D8.4 System usability report

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Summary

This report describes the results and analysis of end-user feedback towards the technically-oriented system usability. Results have been obtained from various expert workshops, expert interviews, and validations in geoscientist-oriented demos at public venues. Overall, the results reflect the stance from the majority of end-users and experts towards the applications, with respect to their technical and practical usability.

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1 Introduction

> **Further reading**
> This section introduces several of the main usability concepts. Further detailed information can be found in report D2.1 on user-centered design.

The rationale of the human-centered work performed in WP8, as well as other related work packages, has followed an incremental and iterative development process using state-of the-art approaches of user-centred design and software engineering. These highly connected methodologies are based on scheduling and staging of the various parts of a system that have been developed in parallel but at different pace. The project specifically focused on developing early prototypes that can be used in **demonstration-oriented activities (WP8)** and **experiments (WP7)**, in order to secure the highly user-centred developments through multiple iterations. The integration of both methodologies assumes that problem definitions is not covered to its full extent in the beginning of the project: the understanding of the problems have grown as prototypes are built that generate feedback from end-users. **Usability tests are an integral part of user-centered design**, verifying design ideas throughout the various stages of development. User-centred design is a design philosophy that aims at improving the overall end-user experience for a product or service by actively involving the identified user into the planning, design and development phases of the new product or service. UCD tries to optimize the designed system around how people can, want, or need to work, rather than forcing the users to change how they work to accommodate the system or function. UCD answers questions about users and their tasks and goals (reported in WP2 reports). The findings have been validated through empirical grounding and have been used to make decisions about development and design. In HYDROSYS two major gains of exercising UCD in the research process should be stated. First of all, it has acted as a mediator between different research-oriented activities and the common system development. It also helped us in providing, as a result of the project, a useful more "market-oriented" research prototype system that satisfies needs of the project partners and defined user groups and above all, provides additional value in the activities they perform.

One of the state of the art user-centred design process methods used within the project is called **Contextual Design** *[1]*. This process puts emphasis on studying the worker in his/her actual working context incorporating a set of practical ethnographic methods. It is well implementable into a system development project such as HYDROSYS where the context of use has a potentially large effect on the usefulness of the system. Much of the ideas presented in the Contextual Design process are applied into the HYDROSYS research project.

Another user-centred design method that has well applied in the project is **Participatory Design** *[2]*, which emphasizes the role of users in development. In HYDROSYS, end-users have taken an active role in designing the system especially by taking part in the participatory workshops (see section 5.4). In general, we regularly talked to a user group of about 65 users, through workshops, casual discussions, and on-site deployments. These two UCD models are not exclusive and both viewpoints can be expected to bring value into a research-oriented system development process. While participatory design is more of a design philosophy without formal methodology, the Contextual Design process proposes using a set of concrete methods, of which some have been directly and others more adaptively implemented into HYDROSYS.

1.1 Methodology

Within work packages 7 and 8, a multitude of interviews and experiments have been performed. The three different main contexts for carrying out these tests are:

- Usability/performance tests in laboratories (WP7 and WP8)
- Usability/performance tests on the field (WP7 and WP8)
- Participatory workshops (mainly WP8)

Following methods can be utilized during these tests and experiments:

- Automated data logging (mainly WP7)
- Eye-tracking (WP7)
- Semi-structured interviews (WP7 and WP8)
- Questionnaires (WP7 and WP8)
- User observations (WP7 and WP8)
- Think-aloud (WP7 and WP8)
- Expert evaluations using guidelines and heuristics (WP7 and WP8)

1.2 User groups

Alpine scenario context: Recently, IPCC Paris Conference has mobilized scientific and political efforts to underline the urgency of the Earth situation in the context of global change and therefore the need to act. However, yet all too often, scientists cannot provide satisfactory answers to open questions, such as: "How are local and regional environmental processes functioning and evolving?", "What are the main causes and consequences of such change on local people?" As example, in Switzerland, warming, melting and disappearance of permafrost have accelerated in recent decades damaging engineered structures and raising public concerns. Consequently, it has been decided to also focus on natural hazard management. Switzerland is an alpine area and is also a confederal state composed of 26 cantons that have a large range of competencies within the general framework of federal laws. The cantons are themselves composed of communes (municipalities) that have large autonomies. Consultation between different administration services is routine in the Switzerland. Concerning water and natural hazards management, the federal and cantonal government edicts laws and guidelines and their executions is delegated to the cantonal and local government. The main instrument to ensure the compliance to these guidelines is the subsidies.

Based on the context and the system design framework of HYDROSYS, the following six end-user groups were chosen to be studied in the context of the Alpine scenario:

- Specialists in charge of managing natural hazards at cantonal level
- Environmental companies
- Environmental researchers
- Municipalities
- Infrastructure companies

- Tourist and environmental association
- Teacher and kids

Nordic scenario context: The Nordic scenario consists of two lines of work: 1) On-site analysis that supports design of ecological restoration and water quality management of a suburban/urban area; and 2) On-site investigation of environmental pollution in a river basin. The first line of work considers catchments of the size 10 … 1000 ha and the second catchments of the size 100… 10 000 km2. Specifically, the focus of the first line of work is a suburban area in Vihti (a Nummela 500 ha catchment, partly urbanized and partly undergoing urbanization with noted water quantity and quality problems, a satellite city 50 km commute from Helsinki), and the focus of the second line of work is the basin of the river Vantaanjoki (1685 km2 which covers large areas of the Helsinki Metropolitan Area). The baseline data for the Nummela area consists of detailed municipal maps including subsurface structures such as storm water pipelines, water quality observation database, soil maps, master plans for restoration activities, and images.
Based on the context and the system design framework of HYDROSYS, the following six end-user groups were chosen to be studied in the context of the Nordic scenario:

- Watershed/Storm water project managers
- Watershed contractor
- National and municipal environmental authorities
- Environmental activists
- Local habitants

1.3 Workshops and events organized and analyzed

A number of events have been analysed in this report, as part of the continuing user-centered design efforts:

- In October and November 2009, the consortium organized two Workshops, in Davos Switzerland, and Lahti, Finland. (Focus: complete system)
- In March 2011, we prepared a large demonstration and event, as part of the SLF celebration (focus: sensor network, handheld augmented reality system)
- At SLF and EPFL , several rounds of expert interviews have been held in April and May 2011 (focus: sensor network, handheld augmented reality system)
- Turku event May 2011

References

1. Hugh, Beyer und Karen, Holtzblatt. *Contextual Design: Defining Customer-centered Systems.* s.l. : Morgan Kaufmann, 1998. ISBN 1558604111.

2. Schuler, Douglas und Namioka, Aki. *Participatory Design: Principles and Practices.* s.l. : Lawrence Erlbaum Associates, 1993. ISBN 0805809511.

2 Results

The following section provides a logically structured overview of the main results gathered from the various usability-oriented actions. The structure reflects the three main functional groups, as well as the general, higher-level technical usability of the applications. For the deeper technical validation it is recommended to refer to report D7.3 final validation report.

Further reading
For in-depth validation of some focused technical issues (specific visualization and user interface techniques) it is recommended to read D7.3 final validation report.

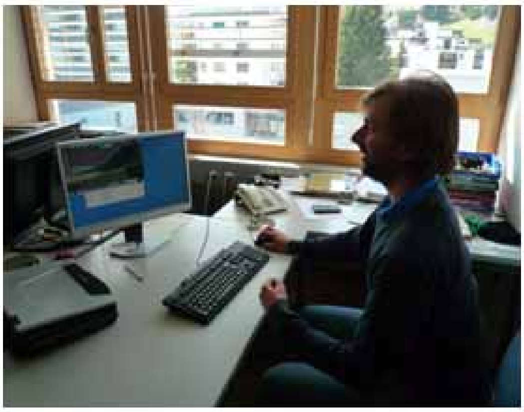
2.1 Sensor setup and maintenance, data pipeline

2.1.1 Expert workshops

A detailed protocol of the expert workshops can be found in the appendix

In general, users expressed very positively on sensor setup maintenance aids, and the directions followed for implementation. The direct feedback on the content and usefulness of a (manually) placed sensor is found to be useful, since it can improve the quality of measurement as well as ease the set up of sensor networks. An example is the direct feedback during usage of a manual sensor, which can save time and avoid returning to site to take samples again (are the measurements appropriate? Do I need more?). To test sensors, whether sensors are working properly and results are sensible can be seen straight away after mounting the sensors by showing **meta data** are found to be beneficial by all parties. End-users may require services though: currently, end-users do not necessarily make use of automated networks of sensors. Furthermore, they are not used to configure / use / maintain databases and the required handhelds. Depending on available personnel within an institution or organization, this could be handled, but, it might be needed to offer commercial or not-commercial aids.

2.1.2 Expert interviews (handheld system)



Users at SLF in Davos, participating in a remote system test from a desktop computer.

During the expert interviews, we showed the final research prototype in a guided fashion. Users were introduced to the main mechanisms of the research system prototype demo, and explored the office-based installation of the mobile demonstration (handheld demo setup).

This setup is exactly the same as the handheld demo, running on prerecorded data. After an initial round of demonstration, users were asked to explore the various features of the system and express their attitude in an unstructured interview as well as a questionnaire (see appendix, Liker scale 1-7, 7 being excellent). Hereby, any particular questions referring to on-site aspects (mobile usage of the demo) were disregarded (questions 29-31).

In Davos, 7 experts were interviewed. We had experts with varying backgrounds – some users were regular site visitors, whereas others are mainly based in the office. As such, the **user background** is expected to have affected the feedback during interviews.

In general, we could observe varying feedbacks on the system – some users were very much enthusiastic about the system, whereas others did not see too much added value. As such, the numerical results (statistics) vary.

Most users found the gaining of metadata on the working of sensors very useful, to observe the sanity of the set up sensor network (avg 5,86, stdev 0,69). Experts also expressed interest in the usage of the mobile sensor, as has been provided by Aalto, but not deployed yet at the time of the interview. In relation, the system would also be beneficial for combination with specialized sensors: for example, the usage of the SLF SnowMicropen system would certainly benefit from obtaining direct feedback in the field, while taking samples with the device.

