D9.4 Final dissemination and exploitation report

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Project coordinator name, title and organisation
Technische Universität Graz
Institute for Computer Graphics and Vision
Dr. Ernst Kruijff
phone: +43 316 873-5055
fax: +43 316 873-5050
mail: kruijff@icg.tugraz.at

Project website http://www.hydrosysonline.eu

Report summary

This document is the final dissemination and exploitation report of the HYDROSYS project (Advanced spatial analysis tools for on-site environmental monitoring and management, grant 224416). This report is a deliverable of Work package 9 (Dissemination and exploitation). This document reports all dissemination and exploitation actions of foreground throughout the project, including those reported in intermediate summary reports I (reports D9.2 and addendum to D9.2) and II (report D9.3); and updates the initial dissemination and exploitation plans of foreground (report D9.1 and those in Annex I). This is a public report and because of that some confidential information on business-related dissemination and exploitation carried out by partners is omitted. Confidential information about dissemination and exploitation, especially business plans are reported as a part of the confidential report D1.6.

The contents of this report describe how the consortium has represented itself, how the end-users were and are intended to be involved or focused in foreground dissemination and exploitation, and how the research results was and is intended to be promoted and exploited through several means and to several audiences. The report highlights how the consortium has dealt with and intends to deal with EU concentration efforts, standardization, and public good such as open research databases and free and open source software. The actions and intentions are organised and reported by expected outcome and by partner.

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Workpackage leader: Ari Jolma

Contributors to this report: Ari Jolma, Ernst Kruijiff, Antti Nurminen, Jaouhar Jemai, Joose Mykkänen, Thanasis Papaioannou, Thomas Grünewald, Olaf Kahler

1 Introduction

This document reports all dissemination and exploitation efforts by the consortium for the duration of the whole project, from June 1, 2008 to May 31, 2011, and future exploitation intentions of the foreground that partners now possess. It thus re-examines the information in report D9.1 and partly repeats information presented already in reports D9.2, D9.2 Addendum and D9.3.

During the time the project was going on, it was presented on several forums to diverse audiences. General publicity for the research project, its topic, and achieved results were generated by public media presence in general and in the the web. The project has disseminated valuable data, information and knowledge to policymakers, resource managers, science researchers and many other experts and decision-makers. The consortium and individual partners have collaborated widely during the project and it has obtained a considerable amount of research foreground, which it will exploit in the near future.

As one of the first steps in the project the coordinator designed a distinctive corporate identity with logos, colors, and fonts. The corporate identity has been used on the website, in presentation templates, and in other material throughout the lifetime of the project. Once the project website http://www.hydrosysonline.eu/ was set up it was regularly revised and updated. The designated project end users were specially targeted as groups at key points in the project and engaged otherwise actively during the whole project. Our thinking has been that a focused dissemination to our end users is a effective method of spread the new way of thinking and results that the project represented. Besides designated end users, the project targeted other distinct groups for example within SwissEx, and within professional and research communities in Switzerland, Finland, and globally. Several discussions and workshops were organized by project partners with prospective partners and new proposals are intended to be made.

The consortium has made many contributions to multiple high-profile free and open source software projects, made approaches to standardization organizations and processes, and participated actively in the global effort to develop an open infrastructure for interconnecting a diverse and growing array of instruments and systems for monitoring and forecasting changes in the global environment.

Several papers, conference presentations and posters were prepared and submitted successfully to international conferences, journals, and professional magazines presenting results obtained within the project. More publications are in the planning and writing phase to be submitted later.

The project organized two major expert workshops October 2009, one in Davos, Switzerland and one in Lahti, Finland. These workshops were designed and carried out to get input to the research, to demonstrate early results and plans, and to disseminate project results. During the last month of the project there are several major events and system demonstrations taking place in Switzerland, Finland, and elsewhere. All these events are a part of dissemination and they are also a way to seek for collaboration partners for future exploitation of the results. More information about expert workshops and demonstration activities can be found in the D8 series of reports. In this report the activities involving end-users, demonstrations, workshops and such are reported from the point of view of how they relate to dissemination and exploitation of the project results.

2 Dissemination

2.1 Public materials and visibility

The project corporate identity is centered on the logo of the project, which is both simple and easily recognizable, and with a strong connection to the projects contents. The logo is built up of three round, blue forms. Most observers immediately recognize a water drop in the logo, next to a human figure – this is exactly what the logo should communicate. It strikes the core of the project (water monitoring and management) and the user-centered approach the project takes into researching and developing new solutions for that. The third form, which may be interpreted as a shadow or a small patch of water on a surface, provides the logo with some depth, related to the spatial analysis characteristics of our foreseen project outcomes.

Figure. The HYDROSYS logo is at the center of the project corporate identity.

To promote the HYDROSYS project outcomes at the various public events, a range of public material including a T-shirt was created. The material describes the project, its scope and aims, the problems it has set out solve, main results, expected impacts, and other aspects. The T-shirt was used at public demonstrations at CHI 2011 and Infratech exhibition.

Early on in the project a flyer was prepared. During the last year the initial flyer was re-evaluated and exchanged for a more neutral and uniform design. A uniform poster was created, representing the various technical components and applications, as well as the mobile interface advancements. The poster functioned as eye catcher at the booth at the CHI conference. Additionally, a glossy brochure and a flyer were created. The brochure is a four-sided A4 text-oriented presentation which outlines in detail the approach, applications and field sites. The brochure is multi-lingual, written in English and German, and has been distributed to all partners. The brochures have been given out at the various public events at the end of the project (Davos celebration, ACM CHI conference booth, Turku Infratech exhibition). The flyer is a glossy short version of the brochure and presents on a single page the general outline of the project. It furthermore specifically looks into the promotion of usage: the text has been written towards end-users wanting to deploy parts of the system.

Figure. At the HYDROSYS booth at CHI 2011, Vancouver, Canada.

Figure. At the HYDROSYS booth at Infratech 2011, Turku, Finland.

Finally, simple sheets describing the overall applications are under finalization, to be placed online at the website.

Public visibility to the project and its results have been sought through several media. While the web and material distributed through the project web page can be considered the main media, also printed promotional material was prepared and distributed. Also postcards made from photos from on-site activities promoting the project efforts, pointing the public and researchers to the website and blog, was prepared.

All printed materials is also available for download from the project website.

Figure. A flyer advertising HYDROSYS and its results.

2.1.1 HYDROSYS website

The project website was designed and established in August 2008 at the URL http://www.hydrosysonline.eu to replace the interim website, which existed even before the project was officially started. The project website is the first URL, which comes up in a web search for “hydrosys”. The website was considerably revised once during the project and it has been regularly updated. The website is the main portal to information about the project for researchers and the public. The front page contains both static information about the project and dynamic, regularly changing content, such as announcements and news. Inner pages of the website are organized in two sections: research issues and resources. Research issues are described with short informative texts and illustrative pictures. Results of the project are included on the pages as they become available or are published. From the resources section visitors can download public reports, images, videos, or other materials or information.The general descriptions in the website of the work being performed within the project represent the current state. Images illuminate the content. To provide a better overview of the project activities for non-technical users, or the public, there is a frequently asked questions page. Significant outcomes of the project can be found under the respective sections. Publications have been linked wherever suitable. Public material and downloadable content are available in the download section. The corporate identity of the project is used in the covers of the reports (see figure below).

Figure. The cover design for public reports.

2.1.2 HYDROSYS blog

The HYDROSYS Blog[1] was started mid term of the project after the consortium came to the conclusion that a blog would likely offer a better possibility to involve people. The reasoning was that in a blog the main author presents a thought-out treatment of a specific subject, which people can then comment in a small discussion. In the first quarter of 2010, the blog came online and has been updated regularly with announcements, results presentations and other information. The blog has mostly replaced the news section at the website. The blog is easily found through the main website of the project.

