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"Beyond usability" – User-centred design of tools that support the communication of planning scenarios

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1 ABSTRACT

The paper illustrates how to apply user-centred design in geovisualization in general and in the design of tools that support the communication of planning scenarios in particular. Based on Neumann's (2005) concept of multi-dimensional navigation, prototypes were developed to test various interfaces and navigation metaphors. The problem is: How to test a concept? With regard to Fuhrmann et al., it is argued that usability engineering testing needs to be extended by user-centred design approaches. As an example, the user-centred design of interfaces for the multi-dimensional navigation of planning scenarios is illustrated in a four-step iterative process.

The results of iterative prototype development and user-centred design show that interactivity in general is very important in planning with the scenario method. Temporal navigation in particular proofed very useful to communicate long-term landscape change over time. In contrast, the inclusion of indicator navigation is still problematic. Although indicators are seen as useful, the current prototypes might still suffer from a lack of usability.

2 USER-CENTRED DESIGN OF GEOVISUALIZATION

2.1 Introduction

The discipline of Human-Computer Interaction (HCI) has developed various methods and approaches of usability engineering, which have their origin in ergonomic workstation design. These methods provide a lot of inspiration for the usability testing of geovisualizations. On the other hand, the methods are limited in testing a concept. For that reason, Fuhrmann et al. (2005) argue that the user-centred design of geovisualization has to go beyond usability testing only.

2.2 Usability testing in Human-Computer Interaction

The usability of a system includes its effectiveness, efficiency and user satisfaction (International Organization for Standardization ISO). According to Mark and Nielsen (1994), the precise specification of small, broken-down, tasks comes first. Then, the solution of these tasks by users is observed and documented, e.g., in focus groups, interviews, questionnaires, on video, or by the "think-aloud" technique, where users comment their actions loudly.

2.3 Beyond usability – User-centred design of geovisualization

Geovisualization research has referred to HCI in many aspects, but Andrienko et al. (2002), Slocum et al. (2001) and Fuhrmann et al. (2005) show that in geovisualization, usability is not enough to test. The first problem in geovisualization is that the tasks are generally ill-defined due to the interactive and exploratory nature of geovisualization (Slocum 2001). If the task is to explore unknown spatial patterns, it is very difficult to measure the outcome by quantitative standard usability methods. Andrienko et al. (2002) point out that geovisualization research often not only tests a specific interface feature but a concept in general, such as interactivity. Because a concept cannot be tested for usability, prototypes illustrating the concept, have to be tested. On this basis, geovisualization research derives the assessment of a new concept from the evaluation of these prototypes. If the results are positive, it is a hint that the concept is successful. In contrast, a negative result does not necessarily indicate a failure of the concept, but can also result from bad design, software bugs, poor research design etc. (Andrienko et al. 2002).

Fuhrmann et al. (2005) argue that usability is not enough to test because HCI does not distinguish between usable and useful. Instead, geovisualization has to be tested whether its application is useful in a domain-specific context. Therefore, geovisualization has to collaborate with other disciplines such as cognitive science, social science, and experts from the domains using geovisualization, e.g., planning. In interdisciplinary research, the way that people use images as support in decision making has to evaluated for planning – beyond the pure usability of the tools.

2.4 Principles of user-centred design for geovisualization as a planning tool

In the workshop on "Exploring Geovisualization", Fuhrmann et al. (2005) defined four principles of the user-centred design process in geovisualization:

- set an early focus on users and tasks;
- apply iterative and participatory design;
- measure the product usage empirically through user testing;
- modify the product repeatedly

(Fuhrmann et al. 2005; with references to Gould and Lewis 1987; Rubin 1994).

Inherently, the users are at the core of user-centred design. In comparison to usability engineering techniques, where user needs are summarized statistically, geovisualization has to focus on user expectations, individual experience, skills, domain specific knowledge, capabilities, and limitations (Andrienko et al. 2005). With regard to users and tasks, planning has to contribute to user research as well in order to address the specific user needs and tasks in planning.

Like users, tasks are specific to planning. Tasks in planning depend on planning regulations, i.e. tools have to be compatible to official regulations, and to planning methods such as participation or scenario planning. In Schroth (2007), the demands of participation are analysed in detail for the development of landscape visualization tools. Tools for dialogue are needed, tools that are interactive enough to respond to diverse user input and to support open-ended decision-making.