With regards to the blimp, 6 out of 7 users saw clear benefits of using the blimp for terrain model refinement and thermal data capturing, but could not assess if the institute could afford it.

With respect to the data pipeline, it was expressed it would be very beneficial if the demo could be easily modified, meaning, the self-setup of an application by “loading a dtm and sensor data”. Principally, this is possible and not too hard (some tools are provided), but we did not test the process with end-users. Most users did see relative advantage of the tools to improve the data pipeline, but the comparison is difficult here: most users make use of GSN and the web interface to access sensor data in the office, which, from an office perspective, is quite similar to what our application provides.

Comparison with expert workshops: the expert interviews were about in the same line as the previous expert workshops, with positive resonance towards sensor setup and maintenance. The data pipeline was not assessed much in the expert workshops, which is why no comparison can be made here.

2.1.3 Summary

Most users reported very positively on the usage of the tools for sensor installation and saw at least some improvement over the current toolset used in daily work, from a data pipeline perspective. The latter is difficult to assess, since some experts already use very advanced tools, whereas others (in the expert workshops) don’t.

Usefulness of results
The expert workshops proved usefulness for meta data feedback on the functioning of sensor networks, thus easing maintenance too of data pipelines.

The positive stance was further confirmed by the expert in expert reviews.

2.2 Monitoring and understanding environmental processes

2.2.1 Expert workshops

Many different situations where on-site monitoring could be useful were brought up during discussions, including monitoring hydrological processes, monitoring spreading of algae, monitoring events that are difficult to predict, and so on. In summary on-site monitoring is useful "almost everywhere" and it's difficult to come up with individual situations where it would be particularly useful. Alpine and Nordic case studies were noted to be **good test examples** and on-site monitoring could be used also in other scenarios elsewhere studying same kind of situations, e.g. transport of pollutants in streams. In Davos, it was particularly expressed that access of data in the field is found to be useful for specific tasks, but not for all. Different levels of complexity are required for different users. As such, it confirms the system as being complementary to in-office work. Tasks that were found particularly useful include the various decision-support tasks that are mentioned in 2.3.1.

Of particular interest were scenarios that can be produced in the field and the results of the model can be visualized, and thus the information of how the modeled situation affects the environment is readily available. E.g. effects of rain to environment can be observed even if it's not raining at the moment. Possible scenarios can be modeled and then with the aid of visualizations signs of realized scenarios can be searched from the field more easily. Also of interest are the utilization in different warning systems, e.g. flood, avalanche or landslide warnings. The biggest challenge of the system was found to be nature itself, since performing even simple continuous measurements is often very difficult. On the other hand events under research and especially extreme conditions may be problematic, e.g. avalanche or flood that destroys measuring devices.

In general it was noted that amount of **work is increased because of on-site monitoring**, but the **benefits gained with it may well compensate** for the drawbacks of increased amount of work. Amount of work was believed to increase especially in the beginning, in testing and calibration stages, but on the other hand also maintenance increases amount of work. As before, the overall benefits are greater than the drawbacks if e.g. failure in measurement device is noticed immediately in the beginning.

On a functional level, in particular annotation received considerable attention. Annotation by professional users would be very beneficial, e.g. employees of forestry and environmental inspectors who are spending most of their time on the field. However, a quality control problem was noted: a quality stamp could be attached to annotated data, general – professional user.

2.2.2 Expert interviews (handheld system)

As with the feedback obtained on direct access of sensor data in the field, we obtained varying interest in using the proposed system in the field. Some users really saw large advantages against office-only tools, whereas others were more skeptical up to negative (3 out of 7 users). Strangely enough 5 out of 7 users expressed they saw benefits in accessing on-site almost real-time data and simulations and to interpret data in various forms (5 out of 7): of course, this is rather in contrast to the other rating, and may be dependent on the complexity of the offered tools, and/or the learning curve. Most users could find one or more advantages in the offered tools, from saving time up to improved workflow: only one user could not see any advantage.

In general, the positive users would take such a kind of application in the field, however, changes would need to be made: as we will describe later on, the dependency on the small but still bulky setup affected the opinion of the users. Most (positive) users expressed they would only take the system in the field if it would be ported onto a smaller platform (Ipad, mobile phone), even though technically, the choice of such a platform would pose a number of constraints on the application. These constraints are not always understood to full extent by the end-users. Nevertheless, to leave the prototypical stage, smaller devices with good sensors would be needed, which is a factor which cannot be covered within the current project. In addition, there was interested in using the software still in a more modular way, selecting only those components that are useful for the specific task at hand.

The notion of a *shared understanding* system was reflected very positively on by the interviewed experts (6 experts rated very positively, one very negatively: avg 4,71, stdev 2,06). This is particularly interesting since most experts know their sites very well. Interest was also expressed in coupling to the “local observation” of micro-sites a regional or national model (so the complete Swiss model, similar to using Google Earth), to explore sensor data while generally being on the road. Currently, such a system would be difficult to assess due to the power of the handheld to process larger models, but this can certainly be foreseen in the future.
6 out of 7 users reported that these tools could be very useful for specialists from research institutes, but not so much suited to communicate information to the general public: here, the cell phone demo seems more suitable, since it is less focused on advanced users. Users were unable to unanimously answer if they would pay for services, since they are not generally used to deal with such issues.

Comparison with expert workshops: in general, most but not all users in the expert workshops and interviews are positive towards using tools for on-site monitoring. The expert workshops had a larger group of users and variety, and in general seemed slightly more positive to have basically any kind of tool for on-site monitoring. What really made a difference on the expert interviews, and which was not so much presented in the expert workshops was the multi-view system, which was received very positively.

2.2.3 Summary

The general stance of most experts was positive towards using presented tools in on-site monitoring. Demos are generally seen as advantageous, even though they may consume time for getting used to, and to actually use them: most users reported they see benefits in using the tools. Of particular interest was the positive resonance on the multi-view system, which seems to add quite a bit to the system, especially considering that users know their sites well. Some experts still complain about the size of the handheld device, and often, it seems the application needs to compete with commercial, leaner applications on smart phones: here it is always difficult to compete as research system prototype, even though we believe we have a very powerful system. The tools offered also seem to be trimmed more towards specialists, whereas most experts reported that “normal” users or even the public would likely less benefit from the tools. The latter is in line with the goals of the system, with the cell phone application tuned more towards the general public.

Usefulness of results
Experts in the workshops clearly expressed that on-site monitoring is very useful, and extends office-only workflows. The scenarios introduced in the project were seen positively.

The user background had an effect on user feedback in the expert interviews – on-site visitors reacted very positively, while office-based workers did reacted average to using such tools.

2.3 Management of environmental processes

2.3.1 Expert workshops

Decision-making support is believed to be improved by usage of the new toolsets. Both short-term and long-term decision making may benefit: those situations that require a quick validation of a situation before a particular action is undertaken can be improved (example single user: check sensor data before triggering avalanche) as well as those situations in which multiple users with different perspectives need to discuss a situation in a short-term manner. These methods only support the decision-making, and are **not aimed** to be part of official warning / evacuation schemes. In general the toolset is thought to provide extra information that may lead to financial benefits because of optimized decision-making supported workflows. This is found to be especially useful in monitoring rapid changes, e.g. evaluating effects of instantaneous emissions or environmental accidents and deciding and allocating needed actions. This may also lead to large (financial) benefits. Here, of course there is a direct dependency with deploying highly dense and fast sensor networks. Augmented Reality was thought to be useful e.g. in field investigation, when it enables making decisions already in the field – this is more on the **enforcement of decisions taken.** E.g. decision could be made about road construction or observe how accumulation of sediment to one part of the stream affects to other parts.

2.3.2 Expert interviews

Experts were positive about the various decision-taking support tools, in particular the annotations. For example, the marking tools were seen beneficial to make small "notes" on screen shots, for later usage. The tools even seemed ok for reporting plans: the annotations are not suited for more complex documents, but ratings were on the positive side (avg 4,28, stdev 1,38). In general, the experts did not see much value in improving communication in mixed teams of users, in particular in more critical situations: the tools seem to be too much specialized (low avg 2,57, stdev 1,40). In contrast, they could see that the tools improve office to on-site communication (avg 4,43, stdev 1,61), even though 3 users just reported mediocre values, noting that it may just improve a little.

Low-level decision-making was seen positively on – experts expressed the usefulness of using the system for non-critical discussions, like between an on-site expert fixing a station, and a electrician located remotely. High-level decision-making, for example to use the system in critical systems such as avalanche emergencies: this feedback overlaps with the goals of the project not to focus on mission-critical systems. Complex team-work scenarios, outside simple sharing of observations, were not reflected positively on.

Comparison with expert workshops: the expert interviews were about on the same line with the expert workshops: general decision making, and in particular taking notes is seen very positively, but the tools should not be used in mission-critical situations.

2.3.3 Summary

With regards to management, most users reported in particular positively on using the system to make notes. Using the handheld system in mission-critical situations was not seen positively, but our system has never been intended for this purpose. Mixed team decision-making strangely enough did not receive good ratings, which may be because the tools are rather specialized. Previously, the tools were found to be advantageous to enforce plans, in particular to see the effects of new (physical) changes made to the environment, for example as part of new infrastructure.

Usefulness of results
The experts were positive about the systems to improve decision-making processes, though it was often hard to qualify it's actual effects.

2.4 General usability

2.4.1 Expert workshops

Visualization

Initially, participants had different opinions about needs and benefits of visualization. On one hand data **gathering and processing** were seen as the most important components of HYDROSYS-system and visualization as just a "nice" add-on. On the other hand other participants saw **visualization as fundamental part** of the system and thought that there is a need for that. There were also different opinions about superiority of 2D vs. 3D. Some participants saw that there isn't need for 3D visualization whereas others thought it is useful. As a conclusion superiority of 2D vs. 3D visualizations is **dependent on the needs of the**

user and the research subject. Same is true for AR as well. There were some comments about 3D-vizualization and AR where it was addressed that those are subjects that are easy to get excited about but it's unknown whether there are any real benefits. It was also considered that 3D and AR might be more interesting to people who are working with or researching those than to environmental experts.