Figure. The HYDROSYS Blog web page.

[1]http://hydrosys.blogspot.com

2.1.3 HYDROSYS elsewhere on the web

HYDROSYS is presented on webpages of all partner organisations. For example Swiss Institute for Snow and Avalanche Research describes HYDROSYS at http://www.slf.ch/ueber/organisation/schnee_permafrost/projekte/Hydrosys/index_EN, the SwissEx web pages mention HYDROSYS several times and also provide a lengthy description of HYDROSYS at page http://www.swiss-experiment.ch/index.php/HYDROSYS:Home. Aalto University (TKK) describes HYDROSYS at http://lahti.tkk.fi/en/research/hydrosys/, while EPFL university maintains a relevant link at http://lsir.epfl.ch/research/projects/hydrosys. Several associated projects' pages link to HYDROSYS pages, for example MeteoIO at http://slfsmm.indefero.net/p/meteoio/.

2.1.4 Public appearances and other public visibility

The consortium has issued press releases through university publicity offices to promote the project. Additionally, individual members of the consortium have appeared on public media and HYDROSYS has been brought up. Public media such as newspapers, magazines and TV have been approached for visibility.

The following public visibility efforts were made during the project.

- A press release was submitted to Austrian news agency at the beginning of the project.
- The Austrian Research Promotion Agency (FFG, the national funding institution for applied industrial research in Austria) prepared a SuccessStory information sheet on the HYDROSYS project and actively distributed it via its communication channels.
- A general overview of the project was published in a special issue of one of the largest Austrian newspapers “Der Standard” (Forschungserfolge - Der Jahresbericht der Österreichischen Forschungsförderungsgesellschaft 08. Der Standard, March 25 2009).
- Antti Nurminen from Aalto appeared in a Finnish newspaper (Turun Sanomat Extra 22.5.2010) with an article ”3D maps will revolutionize map reading”.
- Antti Nurminen from Aalto appeared in a Finnish professional magazine (Tekniikan Akateemiset 1/2010) with an article ”A researcher stuffed the world into a mobile phone”.
- Marc Parlange of EPFL was interviewed for SwissCom's Dialogue Magazine.
- EPFL put up a poster along the tour du Mont Blanc together with Commune de Orsiere describing the experiment they have at the location.
- K. Aberer's (EPFL LSIR) paper 'Made for measure', was published in Public Service Review: Science and Technology 4, August 2009
- Article in the weekly Styrian free newspaper (Die Woche, Wednesday April 14, 2011) presented TU Graz technology for hydrological monitoring, including explanation for general public.
- TUG Research article, January 2011 issue, distributed to external partners of university, as well as university members presented HYDROSYS.
- Article on HYDROSYS appeared in a special issue in one of the largest Austrian newspapers 'Der Standard' (Forschungserfolge - Der Jahresbericht der Österreichischen Forschungsförderungsgesellschaft 08. Der Standard, March 25

2009). Contents: presentation of project to the general public.

- HYDROSYS was presented in a separate section of an article in “Davoser Zeitung” March 22, 2011, which described research at WSL.
- HYDROSYS outcome was presented in Inside Positions (article “Precise location of environmental data” by Jaouhar Jemai (Ubisense) in issue 2010), an annual professional magazine for real time locating systems.

2.2 Focused dissemination

Focused dissemination involved presenting the project and its results to a knowledgeable audience. The project run two specific expert workshops in October 2009 and several final events in 2011, mostly in association with larger conferences or fairs. In these events the project and its outcomes were promoted as whole. Additionally, the project was presented as a whole in a number of other conferences and events. These are listed in a separate subsection. Finally, the project outcomes have been disseminated to the designated end-users.

The project and its specific results were disseminated to designated end-users in numerous field trips including small workshops or demonstrations throughout the project. These events are described in more detail in demonstration report D8.5.

Researchers from WSL had regular meetings with their end-users in Gemsstock and Dorfberg scenarios. Also excursions to the sites were organized. During the PERMOS excursion 11.10.2010 at the Gemstock HYDROSYS was promoted to 25 permafrost experts. In the Gemsstock scenario discussions concerned among other things how to provide the best set up for the inclination measurements. In the Dorfberg scenario discussions concerned among other things field observation, sensor placement, discussion on handheld setup e.g. implementation of sensors. The inclination measurement system was demonstrated directly on site. General information about the site and about the ongoing permafrost research was presented and described including terrestrial laser scanning of rock face and permafrost boreholes. Also, the benchmarks in the building were shown and problems associated with buildings in permafrost was discussed in general. The inclination measurements were demonstrated in a life demo.

Researchers from TKK and Luode met and had field trips with their end-users in Ridalinpuro and Kylmäoja scenarios several times. The Finnish scenarios consisted of intensive measurement campaigns, during which sensor placement and other issues are discussed. In the Finnish scenario targeted group of end users and advisory board members were involved into the planning process of the field campaigns that run in the fall of 2009 and in the spring of 2010. The sensor placements were based on knowledge of local hydrological and water quality conditions in the Kylmäoja catchment. Hydrological and water quality data was available from Luode GSN node and was also delivered to end users via the Luode data service web page during the campaigns.

2.2.1 Expert workshops

In October 2009 one whole-day expert workshop was held in Davos, Switzerland and one in Lahti, Finland. The expert workshops focused on detailed discussions of the HYDROSYS system and its goals with end-users and other experts. Dissemination and exploitation was only one of the goals of the workshops as they also were used to get feedback on initial designs.

The results of the expert workshops have been reported in detail in report D8.1. Report D8.2 contains detailed analysis of the demonstrations given in the workshops.

The expert workshop held at the WSL/SLF in Davos, Switzerland, at October 30th, 2009 focused on applicability of the HYDROSYS system and its components in practical field work.

First the consortium presented the HYDROSYS project, the HYDROSYS system and its components, and the applications. The main focus was given to the applications which are in the Alpine Scenarios and the Dorfberg scenario respectively. Then an intensive discussion was carried out with the aim to collect the experts' input and feedback. Both theoretical and practical applicability the HYDROSYS system were covered in the discussion with a focus on how the system and its modules might be improved.

A total number of 12 experts, both practitioners and researchers attended at the workshop in Davos.

There were four presentations in the Lahti workshop: (i) introduction to HYDROSYS, (ii) Swiss scenarios in HYDROSYS, (iii) current state-of-the-art of online measurements in Finland, and (iv) Finnish scenarios in HYDROSYS. Structured discussions were organized in four groups, each chaired by a person, who had either been working for HYDROSYS or was otherwise an expert in the topic. Each chairperson had prepared for his or her work before the workshop. All participants of the workshop participated in each group in a mixed order.

The topics of the structured workgroups were: (i) users and use cases of the HYDROSYS system, (ii) the product concept of the HYDROSYS system, (iii) sharing of environmental observations and other data, and (iv) hydrological onsite measurements. A topic was first presented to the participants in a short introduction, which was followed by a brief brain-storming session, the third part of the 45 minute session was spent analysing the ideas that had come out in the brain-storming.

The Lahti workshop had 30 participants and it targeted professionals, researchers, and persons representing potential partners in exploitation (i.e. companies).

Figure. The Davos workshop (left) and Lahti workshop (right).

2.2.2 SLF 75 years anniversary event

The project and its results were promoted and presented to public interested in mountain hydrology and snow at the occasion of WSL/SLF 75th anniversary in Davos, March 20, 2011. The event was organized by WSL/SLF as a large scientific outdoor happening, and it consisted of contributions from the different research groups operating at WSL/SLF.

HYDROSYS had a stand of its own where the project was demonstrated to interested public. The event was open to public from 9 till 16.00 and the organisation committee estimated that a total number of 1500 people and several media were present in the event during the day.

