in terms of size and quantity. The reuse emerges as a priority because the buildings partially or completely unused appear in good condition and are placed along infrastructures, which make them easily accessible.

4. Conclusion

The method developed can be a first attempt for future applications, extended to a wider area (regional scale), for the study of specific issues, such as the factors that influence the reuse of industrial buildings, or to establish parameters for future building or yet to assess the land use and the impact of the artificial landscape.

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Model development for web - atlas system applying in administration management

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Abstract. Traditionally, the maps are very important tools in government management and decision making. Nowadays, information technologies blooming as well as wide spreaded of internet involve the evolution in catography technologies. The combining of cartography and internet creating new map generation - web maps. This new maps allow users see and apply it in any place which have internet connection. Web maps have many advences over traditional maps. Therefore, there are many researcher applying them in socio-economical and culture aspecs. This paper describes research results in development of a model for web atlas applying in administration management in Hanoi, Vietnam.

Keywords. Webatlas, Web Map, Electronic Atlas, Internet map, Administration management.

1. Introduction

Administrative management is a very important field and has a huge impact on political stability and socio-economic development of a country or locality. The socio – economic constantly evolving, so the management of state admini-tration must also be constantly improved, enhanced and completed to meet the requi-rements of each development period of nation. Map and GIS technologies have been continuously improving and perfecting support management and decision support for autho-rities[1]. The construction of webatlas support system for the administrative manage-ment is acritical issue, especially as the Inter-net infrastructure has been developed as today.

2. WebAtlas design model to support the administration

2.1. Technology based

In [2, 3] presented the method of con-struction and development of systems based on Map-Xtreme webatlas. This is a method to optimizes using the database map that the agencies is carrying out construction. This paper paper present the MapXtreme application for building a system to management, display, analysis, calculation for a Web-based

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manag-ing administration together with geographical information systems to help users to easily access and use information that is most intuitive.

2.2. Main design

2.2.1. Workflow (figure 1)

Applications are developed on the web environment, the map developed on MapInfo's MapXtreme environments follow the geogra-phic information system's standards [4, 5]; the system's functions are developed in Microsoft ASP.Net.

2.2.2. Database development

The administrative map database is based on MapInfo format. All data used overall administration base and a decentralized level of detail by three administrative levels: City; the district-towns;communes, wards and townships.

2.2.3. Site administration design

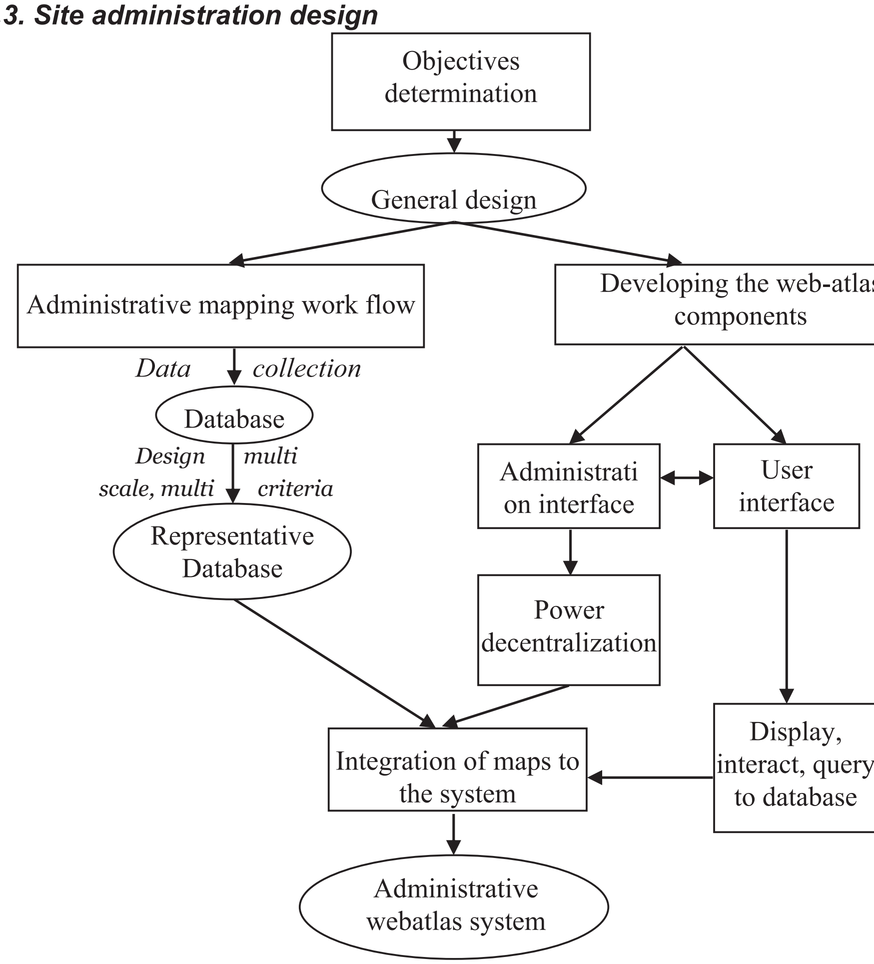

Figure 1. Web-atlas sytem development work

An administration of a website system is updates, fixes and adds information. So, depen-ding on the purpose of each site that needs to system administration interface design accor-dingly. For the administrative web-atlas system, the interface is designed to easily identify and decentralization of administrative units under the directory tree. In this directory tree each directory level would be corresponded to a level administrative unit (City, County, district towns, commune, ward or township). In the system administration, there are tools to manipulate the map as the user interface, however there are some differences such as management: decentralized power to the system log, update and repair database.

2.2.4. Designing the user interface

The user interface is designed with many different functional groups memu such as inte-ractting with the map; display attribute informa-tion, query information on maps and in data-bases; create the thematic map database, ...

2.2.4.1. Designing the directory tree for administrative units

The administrative units in the webatlas system is designed in directory tree similar as in the system administrator. Each administra- tive unit in the city will be linked to a site map and the corresponding database attribute. Users can click to search for administrative units as well as related information and displays the map of administrative units on the website interface.

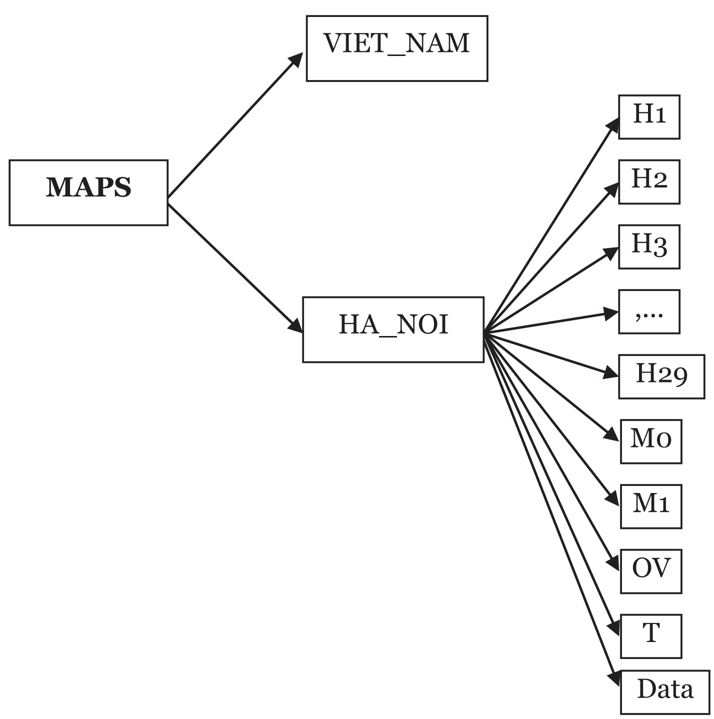

Figure 2. Database storage in atlas.

MAPS (The folder to store the map data)	
H1	(Map of Ba Dinh District)
H2	(Map of Ba Vi District)
...	...
H29	(Map of Tu Liem District)
M0	(The first scale map display)
M1	(The second scale map display)
T	(Full scale map display in Ha Noi)
Data	(Database of administration information structure, maps and annually data...)