Hence, users initial believed that **3D visualization is not necessarily needed for all tasks**: users stated that in many situations the position of sensors and overlay of numeric data on top of a map would be enough for an initial assessment. This approach highly overlaps with traditional map-based overlays used in GIS systems, and partially **contradicts** with positive feedback we obtained on simulation results access in the field, particularly for sensor placement support / manual sampling. Users did find 3D visualization useful for those situations in which **spatial data sets are the basis for analysis**. However, for some tasks / data visualization, 3D is not appropriate: users stated it is may just be a "gadget" for that. In particular single-point data measurements that are not further processed (like through simulation) might fall under this category. On the other hand, 3D visualization is found to be useful for those users that have difficulties reading maps. As such, it may certainly help multi-disciplinary teams of users were different users with different levels of experience cooperate. Also, 3D visualizations was believed to be useful to show "hidden" information. On the other hand, users also believed that for some kinds of data visualization, 3D visualization is believed to make interpretation overly complex. This issues was confirmed by all experts in Davos and Lahti: Experts might prefer using 2D, but a non expert understands 3D-visualizations more easily - When working in unfamiliar environment 3D-visualization is more useful than 2D-visualization.

The ability to **visualize and compare different sources** of information was found to be advantageous for decision-making (e.g. overall situation/background information (see 2.3.1), however, at the point of the expert workshops, users were concerned by potentially slow network connections (a problem we solved later on in the project). The usage of **video overlays (AR)** was found to be useful in the field, though not for all visualization purposes, and merits possible usefulness in the office. Showing sub-surface structures or different layers of "material" (soil, gras, snow) is one example where the usage of AR makes sense. When setting up sensors, a camera is not necessary. In general, though, the camera footage was found to be useful for protocol purposes.

Usefulness of results
Initially, we had varying reflections on 2D/3D visualizations, were in general, 3D was thought to be useful, but not in all cases. This affected our development to a great extent, taking a comparative visualization approach that makes use of various 1D, 2D and 3D formats to support the different users/tasks at hand.

NOTE: Users in the field of environmental science did not have great experience with 3D visualization at the time of the interviews, which is just starting up. In those areas where people use 3D visualization, it seems of great use though. As already expected at that point of time, it once users get more experience with 3D visualization, it likely catches up: the Nordic expert workshop confirmed the 3D is generally believed to be the "future" of hydrology/environmental visualization. Later on, during the final year demonstrations, a clear shift to 3D visualization could already be seen with a notably higher preference for 3D visualization.

User interface

Users expressed they tend to have a longer learning curve with new user interfaces. In general, and highly influenced by "Apple style" interfaces, there is a preference for "single button" interfaces and metaphors that are known from other handheld devices such as the Apple iphone. Functionally, users do not always need all the functionality that we offer: often, users are

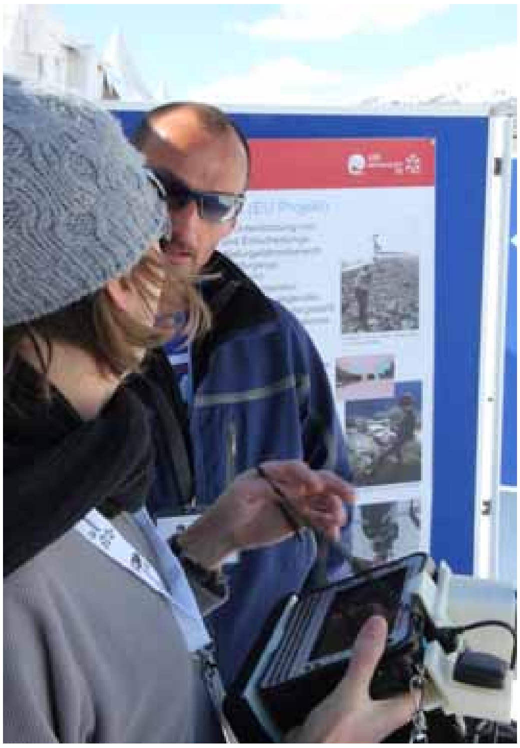
Usefulness of results
The feedback on user-interfaces was rather straightforward, since most users were no experts in HCI. Users prefer simple interfaces, and small devices. This was followed up in the various WP5 user interface developments.

interested in a particular set of functionality. The intended usage of profiles can customize the application to such an extent.
Screen and keypad of the mobile devices are sufficient for data visualization, selecting objects and moving in the 3D-model.However, the keypad was generally found to be too small. The device interface should be controllable with gloves and as such buttons on display have to be big: touch screens were expected to work quite well with gloves when icons are large enough. The pen can be used with a glove, though the Panasonic keyboard is useless. Furthermore, the general device setup was found to be too large. Both device size and text input were solved using specific developments later on in the project. In the same line, mobile devices were thought to be useful for most users, and could not necessarily be replaced by laptops.

2.4.2 Davos celebration usability test

During one of the final events of the project, we performed a brief user study on several higher-level user interface aspects. The test focused on readability and visibility, general workflow aspects, visualization issues, and underlying effects of using augmented reality.

Methodology
As part of the general public (around 1500 visitors) that visited the SLF celebration day, we selected a number of participants. The day was a cloudless, very bright / sunny day: viewing conditions on the used handheld platform (UMPC) were very limited. We selected randomly 22 participants for a small demonstration followed up by short round of questioning. The demonstration was started with a general introduction into the background of the project, which includes the goals of HYDROSYS, and the main ideas behind the deployed technology. Following, the pre-final system (using an intermediate update of the user-interface) was demonstrated using a data set of Davos Dorfberg. This demonstration took about 10 minutes – during and after the demonstration, users were free to make use of the application themselves. After the demonstration, a small questionnaire with 12 questions was requested to be filled out. 11 questions used a 7 point Likert scale, one question just a yes/no answer. Users with a background in geosciences were requested to answer an additional 10 questions – 2 questions deployed a 7 point Likert scale (1 = bad, 7=excellent), the rest was multiple choice (including yes/no answers). After the short validation, most users were invited to a short informal discussion.



Results
From the results obtained, we could only analyze 20 data sets, since 2 users either did not understand the application at all, or gave very conflicting answers (mostly due to old age). Users varied in age between the age groups of 18 up to 75. We had 7 female and 15 male participants. 8 of the users had a geoscientific background.
The results of the initial 12 questions (general public) were good to partly very good, however, as we noticed out of one of the questions and the informal discussion after the validation, the sunny day ***significantly affected*** all our results: the technical platform (the

screen of the handheld computer) is just not good enough for bright outdoor days. As such, the results can only be interpreted to a certain extent.

Question	Average	Stdev	Min	Max
Enjoy using the system	5,21	0,92	3	7
Text readability	3,50	0,96	2	6
Image resolution / detail	4,47	1,02	2	6
Browse data from stations	4,47	1,12	3	7
Select visualization type	4,50	1,22	3	7
Easy to use system	4,93	1,03	4	7
Understand screen content	5,58	1,26	3	7
Localize sensors in real world	4,93	1,16	3	7
Match screen info to real world	5,47	1,97	3	7
3D Overlay useful	5,88	0,99	4	7
Multi perspective useful	5,25	1,39	3	7

The majority of users noted a low score on general visibility / readability of text, basically since it was hard to observe screen content (avg. 3.5, stdev 0.95). The general usability of the system (rated avg. 4,93, stdev 1,03), which is a very reasonable score assuming the difficulties users had to observe the system. The image resolution adequacy (avg. 4,48, stdev. 1,02) was found ok, though this was also affected highly by the sun impact. Users could understand quite well the browsing of data (avg. 4,46, stdev 1,12) and the selection of different visualizations (avg 4.5, stdev 1,12). Users could well locate sensor locations in the real world based on the information retrieved from the screen (avg. 4,93, stdev 1,16), and also match well in general the information on all aspects to what could be seen in the real world (avg. 5,47, stdev. 1,07). The latter value was much higher for geosciences users (avg. 6, 125). 9 users express they could well use the system after little usage (learning curve), 5 users didn’t know if they could use it after usage. The rest of the users could not answer the question.
8 participants had a geosciences background and answered the 10 additional questions. Without exception, all users found the 1D, 2D and 3D data formats useful to use, and were very positive towards accessing and comparing these different representations (avg. 5,88, stdev 0,99). The usage of overlay was also rated well, however, with a higher stdev: some users were very positive, others slightly more skeptical (avg. 5.25, stdev 1,39). Without exception, the access to different perspectives on the field (multi-view system) was found useful. 3 users would directly like to use the setup/system in its current form, 2 more users would use it after changes (including small software changes).

Usefulness

In general, the results presented here are biased by the low visibility of content on the screen, caused by **the limited quality of the screen**. As such, it is difficult to truly draw conclusions especially from the first 12, more general questions. Of course, such an outdoor display should work outside, but currently, technology is still too limited.
Most values can be categorized as “good” – we assume that the ratings would be higher with a better screen.
The additional 10 questions asked to geosciences users were focused more on general principles and provided a more accurate view on some of the concepts of the system. Here, the multi-variate representations and ways of comparing these between each other were rated very positively, underlining the importance of our approach to mix “classical” formats with 3D. The usefulness of the multi-view system were also rated very positively. Augmented Reality in general obtained positive results, both during the general questions (ability to match information from screen to real environment), the geosciences-users questions (overlay

Usefulness of results
Due to the impact of the test conditions (highly sunny day), most values are expected to be lower than under better viewing conditions: usability results were still good to very good, though. Critical concepts such as multi-variate visualization and multi-view analysis obtained very positive results.

question), and the informal discussions. As such, we believe the user interface and the general underlying principles are very much valid. It is hoped that an additional validation can be performed to obtain a comparative analysis.