The HYDROSYS stand consisted of posters describing HYDROSYS and Swissex in detail including the aims, results and state of the projects. During the day, TUG and WSL researchers demonstrated the handheld prototype to interested people. The demonstration location had a free line of sight to the Dorfberg field site and thus an adapted version of the Dorfberg scenario could be demonstrated. Additionally, two new sensorscope stations had been set up directly at the location of the event. The blimp was also demonstrated and flown above the site. Data captured by the blimp was transmitted to ground and displayed on a large screen.

In order to gather direct feedback, interested people were asked to fill in questionnaires. HYDROSYS promotional material was available on the booth and it was distributed.

The event got press coverage in “Davoser Zeitung” March 22, 2011. HYDROSYS was presented in a separate section of the article.

The focus of this event was to present the HYDROSYS results to the general public and specialists in the field, highlighting the actual applications, the sensor network, new sensors (the blimp) and the mobile applications, all as an integrated platform.

Figure. The SLF 75 years event.

2.2.3 ACM CHI 2011 booth

The project and its research results were promoted and presented to participants of CHI 2011 in Vancouver May 7-12, 2011. HYDROSYS had a separate booth at the conference.

CHI 2011, the ACM Conference on Human Factors in Computing Systems, is the premier international conference for the field of human-computer interaction. Taking place at the prestitious Vancouver Convention Centre, the conference was visited by about 2700 specialists. The final mobile systems were demonstrated at the HYDROSYS booth. 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. Also 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.

The focus of this event was to present the advancements of the mobile interface technologies within the frame the general project scope (integrated technology, applications). Attendants were predominantly human-computer interface specialists.

Figure. The HYDROSYS booth at CHI 2011.

2.2.4 Infratech 2011 exhibition

The project and its results were promoted and presented to a large professional audience in Infratech 2011 in Turku, Finland May 18-20, 2011. HYDROSYS had a separate booth at the exhibition.

Infratech is the largest seminar and exhibition for infrastructure and environmental industries in Finland. Infratech is a yearly event attended by several thousand professionals and interested public. The organizers expected approximately seven thousand visitors to the event this year.

The HYDROSYS booth, presentations and organisation are still being planned as of this writing. Plans include similar presentations as in CHI 2011, including real-time measurements and demonstrations of the data pipeline. HYDROSYS posters, publicity materials (also Finnish translations) and dia shows are planned. The booth will be attended by researchers and staff from Aalto, Luode, and possibly Graz. The project advisory board members were invited to the exhibition.

The focus of this event is to present the potential and advancements in information systems for environmental management. The project outcomes and the consortium will be promoted for future collaboration and exploitation. Attendants will be specialists in environmental management including decision makers and field workers.

Figure. The HYDROSYS booth at Infratech 2011.

2.2.5 Final Kylmäoja demonstration

An outdoor event demonstrating the final system was organized on site of the Kylmäoja catchment (Tikkurila, Vantaa, Finland) May 23, 2011 Luode deployed sensors for the event, and the data pipeline was demonstrated. The event demonstrated the capabilities of the developed cell phone application. The event is described in more detail in D8.5.

The focus of this event is to present the HYDROSYS results to the general public and specialists in the field, highlighting the actual applications, the sensor network, and the mobile applications, all as an integrated platform.

Figure. Demonstration at the Kylmäoja catchment May 23, 2011.

2.2.6 Other focused dissemination

During the project several focused dissemination events besides the expert workshops and the final dissemination events took place. In these activities the project, its aims, results and consortium, have been promoted as a whole. These are listed below.

- The project was presented at Europe's biggest Information and Communication Technology event, ICT 2008 in Lyon. Several discussions with visitors to the conference took place. 25-27 November, 2008.
- The project was presented at the eEnvironment 2009 conference in Prague. Several discussions with visitors to the conference took place. 25-27 March, 2009.
- The project and its collaboration with the SwissEx was presented in EPFL Research Day, Category Science and Technology. 30 April, 2009.
- Luode presented the project and how automatic water sensor stations are used in it during a one day training workshop aimed at water and environmental professionals in Kuopio, Finland. 27 May, 2009.
- The project was presented by a poster at the 4th GEO European Projects Workshop in Athens, Greece. 29-30 April, 2010.
- The project was presented by an oral presentation at the OpenWater Symposium in UNESCO-IHE in Delft, Netherlands. 18-19 April, 2011.
- In addition, specific research results of the project have been presented in numerous conferences. These are listed in publications section below.
- GSN and related technologies as they are developed and used in the HYDROSYS project have been disseminated in several focused events. These are reported in more detail in report D8.2.
- EPFL IC Research Day 2009

- COGEAR project meeting, by EPFL LSIR members 2009
- Permasense project,seminar series, University of Zurich, by EPFL LSIR members 2009
- EPFL IC Welcome day 2009
- MICS Site Visit, by EPFL LSIR members 2009
- International Snow Science Workshop (ISSW) 2009
- “Engineer Shape our Future Event”, EPFL 2009
- EPFL Visit of Swiss German and Italian High School students 2009
- NCCR MICS Site Visit, by EPFL LSIR members 2010
- EDIC Open House 2010, by EPFL LSIR members
- EDIC Open House 2011, by EPFL LSIR members

These dissemination events have promoted vision, innovation, research, social impact, and results of HYDROSYS to various focused groups.

2.3 Publications

2.3.1 Accepted peer-reviewed papers

N. Bonvin, T. G. Papaioannou, and K. Aberer. Cost-efficient and Differentiated Data Availability Guarantees in Data Clouds. In International Conference on Data Engineering (ICDE2010), Long Beach, CA, March 2010. Presented at ICDE 2010 by T. G. Papaioannou.

N. Bonvin, T. G. Papaioannou, and K. Aberer. A self-organized, fault-tolerant and scalable replication scheme for cloud storage. In Proc. of the ACM Symposium on Cloud Computing 2010 (SoCC 2010), Indianapolis, IN, June 2010. Presented at SoCC 2010 by T. G. Papaioannou.

N. Bonvin, T. G. Papaioannou, and K. Aberer. An economic approach for scalable and highly-available distributed applications. In Proc. of the 3rd IEEE International Conference on Cloud Computing, Miami, FL, July 2010. Presented at CLOUD 2010 by N. Bonvin.

N. Bonvin, T. G. Papaioannou, and K. Aberer. Autonomic SLA-driven Provisioning for Cloud Applications. In 11th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid), 2011.

Dawes N., Lehning M., Aberer K., Parlange M., Bavay M., Berne M.: Swiss Experiment: Providing diverse snow research data sets when and where they are required; Proc. International Snow Science Workshop (ISSW 09 Europe), Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland, September 2009.

Ferencik, I., Niemi, T. and Jolma, A. 2010. On site environmental modeling and monitoring: the Nordic Scenario in HYDROSYS project. In Proceedings of iEMSs 2010 International Congress on Environmental Modelling and Software. Ottawa, Canada.

Froechlich, P., Baldauf, M., Oulasvirta, A. and Nurminen, A. On the move and wired to the world. Communications of the ACM. (in press)

Jeung H., Sarni S., Paparrizos I., Sathe S., Aberer K., Dawes N., Papaioannou T. G., Lehning M.: Effective Metadata Management in Federated Sensor Networks; SUTC, Newport

Beach, CA, March 2010. Presented at SUTC 2010 by H. Jeung.