Table 1. Database storage in atlas

ID	Name of admintration unit	Unit
T	Hanoi Capital	1
H1	Ba Dinh District	2
H1_X1	Quan Thanh Commune	3
H1_X3	Doi Can Commune	3
...	...	
H2	Ba Vi District	2
H2_X1	Phu Chau Commune	3
H2_X2	Tay Dang Town	3
...	....	
H3	Cau Giay District	2
H4	Dong Da District	2
...	...	

Table2. Database storage of admintration unit

2.2.4.2. Developing the basic functions

Web-atlas system is designed as an interact-tive software with maps through the web, users can display the entire map on the interface or it can turn on / off separately to display the content layer maps; can zoom in, zoom out, move the map in different directions; map display according to the different scale, mea-sure distances on the map, display information properties of all objects on the map, ...

Below is a description of the code for some basic tools to interact with Webbased map [5]:

+ Zoom in:

<cong_cu_bd:ZoomInTool ID="ZoomInTool1" runat="server" MapControlID="MapControl1"/>

+ Zoom out:

<cong_cu_bd:ZoomOutToolID="ZoomOutTool1"runat="server" MapControlID="MapControl1"/>

+ Pan move:

<cong_cu_bd:PanTool ID="PanTool1"runat="server" MapControlID="MapControl1"/>

+ Scale:

<cong_cu_bd:ZoomBarTool ID="ZoomBarTool1" runat="server" ZoomLevel="12500" MapControlID="MapControl1" />

<cong_cu_bd:ZoomBarTool ID="ZoomBarTool2" runat="server" ZoomLevel="6500" MapControlID="MapControl1" />

<cong_cu_bd:ZoomBarTool ID="ZoomBarTool3" runat="server" ZoomLevel="3550" MapControlID="MapControl1" />

<cong_cu_bd:ZoomBarTool ID="ZoomBarTool4" runat="server" ZoomLevel="1500" MapControlID="MapControl1" />

<cong_cu_bd:ZoomBarTool ID="ZoomBarTool7" runat="server" ZoomLevel="500" MapControlID="MapControl1" />

2.2.4.3.Develop the function to create them-atic maps on webatlas

Besides the basic functions to interact with the map, Hanoi administration web-atlas system was built to create a thematic criteria different from base map data and attribute information in database systems. The system can perform creation of administrative units based on the data area, population, ... combined with the color index; the division level indicator which produces thematic maps on the website.

2.2.4.4.Develop the advanced query function

The system is to build an engine to search objects on the map at all administrative levels (city,county, district communes, wards, towns, villages, ...). After performing this search function, the user can display a map of the objects on the search interface of web-atlas. In addition, this tool can also search for administrative units according to statistics (area, population, ...) and display maps for the administrative units that can simultaneously view all details of those administrative units.

3. Result

3.1. Main system administration

Database administration via secure web system with account and password for each member of the system.

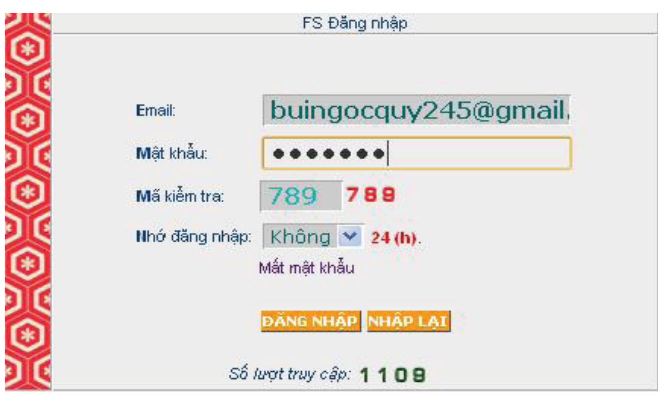

Figure 3. Login.

After login, depending on which authority is permitted administrators can use the different functions of the system, management system is divided into 3 levels (1st, 2nd and 3rd) corresponding to administrative level (city, district and commune district). The 1st level administrators can use all the functions of the system.

Figure 4. User interface of system administration and member administration.

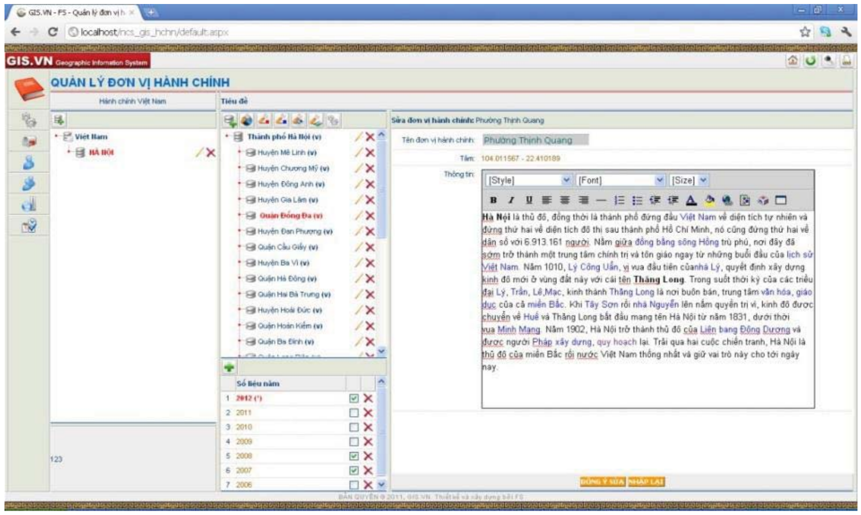

Figure 5. Updating the information for administrative units.

With the functions of the system adminis-trator, we can update the administrative data such as area, population, population density, number of male, female,... the multimedia data, the inventory report, the documents via e-mail system or other features of the system.

3.2. User interface

Users can use the utilities of Web-atlas system to lookup the information is integrated on the map by the support tools as zoom in, zoom out, move, measuring, search, create thematic maps, ...

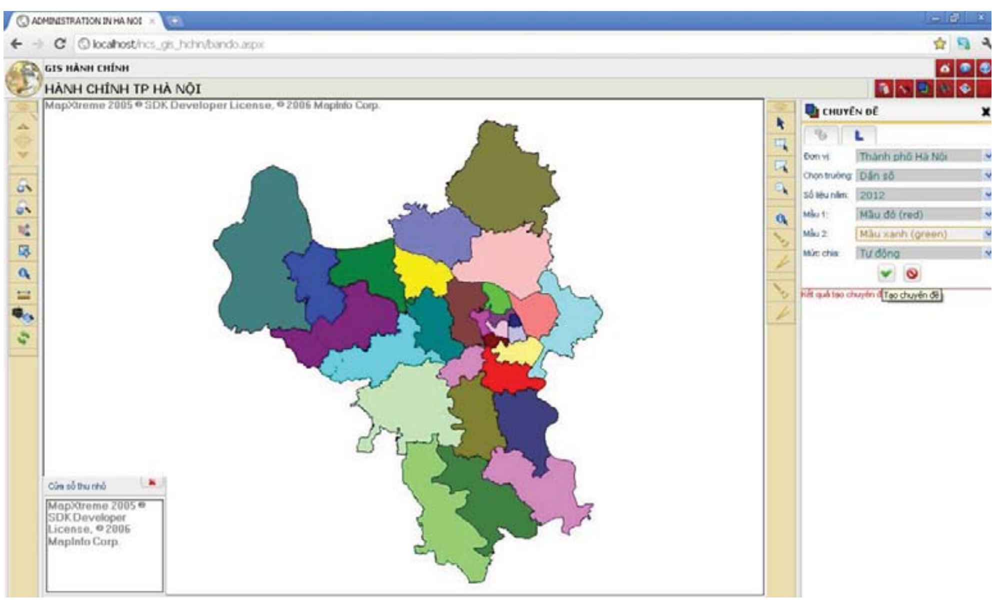

Figure 6. Create the thematic map based on database in web-atlas system.

4. Conclusion

Through research and practical implement-tation web-atlas systems for the administration of Hanoi, we found Web-atlas system can be installed on personal computers, local area network or internet and can be applied to the provincial-level administrative divisions, cities, the departments management ... system can help the managers, experts, ordinary users can use to view, search, searching, analysis and calculations ... The administrative information based website together with geographical information systems in an intuitive way on the map. The system can edit, update, supplement easily at any time on the system. Create and and display thematic map quickly with supporting multi-criteria criteria and multi-temporal data of different years for the comparison and evaluation of a more favorable way. The information provided on the system along multiple dimensions: both on the map, search by administrative units, search by objects ...