Comparison with expert workshops: in comparison with the expert workshops in Switzerland and Finland, several issues can be noted. First of all, the rating of usefulness of 3D visualization has improved – all users expressed positively now, whereas in the past we had mixed feedback. The combination of different representations / data sources was still found useful, similar to the expert workshops. The approach in general towards augmented reality seemed more positive. These informally obtained tendencies may be due to the increasing number of 3D / augmented reality applications that became available over the last year. Also, in general, we had much fewer comments on the size aspects of the handheld (informal discussions only).

2.4.3 Expert interviews (handheld system)

Users filled out questionnaires at the end of their trial session in which they were asked to evaluate their experience using the system. In Davos, most users could quite easily browse data from sensors (avg 4,71, stdev 1,11). The overall usability of the system obtained similar results (avg 4,71, stdev 1,25). Strangely enough, some users did not completely understand the screen content, which cannot be explained.
The results of the questionnaires suggest that the system may be suitable for use by people who have a lot of experience with using systems under development, but it may still need to be refined in order to be useful for users with varied backgrounds and skills. As we expect, there will be learning curve effects of using the system: the system introduces some new (mobile) methodologies that will require a bit of experience.

Visualization
While the interviews were performed we received good results for both text readability (avg 5,33, stdev 1,63), as well as reasonable results for the quality of the images (resolution, avg 4,28, stdev 1,38). The latter still reflects the optimized graphics for small platforms, whereas desktop system could potentially handle much higher resolution textures (which is currently not supported). Experts rated the positively to compare different kinds of representations very positively (avg 5.43, stdev 1,27).
End-users reacted very positively on the usage of 3D systems: 6 out of 7 users reported positively on 3D, and about the same percentage was positive about the inclusion of 1D and 2D data.. Simulation data and mapping was seen positively, even though users expressed they would prefer the inclusion of a legend to improve data interpretation. Also, most users found the usage of augmented reality useful (avg 5,00, stdev 1,15).

User interface
General usability of the user interface was found positive (avg 4,71, stdev 1,36) – the user interface with the underlying application logic was seen positive, and could be used quite well even after just a short introduction. Only few more specialized icons/tasks were not directly recognized. As such, the learning curve was very satisfactory, even though it is expected that user ratings will increase after more prolonged usage. With regards to multiple perspectives, most users reported positively on its usage, with a 2 users reporting very negatively, thereby lowering the score considerably (avg 4,71, stdev 2,06).

One of the more important issues is still the size of the device with the sensors. Most users expressed they would love to see the application on a smaller platform. As stated previously, the dependency on high-accuracy sensors is not always understood. It is difficult to assess of the same system with lower quality sensors would actually receive a higher acceptance by the end-users.

Comparison with previous interviews: during the open day we could see clear tendency towards 3D visualization, this was confirmed by specialists. The readability of visuals / text is dependant on the screen: whereas users in the outdoor situation reported rather low (3.50 avg), the indoor test was much better (avg 5,33) even when the increase display size (about 1,4 x diameter) needs to be taken into account.

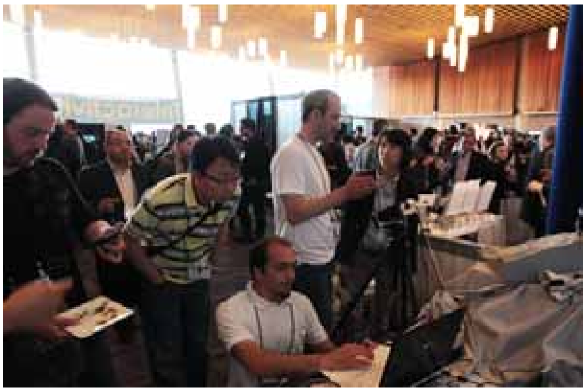
Usefulness of results
End-users confirmed the technical approaches and rated the majority of technical aspects as very satisfactory. The results should be seen in the light of comparison with desktop tools, since there are not many advanced mobile tools available for mobile GIS.

Usefulness
The interviews confirmed the updated approaches we have taken, based on user feedback. Visualization seems to be improved and is very much acceptable for most users, even though a better technical platform over time would help to increase the visual quality.

Comparison with expert workshops: results towards using more advanced visualization methods has improved over time: the advantages of 3D visualization increasingly seem to get recognized. Between the expert workshops and the latest interviews, the applications have changed quite a bit – in particular the handheld system has become much more advanced, with much more functionality: some users seem to have problems getting into the system without using it for a longer time, but most users report they expect they can use the system after some usage time. In general, the user interface techniques were seen positively on, with a generally good usability.

2.4.4 ACM CHI conference presentation and interviews

The HYDROSYS consortium presented their project outcomes at the ACM CHI conference. The ACM CHI Conference on Human Factors in Computing Systems is the premier international conference of human-computer interaction. This year, it took place in Vancouver, Canada, where it attracted around 2700 specialists in the field of human-computer interaction. CHI 2011, the ACM Conference on Human Factors in Computing Systems, is the premier international conference for the field of human-computer interaction. At the demo booth, the final mobile systems were presented. This included the handheld system showing the Dorfberg scenario using a real model of the site, the multi-view system using various pre-recorded data sets. On the other hand, the cell phone system was demonstrated with the specially designed mobile sensor, using several small water buckets at the booth. For a bit of atmosphere, the booth was decorated with alpine "gadgets", as well as a laptop hosting a slideshow, and player scenery sounds (wind, water). All together, the booth attracted a lot of attention and was a nice eye catcher at the CHI conference exhibition space.



At the booth, as well as separately, we performed several unstructured interviews with a handful of specialists, digging deeper in several concepts of the research prototypes. Discussions with these specialists (including a member of our advisory board) took up to about one hour. In general, we received very positive feedback. Specialists confirmed several key-concepts from the perspective of human-computer interaction as well as computer graphics:

- The state of the research prototypes, both from a functional as well as novel perspective, represent the state of the art in the field. It was confirmed that no functionally more complex mobile systems where known at hand, and the general approaches followed to structure the application were reflected positively on. Specialists seemed easily able to understand the general functioning of the applications.

- The multi-view system was discussed in detail with several specialists whom were truly enthusiastic about it: they confirmed its usefulness, approach, and qualified the methods used as great basis for further research / projects. A structured outline of various research questions and validation approach was discussed that could be used as basis for a future project.
- The various functional (structure/workflow) and perceptual (visualization) optimizations presented were reflected positively on. Specialists (in particular a member of the advisory board) encouraged us to further work on perceptual optimization, as interesting and useful field for further research.
- The mobile sensor was seen positively – many users, as well as the specialists, reflected positively on the simplistic two-button approach of controlling the sensor.

2.4.5 Nordic final events and expert interviews

The final prototype of the HYDROSYS system was presented and demonstrated both to the public and to end users and advisory board members. First, a HYDROSYS stand was set up [Figure 1] followed by a general presentation of the project continued with demonstrations of the HYDROSYS backbone functions: data acquisition, processing and visualization. The data acquisition demonstration consisted of reading oxygen sensors output and displaying it with the HYDRPSYS mobile client running the 3D model of Kylmäoja site. Consecutively, data processing and visualization functionality was demonstrated using both, the mobile and Augmented Reality HYDROSYS smart client. The data pipeline was tested by displaying the oxygen sensor readings in real time as well as annotating capabilities using the mobile client. The AR client was used to present the look and fell of the 3D AR environments in the context of environmental management and modeling. The public was familiarized with the sensor and simulation-modeling capabilities which were detailed to a large extent.
The attendees belonged to both, public organizations and industry and perceived the system as a practical tool for experts and common people dealing with environmental issues, and in general it was seen as a required step in the development of environmental monitoring and planning. From a couple of environmental professionals taking part of the event more detailed feedback was asked in a form of a questionnaire.

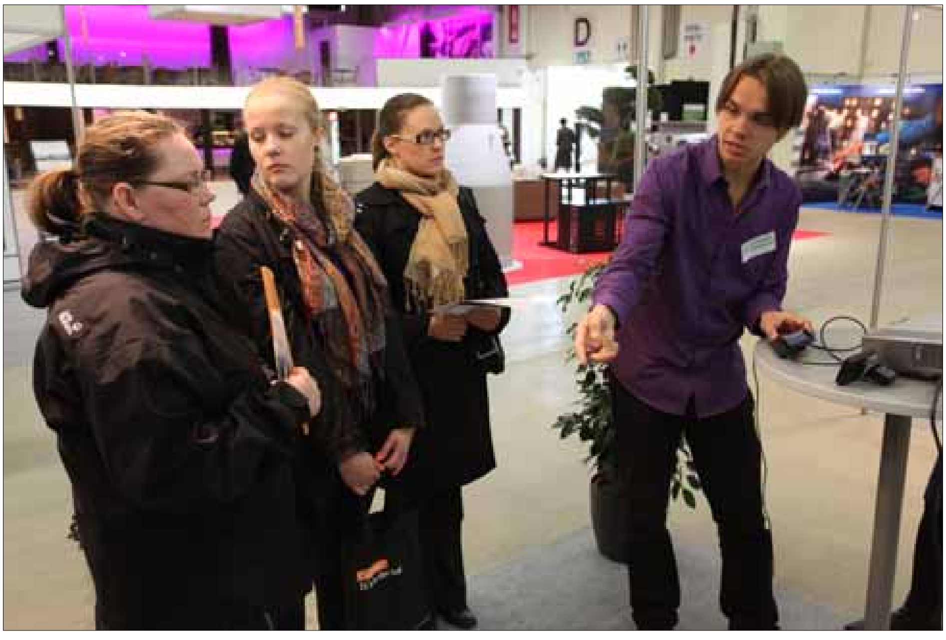


Figure 1. Demonstrating HYDROSYS to visitors of Infratech 2011 Exhibition in Turku, Finland.