Jurca O., Michel S., Herrmann A., Aberer K.: Processing Publish/Subscribe Queries over Distributed Data Streams; In proceedings of the 3rd ACM International Conference on Distributed Event-Based Systems, 2009

Kenner, R., Phillips, M., Danioth, C., Denier, C., Thee, P., Zgraggen, A. Investigation of rock and ice loss in a recently deglaciated mountain rock wall using terrestrial laser scanning: Gemsstock, Swiss Alps. Cold Regions Science and Technology. In press

Kruijff, E., Mendez, E., Veas, E., Gruenewald, T., Simoni, S., Luyet, V., Salminen, O., Nurminen, A., Lehtinen, V. HYDROSYS: on-site monitoring and management of environmental processes using handheld devices. To appear in: Anand, S., Ware, M., Jackson, M., Vairavamoorthy, E. GeoHydroinformatics: Integrating GIS and Water Engineering. CRC Press.

Kruijff, E. Swan II, E. Jr., Feiner, S. Perceptual Issues for Augmented Reality Revisited. Accepted for publication at the The IEEE International Symposium on Mixed and Augmented Reality 2010, Seoul, South-Korea, 2010.

Kuonen, P., Bavay, M., Lehning, M., 2010. POP-C++ and Alpine3D: petition for a new HPC approach. In: Asimakopoulou, E. and Bessis, N.: Advanced ICTs for Disaster Management and Threat Detection: Collaborative and Distributed Frameworks. DOI: 10.4018/978-1-61520-987-3

Mendez, E., Feiner, S., Schmalstieg, D. Focus and Context in Mixed Reality by Modulating First Order Salient Features. In Proceedings of the ACM International Symposium on Smart Graphics, 2010.

Mendez, E., Schmalstieg, D., Feiner, S. Experiences on Attention Direction through Manipulation of Salient Features. In Proceedings of the IEEE Virtual Reality Workshop on Perceptual Illusions in Virtual Environments (IEEE VR 2010), 2010.

Erick Mendez, “On the use of Context for Augmented Reality Visualization”. PHD, TU Graz, 2011.

Mitterer, C., Hirashima, H. and Schweizer, J., 2010. Wet-snow instabilities: Comparison of measured and modelled liquid water content and snow stratigraphy. Annals of Glaciology. In press

Mott, R., Schirmer, M., Bavey, M., Grünewald, T., and Lehning, M. 2010. Understanding snow-transport processes shaping the mountain snow-cover, The Cryopshere, 4, 545-559.

Mott, R. and Lehning, M. 2010: Meteorological modelling of very high resolution wind fields and snow deposition for mountains, J. Hydromet., 11, p934-949. doi:10.1175/2010JHM1216.1.

Niemi, T. 2010. Development of a hydraulic model and its application to a small urban stream . Master's thesis. Aalto University.

Nurminen, A. 2009. Mobile 3D City Maps, Doctoral Dissertation. Helsinki University of Technology

Nurminen, A., Kruijff, E., Veas, E. HYDROSYS - A mixed reality platform for on-site visualization of environmental data. To appear in Proceedings of the 10th International Symposium on Web and Wireless Geographical Information Systems, Springer Lecture Notes in Computer Science, 2011.

T.G. Papaioannou, M. Riahi, and K. Aberer. Towards Online Multi-Model Approximation of Time Series. In MDM 2011 - 12th International Conference on Mobile Data Management, 2011.

T.G. Papaioannou, S. Sarni, K. Aberer, S. Simoni, M. Parlange, M. Bavay, and M. Lehning. Automated Model-driven Simulation and Visualization of Field Sensor Data. In European Geosciences Union General Assembly 2011, Earth & Space Science Informatics, 2011.

Partala, T, Nurminen, A. and Vainio, T. 2010. Salience of visual cues in 3D city maps. British HCI 2010. (in press)

S. Sathe, H. Jeung, K. Aberer. Creating Probabilistic Databases from Imprecise Time-Series Data. ICDE, 2011.

Simoni, S., Assessing of the impact of spatial heterogeneity on natural hazards for an Alpine watershed, Newsletter of the Mountain Research Initiative, no. 4, May 2010

Veas, E., Kruijff, E., Mendez, E. HYDROSYS - first approaches towards on-site monitoring and management with handhelds. eEnvironment 2009, Prague, 2009.

Veas, E., Mulloni, A., Kruijff, E., Regenbrecht, H., Schmalstieg, D. Techniques for View Transition in Multi-Camera Outdoor Environments. In Proceedings of Graphics Interface 2010 (GI2010), 2010.

Veas, E., Kruijff, E. Handheld Devices for Mobile Augmented Reality. In Proceedings of the 9th ACM International Conference on Mobile and Ubiquitous Multimedia (MUM2010), 2010.

Veas Eduardo, Mendez Erick, Steven K. Feiner, Schmalstieg Dieter. Directing Attention and Influencing Memory with Visual Saliency Modulation. In Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI2011)

Wu J., Zhou Y., Aberer K., and Tan L.: Towards Integrated and Efficient Scientific Sensor Data Processing: A Database Approach; In proceedings of the 12th International Conference on Extending Database Technology, 2009

Zhou Y., Salehi A., Aberer K.: Scalable Delivery of Stream Query Result; In proceedings of the 35th International Conference on Very Large Data Bases (VLDB), July 2009.

2.3.2 Submitted papers and papers in preparation

Ferencik, I. Terrain modeling with LiDAR data for environmental hydraulics applications. Manuscript.

Ferencik, I. A distributed modeling system for peri-urban water environment. Manuscript.

Jeung H., Sarni S., Arion A., Sathe S., Aberer K., Beutel J. A Model-Based Data Cleaning System for Sensor Data. Submitted to VLDB 2010.

H. Jeung, S. Sarni, I. Paparrizos, S. Sathe, K. Aberer. An End-to-End System for Cleaning Sensor Data: Model-Based Approaches. Submitted to Information Systems journal, Elsevier, 2011.

Lehtinen, V., Nurminen, A., Egocentric and Exocentric interactions for mobile mixed reality information portals. Submitted to the 10th IEEE International Symposium on Mixed and Augmented Reality 2011, Basel, Switzerland, 2011.

Moll, V. Intensive measurement campaigns in a small suburban catchment in South Finland.

Manuscript.

Sathe S., Jeung H., Aberer K. Creating Probabilistic Databases from Imprecise Time Series. Submitted to VLDB 2010.

Simoni S, S Padoan, DF Nadeau, M Diebold, A Porporato, G Barrenetxea, F Inglrest, M Vetterli and MB Parlange, Hydrologic Response of an Alpine Watershed: Application of a Meteorological Wireless Sensor Network, submitted to Water Resources Research.

Veas,E., Kruijff, E., Grasset, R., Schmalstieg. Mobile interfaces for environmental sensor networks. Publication under submission.

WSL researchers are preparing a paper about MeteoIO.

PhD thesis Eduardo Veas, expected end of 2011.

2.3.3 Conference abstracts, presentations and posters

Aberer K.: Infrastructures for a smart earth; ASUT Seminar at SWISS TELECOMMUNICATION SUMMIT, Bern, June 2009

Aberer K.: Swiss Experiment - From Wireless Sensor Networks to Sensor Data Management; Invited Talk at DMSN Workshop, July 2009.

Mathias Bavay, Thomas Egger, Laurent Winkler. 2010. MeteoIO: A Meteorological Data Pre-Processing Library for Numerical Models. Presentation at the European Geophysical Union General Assembly, May 2nd to May 7th 2010, Vienna, Austria.

Juliette Blanchet and Michael Lehning. 2010. Spatial models for climate extremes. Application to extreme snow depth in the Swiss Alps. Presentation at the European Geophysical Union General Assembly, May 2nd to May 7th 2010, Vienna, Austria.