The need for iterative and participatory tool design fits very well to the general approach of planning participation. User research on geovisualization and landscape visualization has been conducted by Al-Kodmany (1999), Lange and Hehl-Lange (2005), Sheppard and Meitner (2005), Schroth (2007), and Wissen (2007). These authors applied mixed methods, using qualitative and quantitative methods from social sciences, psychology and cognitive science, i.e. focus groups, participant observations, and qualitative interviews. Salter (2005) evaluated the effectiveness of interfaces in the communication of the spatial and temporal dimensions of landscapes. His approach was closer to usability engineering as he recorded users while solving precise tasks and analysed the data with techniques from cognitive science. Salter also used prototypes for an iterative design cycle such as it is described in the following chapter.

3 PRACTICAL EXAMPLE: DESIGNING A MULTI-DIMENSIONAL NAVIGATION TOOL FOR SCENARIO PLANNING

One of the core workpackages in the EU-project VisuLands (Miller et al. 2006) was the development of scenario visualizations that support participation in collaborative workshops. According to the participative idea of the project, an user-centred design approach with iterative and participative tool development was chosen. The principles of user-centred design (chapter 2.4) were implemented in the task analysis and in four iterative loops of prototype development and evaluation. The methods, process and results are described in this chapter to illustrate the concept of user-centred design of geovisualization tools in practice.

3.1 Users and tasks in collaborative scenario planning

Fuhrmann et al. (2005) suggest starting with the analysis of users and tasks (cf. chapter 2.4). Planning users are special in three aspects. First, decision-making in planning is usually a group process, which differs significantly from individual human-computer interaction. In addition to individual responses, group dynamics have to be analysed. Second, planning users are usually stakeholders with considerable local knowledge, i.e. knowledge about the history, traditions and relationships of a location. However, stakeholders not necessarily obtain high knowledge in planning theory or geovisualization. Often, planning stakeholders are lay people in these subjects. Third, time is the major constraint. In collaborative planning, time is generally very limited because most stakeholders engage in planning workshops in their leisure time. Furthermore, lay people are more likely to expect quick results from a geovisualization system than experts. On the other hand, lay people do not want to go into that much detail from the beginning on. For that reason, Andrienko et al. refer to Shneiderman's (1996) mantra "overview first then details on demand".

The tasks in collaborative scenario planning are determined by three issues, i.e., participation methods, scenario methods, and data issues. In general, participation requires an ethical approach to visualization, which was proposed by Sheppard (2001; 2005) as guideline: accuracy, representativeness, visual clarity, interest, legitimacy, access to visual information. In participation, visualization tools particularly need to support an open-ended dialogue. Here, a trade-off between fully prepared visualizations and an open visualization process is necessary because a pre-decided and fixed blue-print plan of the outcome will inhibit any successful participation. In consequence, a certain level of interactivity is necessary in order to provide the participants with sufficient choices (Schroth 2007).

The visual working with scenarios is rather complicated because it involves not only various tasks of matching time and space patterns (MacEachren 1995) but also different timelines for different scenarios. In consequence, the user has to cope with multiple dimensions beyond space. The availability of additional dimensions is highly dependent on the data and its structure. Current Geographic Information Systems (GIS) are still limited in their ability to manage temporal data, so that the idea of multi-dimensional navigation can only be tested through prototypes without full functionality. The complex issues of visualizing scenarios have been topic to many previous CORP papers, e.g., Lindquist and Danahy (2006), or Paar and Clasen (2007).

In summary, the tasks and requirements are rather vague and very difficult to test by traditional methods from usability engineering. Only well-defined sub-tasks of matching time-space patterns, e.g., the comparison of land-uses for a specific parcel over time might be tested through usability testing. In contrast, participatory criteria such as visual clarity or interest have to be queried through additional qualitative methods. The next chapter describes the development of prototypes to test the most important sub-tasks of visualizing scenarios and the exploratory methods in user-centred design for testing them.