The other final event for advisory board members and the designated end-users was held outdoors on 23.5.2011 at Kylmäoja site. The event was attended by five members of the advisory board and members of the HYDRSYS team. Primo, a tent was elevated in the vicinity of the Kylmäoja pond serving as shelter for the attendees and the equipment [Figure 2]. At first, the project scope was briefly discussed focusing on the environmental simulation and modeling. Once the rain stopped, the demonstration proceeded with the de facto demonstration.

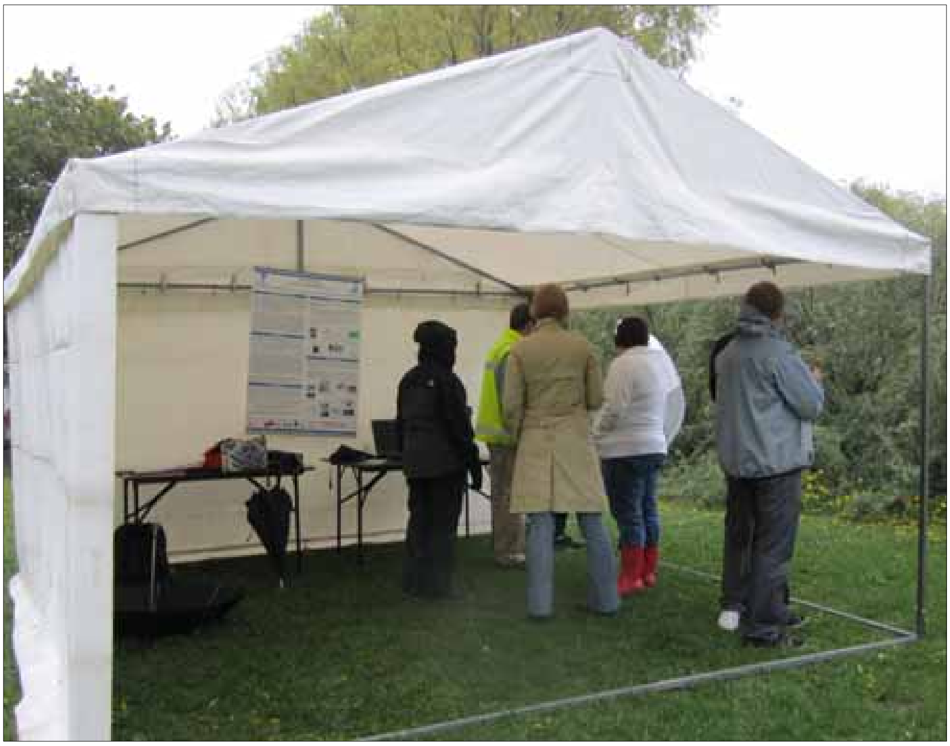


Figure 2. The tent elevated as shelter during the Kylmäoja final demonstration in Finland

The end-users were demonstrated the data pipeline and specially the visualization of the sensor information and simulation modeling. The users used the AR and mobile client to navigate in 3D simultaneously with walking around the pond and displaying the results of the simulation models [Figure 3a and b]. Both the mobile and 3D AR clients were used during the event. The clients were fed real time sensor readings and used to display the results of a hydrological simulation model. Figure 3b depicts the 3D AR client augmenting the environmental reality with information presented as water level raster layers. The simulation was executed for a 75 mm/hr rain event in a clayey area with 5 mm/hr infiltration and the results were portrayed as time series raster surfaces overlayed on top of the Digital Elevation Model. The users could inspect in the field the predictions of the model experiencing an information rich augmented reality.

Figure 3. The Final demonstration in Kylmäoja site, Finland on 23.05.2001
a) End users (watershed manager) manipulating the HYDROSYS 3D AR client

In the last part of the demonstration the participating end-users were asked to fill in the HYDROSYS questionnaires.

Expert interviews:
At both of the final events, those users that had gained sufficient overview of the system and were asked to fill out the HYDROSYS project questionnaires. A total of nine users, all experts in the field of geospatial analysis filled out the whole questionnaire regarding both general usability and expert usability of the system. Our demonstrations focused mainly on showcasing the mobile phone client and its respective features. We thus left those questions only applicable for the AR system out of the analysis. Specifically these questions cover the multi-camera functionality and the switching between different views. While the latter functionality was also present in the mobile client in one form or another, we concluded that few participants really understood how to apply the question for the mobile client.

The ten Likert-scale questions for the general usability of the system gave a fairly positive result with the seven-point Likert scale averages ranging from 4.22 (Readability of the text) to 5.83 (Match of information between real and virtual environment). The low readability of text is a credible result for using the system with the high-resolution display of the N900. Most of the interface components, especially the menus are built using a much too small fontsize. A very positive result are the high scores regarding the representativeness of the system; The three-dimensional view seems to be well-regarded for visualizing the real environment and matching information between the real and virtual environment.

Question	Average	Stdev	Min	Max
Enjoy using the system	4.89	1.17	3	7
Text readability	4.22	1.64	2	6
Image resulition / Readability	4.78	0.83	4	6
Browse data from stations	5.25	0.89	4	6
Ease of use of the system	4.89	0.78	3	6
Understand screen content	5.00	0.93	4	6
Localize sensors in real world	5.67	1.00	4	7
Match information between real world and screen	5.17	0.98	4	7
3D overlay usefulness	4.33	0.52	4	5

The expert questions on specific aspects of the system also provide a generally positive view of the system

Sensor setup/maintenance/Data pipeline:
The four Likert questions on the sensor setup, maintenance and data pipeline offered again a positive result for the system with the averages for the questions ranging from a low 4.5 (usefulness of simulation tools, stdev 0.57) to a high 5.16 (real-time information on the state of the sensor-station, stdev 1.17).

On-site monitoring:
The questions on the on-site monitoring seemed difficult for some of the users to evaluate. Only 5 users answered the questions about the usefulness of the system for the sake of on-site monitoring (not all of the subjects were hydrologists). The more hydrology-oriented users estimated that the system would be useful for improving workflows and improving understanding on environemtnal processes. Not all users however felt that the system would enable for better communicating with teams of users or between users in office and field. The averages for the four Likert-scale questions were 4.4, 5.2, 5.2, and 4.7 (questions 4,5,6,9).

Management tasks:
The management-related questions were about reporting on events in the field (q13), communicating between users with different backgrounds (q14) and usefulness of being able to make annotations (q15). The respective values are good, but not excellent: Averages 4.8, 4.7 and 4.7 respectively with a relatively high standard deviation for q15, 1.17. In practice the idea of communicating through the scene itself was seen positively, but the annotation system divided opinions.

The overall usefulness of the system gained a generally good response. 4 out of 6 users estimated that they would be ready to pay for a mobile data access service to the field. All thought that the system would provide competitive advantage in company settings and that the system would be useful for research institutes. 7 of 7 users also thought that the system would also have a positive effect on providing information for the general public. Some users did not answer these questions due to the perceived poor applicability of it for their respective fields of work. Only two subjects provided an estimate for a suitable infrastructure and service cost for the system; both 10 000 for the infrastructure, one 1000 for the service and the other 10 000+ for the service.

2.4.6 Summary

In general, the technical usability received satisfactory results. In particular considering the fact that users compare our tools to potentially very advanced desktop tools, the technical usability received very good scores. We did not perform comparative evaluations, which would be hard to perform, since desktop tools are very different from our mobile tools, and the currently available mobile GIS tools such as Arcgis) are a difficult match, function and visualization-wise.

3 Summary and analysis

3.1 Analysis

As a result of the various system usability assessments, we can report positively on the usability of the applications: we could show that the applications could be a practical tool for many end-users, even though the applications are still research prototypes. The applications are, however, not a tool for every end-user per se: not every geoscientist will find benefit in using the system, since its task domain is quite focused.
What has been a continuous issue in the evaluation of the applications is the general comparison to applications on smart phones: for the handheld platform, it is often difficult to compete with simpler but “fancier” applications. Additionally, users cannot compare to any other mobile tool, hence, do compare mostly on a functional and usability level to desktop

tools: of course, this is difficult to assess. In the future, it would be interesting to compare the tools side by side to a similar mobile GIS application – unfortunately, such a comparison is difficult to achieve at the moment, since approaches and functionality differ too much.

General usability: the general usability spanned from good to excellent. Most system concepts were very much appreciated and were well usable, though often users require more time to use the system. Currently, the systems are very well usable by expert end-users, but still research prototypes: even though the applications are powerful, it would require modifications or services to truly use the systems in long-term usage scenarios by themselves. As such, we can only make assumptions on the numerous short-term assessments we have made. Also, the handheld system seems less useful for less-specialized end-users: this is more the domain of the cell phone application. Specialists in the field of human-computer interaction acted positively on the implemented user interface methods and workflow structure.

The effects of user background: user background often has an effect on the ratings we achieved. Users that were going more often to the field generally reacted very positively to the demonstrated systems, whereas office-workers did see the applications positively, but mostly rated them good but not excellent. As such, it can be stated that the applications are very good for most (but not all) specialized users: it really depends on the users activities. In the long run, some effects (such as smaller hardware) are expected to lead to further interest by also the more skeptical users. Nonetheless, users at all levels (from field worker to governmental decision makers) have expressed that the usage of these kinds of tools are the way for the future.

Sensor setup and maintenance: using the system during sensor network setup and maintenance is generally seen very positively, in particular with respect to metadata that can be retrieved, as well as the (mentioned during monitoring) way of annotating problems when they occur. A side effect which was also noted positively is the ability to communicate with remote users, for example to be able to fix a station.

On-site monitoring: for those users that have a generally positive stance to on-site monitoring, the systems / approaches are generally seen positive on. Often, users express they would like to use the systems, though in general, some modifications would need to be made (modular software, smaller hardware). Almost all users could see some benefit of using the system.

Management tasks: using the applications for management-oriented tasks was seen with mixed perspectives. Users expressed themselves positively in using the applications in "explorative scenarios", but did not see their usage of the applications in mission-critical systems. Whereas the collaborative aspects of the applications, such as annotations, were reacted very positively on, the applications were not seen as useful in mission-critical assessments: users could not imagine using the systems in real urgencies, such as emergencies in avalanches situations or floodings. It should be clearly stated that from the start of the project on, this was also not seen as goal or priority, even though we believe that the next level of more mature applications could potentially be useful in these situations.