Megan Daniels, Eric Pardyjak, Wilfried Brutsaert, Daniel Nadeau, Susana Fernandez-Vidal, Gillermo Barrenetxea, and Marc Parlange, Observed effects of soil moisture on surface fluxes and slope winds in an alpine valley, Abstract 8531, presented at 2011 General Meeting, EGU, Vienna, Austria, 4-8 April

Dawes, N., Lehning M., Aberer K., Parlange M., Bavay M., Berne M., 2009: Swiss Experiment: Providing diverse snow research data sets when and where they are required. . Poster presented at the International Snow Science Workshop 27 September to 2 October 2009, Davos, Switzerland.

Feick, S., Brunner, S., Mitterer, C. and Jürg Schweizer, J., 2011. Automated detection and analysis of gliding snow. Poster presented at the European Geoscience Unition General Assembly 2011, April 3-8. Vieanna, Austria.

Fernandez, S, Simoni, S, Rinaldo, A, Daniels, M H, and Parlange, M B (2010), Spatially distributed hydrologic response in a small catchment in the Swiss Alps, Abstract H11G-0895 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Van De Giesen, N, Baerenbold, F, Nadeau, D F, Pardyjak, E, and Parlange, M B (2010), Distributed landsurface skin temperature sensing in Swiss Alps, Abstract H11A-0790 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Grünewald, T., Kruijff, E., Dawes, N., Lehning, M. et al. 2009. HYDROSYS: in-area feedback development on top of SwissEx technology. Poster presented at the International Snow Science Workshop 27 September to 2 October 2009, Davos, Switzerland.

Grünewald, T., Mendez E., Roos, U., Danioth, C. and Phillips, M. 2011. Monitoring infrastructure stability in alpine permafrost. Presentation at the European Geoscience Union General Assembly, April, 3rd to 8th 2011, Vienna, Austria.

Higgins, C W, Mimouni, T, Nadeau, D F, Pardyjak, E, and Parlange, M B (2010), The Effect of Energy Flux Partitioning on the Atmospheric Boundary Layer Height, Abstract H21J-03 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

A. Jolma, A. Nurminen, I. Ferencik, V. Lehtinen, M. Kamalov, E. Kruijff, E. Mendez, E. Veas, M. Parlange, S. Simoni, S. F. Vidal, T. Papaioannou, M. Bavay, N. Dawes, T. Drummond, E. Rosten, O. Kaehler, J. Mykkänen, J. Jemai . HYDROSYS: spatial analysis tools for on-site environmental monitoring and management. Poster presented at the 4th GEO European Projects Workshop, 29-30 April 2010, Athens, Greece.

A. Jolma, A. Nurminen, I. Ferencik, V. Lehtinen, M. Kamalov, E. Kruijff, E. Mendez, E. Veas, M. Parlange, S. Simoni, S. F. Vidal, T. Papaioannou, M. Bavay, N. Dawes, T. Drummond, E. Rosten, O. Kaehler, J. Mykkänen, J. Jemai . HYDROSYS: On-site monitoring and management of water environment. Extended abstract. OpenWater symposium. 19 April, 2011. UNESCO-IHE, Delft, Netherlands. pp. 57-58. http://hikm.ihe.nl/openwater_eg/index.php/openwater

Mitterer, C.; Mott, R.; Schweizer, J., 2009: Observations and analysis of two large wet-snow avalanche cycles. Presentation at the International Snow Science Workshop 27 September to 2 October 2009, Davos, Switzerland.

Mitterer, C., Hirashima, H. and Schweizer, J., 2010. Wet-snow instabilities: Comparison of measured and modelled liquid water content and snow stratigraphy. Presentation given at the International Symposium on Snow, Ice and Humanity in a changing Climate, 21-25 June 2010, Sapporo, Japan.

Mitterer, C., Heilig, A., Schmid, L., Schweizer, J., Eisen, O. 2011. Measuring wet-snow properties with ground-penetrating radar Technology. Presentation at the European Geoscience Union General Assembly, April, 3rd to 8th 2011, Vienna, Austria.

Mitterer, C.; Mott, R.; Schweizer, J., 2009: Observations and analysis of two large wet-snow avalanche cycles. Presentation at the International Snow Science Workshop 27 September to 2 October 2009, Davos, Switzerland - In: Schweizer, J. and Van Herwijen, A. (Eds): Proceedings of the ISSW Europe 2009. http://www.issw.ch/proceedings/ISSW09_Proceedings.pdf

Mott, R., Grünewald, T., Schirmer, M., Wirz, V. and Lehning, M. 2010. Understanding snow deposition on mountain slopes Presentation at the European Geophysical Union General Assembly, Mai, 2nd to Mai 7th 2010, Vienna, Austria.

Mott, R., Schirmer, M., Bavey, M., and Lehning, M., 2010: Understanding small scale variability of the mountain snow cover. Presentation given at the International Symposium on Snow, Ice and Humanity in a changing Climate, 21-25 June 2010, Sapporo, Japan.

Mott, R., Bavay, M. and Lehning, M. 2011. Typical errors when calculating snow ablation in mountains. Presentation at the European Geoscience Union General Assembly, April, 3rd to 8th 2011, Vienna, Austria.

Tero Niemi. 2010. Modelling the hydraulics of a small suburban stream. Presentation in a conference ”Kansallinen mallinnusseminaari”. 8.2.2010. Helsinki, Finland.

Antti Nurminen. 2009. Maps in Mobile Services. Presentation at the Cartographic Society of Finland (SKS) and ProGIS Autumn Seminar 29.9.2009, Helsinki.

Antti Nurminen. 2009. Mobile 3D Maps. Keynote at SIGGRAPH Finland Autumn Event "Syysgraph 2009", 27.10.2009.

T.G. Papaioannou, S. Sarni, K. Aberer, S. Simoni, M. Parlange, M. Bavay, and M. Lehning. Automated Model-driven Simulation and Visualization of Field Sensor Data. In *European Geosciences Union General Assembly 2011, Earth & Space Science Informatics, 2011*.

Reiweger, I., Mitterer, C. and Schweizer, J. 2011. 2-D modelling of water flow in snow. . Presentation at the European Geoscience Union General Assembly, April, 3rd to 8th 2011, Vienna, Austria.

Michael Schirmer and Michael Lehning. Snow Surface Scaling and Roughness in Mountains. Presentation at the European Geophysical Union General Assembly, May 2nd to May 7th 2010, Vienna, Austria.

Silvia Simoni, Simone Padoan, Amilcare Porporato, Martin Vetterli, Guillermo Barrenetxea, and Marc Brendan Parlange, Sensitivity of streamflow components to spatial variability of meteoreological forcing in high alpine watershed: application of a wireless sensor network, Abstract 4577, presented at 2011 General Meeting, EGU, Vienna, Austria, 4-8 April

Simoni, S., Egger, .T. and Bavay, M. the HYDROSYS toolchain GSN-MeteoIO-GEOtop. 2009. A presentation in joint EPFL TUG meeting.

Eduardo Veas. 2010. Techniques for Exploring Multi-camera Setups. Winter Augmented Reality Meeting (WARM’10). Graz, Austria.

Veas, E., Kruijff, E., Mendez, E. HYDROSYS - first approaches towards on-site monitoring and management with handhelds. eEnvironment 2009, Prague, 2009.

3 Collaboration

3.1 *Contribution to standards*

Work on possible extensions to formats such as X3D, CityGML, and COLLADA and programming interfaces such as WPS and OpenMI based on project results is going on in the consortium. X3D is an ISO standard format for representing 3D computer graphics and a successor to the virtual reality modelling language (VRML). CityGML is a common information model for representation of 3D urban objects. CityGML is based on GML, which is a grammar for expressing geographical features. GML and CityGML are Open Geospatial Consortium, Inc (OGC, a not-for-profit technology consortium) standards. COLLADA is a data interchange file format for interactive 3D applications. COLLADA is an activity of a not-for-profit technology consortium Khronos Group. WPS is an OGC standard for describing geospatial computations implemented as web processing services in the Internet. OpenMI is a standard defined by the OpenMI Association that defines an interface for simulation model components to exchange data at run-time.