With this model, we can create an archive system information to help the leaders, professionals, researchers ... have complement views on the administrative of Hanoi in particular and the provinces in the country in general. That can help to make policy, strategy or prediction for the next year more convenient and simple as to compare against the data in the text.

The development of map and GIS technologies, together with the rise of the Internet infrastructure of the localities in our country today is the deployment of administrative web-atlas systems support for management of the provinces is entirely feasible. However, the extensive development system should pay attention to the security issues.

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Open-source web-based viewer application for TLS surveys in caves

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Abstract. This paper introduces an open-source web viewer developed for terrestrial laser scanning (TLS) surveys carried out in caves. The survey data is visualized as a set of rotatable and measurable spherical panoramas supplemented with an overview map. The viewer includes a tool for measurements in the point cloud and a simple cross-section tool as well. The application was implemented using Pannellum, an open-source WebGL based panorama viewer and the OpenLayers web mapping framework.

Keywords. cave, TLS survey, web viewer

1. Introduction

In the recent years, laser scanning became more and more popular in cave surveying (e.g. Buchroithner, Milius, Petters 2011 or Silvestre, Rodrigues, Figueiredo, Veiga-Pires 2015). The authors also had previous works in the Pál-völgy Cave (Gede et. al. 2013) and the Szemlő-hegy Cave, Budapest. Due to the size of the equipment, TLS is usually used in spacious chambers of caves; however, these data can indirectly help in the research of narrower passages as well by verifying the results of various cave shape and size estimating models (e.g. Albert, Virág, Erőss 2015).

These surveys result in enormous amount of data in the form of dense point clouds. While this data can be very useful source material of further speleological research, its processing requires high-performance computers and

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special - usually expensive - software, which excludes several possible researchers from this possibility. Our aim was to develop an open source framework for viewing these point clouds on the web, as well as providing simple measuring tools for researchers and annotation possibilities for disseminating information connected to caves.

This tool is not a real 3D viewer, but a series of spherical panoramas emulating the point clouds of the separate scanning stations. The advantage of this solution is that it does not require any special hardware or software for viewing - the only thing needed is a decent web-browser with WebGL support.

There are, of course, similar solutions for this task, e.g. Leica's TruView or Faro WebShare. These software have, however, serious drawbacks: TruView depends on a client-side plug-in working only in Internet Explorer on Windows systems (Leica Geosystems 2015); WebShare requires a high performance server (FARO 2015).

2. The survey

The viewer application introduced in this paper was created for visualizing the data of a recent TLS survey. This survey was carried out in February, 2015, in the Béke Cave of the Aggtelek Karst Plateau in northeastern Hungary. This cave was discovered in 1952 and is part of the UNESCO World Heritage since 1995. Its total length is 7 kilometers, of which the main cavern is about 4300 meters. It has been formed by a constantly active cave stream, so numerous spectacular erosional forms (e.g. meanders, siphons, terraces) can be found in the cave. The cave is also abounding in stalactites and stalagmites, additionally, there is a large calc-tufa dam, subject of several recent geological studies.The cave is also used for medical purposes: its air is rich in carbon dioxide which is utilized in the treatment of respiratory diseases.

The first map of the cave was drawn by László Jakucs and his group in the years after the discovery. It served as a basis of the next, more accurate survey in 1964-65 by Gábor Kőhalmi. Based on the data of this latter survey, a new adit was built, connecting the cave to the nearby village of Jósvafő. These surveys represented the cave as a thin, solid line, but it was not enough for scientific research, and nature protection objectives. In 1990-95, Gábor Szunyogh and Judit Kisbán carried out an 1:100 scale survey with analogue methods and created a topographic atlas of the cave in 74 A1 pages (Szunyogh, Kisbán 2004; Aggtelek National Park, 2015).

During the present survey, the surveyor group worked 18 hours underground in 2 days. 32 scenes were scanned by a Leica ScanStation C10 terrestrial laser scanner (courtesy of the Institute of Geoinformatics, Alba Regia Technical

Faculty, Óbuda University), creating a continuous point cloud of an approximately 350 m long part of the cave. This scanner has 360° x 270° field-of-view which means that only a small circle under the scanner is not scanned. The scanner resolution was set to 1000 points per radian, which means one centimeter between the points on a perpendicular wall in 10m distance from the scanner. As the average width of the cave is about 4-5 meters, the actual point density is much more.

Although the field work was timed to the driest part of the winter, the melting of the snow caused by mild February weather resulted unexpected water level of the underground stream in the cave: its depth reached half a meter at some places, making sometimes troublesome to place the scanner and even to move in the caverns. Additional difficulties included the lack of electricity and lighting in the cave (the helmet lamps were the only light sources), and the hard terrain (the cave entrance can only reached by AWD vehicles on a rocky and muddy dirt road).

The point cloud was georeferenced using the control points of a previous geodetic survey. These control points (small metal rivets in the wall) were scanned in high resolution wherever it was possible.

3. The base viewer

The point cloud viewer is based on the open-source Pannellum panorama viewer developed by Michael Petroff (Petroff 2015). The original Pannellum viewer can be embedded to web pages using an <iframe> element, and supports equirectangular and cubemap panoramas - this latter in multi-resolution as well. The panoramas can be supplemented with annotations, hyperlinks and organized into “panorama tours” (multiple panoramas linked to each other) via JSON configuration files. Pannellum requires no plug-in or any additional software as it is JavaScript and WebGL based. The software supports traditional desktop use as well as touchscreens and – if the browser supports it – fullscreen mode.

The only drawback of Pannellum is that running in an <iframe> element means it is hard to interact with the embedding web page, which is essential in our case.

4. The modified viewer

As the MIT License (under which Pannellum is distributed) grants the right of modification, the viewer was restructured and supplemented with additional features.

The most important change is that the viewer is no longer embedded into an <iframe> but into a <div> element instead; embedding is realized with a JavaScript function call. It means that the panorama becomes an integrated part of the embedding HTML document's Document Object Model, therefore the page and the embedded panorama can interact with each other. To facilitate this, a set of event handler functions can be defined when embedding the viewer to events like "viewchange" (the panorama was rotated or zoomed into), "scenechange" (user changed to a new panorama) and other events in relation with the new functions dealing with the point cloud data.

Another significant modification is the use of point cloud data in panoramas. Any of the panoramas can be accompanied by such data, simply by defining its source and properties in the appropriate section of the JSON configuration file. Once the viewer loads the data, a panel appears in the corner of the panorama viewer with the Cartesian coordinates of the point under the mouse pointer, as well as buttons of two additional tools. The first one is a "tape measure" to measure distances in the point cloud. The user can place measure lines within the panorama that remain there while the measure tool is active. The second one is a dynamic section drawing tool. When active, the cross-section of the point cloud appears on a small panel. The section plane is a vertical plane crossing the current scanner station position, rotated always to the viewing direction – which means that the cross-section image changes if the panorama is rotated (Figure 1).

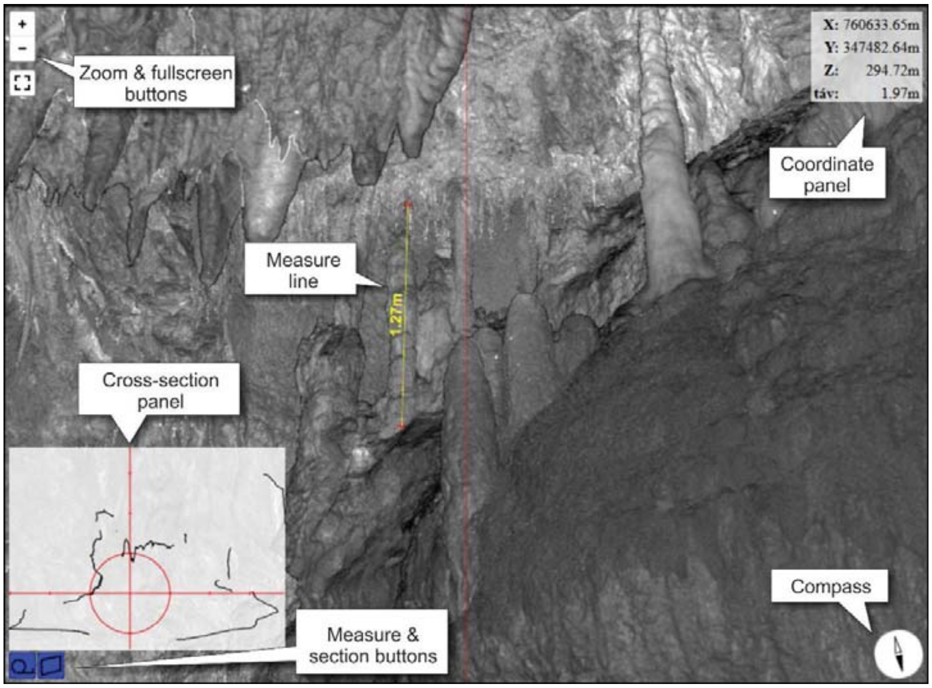

Figure 1. Features of the point cloud viewer.