Data pipeline: the data pipeline was seen positively on, even though it would require a long-term assessment to really understand its full effects. Some users also are already using advanced systems, for which reason it is often difficult to assess the step forward. The sensor network system in general is used widely by now, but the full data pipeline and its effects (from sensor data to storage and simulation to usage on mobile devices) is mostly understood well by the developers, and can be understood by end-users, but would require more "real usage" over time by end-users to see its true advantages.

Visualization approach: the usage of mixed representations was seen very positively. Many users reported that using the mix of 1D, 2D and 3D representations was very useful, and comparing between them seen as advantage. Augmented Reality was seen positive on in general, but sometimes users also reported they could do without. 3D in general obtained a more positive stance upon over time, even though there are still users that do not see its advantage. Some issues in readability/visibility were noted – they improved over time due to new methods we applied, however, there are still some technical limitations in outdoor situations (see below). Specialists in the field of computer graphics confirmed the usefulness and novelty of perceptual optimization approaches.

Learning curve: in particular the handheld computer platform requires some experience: the application is quite complex and tuned more towards usage by experts. The application generally has good to excellent usability, but there are numerous functions that are seen as useful, but require some training. Most users reported they expect to either be able to learn them quickly and/or see the good potential for “leaner” applications that have just the functional set required for a particular field event.

Technical issues devices: many users still noted the form factor of the handheld system. Even though the reduction of size was reacted positively on, in general users prefer small devices to take in the field. In many cases users would not take the big setup, even though informed on the technical requirements (sensor quality) which need to be guaranteed. Within the project, this project cannot be solved, since it requires a more industrial approach to create truly small devices with high-quality sensors. A second issue that often played a dominant role is the quality of the screens. In outdoor situations, especially at bright days, most displays are hardly usable. Fortunately for both issues, we still a fast-paced industry taking up: more and better sensors are being put in smaller devices, and screens improve considerably. As such, these problems are expected to be solved over time, likely within the next few years.

3.2 Conclusion

The bottom line is, that the consortium has developed applications that are well usable by a large number of users with a geoscientist background. The concepts followed and implemented in the project have been reacted positively on, and have been a direct result of the strong end-user involvement during all the project life cycles. Even the more research oriented developments (for example experimental user interface techniques) were reacted very positively on by many users, seeing their advantages. As such, the research prototypes have been successfully developed and assessed.

Still, there is room improvement – we achieved in general scores around 5 out of 7 (7 being excellent): it is often difficult to assess the tools by experts (most user feedback this report is based on were specialists), especially since there is no real alternative technology available. It can be expected that when more tools become available, a direct comparison would be useful to really compare the qualities of the system.

One may wonder why we did not perform a direct comparison between cell phone and handheld platform. The answer is quite simple: we did not plan to have both systems operational at the same sites, which, by accident (to cover for the un-accessibility at la Fouly) happened anyway. It would have been difficult to assess (biased feedback) the quality of the systems with the limited number of users, who did not have a background with the handheld, but had been using quite frequently the cell phone.

Appendix 1 – questionnaires

General questions [end-users informed in project-related context]

Test location ◻on-site (outdoor) ◻remote participant nr:

[Sensor setup / maintenance / data pipeline]

4 Do you think the tools improve the process of gathering and processing sensor data?

No improvement Ok Big improvement

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

5 Is it useful for you to get a status (metadata) of the sensors as well as data quality indicators to react better to potential problems in the sensor network?

Not useful at all Ok Really useful

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

6 Do you think the sensor data acquisition and processing "pipeline" as developed within HYDROSYS could improve your daily work?

No improvement at all Some improvement Big improvement

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

7 In case you make use of simulations in your daily practice: can the offered simulation tools developed in the project improve your work situation?

No improvement at all Some improvement Big improvement

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

◻ cannot answer: I do not make use of provided simulation functionality

◻ I am missing some simulation tool/functionality:

[Monitoring and understanding environment processes at workplace and on-site]

8 Does the system improve the assessment of situations / events over office-only work?

Little Quite a bit A lot

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

□ I don't know (*check here if user cannot answer due to background*)

9 How well can you assess the situation (understanding of site and related environmental processes) using the tools on the mobile device?

Not well at all Quite a bit Very well

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

I don't know (*check here if user cannot answer due to background*)

10 Which parts of the system are beneficial for your daily work?

Access to almost real-time sensor data	□yes	□no
Access to near-real time simulation results	□yes	□no
Interpret sensor data in various ways (visualization formats)	□yes	□no
Ability to make annotations	□yes	□no

11 How does the system improve the work situation (*check appropriate*)

□Save time □Save resources □Improve workflows
□Improve communication between multiple parties
□Improve understanding of environmental processes
□Improve discussion of solutions
□Other:

12 How well can the presented information (graphs, simulation data) help you to understand the site, and potentially think about ways of solving problems? (example: destroyed bridge by mud flow, building new bridge)

Really bad Ok Really good

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

13 Do you believe the system improves communication between office and in-field activities?

No improvement at all Quite a bit Big improvement

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

14 Do you believe the system may change workflows positively in governmental organizations (non-research organizations such as municipalities of government itself)?
□yes □no □don't know

15 Could you imagine the system to be used only by specialists, or do you think it could have a wide field of application?
□Specialists only □Education
□General public □Other:

[Managing environmental processes: decision making and communication]

16 Do you think the tools can help you to report enough information to make plans later on, for example, to solve a problem noticed in the field?

Not helpful at all Quite a bit Very helpful

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

□ I don’t know (*check here if user cannot answer due to background*)

17 Do you think that the system can improve communication between users with varying backgrounds?

No improvement at all Some improvement Big improvement

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

18 Do you find it useful to make annotations while being in the field with mobile devices?

Not useful at all Ok Very useful

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

[Additional questions]

19 Would you pay for a service for mobile support (data access) in the field?

□yes □no

20 Does the usage of the system provide competitive advantages in company settings?

□yes □no □not able to answer

21 Is the usage of the system useful for research institutes?

□yes □no □not able to answer

22 Do you think the system could help to develop new research areas or improve current research directions? □yes □no □don't know

23 May the system have a positive effect on providing information on environmental conditions to the general public? □yes □no □don't know

24 Would your institution/company be able to afford this type of system (handhelds, mobile phones, support infrastructure) at the considered cost?

Infrastructure (select appropriate)
□5000 Euro □10000 Euro □15000+ Euro □ can’t afford □don't know

Service costs per year
□1000 Euro □5000 Euro □10000+ Euro □ can’t afford □don't know

25 Do you see a benefit of using an affordable service for generating detailed terrain models through a small zeppelin? □yes □no □don't know

How much would your institute/organization be able to pay per reconstructed medium size site (up to 10km2) (high resolution DEM)?
□2500 Euro □5000 Euro □10000 Euro □15000+ Euro □can’t afford
□cannot answer

Thank you very much for your time and interest.

□on-site (outdoor) □remote duration: participant nr:

Dear participant!

Thanks very much for taking time to answer some questions we have about the system you have just been demonstrated. With your answers, you really help us! Answering the questions take 5-10 minutes, approximately (15-20 minutes for extended questionnaire). Please make a **circle** around the number while rating, thanks very much!

26 Did you enjoy using the system?

Did not enjoy at all Ok Enjoyed a lot
1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

27 How well could you read the text on the screen?

Hard to read Ok Easy to read
1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

28 How do you rate the image quality of the information on the screen (resolution, textures, detail in both 2D and 3D) to perform the tasks at hand?

Not sufficient Ok Sufficient
1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

29 Is the user interface easy to use?

a. Browse data from sensor stations

Hard to use Ok Easy to use
1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

b. Select different visualization types (1D/2D/3D)

Hard to use Ok Easy to use
1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

c. Navigate through environment / see different perspectives

Hard to use Ok Easy to use
1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

30 How easy is it to use the system?

Difficult to use Ok Easy to use
1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

31 Did you understand what you saw on the screen?

Hard to understand Ok Easy to understand
1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

32 How easy was it to localize the sensors(stations) in the real world after viewing their location on the screen?

Difficult Ok Easy
1- - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

33 How easy was it to match the location of the information on the screen to the actual environment around you?

Difficult to use Ok Easy to use
1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

34 Where you able to understand / match the location and viewing direction of the remote camera to your own viewpoint onto the site?

Not able at all Ok Easily able
1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

35 Do you think you are able to use the system after learning / using it for about half a day?

□yes □no □ not sure

36 Suggestions:

Personal information

□ female □ male Age 10- 17 | 18-25 | 25-35 | 35-45 | 45 – 55 | 55 +

Computer usage: □ mail □ games □ office work
□ GIS systems □ GPS device

Do you use a ”smartphone”? □ yes □ no

Do you work within the geosciences area? □ yes □ no

If answered "yes", please continue with question 12

37 The system can display in different formats – are the representations useful for you?
1D (values) □yes □no
2D (plots) □yes □no
3D (3d model and/or overlay) □yes □no

38 Is it useful to be able to access and switch between the different representations (mentioned in the previous question) ?

Not useful at all Ok Very useful

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

39 Is it useful to overlay digital environmental information over video image (hence, over the environment image) ?

Not useful at all Ok Very useful

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

40 Do you be think it is useful to be able to take multiple perspectives on the site being observed, by accessing other cameras that are looking at the site?

Not useful at all Ok Very useful

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5 - - - - - - - - 6 - - - - - - - - 7

Why?

41 Which additional information would you like to access which is not available in the current system?

42 Could you imagine using a similar system in your daily work?

□yes □possibly after modification □ no

When answered “possibly”, what would need to be changed?

□software
□size of device
□other:

43 Do you have any suggestions for other components / functionality?

Appendix 2 - Davos and Lathi expert workshop, Lausanne interviews

Davos expert workshop, October 30, 2009 (9.30-15.00)

12 end-users from research, environmental organizations. Shown: slide presentation, AR device setup #2 with all sensors, initial milestone 2 research prototype, Davos question list, storyboards.