3.2 The concept of multi-dimensional navigation as conceptual approach

In his work on atlas systems, Neumann (2005) refers to the space/time/theme model by Ott and Swiaczny (2001). Neumann locates historic events by their spatial, temporal and thematic configuration. The approach is transferable to planning, especially with regard to the scenario method. Figure 1 illustrates the various dimensions of a multi-dimensional problem. The alternative storylines of a planning scenario are comparable to the lines of development in Neumann's model. Therefore, the "what-if" scenarios in planning create an abstract space with five dimensions. In addition to the three spatial dimensions, scenario storylines have a temporal and a thematic dimension. Tools are needed that make these five dimensions perceptible and to test the concept itself. For combined multi-dimensional spatial, temporal and thematic navigation, selected metaphors were tested in the case study in order to assess their benefits in collaborative planning processes.

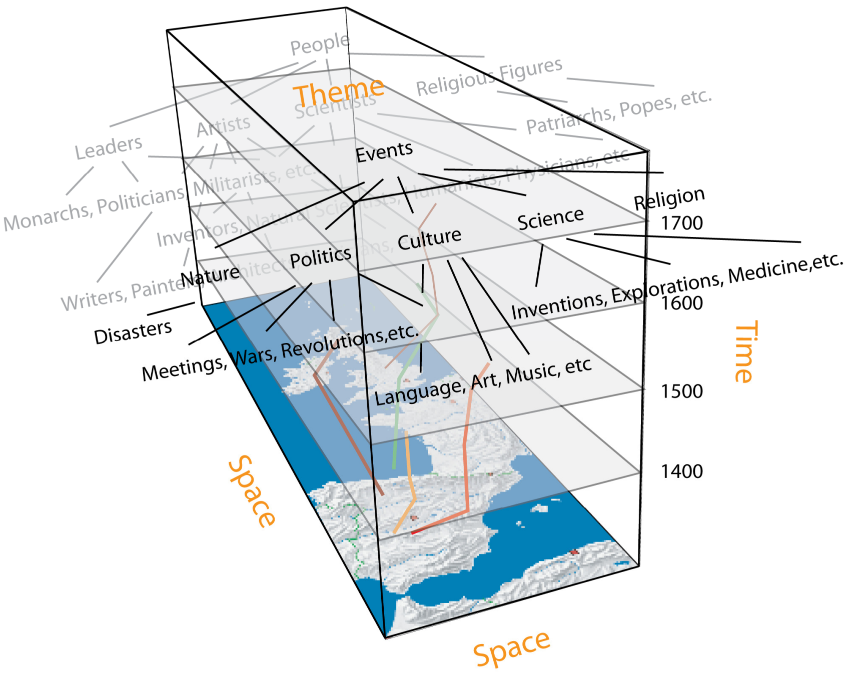

Figure 1: Space/Time/Theme model by Neumann (2005), in Hurni (2005).

3.3 Evaluation methods: Focus group, qualitative analysis of key moments, quantitative ranking

In the analysis, user research methods from social sciences and psychology were adopted to planning by Schroth (2007). A first prototype was tested in a focus group (Monmonier and Gluk 1994) with invited end-users from planning in different European countries. On basis of those results, various additional features were implemented in further interactive prototypes and by using the commercial software LandXplorer. The more advanced prototypes were then tested "in-situ" with current spatial data and in planning workshops with stakeholders from tourism, agriculture, and forestry (Schroth et al. 2006). The qualitative analysis focused on the key moments in which interactive visualizations had an impact on the process or outcome. For these key moments, the discussion was observed and analysed how the argument changed in response to the visualization. The stakeholders and facilitators were interviewed with regard to qualitative aspects of participation such as credibility, enrichment of information, learning, etc., described in Schroth (2007).

Finally, a prototype for temporal navigation was tested with quantitative methods by Hislop (2005). A series of images, showing historic landscape change, was presented to local exhibition visitors. Then, the visitors were asked to rank the importance of temporal navigation in comparison to other visualization features such as walk-through movement and linking to indicators.

3.4 Practical examples from the user-centred design process

3.4.1 First iteration: Presenting an animated prototype to a focus group

A first interactive prototype was implemented with the authoring tool "Adobe Flash". An appropriate metaphor for navigation over time is the time-line (Edsall and Sydney 2005). In this prototype, users could select different land-use scenarios by switching the buttons on the right and compare them for three time steps using the time slider in the bottom (figure 2). The landscape visualization was also presented in different levels of realism (Lange 2001), ranging from rather abstract to highly realistic. Among other questions, the focus group was asked how much realism and how much interactivity they required for participatory group work.