5. Storing point cloud data

Due to the working mechanism of the scanner, the point cloud of a single scanning station consists of non-overlapping points forming a grid when using 3D polar coordinates (yaw, pitch and range) instead of 3D Cartesian ones. Therefore, the simplest way of storing the point positions is a raster format: a matrix of distance and intensity values, where the row number of the matrix is proportional to the pitch of the point while the column number to the yaw.

The intensity matrix forms an image (Figure 2) which can be used as an equirectangular panorama image in panorama viewers. Using a raster image format can also be an option for the distance matrix as well, encoding distances into 24-bit fixed point numbers treated as RGB codes. The only restriction is that the image must use a lossless compression. Our application stores the distance matrix as a PNG image (Figure 3). This way the data is compressed, which results in shorter downloading times and less space needed on the server, while there is no need of additional software components for decompressing as the JavaScript interface of HTML Canvas element (which is supported in all recent browsers) provides functions for reading image data.

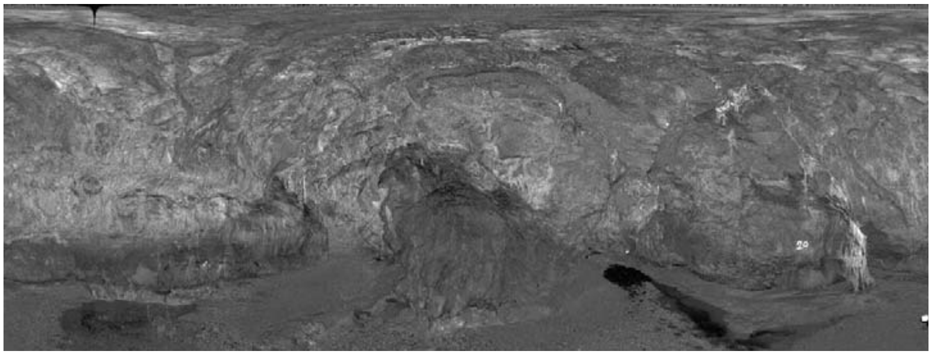

Figure 2. Intensity matrix as equirectangular panorama image

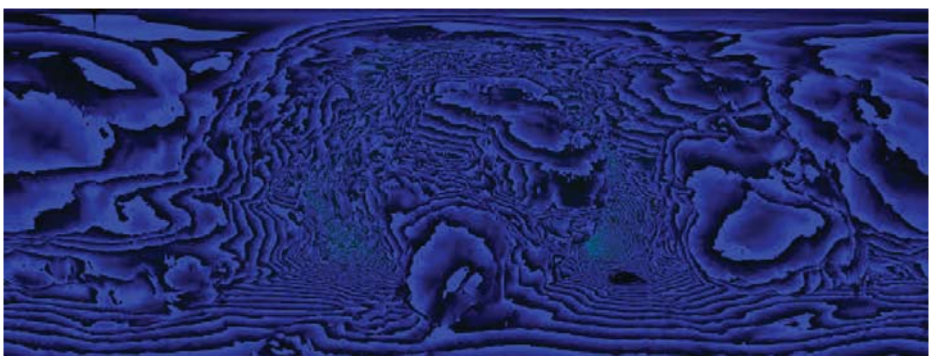

Figure 3. Distance matrix encoded as 24-bit RGB image

6. Integrating the panorama viewer and the cave map

Cave surveys usually consist of several scans therefore it is advisable to show information about the relative and/or absolute position of the scanner positions. The website of the current survey shows a possible solution for this. The website (http://lazarus.elte.hu/cavescan/beke/pano) consists of two panels: an overview map on the left side and the panorama viewer on the right (Figure 4). Initially the panels are equal in size, but it can be changed by dragging the separator line between them.

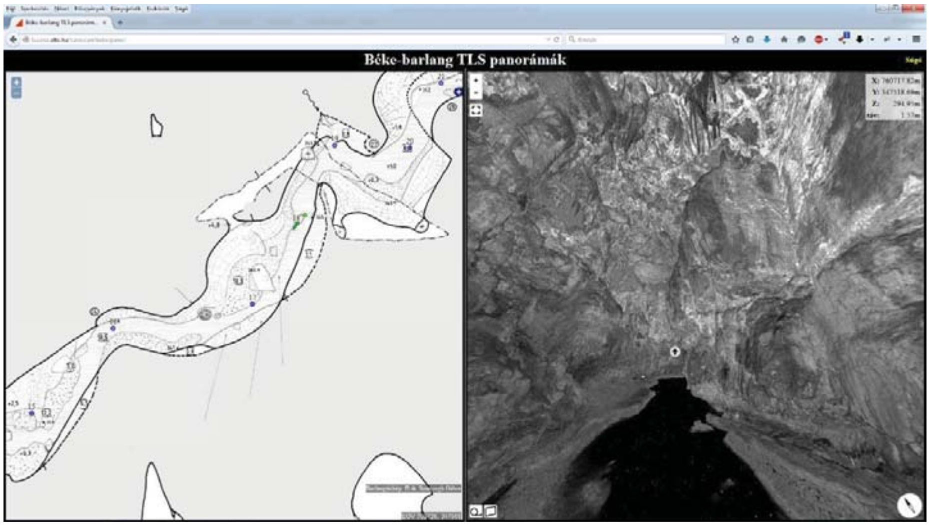

Figure 4. Screenshot of the sample website

The overview map was implemented using OpenLayers. Users can switch between two base layers: a georeferenced mosaic of a hand-drawn cave map and the vertical orthographic view of the point cloud. The places of the scanning stations appear as numbered dots; clicking the symbol switches the panorama viewer to the given station. The symbol of the active station is an arrow, always pointing to the viewing direction. A moving green dot on the map represents the current position of the mouse pointer if it is in the panorama viewer. If the cross-section tool is active, a red line indicates the horizontal footprint of the current cross-section.

The website is supplemented with brief help which appears in a popup window when the user clicks the “Help” link in the top right corner.

7. Feedbacks, Conclusions, Further plans

The first feedbacks show that this viewer is a useful tool for earth science researchers working on topics related to the cave, as they can examine the underground scenes and make measurements on it from the office without the need of special software or hardware.

Although the viewer supports touchscreen operations, a mouse is needed to get full functionality, as there is no touch gesture equivalent of moving the mouse without dragging something. Further examinations should find an efficient substitution of this event (that currently drives point cloud coordinate displaying) on touchscreens in a way that does not interfere with other touch gestures.

A simple 3D line tracking tool is under construction; this tool will allow users to draw polylines and polygons in the panoramas that can be saved as 3D vector graphics (in X3D or VRML format).

The viewer is free and open source and can be adapted to other uses even in its present form. To facilitate such use, we plan to add more flexibility to the application programming interface as well as a detailed documentation for developers and tools to produce the required JSON files, the distance and intensity matrices from various point cloud formats.

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Hybrid approach for large-scale Energy Performance estimation based on 3D city model data and typological classification

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Extended Abstract

"Smart-cities" is certainly one of the current hottest topics in the information technology research area. Many definitions exist in current literature (Fenger, 1999), (Giffinger, 2007), (Giffinger, et al., 2010), (Washburn, et al., 2009) and all of them have a factor in common: the existence of an underlying ICT infrastructure that connects the physical infrastructure of the city with web 2.0 capabilities and enables innovative solutions for city management, in order to improve sustainability and the quality of life for citizens. Urban metropolises, despite covering only 2%, of the Earth's surface are the lead contributors of greenhouse gas production accountable for around 80% of the oil, gas and coal world consumption. Therefore, energy consumption efficiency of residential houses is an important factor having an impact on the overall city ecosystem and quality of living and it would greatly benefit from an ICT-enabled smart approach. In fact, increasing building energy efficiency would not only mean a cut-down in energy expense for citizens, but would also have an impact on the overall production of CO_2 at energy plants and also, even if less intuitively, on the city air pollution.