The workshop started with a 45 minute presentation of the HYDROSYS project, followed by a 30 minute presentation of the Nordic and Alpine applications. As a next step, a clear outline of the issues that were to be discussed was provided, next to a demonstration of the research prototype. Afterwards, an over 2 hours long intense discussion took place.

Questions expert

Theoretical application

- Does your idea on on-site monitoring agree with the one presented here?
- How important is on-site monitoring in general ? in your application area?
- Would the HYDROSYS-system be applicable in your application area? How would it change your methods?
- Which modules are the most interesting ones? (sensor network and setup, real-time monitoring, data organization, visualization, simulation,…)
- Which are not practical?
- Which benefits could such a system come with? (costs, time, data availability …)
- What are the limitations of the system?
- Who (else) could need HYDROSYS?
- Who could benefit from HYDROSYS? (non-users)

Practical application

- Can such a scenario (as presented before) work in practice?
- Would you take such a device to your fieldwork?
- What can you do with the device which you cannot do without it?
- What problems might arise when using the device?
- How much can such a system cost to be affordable in practice?
- What technical appointments can be assumed for possible users? (IT, technical know-how, technical support required?)
- In which time frame (years, decades, never) could the practical use of such a system be possible?

Data

- For what could the data we are gathering be used?
- What are the advantages of collecting data like this?

Improvements

- o How could the overall concept be improved?
- o What must be improved with the single modules?
- o Would it make sense to integrate more sensors? Which?
- o How should the system design be improved?

Approach and application

- The access of data in the field is found to be useful for specific tasks, but not for all. Different levels of complexity are required for different users. As such, it confirms the system as being complementary to in-office work. Tasks that were found particularly useful include:

  Decision-making support

  - o Short-term decision-making: those situations that require a quick validation of a situation before a particular action is undertaken. Example single user: check sensor data before triggering avalanche
  - o Decision-making in which multiple users with different perspectives need to discuss a situation in a short-term manner. These methods only support the decision-making, and are not aimed to be part of official warning / evacuation schemes.

  Sensor placement feedback

  - o The direct feedback on the content and usefulness of a manually placed sensor is found to be useful, since it can improve the quality of measurement. Example: direct feedback during usage of Snow-Micro-pen, saving time and avoiding returning to site to take samples again (are the measurements appropriate? Do I need more?)

- End-users may require services: currently, end-users do not necessarily make use of automated networks of sensors. Furthermore, they are not used to configure / use / maintain databases and the required handhelds. Depending on available personnel within an institution or organization, this could be handled, but, it might be needed to offer commercial or not-commercial aids.
- End-users are interested in the different price levels of a possible “product”

Visualization and simulation

- Users do not necessarily need 3D visualization for all tasks: users stated that in many situations the position of sensors and overlay of numeric data on top of a map would be enough for an initial assessment. This contradicts partially, though, with their positive feedback on simulation results access in the field, particularly for sensor placement support / manual sampling.
- Users did find 3D visualization useful for those situations in which spatial data sets are the basis for analysis. For some tasks / data visualization, 3D is not appropriate: users stated it is may just be a “gadget” for that. In particular single-point data measurements that are not further processed (like through simulation) might fall under this category.
- 3D visualization is found to be useful for those users that have difficulties reading maps.
- For some kinds of data visualization, 3D visualization is believed to make interpretation overly complex.

  → NOTE: Users in the field of environmental science have not yet great experience with 3D visualization, which is just starting up. In those areas where people use 3D visualization, it seems of great use though. As such, it can be useful to offer different visualization modes anyway, but start the application with a standard map-like representation: by clicking a button, users can then switch to 3D mode at will. It can be expected that once users get more experience with 3D visualization, it likely catches up: the Nordic expert workshop confirmed the 3D is generally believed to be the “future” of hydrology/environmental visualization.

- The ability to visualize / combine different sources of information is found to be advantageous for decision-making (e.g. overall situation/background information (e.g. geology))
- There is a concern whether simulation data might be too big to transfer
- 3D may be more interesting for hydrologists, for hidden objects / things
- Visualizing some interpolations on-site may not be always beneficial – example: temperature values are sometimes also enough as point data.

Device setup

- The device construction (handheld computer with sensors) is too big. The computer itself was positively reflected and the display size was found to be apt enough.

  → NOTE: though for demonstration/research purposes, the device setup is suitable, but for real usage a more compact version is needed. Users have high expectations due to the possibilities of miniaturization of devices, but often lack the knowledge on the technical quality (such as resolution) of such devices. It is likely that miniaturization continues and advances the sensors to a useful level: providing an industrial-strength and miniaturized device is not possible with the scope of the project, but it can be expected that this is solved by industry itself soon enough.

- The handheld setup should be made more modular: there is not always a need to take all external sensors. The user should be able to configure its own device setup.
- The usage of video overlays (AR) is found to be useful in the field, though not for all visualization purposes, and merits possible usefulness in the office. Showing sub-surface structures or different layers of “material” (soil, gras, snow) is one example where the usage of AR makes sense. When setting up sensors, a camera is not necessary. A handheld thermal camera could potentially be useful.

  → The users are used to this kind of representation and might need further experience with it during demonstrations of later prototypes. Other related fields of usage have shown that once people make use of the new methods, certain gains are recognized.

- Using the camera as “sensor” for protocol / documentation in the field is found useful.
- The possibility to extend the handheld with sensors is found to be particularly advantageous.

Controls

- The device interface should be controllable with gloves and as such buttons on display have to be big, touchscreen works quite well with gloves. It might be possible to completely remove the external joypad and just use the touchscreen. The pen can be used with a glove, though the Panasonic keyboard is useless. This concern mainly on temperatures at minus 20 degrees. Disabling the keyboard should be made available as accidental key presses are likely unavoidable.

User interaction / menu

- Users tend to have a longer learning curve with new user interfaces. There is a preference for “single button” interfaces and metaphors that are known from other handheld devices such as the Apple iphone.
- Users do not always need all the functionality that we offer: often, users are interested in a

particular set of functionality. The intended usage of profiles can customize the application to such an extend.

Lahti expert workshop, 19.11.2009 (9.00 – 16.00)

Around 40 end-users from research, government/municipalities, and companies. Participants went through workshops in groups of 3-5 people. Workshops 1 and 2 were HYDROSYS expert workshops and workshops 3 and 4 (not handled here) different hydrological issues. With each group (at least in workshop 1) first couple of minutes were used to introduce the subject of workshop and to go through the questions or subjects of discussion. Then about 10-15 minutes was given to participants to collect thoughts and to make notes for discussion. Rest of the time (~ 30minutes) was used to discuss the questions and thoughts questions had raised up. Host or hostess of the table made notes about the discussion. When everyone had been in every workshop all participants were gathered up and short summaries of discussions in each workshop were presented by hosts and hostesses for all the participants.

Environmental and user aspects of HYDROSYS-project

1. Where or in what type of situations the presented on-site monitoring system is needed or could be useful?

1. How does on-site monitoring affect work process? Does it increase or decrease the amount of work? How? What advantages does it provide?
2. What kind of limitations does the target site set for on-site monitoring? (e.g. no access to wireless network, accessibility)

2. What needs different user groups have for HYDROSYS-system and how those are directed towards different modules (sensor network and data acquisition, data storage and processing, data visualization and analysis)?

1. Which modules are the most interesting or useful ones, which are the opposite?
2. What should be monitored (sensors)? What should be modeled/simulated?

3. How could handheld visualization devices be useful in environmental research and is there need for such devices? 2D/3D visualization?

1. What kind of visualization devices are wanted? High-tech cell phone, mini notebook, …?
2. What should be visualized? How?
3. Is there need for 2D or 3D visualization? Where and in which situations those are useful?

4. Are presented scenarios (Alpine/Finland) viable and useful? Is the system or parts of it re-usable elsewhere?

1. Are presented scenarios useful in enhancing quality of environment or preventing environmental harm? (pollution, floods,…)
2. How should the system be improved in order to enhance quality of environment?
3. Can data, models or whole system be re-used by other parties or in other scenarios?

5. Does the information gained in project have societal importance and should it be utilized in education or training?

1. What can be achieved in publishing results of the project for general public?
2. Could system be utilized in education of masses, e.g. visualize pollution in waterbodies?
3. Could system be utilized e.g. in environmental training and education?
4. How should the information be marketed/distributed?

Results

Usefulness of on-site monitoring and the presented system

Many different situations where on-site monitoring could be useful were brought up during discussion e.g. monitoring hydrological processes, monitoring spreading of algae, monitoring events that are difficult to predict, … . In summary on-site monitoring is useful "almost everywhere" and it's difficult to come up with individual situations where it would be especially useful. Alpine and Nordic case studies were noted to be good and on-site monitoring could be used also in other scenarios elsewhere studying same kind of situations, e.g. transport of pollutants in streams. Also other benefits that could be achieved with on-site monitoring or presented system were brought up e.g.:

- Extra information is gained to support decision making in the field, which may lead to financial benefits
- Scenario can be produced in the field and the results of the model can be visualized, and thus the information of how the modeled situation affects the environment is readily available. E.g. effects of rain to environment can be observed even if it's not raining at the moment.
- Possible scenarios can be modeled and then with the aid of visualizations signs of realized scenarios can be searched from the field more easily.
- Usefulness in monitoring rapid changes, e.g. evaluating effects of instantaneous emissions or environmental accidents and deciding and allocating needed actions. This may also lead to large (financial) benefits.
- Understanding and visualization of the processes in environment, which benefits research, education and decision making.
- Understanding and observing something that hadn't been thought about without on-site monitoring.
- Testing sensors; whether sensor is working properly and results are sensible can be seen straight away after mounting the sensors.
- Utilization in different warning systems, e.g. flood, avalanche or landslide warnings.