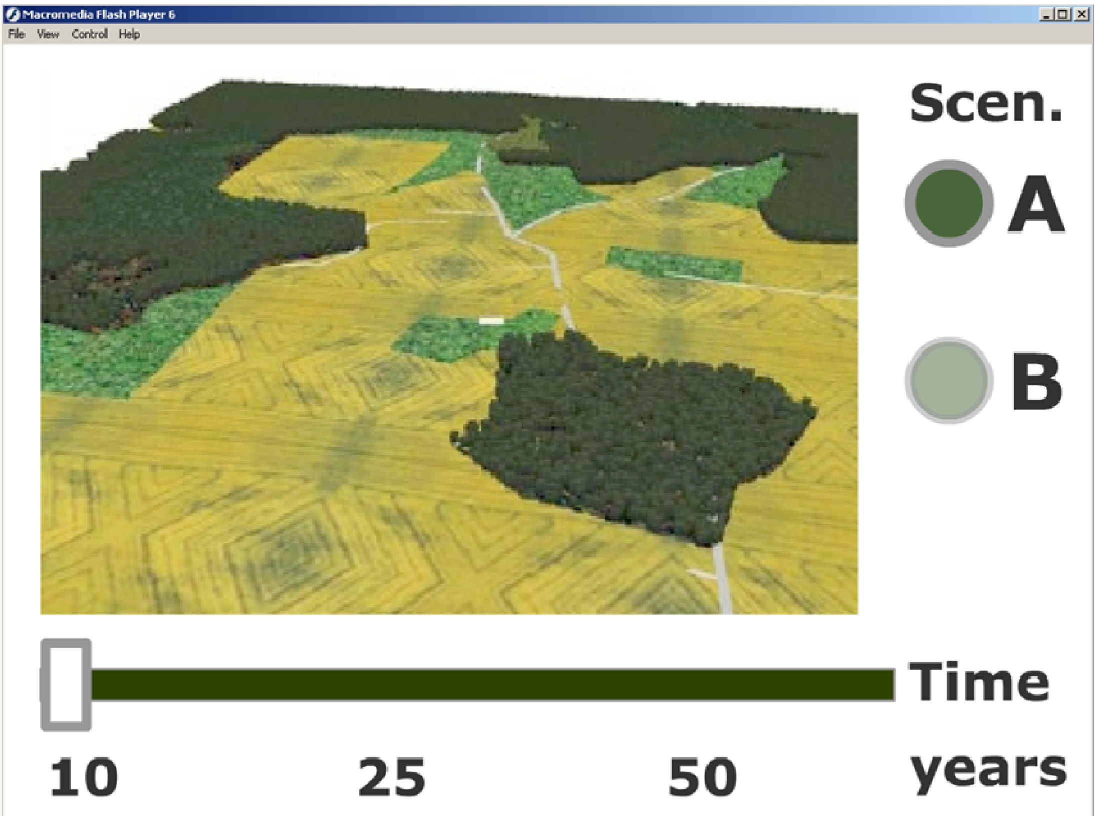

Fig. 2: Interactive prototype to test thematic (scenario A and B) and temporal (10, 25, 50 years) navigation

It depends on the actual planning task which level of realism is necessary. In a follow-up project, different levels of realism were tested for different tasks in visual landscape assessment in an online survey (Paar et al. 2004; Schroth, unpublished). However, the focus group members agreed that they generally consider a high level of interactivity as crucial for participation. For that reason, different types of interactions were implemented in follow-up prototypes.

3.4.2 Second iteration: Applying a prototype in real stakeholder workshops

After the first design loop together with the focus group, visualizations were rendered for the UBE case study area for different historic and future time steps. In this step, the interaction was only simulated in a slide-show demonstrator. However, the visualizations were based on geodata and referred to local stakeholder issues. The tool was applied in collaborative workshops with farmers to foster the discussion about future land-use management strategies. The visualizations from a pedestrian's perspective (Wissen2007) showed the rate of reforestation in case of land abandonment for the next 30 years. Observations, expert interviews with the facilitator, and protocols of the group discussions showed that showing landscape change over time facilitated the discussion. The farmers discussed which species will come first and how to prevent the spontaneous reforestation.