In this context, 3D city modelling can be an essential tool (Prandi et al.2014) for energy planners and municipal managers, enabling them to perform accurate diagnostics of the existing building stock, and to plan low-carbon urban energy strategies. Indeed on top of that several smart services can be designed in order to support the increase of building energy efficiency and improve the city quality of life.

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The paper will illustrate the concept and the development of smart services, which allow the assessment of the energy performance of all the residential buildings in a city, its validation and visualization in a format accessible to citizens and urban planning experts alike.

The development of these services is part of the scope of the SUNSHINE[1] (2013) project (Smart UrbaN ServIces for Higher eNergy Efficiency), that aims at delivering innovative digital services, interoperable with existing geographic web-service infrastructures, supporting improved energy efficiency at the urban and building level.

The work focuses on the preliminary results for the Building Energy Performance Assessment. The aim is to evaluate the accuracy and strength of a new approach that automatically calculates the heating demand of whole district areas, modelled in 3D. The service provides an automatic large-scale assessment of building energy behaviour and the visualization of the assessed information using the so called Energy maps which will be made publicly available via a 3D virtual globe interface based on WebGL.

The presentation of the energy maps in a 3D spatial-geographic framework, leveraging on interoperable OGC standards, allows citizens, public administrations and government agencies to evaluate and perform analysis on the building energy performance data, and provides a global perspective on the overall performance conditions of the residential building stock as well as on its fluctuations on the neighbourhood and block scale.

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The Use of Methods of Cartography and GIS Tools in Cultural Anthropology Research: Pilot Study in Localities Yawan and Toweth (Papua New Guinea)

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Extended Abstract

While cartography and geoinformatics technologies and tools were originally interconnected mainly with technical and science oriented fields of human activity, these methods and tools have also been entering applications within social and human oriented disciplines more frequently in recent years. An example of this could be the large amount of research into archaeologists and historians.

It is astonishing that in the past maps and other cartographic works have been and often still are accompanying anthropological research only in the form of locating cultural communities and cultural phenomena or in the form of simple spatial schemas. However, all the social and cultural phenomena involve, in addition to the historical content, a spatial aspect, too, including categorization, changes and behaviour of cultural communities and phenomena. Not only for this reason, cartography, geography, and GIS tools should therefore be closely related particularly to anthropology.

Nowadays, however, methods of cartography, geography and geoinformatics have been confronted with methods of sociological and anthropological research, which are known in the form of questionnaires and interviews (sociology), and also in the form of extensive, intensive, and comparative field research (cultural anthropology).

In this contribution, the authors will introduce the first output of a pilot study, which was carried out from April to June 2015 by the Nungon people in the villages of Yawan, Toweth and Kotet (Uruwa Valley, Morobe prov-

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ince, Papua New Guinea). Considering that the Nungon people live in the mountains of the Saruwaged Range, relatively far away from large cities, there was no actual detailed spatial data available and the whole mapping had to be carried out in combination with the local coordinate system with the connection to WGS-84 via GPS. Therefore, besides using methods of cultural anthropology within the field research, terrestrial and GPS methods of data collection were used, too. Quality control of the data was thus carried out directly in the mapped locations using mobile GIS mapping applications, and subsequent processing and and data analysis run in software ArcGIS for Desktop upon arrival in Czechia. The research output should then be, among others, a dataset and a series of maps showing cultural specifics and phenomena of the Nungon people in the locations of Yawan and Toweth.

The combination of methodological approaches mentioned above has proved to be very useful. It is obvious now that GIS tools could considerably change the form of cultural anthropology field research. The authors are convinced that this connection has potential for the future and it might not be at all unique in time. Therefore they are preparing rather extensive research, based on the pilot study, with the possibility of using a comparative method in other communities and locations, not only in the macroregion Oceania. The use of distance methods of data collection is expected, too.

Anthropogenic Influence Mapping in Protected Areas. A Case Study from Bucegi Natural Park, Romanian Carpathians

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Extended Abstract

Evaluating environmental problems in protected areas is still not an easy task. As these areas are usually created in order to preserve natural complex diversity, there are many parameters to keep track with. Whether the main focus is on the habitat fragmentation or on the endangered species sensitivity to an impact factor, the evaluation must balance all these indicators for a more objective evaluation (Cucu et al, 2013).

Bucegi Natural Park is a good example for this type of study as one may find almost all types of impact factors, from chaotic tourist traffic, track extension, up to illegal hunting and construction expansion (Knorn et al 2012, Mihai et al, 2009,). The main objectives for this study were to evaluate the park's environmental problems, mapping the impact factors, elaborate an algorithm for analysis and finally find a way to cartographically represent all the resulted features.

The anthropogenic influence is the expression of the actual environmental state which indicates the level of change from the initial state, expressed in quantifiable data. The methodology used for the study was based on field data collection, processing and analysing, then validation and finally cartographic representation. Firstly, habitats were mapped, using Landsat 8 images for supervised classification analysis and NDVI (Weiers et al, 2004), same as all the impact factors (constructions, roads, tracks, sheepfolds, pastures, utilities, traffic, affected vegetation, soil erosion, pollution and any other environmental disturbance). Afterwards, all these data were analysed using GIS tools. Several models were applied for the analysis, including the InVEST model. A grid was generated for the study area and based on all raster data that was mapped and analysed, scores were derived. The result

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is a new raster map, with information for all levels of anthropogenic influence.

The last step consisted in finding the best way to represent all the features that were valuable for an environmental evaluation. Thus, for constructing the final map a hillshade of the elevation grid model was used together with the anthropogenic influence raster and selective data for the impact factors, in order to have a clear extent of the impact sources. Some of the symbols were manually designed for a better fit, turning the map into a complex, yet easy to read, “Report” of the environmental state of Bucegi Natural Park.

Key words: conservation, anthropogenic influence, cartographic representation, GIS, Bucegi Natural Park

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The Role of Service-Oriented Mapping in Spatial and Regional Sciences

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Extended Abstract

By now geoinformation is available everytime and modern maps rule our daily life. Whenever we leave our homes, we have made plans where to go to. If it is a new route we have generally used a map (application). We plan the way to take or evaluate the transport network and its connections. If we feel lost, we take another look in a map and/or try to find reference semantics which will bring us back to our geospatial imagery - our individual mental picture of the world.

At the same time, in our cross-linked world, we produce tons of unstructured data that describe the way we use our environment (nature, things and people). For example: when do we need electricity? For what actions? How much do we consume to what time of the day or in which situation? Does this electricity usage change with our age, education, employment – or any other demographic value? What is the impact of the surrounding topography on our electricity needs? All these questions can be answered by data that we leave with our actions and devices in addition to existing geospatial core data. In order to make use of unstructured data, we have to ask questions which allow for a first requirement analysis and lead to the primary model of data: a first data structure considering our questionnaire requirements. These models are worth distributing because a lot of questions are similar and variety of people could make value out of it. Information about validity, lineage, purpose of creation, recording method, and so on are needed to evaluate the data for specific use cases.

Service-Oriented Architecture (SOA) is the main paradigm to connect and explore everything (Hendriks et al 2012). The metadata are the key to publish available structured data and their accessibility. The access to unstructured information is not well published nowadays and often its access does

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not follow standardized interfaces. SOA is the main working principle for spatial data infrastructures (SDI), which are the human- and machine accessible catalogs for metadata information. So to say SDI are the publication portals for geospatial content (de Kleijn et al 2014).

At the moment we can observe three generations of SDI, which highlight the shift from product-centered solutions to user-centric SDI approaches (Rajabifard et al 2006, Hennig et al 2011). This user-centric paradigm allows a wider audience, beyond geoinformation experts, to make use of SDI and to leave technical barriers behind.

Spatial and regional sciences observe non visible phenomena in relation to its spatial environment and try to deviate rules. The consequential idea is to support influence on these phenomena. Therefore a successful spatial communication across different expert groups, based on well-understood semantic reference geometries, is needed. The main aim is to transmit any knowledge of observed phenomena and explain its political, regional and structural consequences.