Challenges and limitations of on-site monitoring

Greatest challenge for on-site monitoring is nature itself, since performing even simple continuous measurements is often very difficult. On the other hand events under research and especially extreme conditions may be problematic, e.g. avalanche or flood that destroys measuring devices.

Effects of on-site monitoring to work methods and amount of work

In general it was noted that amount of work is increased because of on-site monitoring, but the benefits gained with it may well compensate for the drawbacks of increased amount of work. Amount of work was believed to increase especially in the beginning, in testing and calibration stages, but on the other hand also maintenance increases amount of work. As before, the overall benefits are greater than the drawbacks if e.g. failure in measurement device is noticed immediately in the beginning.

Data gathering

- There must be enough data for modeling. E.g. in case of pollutant transport in surface waters all the needed parameters must be known (decay constants, dispersion coefficients, amounts of water, …); some of these are provided by sensors and others from literature but how about the rest of the parameters?
- There must be enough sensor stations in order to have truly useful data.
- Mobility of measuring system is advantage.

Needs and benefits from 2D/3D visualization and AR

Participants had different opinions about needs and benefits of visualization. On one hand data gathering and processing were seen as the most important components of HYDROSYS-system and visualization as just a "nice" add-on. On the other hand other participants saw visualization as fundamental part of the system and thought that there is a need for that. There were also different opinions about superiority of 2D vs. 3D. Some participants saw that there isn't need for 3D visualization whereas others thought it is useful. As a conclusion superiority of 2D vs. 3D visualizations is dependent on the needs of the user and the research subject. Same is true for AR as well. There were some comments about 3D-vizualization and AR where it was addressed that those are subjects that are easy to get excited about but it's unknown whether there are any real benefits. It was also considered that 3D and AR might be more interesting to people who are working with or researching those than to environmental experts.

Other opinions:

- Video image and/or 3D-model might not be useful everywhere or it might not have any added value, but usually 2D-visualization is enough.
- 3D-model is useful in the Alps where experts can draw conclusions based on it, but less important in Finland. However it might be useful in some situations in Finland also, e.g. if it makes it possible to see underground or to other "invisible" targets.
- AR is useful e.g. in field investigation, when it enables making decisions already in the field. E.g. decision could be made about road construction or observe how accumulation of sediment to one part of the stream affects to other parts.
- Need for 2D or 3D depends on user and environment. Expert might prefer using 2D, but inexpert understands 3D-visualizations more easily. When working in unfamiliar environment 3D-visualization is more useful than 2D-visualization.

Handheld device and its properties

There were two opposite views about the handheld device among participants. Majority though that best device would be common new cell phone, because it's small and thus easily portable and most importantly everyone has one with them always anyway. Disadvantages of cell phone are small size of its screen and small keyboard, which however are improving constantly. Other proposed device was common laptop, which, like cell phone, nearly every expert carries with them anyway and especially is cheap compared to independent visualization device. The current state of the demonstrated handheld device was not liked, but it was admitted that it was just a prototype: it was found to be too big. Instead of developing unique visualization device just for HYDROSYS-project it's important that the system is adaptable to the device in use, whether it is cell phone, laptop or some other device.

Expert use vs. public use

Both experts and public can benefit from the system. In public use more general information, like in warnings, is needed whereas experts need more specific information. The system could be useful in education, especially educating environmental experts and people working in the field of environment, but also in schools or in public when e.g. visualization of state of nearby water bodies is possible thus growing awareness of state of environment. Because of different needs amongst experts and public, there is need for different user profiles and possibly also differences in physical appearance of the device. Experts understand what is visualized whereas public might not. For that reason care must be taken deciding what kind of information is distributed and how it's visualized so that e.g. false conclusions or hysteria is avoided.

Economical impacts and opportunities of HYDROSYS results

Questions

Could the HYDROSYS results be productized and what would be marketing potential of the results?

- Which modules (on-site monitoring – data delivery – simulation – visualization) are most interesting on the productization point of view?
- Does the product or part of it increase competitiveness of companies?
- What would be a comfortable form of product, a mobile device or software to be downloaded to mobile phone?
- How would your organization benefit of the product?
- Why could the product not be productized, how should the system be developed?

Who would be potential service provider and customers, who would benefit of the results?

- Private companies?
- Authority?
- Consumer?

Could the HYDROSYS research prototypes create new companies or services based on benefits of the results or part of it?

- Would the product or service change working methods?

What economical benefits does the HYDROSYS results offer?

- Expenses, time, rising up new companies?

How could HYDROSYS results be utilized in activities of public authority?

- What kind of economical benefits it offers in short and long time period?

Results

“Productization”

- The project outcome (the *research system prototype)*, a mobile device that is visualizing existing environmental data together with real time monitoring and simulation data has good marketing potential on the point of view of both private companies and public authority
- Components of the project outcome are out of interests of professional users because they are already using them on everyday work
- General development of environmental data visualization is heading to 3D-visualization direction - 15 years ago it was visualized with ”excel black and with blocks”
- A software to be downloaded to cell phone is reasonable investment for general users, a new mobile device possibly too expensive
- Professional users are interested of sophisticated mobile device, but purchasing is a question of price
- Cell phone user interface is sufficient for the basic needs of professional users, they are anyway carrying it on the field – no extra load
- Competitiveness – Companies participated to the workshop thought the product doesn’t increase competitiveness, their target groups don’t need any extra services
- The result might stimulate formation of new firms once markets are ready

Markets

- Markets for the project outcome will open when hundreds of sensors are deployed to the field instead of just few sensors, and when geographical information data of visualized objects is accurate enough, for example pipeline network location.
- A standard for geographical information data of environmental information (e.g. pipeline network location) would accelerate development
- Decreasing of sensor prices will open the markets for the project outcomes, sensors are too expensive nowadays for building up a sufficient sensor network

Economical impacts

- Saving time in preparation of field trips. When all the data needed on the field is combined and visualized in the mobile device, user doesn't have to spend hours by collecting, analyzing and printing data from the scattered databases.
- Intensification of field activities. Environmental data visualized in the mobile device helps user to notice important things on the field, which would be missed without the device. Returning back to the field to check the missed information takes a lot of time.
- Navigation with the mobile device helps to achieve target areas efficiently. The track of the field trip stored to the memory of the device is important when analyzing results and planning further field activities
- Avoiding damage expenses, influenced area could be alarmed when e.g. flood risk is high according to environmental data visualized in the mobile device. Damages will be avoided or decreased when people are prepared for the risk.

Mobile device

- Screen and keypad of mobile phone is sufficient for data visualization, selecting objects and moving in the 3D-model.
- Keypad of mobile phone is too small for inputting text to the system on the field
- Simple buttons are needed in the winter conditions; on the other hand e.g. "a mouse integrated to user hand" is available.
- Large screen for professional users, laptop size is anyway too big to carry on the field.
- Mobile phone is suitable for general users
- The mobile device presented in the workshop (Alpine scenario prototype) is too big for field activities.

Usage of the results

- Annotation of environmental data to the system on the field is very interesting option
- Annotation of professional users would be very beneficial, e.g. employees of forestry and environmental inspectors who are spending most of their time on the field
- Quality control problem in annotation - Quality stamp could be attached to annotated data, general – professional user
- What should be observed with mobile device on the field, what visually of environment?
- Visualization of objects that are not visible by mobile device is interesting, e.g. underground pipeline networks
- Knowledge of environmental problem should be high when using presented system as a tool in decision making process
- Visualization is always useful
- The system doesn't change working methods with current sensor network coverage, but change might happen when sensor network thickens
- Reference: People as sensors; pollen allergic people annotate their observations to web based system, and pollen dispersal map is created based on their observations and published on a web

page

Applications

- Some additional ideas were offered for application outside those covered by the Nordic and Alpine scenarios:
- Flooding is found to be a particularly useful field of application
- Running predictive simulations in the mobile device, how large area is flooded if water level rises one meter?
- Real estate deal – visualization recreation value of coastal or lake water
- Planning tool for field measurements
- General information tool of the area, guidance assistant
- Visualization environmental data on the TV-news
- Monitoring and visualization snow properties of cross country skiing track
- Localization of damaged structures underground, e.g. leakages in the pipeline network.
- A camera in elevator for monitoring snow quality of ski slope, visualization frozen areas of the slope

July 1, 2010, HYDROSYS Meeting in Lausanne

Updates and first results were presented in a series of short talks on how the data are being used to develop improved runoff predictions as well the micrometeorological patterns that impact evaporation and antecedent soil moisture. This was a formal occasion where HYDROSYS products and their application in the case of La Fouly catchment were discussed in depth.

HYDROSYS Meeting in Lausanne (July 1, 2010) with end users on real time distributed sensor measurements and model predictions on river discharge from La Fouly, CH.

The participation of both visiting scientists and engineers from other institutions (e.g. Delft, Utah, Berkeley, Grenoble) along with colleagues from the Federal Office of the Environment and Meteo Swiss made for a dynamic interaction. The real need continues to be the identification and timing of peak river discharges and predictions in river basins not monitored as intensely. Rapid 'first-order' predictions in field visits during storm events points to the need for simple models that capture the primary responses (both snow melt and rainfall).

October 17-20, 2010, LATSIS Meeting in Lausanne

LATSIS Meeting in Lausanne (October 17-20, 2010) where experts and end users learned about real time distributed sensor measurements, measurements of stream discharge, and model predictions from La Fouly, CH.

Latsis was an international meeting of hydrologists from a wide range of institutions, including Princeton, Duke, Berkeley, Davis, Texas A&M, Purdue, Virginia, Oregon State, Cornell, and Stanford Universities from the US, as well as WSL, ETH, and EAWAG from Switzerland, Stuttgart from Germany, Wageningen from the Netherlands, Athens from Greece, and University of Western Australia. The presence of scientists from around the globe meant that HYDROSYS gained considerable exposure at this meeting. One field trip to the Alps was held and break out group meetings to study the technical side of the sensorscope technology were run. This conference has led to a number of spin-off projects and the incorporation of the sensorscope tools by other teams who attended the meeting (e.g. Princeton).