Fig. 3: Showing different time steps in a stakeholder workshop

3.4.3 Third iteration: Testing user-group differences (lay people vs. experts) in an experiment

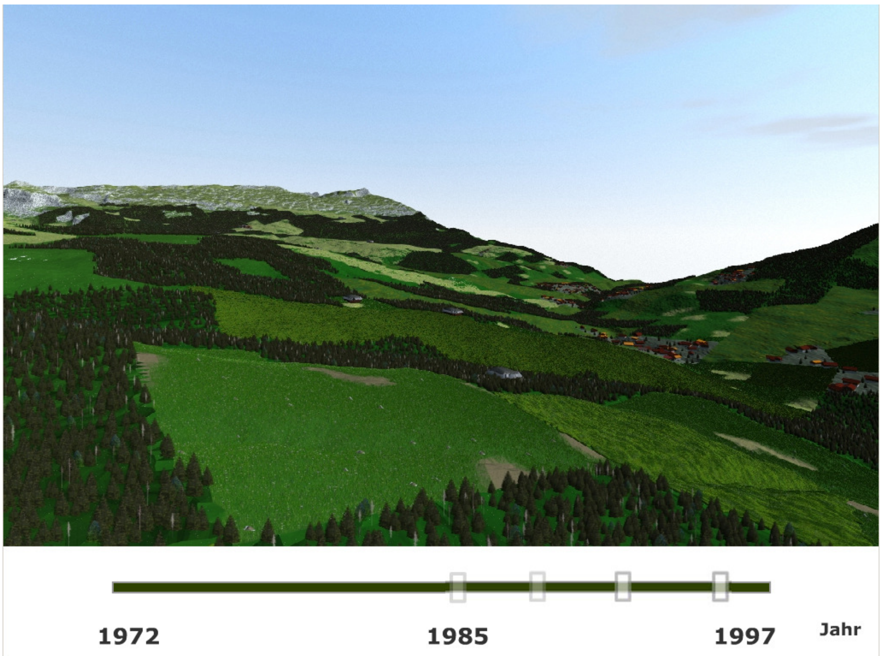

Fig. 4: Interactive prototype for temporal navigation

Figure 4 shows the prototype for temporal navigation. It includes a time bar to navigate between a sequence of three pre-rendered images of land-use in 1972, 1985, and 1997 in the Entlebuch in central Switzerland. This prototype was presented to local residents (n=53) knowing the area and after the presentation, they were asked to rank the usefulness of the tool on a scale of school grades from 1 (very useful) to 5 (not very useful) in comparison to other interactive features, i.e., walk-through movement, viewing different options, photo-realistic images, inclusion of non-visual information. The full setup of the questionnaire is described in Schroth and Schmid (2006) and Schroth (2007), concentrating on the response to the prototype for temporal navigation here. However, temporal navigation was ranked highest from all features (the graph in figure 5 shows the high numbers of first and second ranks) by both lay people and experts (lay people and experts were distinguished with regard to their map-reading skills). In contrast to temporal navigation, the linking of thematic indicator information showed a bimodal distribution. The ranking by lay people was very low whereas expert map-users ranked it significantly higher.

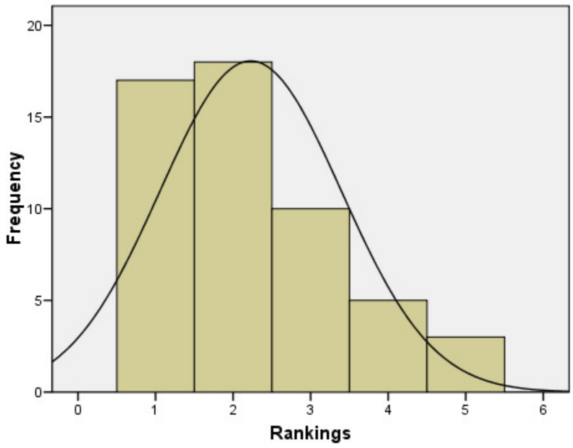

Fig. 5: Questionnaire setting at local exhibition (left photo)

Histogram of the frequency distributions of the overall respondent's (lay people and experts) preference rankings (right)

3.4.4 Fourth iteration: Designing a prototype for a specific user-group (experts)

In comparison to temporal navigation, the linking to thematic information on indicators was ranked very low by lay people, although it is seen as very promising in the literature (Wissen et al., in press). However, the user tests suggest that indicators are an expert tool, which is difficult to read for people with low map-reading skills. Figure 6 shows an interactive prototype combining spatial, temporal and thematic navigation with indicator diagrams (spider diagram and indicator map in the lower part of the interface). The prototype was developed together with experts in landscape assessment, but for lay people it is suggested to include the indicators on demand as suggested by Shneiderman (1996). For future research, it is suggested to test this prototype and alternative implementations with lay people and experts.