Generally spatial knowledge in regional sciences structures itself in statistical models that embed all kinds of available spatial references. These references are selected according to requirements analysis of the analyzing topic. In addition possible consequences for a region/structure are derived on the basis of these (spatial) models. If the model is restricted in its expressiveness the consequences may be wrong and therefore mislead political, regional and structural decisions.

Service-Oriented Mapping may enhance expressiveness of spatial models for regional sciences due to its wide data accessibility, content actuality, recherchability and appropriate scaling. More accessible data allow to intensify geospatial statistical models. A higher content actuality enhances time quality and even allows for historicized analysis. Recherchability allows for detailed requirement analysis and selection of appropriate sources. An appropriate scaling supports dynamic combinations of data sources and leads to more consistent geovisualization.

This contribution describes a work in progress on the role of Service Oriented Mapping in spatial and regional sciences. Therefore it follows the thesis that specific requirements for the analysis and knowledge transmission in regional sciences exist. These specific requirements could be served by the specific structure of Service-Oriented Mapping.

The requirements of regional sciences as well as the offers of Service-Oriented Mapping will be exemplified on the basis of a case study. Future tasks for the field of Service-Oriented Mapping and its communication issues could be defined from this first requirements analysis and the future perspective of “Service-Oriented regional sciences” could be formulated.

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The Role of Visual Representations in Urban Planning

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Visual representations in its all different forms help us to understand our cities, make it available for analysis. They help us to make useful conceptual shortcuts in our understanding in order to have a glimpse of “what’s happening” in our cities.

This research focuses on visuals as representations of cities. These visuals may be a single spatial representation as a map or a sketch, or it may be in form of a visual metaphor (for example Blue Banana, European Bunch of Grapes, London Green Belt, the finger model of Copenhagen …etc.) or a complex set of images.

Throughout the history, urban planning discipline has looked at visual representations in various different ways, giving little to no attention at all (Jarvis 1994; Neuman 1996, 2000; Faludi 1996; Dühr 2007).

Since the notion of “planning through debate” (Healey, 1992) they are accepted as powerful communication tools which shape attention (Forester 1989) therefore shape the discourse (Kunzmann 1996; Healey 1997, 2006; Forester 1999). On the other hand, they are object to “treacherous selective vision” (Shields, 1996) which allows manipulations (Pickels 1992; Neuman 1996; Harvey 1996). It is recognized that they may focus on certain parts while inevitably neglecting others (Harvey 1996). Since the visual representations of spaces like cartographical maps are not accepted as objective and scientifically informed instruments only, they as well are object to communicative distortions (Dühr, 2007). That’s why it is believed by some theoreticians that it is probably better to abstain visual representations (Eeten and Roe, 2000) because they can lead to serious conflict (Zonneveld, 2000) through their biased perspective of reality (Crampton, 2001).

Despite the recognized useful consensus building purpose of representations; growing chaos, complexity and fuzzy reasoning hinders the effective outcomes (Forester, 1999; Healey, 2007; Innes and Booher, 2010; Neuman, 2010). Growing complexity makes planning messier, their outcomes sketchier (Neuman, 2012) and their discourse more abstract. On the other hand how can we make planning interesting and understandable without using visual representations (Zech, 2013)?

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Nevertheless discourse helps finding meaning in complexity and it can create unquestioned knowledge that requires unconventional creative thinking. Visual representations in its all different forms help us to understand the urban complexity.
The web has become a new opinion space today, a virtual but de facto public space (Shields, 2013). It is re-wiring our way of thinking, how we perceive our cities and how we respond to changes.
But we face a great challenge, besides the obvious complexity of our cities; there is the "big data" phenomenon. We are producing an enormous diversity of data, from governments to city councils to institutions. It is getting incredibly difficult to make sense of all these data, how to analyse it, how to see through it, how to communicate it, how to visualize it.
The open-ness of the virtual public space makes cities more inclusive, enabling its citizen and different organizations to actively take part in it. Open data initiatives and institutions are actively encouraging their 'smart' citizens to use the urban data and make meaning out of it.
Urban needs to be represented collectively, not only from certain perspectives or in certain forms. If we can have a glimpse of what's happening, then we might have a better chance to intervene, to plan, to design and sometimes to resist (Mitchell, 1996).
To empirically analyse this hypothesis UCIT (www.ucit.or.at) is created, it is an open source API consisting of open source solutions, except the data-set used. Here, the purpose was to make urban data interesting to the media and public, just by creating an application which has a bit of an unconventional way of showing urban data with its time-space character, showing the City of Vienna from a different perspective. We need to re-examine the city, keep it open to further critical analysis and showing the urban data in different ways from different perspectives may lead to reveal unquestioned knowledge and creative thinking.

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Measuring the Adequacy of Maps for Field Use

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Introduction

The study is aimed to work out a method for **estimating the adequacy of a map for field use**. Studies show that a person's **map reading skills can be measured with tests** (Wakabayashi 2013, Wakabayashi and Matsui 2013). According to the results, using small scale maps requires geographic knowledge, while the use of large scale maps is affected by spatial abilities. Even the comprehension of different map objects varies in difficulty for map readers: for example understanding symbols is a simpler task than comprehending contour lines and hypsography. **Cultural differences can also affect** the orienting and **map reading skills** (Ito and Sano 2011). While test subjects from North America could orient better using verbal directions, Japanese participants were more effective with maps. By studying the **perceptive and cognitive-skills required for orienting and spatial thinking** (Guzmán et al. 2008) it is found, that memory has an important role in orienting and recognition of relief forms. **The adequacy of map symbols can also be measured** (Pődör, 2002). Geometric symbols and pictograms can be recognised easier, than identical shapes with different colours. A previous study by Albert (2014) that **measures the amount of information that map readers receive while reading an archive map** defines seven map categories (directions; linear features; hypsography; names; measure units; coverage; points) to classify the data used by the subjects during map reading tests.

Methods

In the present research, **the use of two different types of maps** (a geological and a tourist map) **was tested** with 44 voluntary participants. The participants filled out a **questionnaire**, then took part in an **interview**. The purpose of the questionnaire was to **measure the map reading ability** of the subjects, this way distinguishing them into three categories: **beginner, intermediate, expert**. The analysis focused on the competences of the subjects, in connection with reading different map categories. The score of each task was weighted depending on the number of good answers given (the question's difficulty and the weighting was proportionate). The participants' map using habit was also tested to find out, if it is related

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to the map reading skills. These questions focused on the map types the subjects used, and the frequency they used them.

During the interview, the participants had to **study and explain a route with their own words**. The route was the same on both types of maps and the scale of the maps was also the same (1:25 000), this way **the topographic information** used on the two maps **could be compared**. The verbal descriptions were digitized as texts, and the expressions, describing the different map categories were extracted from the texts with a semi-automated data-mining application.

After analysing the extracted data, the **difference between the adequacy of the two types of maps was expressed** for the three map user categories (Table 1.). Additionally it was also shown, which map category was used most frequently by the different map users. The relative adequacy of the compared maps was measured based on the assumption, that **a map is more adequate for field use, if a map reader used more expression while reading it**. This comparison can be expressed by percentages (100% means total similarity, a smaller number means less expression on the geologic map, while a larger number means more).

Results

According to the results, those participants, who often use **topographic maps** reached the **highest score** in the questionnaire (76% on average) meaning they are the most familiar with maps, while those who use **city maps** the most, reached the **lowest score** (64% on average). The participants, who read **tourist maps** often**,** used the **most expressions** (50 words on average) during the interview, while those who read **thematic maps** the most **used the least** (22 words on average).

The results also show that the **topographic content of the geological map was difficult to read** for all participants, while the same category on the tourist map was easy to read for them. The participants **used more expressions** on average **while reading the tourist map** (77 words), than reading the geological map (24 words). The **expert map readers used the most expressions**, an average of 51 words, while the beginners only used 19 words (the total average was 41 words). By measuring the **relative adequacy of the map categories** (Table 1.), it can be seen that the **linear features** (6-16%), the **hypsography** (75-200%) and the **coverage** (18-50%) **differed the most** amongst the map readers. The **smallest difference** can be found in **the directions** (60-69%) and **names** (63-83%). Although most map categories could be used better on the tourist map, **expressions of hypsography occurred more often on the geological map**. This suggests that by the lack of linear map objects, the participants tried to use the morphography for orientation. The overall results show that the **field-use adequacy of the geological map relative**

to the tourist map was 31-34%, meaning that the test subjects could understand **less topographic information** on the geological map by **67%**.