The work related to the data formats in the consortium focuses on data compression, conversion, and final delivery of 3D data. The work related to the programming interfaces focuses on HYDROSYS system architecture for simulation models.

Ari Jolma from TKK was selected into one of the two seats reserved for International Environmental Modelling & Software Society (iEMSs) in OGC. He is involved in the iEMSs – OGC joint process hoped to develop standards for geospatial environmental data interoperability with environmental simulation models. An example and very early outcome of this process was a one day workshop in the iEMSs 2010 International Conference in Ottawa, Canada. The experience gained in the HYDROSYS project will be exploited in the process.

A REST interface was defined for GSN[2] for getting the data in standard GML format. Also, REST interfaces have been developed for fetching the data from GSN. The model-view-controller (MVC) architectural pattern has been employed for the implementation of the GSN access control framework.

3.2 *Contribution to open source software and data sharing*

The project consortium contributes to free and open source software projects and efforts to share environmental data in the Internet. Specific actions carried out in the project in the its second year include the following.

- GSN (Global Sensor Network), a widely used free and open source sensor network software, is used in the project extensively. With the help of the project a new stable version of GSN has been released including comprehensive documentation. The new version contains many new features.
    - GSN Scriptlet processing class: This Processor (processing class) executes a scriptlet upon reception of a newStreamElement and can be used to implement arbitrary complex processing by specifying the script directly in the virtual sensor description file. This way of implementing processing classes offer a higer level of flexibility. As the script is defined in the Virtual Sensor description file, the implementation can be quickly and easily modified with no need to edit, compile Java code nor to restart GSN. Typical applications:

[2] http://localhost:22001/gsn?REQUEST=901&name=VirtualSensorName?

flexible notifications (email, twitter), data transformations.

- Scheduled bridge: This processing class stores the data and periodically publish an aggregated version of it.
- GSN web service interfaces: A web service interface for GSN which provide all the query features (aggregation, limits, criteria) available for getting the data through the servlets. Moreover, it provides paginated results in a push-based mode.
- GML web call: for outputting data following GML standard
- Alpine3DWebService: for fetching data from meteo IO
- Web method (/geodata): for spatial queries
- New GSN Wrappers have beed written for
- Sensorscope wrapper: connects to sensorcope stations
- Image wrapper: fetches images from local/remote file systems
- Sparql wrapper: queries metadata in Swiss-Experiment wiki
- JDBC wrapper: to synchronize DB tables between different GSN instances
- Grid wrapper: allows to load grid data (e.g. ESRI maps)
- New Virtual sensors include
- Clocked Bridge Virtual sensor: for caching data with slow databases (e.g. IMIS deployement)
- Dataclean virtual sensor: uses parametric and non-parametric models to clean data
- GSN Sensorscope virtual sensors now allowing renaming of fields, support null values and varying rates of sensor measurements
- Monitoring tool for watching GSN deployments, updates of virtual sensors, generating alerts has been developed
- GSN Access control infrastructure. Authentication is allowed by means of username/password and authorization is provided for read/write access to virtual sensors. Confidentiality is provided by means of SSL/TLS.
- GSN-Wiki integration. This will allow joining of metadata location information of stationary sensor stations with real-time or archived measurement from these sensors. As a result, spatial queries on sensor measurements from existing stationary stations will be possible.
- The project collaborates with the SwissEx project. The SwissEx home page is hosted on open source Wiki platform MediaWiki. The project has developed several MediaWiki templates for for example metadata management, real-time data processing, project management, and blogging. These templates are available as open source.

- Consortium researchers have participated in the development of MeteoIO: a free and open source meteorological data access and data preprocessing library. In addition, the MeteoIO documentation has improved significantly. MeteoIO home page is at http://slfsmm.indefero.net/p/meteoio

- Updates to the Studierstube software framework have been performed. There is now also a version optimized for ultra-mobile PC. Studierstube is OpenSource.
- Other free and open source projects HYDROSYS researchers have been contributing to include GEOtop (http://www.geotop.org), JGRASS (http://www.jgrass.org).
- The website Climaps (http://sensorscope.epfl.ch/climaps/) publishes the HYDROSYS data collected by EPFL.

3.3 Cooperation with other projects

3.3.1 Cooperation with the Swiss Experiment

HYDROSYS cooperates closely with the SwissEx initiative, by actively exchanging research results. HYDROSYS made use of the GSN base infrastructure, extending GSN with some specific components for on-site monitoring. HYDROSYS also profits from the sensor developments being made under the SwissEx initiative.

Swiss Experiment made significant progress over the course of the project and is now seeing rapid uptake as new advanced tools are implemented. Systems supporting the acquisition and storage of metadata, streaming data and manually sampled data are rapidly converging to a fully integrated and highly searchable database, where data can be reliably reused based on the stored metadata. Automated data cleaning structures and algorithms, automated correction algorithms and new, standardised storage methods are the next steps on the verge of public implementation which will provide significant advantages to the users. The following components directly or indirectly affect HYDROSYS.

Synchronisation of GSN and the wiki: Within Swiss Experiment, the wiki-based metadata system has been expanded and improved. Work is currently underway to acquire and link manually sampled data to the metadata in the same method as the streaming data, so that to the user, the system is seamless. Combined with a new GSN SPARQL wrapper, GSN now has the capability to exchange metadata information with the wiki-based metadata database, forming the underlying structure for upcoming automated data quality assessments and data cleaning.

Integration of GSN functionality into the wiki: This will allow joining of metadata location information about stationary sensor stations with real-time or archived measurements from these sensors. The result will be a searchable database of sensor deployments, from where the data is directly accessible, either through web-based tools or plugins to 3rd party software. The integration of GSN and the wiki is also making collaborative tool building possible. GSN configuration tools are one such development, which will decrease the complexity of acquiring data through GSN.

Integration of GSN functionality into 3rd party tools: Plugins and data access methods for several 3rd party scientific tools are available over the SwissEx wiki. These tools allow the user to access data directly from their chosen analysis tools.

GSN developments: The distribution version of GSN now also contains a number of new tools, e.g. email warnings based on data parameters (e.g. sensor not updating) as well as integration of the R and Matlab programming languages for efficient re-use of existing processing algorithms written by scientific researchers, a wrapper for gridded, spatially aware data as well as the tools to query it, a new image wrapper and a comprehensive user authentication system. Other tools relating to data cleaning, data quality assessment and standardisation have been in development for a while and should see public use soon. A

GSN developers conference is held annually.

GSN integration with Microsoft SensorMap: The joint project between EPFL and Microsoft research to achieve GSN integration with Microsoft SensorMap was completed. These capabilities are still available, though are being rapidly overtaken by those of the rest of Swiss Experiment.

Data: Data from 170 IMIS/ENET stations as well as data from approx. 400 experimental stations are now implemented in GSN at WSL/SLF and this number is increasing daily. New implementations of GSN at other institutions are increasing this number further. These experimental stations include the La Fouly and Dorfberg fieldsites. A new server is planned this year, which will also support the acquisition of many other data sources from La Fouly.

Documentation: Significant effort is now going into documentation of the tools available in SwissEx as well as easing user implementation and data access.

Sensor Technology: SensorScope have now formed a spin-off company, SensorScope Sàrl, to manufacture their 2nd generation stations and the project-team are working to develop their 3rd generation stations. These stations will include the results of a significant amount of research into power saving and data compression. SwissEx have procured stations to a value of approx 160,000CHF, which have been used in La Fouly and Dorfberg experiments. Work is well underway on other sensors and sensor network technologies which may eventually be of use within HYDROSYS: wind sensors, water quality sensors, radars, disdrometers. A demonstration of the wifi link developed under HYDROSYS has been in operation for 2 years, retrieving data from Wannengrat and Jakobshorn, Davos back to WSL/SLF, Davos.