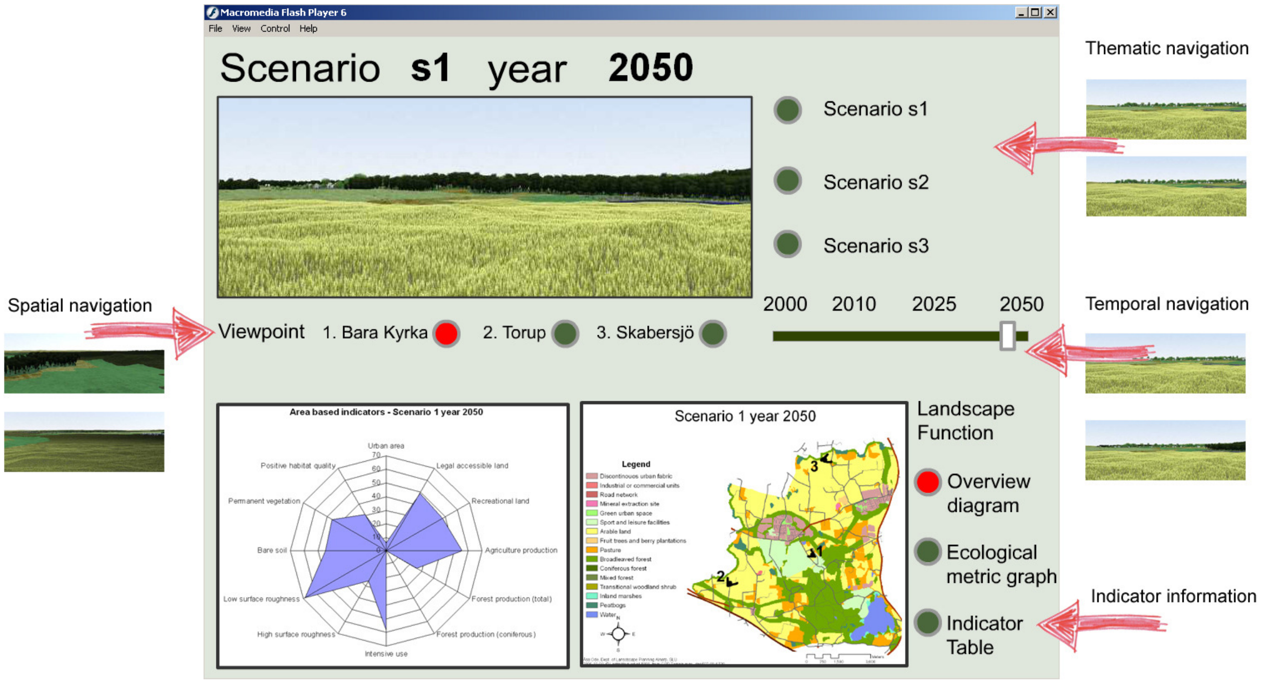

Figure 6: Interactive prototype for an expert interface for scenario navigation (image: Schroth and Ode, in Miller et al. 2006).

4 CONCLUSIONS

The paper presented an example for the development of computer-aided planning tools through the creative and participatory application of user-centred design principles as defined in chapter 2.4. In comparison to usability engineering techniques, the focus was not on usability but on testing the concept of multi-dimensional navigation for the communication of planning scenarios. The feedback showed that interactivity is the key to the successful understanding of scenarios and for participation in scenario development. The more advanced prototypes indicated that temporal navigation is particularly useful in planning landscape scenarios. Landscapes are dynamic by nature, but it is difficult to communicate landscape change because it stretches over very long time spans. Tools that can illustrate landscape change by collapsing the long-term change in a few seconds proved very helpful. Here, a simple time bar was an appropriate navigation metaphor.

Beyond spatial and temporal navigation, the inclusion of additional thematic information becomes more difficult. Although indicators are regarded as necessary (Wissen et al., in press), they are difficult to include in the multi-dimensional navigation. If the usefulness of including indicators could be proved, it will be necessary to focus on usability as well. Here, further user-centred design is required.

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