By using this method, other maps' adequacy can be measured numerically, and with the results, the maps can be changed to fit the map readers' demand.

	Dir.	Linear features	Hyps.	Names	Units	Cover-age	Points	Relative adequacy
Expert	50%	13%	200%	50%	67%	13%	0%	31%
Interme-diate	57%	12%	75%	83%	0%	25%	0%	33%
Begin-ner	60%	6%	200%	67%	100%	50%	0%	34%

1**. Table** The geological map's adequacy relative to the tourist map (100% means total similarity).

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User Requirements Analysis for a Mobile Augmented Reality Application Supporting Geography Fieldwork

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Extended Abstract

Geography fieldwork, a geographical learning/teaching activity in real space, is essential to increase learners' understanding of the geography of a certain area (HMI 1992). At the same time, how to achieve optimal geographic understanding in the field needs to be considered, especially with the increasing use of new information and communication technologies (ICTs). Right now, one of the most promising technologies is Augmented Reality (AR), which extends perceptions of a real space with additional contextual information. In recent years, thanks to the availability of mobile devices, the application of mobile AR has a vast potential to make a difference (Specht et al. 2011), especially in situational education like geography fieldwork. However, in geography fieldwork, the current problem is that mobile AR applications have not been applied till now. Therefore, it is necessary to integrate a mobile AR application that can also provide additional visualizations to assist learning/teaching and gaining geographic understanding in geography fieldwork. Central to the development of a new and usable application is adopting the principle of a User-Centered Design (UCD) approach, the first phase of which is identifying user requirements (ISO 1999).

This research first establishes the current situation of using AR in education based on a literature review. At the same time, in a real educational human geography fieldwork executed in China, we have investigated 1) students' background and experience with the use of (cartographic) visualization tools (through a survey); 2) how both the organizers and students use current (mobile) cartographic tools in helping teaching and learning geography (through observation and interviews); 3) the difficulties of using

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these tools and the expectations of an alternative visualization tool (through interviews).

The results of these investigations can be used to formulate the basic user requirements of a mobile AR application for supporting human geography fieldwork. It was found out that it is practical to make use of a mobile AR application in geography fieldwork because of the students' smartphone ownership and their cartographic education background. Both teachers and students thought that it is useful and important to use it during the execution stage of the fieldwork. Students use their mobile phones for both daily and academic purposes. In terms of using mobile cartographic tools, most of them prefer to use digital maps on mobile devices with the main purposes of checking locations of unfamiliar places, planning a route between different places, and navigating in unfamiliar areas. In this fieldwork, students used their mobile phones to mainly collect data and browse digital maps of the fieldwork area, with the purposes of completing the fieldwork tasks and assisting geographic understanding of the fieldwork area, respectively. In doing so, they experienced some difficulties, e.g. the time required and troubles in switching between different mobile applications and the data collected in the field lacking locational details. The difficulties they experienced give a picture of what aspects should be paid attention to and which difficulties should be tried to be avoided and (or) should be solved when designing a new mobile application involving AR. Both teachers and students, as users, expressed their expectations of such an alternative visualization tool for fieldwork use and indicated some basic key requirements, e.g., labeling geo-locations of all field collected data, making notes, recording voice data and field walking routes and optionally viewing various materials (maps, satellite images, etc.) of the fieldwork area. An analysis of these user requirements suggests the basic functionalities of a mobile AR tool to be used in human geography fieldwork. After having obtained these requirements from the actual users in this real human geography fieldwork, we can move forward to design a prototype of a new mobile AR application.

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Contextual Adaptability of Navigational Spatial Descriptions: A Pragmatic Comparison

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Extended Abstract

Spatial descriptions are frequently used for navigation in urban environments. For example, they can take the form of an address or a route description, both of which are expressions that uniquely refer to a destination or to a route toward a location through a set of spatial features and relations (Paraboni et al. 2007).

Today's information systems provide these two forms of spatial descriptions as a combination of map features (e.g. street name and district number) in a predefined way (Schmidt and Weiser 2012), but offer no way to adapt to different users and environments (Hirtle et al. 2011). In contrast, in a spatial communication setting between humans, navigational descriptions are more flexible in the sense that factors like a user's prior knowledge and the structure of the environment shape the communication. For example, instead of using a formal address, you may describe a travel destination to a taxi driver by referring to features of the environment assumed to be known to both of you. Or a friend may direct you toward a location while considering your prior shared knowledge of the environment and its structure, which results in a generalized route description that includes only the relevant references to spatial features, e.g. buildings, junctions, subway stations, etc. (Dale et al. 2005). Although these different types of spatial descriptions refer to the same location, or provide instructions on how to navigate to it, their contextual meanings are quite different.

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In this paper, we compare the potential for adaptability of contextual meaning of formal addresses, route descriptions (generated either by computers or humans), and destination descriptions in the context of human navigation in urban environments. The notion of pragmatics is deployed for the intended comparison. Here we understand pragmatics as the relation between spatial descriptions and description-using agents. We consider spatial descriptions as linguistic descriptions (i.e. a spatial description is our linguistic unit in this research) and introduce common topics of linguistic pragmatics such as redundancy, relevancy, cohesion, coherence, context, and common ground within the spatial descriptions studied in this paper.

As the result, those spatial descriptions that are expressed in natural language and directly made based on human spatial thinking might be seen as global among human beings. Such descriptions are among those forms of spatial description where the basic formations are the same everywhere around the world: in order to give efficient route directions, one should select some elements that are referred to as *good* on the levels of both semantics and pragmatics. In contrast, although addresses are among the most commonly used spatial descriptions, their structure, and consequently their semantic and pragmatic considerations show geographical differences. Different addressing systems around the world fundamentally differ even on the syntactic level. Some countries have declared a strict structure for addressing, from the type of the selected elements to their order of appearance, which does not fully correspond to our spatial thinking. But there also exist descriptive addressing systems, in which addresses are expressed in natural languages and thus treated like human-generated spatial descriptions (Karimipour et al. 2014).

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Requirements Survey and Documentation of a Geo-information System Applied to Land Value Capture Policies

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Extended Abstract

In this paper we present an ongoing research that seeks to determine how the spatial characteristics of geo-information have to be considered, and included in a system requirements documentation.

In the last decades, researchers point out that the production and use of maps is no more an exclusive task of cartographers or geographic information experts (Green 1993, Brus et al. 2010, Brown et al. 2013). Due to technological advances in GIScience and Cartography, and the easiness in acquiring, disseminating, and using geographic information systems and geospatial data, users from different areas of expertise produce their own geo-information products. However, significant problems can be observed in these products, as a result of this geographic information spread: the lack of theoretical knowledge in Cartography results in cartographic products with communication problems (Green 1993), deficiencies in understanding the significance of data (and thus their analysis), lack of context for data use or data control (Brown *et al.*, 2013), to point out just a few.

One of many different areas that work with spatial information is municipal governments for the collection of taxes on land, such as the land value capture policies. Land valuation represents the increment of a land value

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due to public investment in infrastructure. When a land parcel benefit from certain service – like urban paving; constructions of public squares and parks; access to bus stops and terminals; sewer systems; water supply; among others – its value tend to increase. However, the parcel owner had no direct influence on this valuation. It's socially unfair for a private owner to benefit from a public investment that should improve the whole community. So, land valuation capture refers to the return to society of the amount of undue valuation. One way to capture the land valuation is through *betterment taxes*. Those taxes are applied over a valued land, so the amount can be reapplied to fund and enable new investments and to benefit the community. In order to be fair and efficient, the charging of those taxes should be based on spatial analysis. Those analyses must be accurate because the collection of taxes directly affects taxpayers and, therefore, the society. Consequently, the use of geographic information systems by municipality technicians must achieve this desired goal.