The future of the Swiss Experiment Platform

SwissEx is rapidly gaining support from many institutions across Switzerland. The current project will continue until September 2012. An application for an extension to the project will be made in August 2011. This extension will most likely focus on the continuation of the data platform, its extension to advanced statistical and analytical tools and its use within public outreach.

The collaborative potential of SwissEx has been realised in many experiments, both within the SwissEx core team and outside. Once more advanced tools show how the infrastructure can provide additional value to the non-collaborative user, its popularity will increase. The data integration workload is already significant, so SwissEx personnel are now working to provide the tools, documentation and education, that this may become a truly self-sustaining collaborative platform.

3.3.2 Cooperation with the MeteoIO project

Parts of the development of the input-output management platform MeteoIO have been developed within the project. The MeteoIO data preprocessing library has received the attention of a number of other projects, namely GIN (a Swiss cantons hydrological flood warning project), Sensorscope, Crocus (Meteo France snow pack model) as well as a canton Valais hydrological project (preliminary contacts). The MeteoIO library has been integrated into GEOtop and Alpine 3D software packages.

3.3.3 Other cooperation

Other cooperation activities carried out in the project include the following.

- In 2009, TUG performed talks with the University of South Australia (UNISA). The Southern Australian Government is currently supporting research efforts in the direction of water management. UNISA approached one of the largest water suppliers in the area, to set up a possible test site for the deployment of the HYDROSYS infrastructure. Unfortunately, due to deployment restrictions, UNISA decided not to apply for a grant at this moment.
- TUG has continuously been looking for possibilities to cooperate with HITLab New Zealand, one of the largest laboratories in the world working in the field of Augmented Reality, and NIWA, the National Institute of Water & Atmospheric Research in New Zealand. The major aim would be to use the HYDROSYS project results in a small case-study in New Zealand. The work has been successful to that extend that in Summer 2011 the system will be demonstrated in New Zealand; probably a new application will be created, tailored to local needs. One of the members of advisory board, Ross Woods, is a member of NIWA.
- TUG looked into cooperation with INRIA/Iparla from Bordeaux on navigation on small devices. The group has great experience in navigation interfaces – till now, the intentions have not yet led to cooperation, since the appropriate forum (funding) was not available.
- TUG performed some talks with researchers met at eEnvironment 2009 and eEnvironment 2010. As a follow up, the consortium joined the ENVIP initiative[3]. The initiative focuses on Environmental Information Infrastructures and Platforms. It forms a communication platform between a range of European projects focusing on similar topics.
- TUG discussed the availability of environmental data with ZAMG Austria (Zentralanstalt für Meteorologie und Geodynamik), a large academically oriented institute. Unfortunately, the kind of data ZAMG could provide is at a low resolution (1KM grid interpolation) and as such of only limited value for the consortium.
- TUG has been looking into a possible cooperation with German Research Center for Artificial Intelligence (DFKI), on issues regarding user interfaces and robotics. It is likely that after the project's end, new cooperation will be set up.
- During the whole project duration, various discussions have taken place with University College London, which focused at various continuations of work performed within the HYDROSYS project:
    - Perceptual modulation of augmented content: currently intended as part of several student projects at UCL, it is intended to explore potential project possibilities
    - Combining robotics, sensor networks and augmented reality for search and rescue situations. A European project proposal was submitted.
- TKK cooperated with another project and the "reality experiment" tests were done in collaboration with another (unrelated) project called THESEUS (by sharing the software platform being developed in HYDROSYS. The tests addressed higher level

[3] http://52north.org/envip

perceptual factors that were of interest to both projects. Website: http://www.jyu.fi/erillis/agoracenter/tutkimus/acprojektit/katsy/engtheseus

- TKK has been engaged in discussions with the Lahti region research platform and Helsinki University about possibilities in exploiting the HYDROSYS outcomes
- EPFL organized a meeting with South-African scientists and managers in November 2009. The topic was the state-of-the-art technology within the context of measuring and monitoring natural hazards. The feasibility of a joint project between Switzerland and South Africa was discussed. HYDROSYS was presented at the meeting and discussed as a basis for cooperation.
- The researchers at WSL attended a demonstration and discussion event at MAVinci, a private company which provides aerial photography services from remotely controlled, small airplanes. (Micro Aerial Vehicles). They provide very good flight control and good flying altitude but are limited in terms of preload and spatial accuracy.
- The cooperation with advisory board member Steve Feiner (Columbia University) was extended and has resulted in several submitted and accepted publications on saliency and perceptual optimization of graphics.
- To strengthen the work on perceptual optimization, further advise was sought from J. Edward Swan II (is an Associate Professor of Computer Science and Engineering, and an Adjunct Associate Professor of Psychology, at Mississippi State University), a specialist in perceptual issues for augmented reality. The cooperation has resulted in the submission of a cooperative publication (Kruijff, Swan, Feiner from TUG)
- The cooperation with Simon Julier has been extended to discuss and strengthen the work on multi-camera navigation, following up the review 1 comment. Actions are undertaken for a EU project proposal focusing on robotics + multi-camera navigation.
- TUG, together with the other partners (WSL, EPFL and TKK), evaluated the work of Dr. Werner Mueller and found it of limited applicability to HYDROSYS specifically. At current, though, the comments for providing access to “quick” simulations is taken very seriously, being undertaken as part of the sensitivity map work performed between TUG and WSL. In the final year of the project, we included the METEOIO libabry in the handheld software, thereby being able to run ad hoc simulations (interpolations) on the handheld itself.

4 Exploitation

“Exploitation” refers to the use of the outcomes of the project. Those exploiting the outcomes of HYDROSYS are, by default the consortium and its members, but also almost anybody else provided that they have the proper right to the outcome intellectual property to do so. Publication of scientific articles is a common form of exploitation for academic partners as it is of immediate value to them. SMEs look for seeds of exploitable products and services in the outcomes. Project outcomes can also be exploited in collaboration or discussions preceeding collaboration because they improve one's situation in them. Publications and collaborations during the project have been described above. This chapter discusses and describes exploitation avenues and intentions looking forward.

An outcome is typically exploited in progressive steps beginning at internal use and proceeding to publishing, using it as a basis for collaboration, and finally in some cases delivering it to an external organization or company for further development and use. Internal uses include using the product for further research; using it to increase the in-house knowledge and capacity, to develop a new service to the market; and using it as educational material, or as a part of an academic dissertation. Using results in collaboration and in other interaction with external institutions is always based on its internal use.

HYDROSYS has produced several outcomes, most of which are either knowledge or things built using knowledge: software or combined software—hardware prototypes. The main outcome is the research system prototype that has been developed alongside actual measurement campaigns. The knowledge and things developed are related to the main theme of the project, which is “geospatial analysis tools for on-site environmental monitoring and management”, a subtheme of the programme theme “collaborative systems for environmental management”. Knowledge, i.e., research products, in physical form is either documentation or manuscripts describing the prototypes and their design, their use, results and experience obtained with their use, or methods and experience that have been developed and gained within the project.

The consortium has thus far exploited the project outcomes in

- **environmental field work***:* making, transmitting, processing, and displaying the data
- **collection of environmental data sets**: generating multifaceted intensive data sets
- **student education***:* both doctoral level education and on field trips for other
- **increasing in-house knowledge and capacity***:* consortium members have increased both in depth and in breadth knowledge
- **conference presentations**: results have been presented at geophysical, environmental, and various computer science related conferences
- **collaborative work with designated end-users**: carried out in joint workshops, field trips and problem solving
- **scientific papers***:* The final outcomes are intended to be exploited in addition to above mentioned in
- **continuing internal research and development***:* some key research assets, for example software libraries, have been and will be improved
- **broader collaboration**: the project outcomes provide cornerstones for new collaboration

- **development of new sellable services and products***:* several ideas are presented below by SMEs in project
- **further development of expertise in the area**: some open questions remain, but the problems have been structured in the project

The consortium intends to explicitly seek and in some cases propose new initiatives and platforms that would exploit and develop further the existing research system prototype. Preliminary talks with parties linked to such initiatives have already been reported as dissemination activities.