We propose a Requirements Engineering (RE) approach for the design of a geographical information system to the problem of land valuation capture. Through well-known techniques of Requirements Engineering (Kotonya & Sommerville 1998, Sluter *et al.* 2014, Sommerville & Sawyer 1997), we aim to collect and document (ISO, EC & IEEE 2011) the information from users of the system. The requirements engineering allows computational systems to be built according to the users' needs, by incorporating their needs in the early stages of the system construction, and referring to those needs during the entire construction process. However, despite being widely used in computational science, requirements engineering is poorly used in GIScience. There are few methodological or technical contributions of requirements engineering to geo-information system design in the scientific literature. Therefore, this research aims to determine how users' requirements may contribute to the design of geo-information systems for the land value capture policies.

The process of requirements engineering is here divided in four stages, in accordance with the literature, and adapted to the characteristics of the geo-information (Kotonya & Sommerville 1998, Sluter *et al.* 2014). In the first stage, that is requirements elicitation, information about the users will be gathered together with the use context of the system and its application domain. Following, the elicited information will be analyzed and negotiated with the system stakeholders. At this stage the goal is to eliminate or minimize ambiguities, conflicts and misinformation. From these results, the next stage will be the official documentation of requirements survey. The documentation standards **ISO, EC & IEEE 29148:2011 – Systems and Software Engineering – Life-cycle processes – Requirements Engineering** (ISO, IEC & IEEE 2011) will be used as foundation for the definition of a geo-information system documentation standard, taking into account the geo-information particularities. We are trying to define how those particularities can modify the requirements specification and what could be changed or added in the final documentation for these characteristics to be considered.

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Designing an user-centric academic SDI

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Extended Abstract

The Action Plan for the Brazilian NSDI defined the role of universities in the infrastructure primarily as capacity building actors (CONCAR 2010). However, universities, in their activities of research, teaching and public services are important geospatial data users and producers. Research data are often spread among several academic units and recover this data is and effort that demands time and resources (Davis Jr et al., 2009). Additionally, federal universities in Brazil are public and are required to follow federal-level Open Data Policy and the NSDI rules and standards. At this point, no Brazilian university has joined the official Brazilian NSDI initiative (Brito et al 2014). Universities have their autonomy, therefore the project of a SDI to accomplish both the internal needs for data re-use and external needs of data publicity must be address carefully the uses and needs of each institution.

There are an increasing number of data sharing studies and SDI initiatives among the academic and research communities, both in Brazil and around the world (Arzberger et al. 2004, Campbell et al 2003, Davis Jr 2009, Hill et al. 2012, Kethers et al 2010, Oliveira & Ramos 2013 and Painho 2010). This ongoing project aims to assess the requirements of the community in the Earth Sciences Sector of Federal University of Paraná (UFPR) in order to design and implement an SDI to accomplish these objectives. This project is also connected with a network of other Brazilian universities that are together exchange experiences in SDI implementation on the academic sector (Brito et al. 2014).

Today, geospatial data produced in research at UFPR is stored in non-standardized way among several research labs and seldom distributed for society and other researchers. This project aims to assess the need of the academic users, their requirements and legal constraints, including those regarding privacy and legal rights. The concept in this SDI is of an inverse infrastruc-

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ture: user-driven, self-organizing infrastructures with decentralized governance where development is influenced from the bottom-up (Coetzee & Wolff-Piggott 2015).

In the requirements elicitations phase, the chiefs of the four graduate programmes in the Earth Sciences Sector (Geography, Geology, Geodetic Sciences and Ocean and Coastal Systems) were interviewed. The objective was to assess the programmes current policies on data management, and their views about data sharing. They expressed some concerns regarding data misuse or misinterpretation, and commercial use of data. This phase also presented the main project ideas in order to build synergy between programmes, and other departments of the university, such as the library, in this subject.

Additionally, an online questionnaire was addressed to researchers, both staff and students, in the programmes. There were 30 respondents, most of them willing to share their research data under a creative commons license. The survey was divided in Data Acquisition, Storage and Management, and Sharing. There was also an additional topic asking their opinion on the most needed features on a research geoportal.

In the Data Acquisition section, 87% of the researchers stated that is not easy to acquire data for their projects, describing the process as bureaucratic, time-consuming, and sometimes expensive. Among them, 43% create their own data in field surveys and other primary sources. Only 7% uses data from geoservices such as WMS and WFS, which shows how little SDI architecture is been actually integrated in the research routine.

Regarding Storage and Management, most of the users store data in their own computer, with only a few storing it in a database system, or a data server, or in the cloud. Another question was about the geospatial software: 80% uses proprietary software, although the most popular open source software (QGIS) is also chosen by over 53% of them.

The third group of questions were about Data Sharing. Most of the users (80%) did not see problems in share their data, although 84% of them would feel safer if this sharing would occur under a license. Finally, about the geoportal, the main features the users considered essential were an efficient search engine, including map based search, geospatial data download, geoservices such as WMS and WFS, and bibliographic related information.

Next steps in this project involve the creation of an open source and open standards based geoportal, integrated with the NSDI. The start point is to publish metadata from thesis and dissertations on Earth Sciences graduate programmes. This first metadata geoportal will use ISO 19115 profile that was created for use in Brazilian NSDI, with academic-related additional metadata. After that, the last phase propose the creation of a geographic data repository, where the researchers will be able store and share geospatial data within the university and with community in general. The lessons learned in this project will be shared with other Brazilian universities in order to promote open source, open data and open standards to facilitate both the research process and the outreach of the academic data for a wider audience.

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Maps in Documentary Videos

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Abstract.

The paper deals with user issues related to maps in documentary videos. The aim of the paper is to present concept and results of experiments on maps included in documentary videos so called video maps.

In many industries, the video maps are the simplest way to visualize the spoken interpretation of the territory. They are used mostly as an adjunct in films, serials and reports. Their "lifetime" is very short. They appear for a few seconds, exceptionally several tens of seconds. Thanks to very short time for its reading the video map needs to be prepared with adequate detail so that the reader gets out of it quickly with just this information that the map author intends. It is very important to conduct a proper visual hierarchy, so that the reader's attention to the map has not been charged by less significant element. It is much easier to add map of the spoken word.

20 video maps were included in the experiments. Using various streaming video programs the video maps were cut with 45 seconds before the map and one minute after it. The video maps were evaluated in two phases. First, they were analyzed as a static map. The symbol key, composition elements, map content, labeling was evaluated. Then the video maps were analyzed as a part of the video, mainly:

- portion of visibility of the map
- number of displaying of the map (full screen, part of the screen)
- total time of map displaying (the entire screen, part of the screen)
- relationship of the main phenomenon to the map (total time for verbal comments, etc.)

Mostly the video maps occupied 100% of the image areas for 7 seconds and for another 2 seconds when the map was covered with partially transparent image and accompanied by verbal commentary (longer than displaying

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maps - about 13 seconds), which described the main thematic content of the map.

The map use experiments were the main part of the research. The experiments with individual maps are always attended by 10 people, mostly 6 women and 4 men. All ages (from 18 to 77 years) were included. Respondents were asked three questions:

- the first open question was related to the main phenomenon (eg. Where is Chicago?) and examined the relationship video map and text comments.
- the second closed question was focused on the phenomenon of the highest levels of visual hierarchy (eg. Chicago is on the coast or inland?) and studied how much attention the map draws and if detail are seen.
- the third open question concerned the content of the map (eg. What was the map?) and examined the clarity of symbol key.

From experiments it was showed that compliance of cartographic rules and sufficient simplicity of implementation are more important than time in which the map is displayed. If all elements of the chosen correctly with regard to the topic mapped, then the reader does not need to analyze such maps for more than 15 seconds. This does not apply if the user does not have the language in which the map is drawn. In this case, the time map reading extends for a few seconds because of that the reader cannot be used labelling. In a properly assembled maps the time of interpretation would not be extended, however the experiment showed that it cannot be always provided. It would be interesting to view the same map in Cyrillic or Arabic, a language that most Europeans cannot read. But this was not the aim of the experiments.

Video maps are field of cartography which cartographers must pay special attention. Compilation of the map is a complex task. Ideally, the cartographer should be familiar with the target audience and its needs. However, when creating documents for a wide range of users, it is not possible. So a cartographer is to rely on their own intuition. Time and other constraints do not allow the creation of maps to use some advanced methods that would phenomena could be shown, a mastery of the map lies in the simplicity and the use of only a small number of content elements to represent the most phenomena. This is not an easy task, so to build video maps can only be recommended to the map professionals with experience in cartography.