Scientific results are published in the form of papers and, increasingly, as free and open source software (FOSS) implementations. All of the consortium members have intentions to publish software either directly as results of the research or as products developed on the basis of increased in-house knowledge and capacity. These intentions include new components to GSN, other FOSS, and also closed source software for licensing or inclusion into other sellable products. The SMEs have more explicit intentions towards obtaining patents by publishing inventions made in the project, but universities have such intentions too.

The intent of the project consortium as whole is to deliver results obtained within the project directly to external institutions. The consortium has had several direct contacts with end users in meetings, workshops and demonstrations to this end.

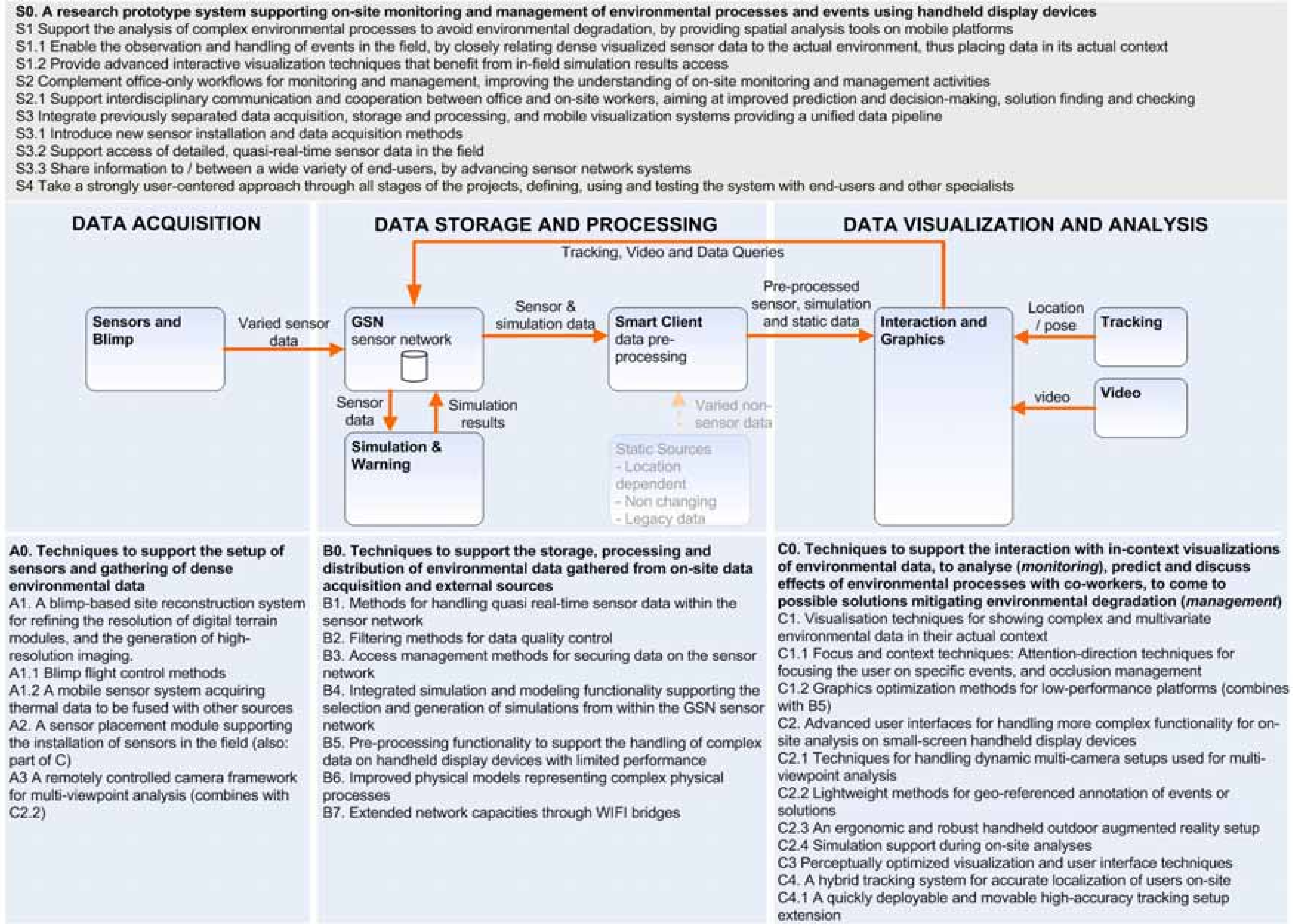

Figure. The outcomes of the project.

4.1 Exploitation by outcome

HYDROSYS resulted in several main outcomes, which can often be further divided into sub-outcomes. Below exploitation avenues and intentions are described by outcome.

S0 A research system prototype supporting on-site monitoring and management of environmental processes using handheld display devices

There are several main directions for the exploitation of the research system prototype outcome. These are

- Organizational end users,
- A comprehensive tool for collaborative environmental monitoring and management,
- Environmental information service improvement and new services,
- Use in field research and associated education,
- Research for environmental processes.

The consortium has promoted the research system for potential organizational end users broadly. Specific efforts will continue among the hydrological institutions in Austria, Switzerland and Finland, extending the previous contacts to for example the ZAMG (Austrian weather service) and Finnish Environment Institute, and worldwide, for example New Zealand, in cooperation with HITLab / University of Canterbury and NIWA. This outcome is also more widely applicable, the scope of multiple methods can be of high interest to the wider geosciences domain (such as more technical construction-technical applications), as well as other survey applications that make use of large sensor networks (from search and rescue missions to “humane” security systems).

On-site monitoring and management encompasses several activities related to prediction and decision-making in the field. Users can analyse environmental processes, and make predictions of its effects based on both simulation results shown by the system and the knowledge acquired by seeing the quasi real-time sensor data in its actual context. Hereby, a very useful outcome is the testing of on-site modelling in practical use: HYDROSYS aims to provide the possibility of both triggering simulations from the field using real-time data input and visualizing the simulation results on-site.

Based on the acquired knowledge, interdisciplinary teams of users can cooperatively discuss their interpretation of the processes, and possibly come up with solutions or plans that may limit environmental degradation. Assumptions and possible mitigation plans may be checked by visiting the site in regular time intervals. Hereby, the system complements office work, by allowing interplay between activities in the office and in the field.

The premise of the system consists of a common platform that integrates data acquisition from static and mobile sensors in the field, data storage and processing of the sensor data, and the final data visualization and analysis functionality provided at the mobile devices, being either handheld computers or cell phones. The two display platforms represent both a functionally more straightforward approach, but therefore more mobile approach using the cellphones, and a more functionally encompassing and complex approach using the handheld computers. The platforms are tuned to the varying end-users needs regarding functionality / tasks in the field.

The system binds different data sources and can share the data among many users. The system as envisioned in this project does not exist to this extent: at current, the most advanced mobile systems used for on-site work predominantly make use of non- contextual visualizations of static data and very limited functionality that hardly supports effective decision-making.

The research system prototype can be developed further into a comprehensive service for supporting environmental planning, management and decision making. Theres is potential in exploiting the outcome in a future sellable system that combines and visualises all data that is needed for example to support decision making in urban planning. Such a system could also be used by the company in commercial educational material and workshops.

This outcome has the potential to be integrated in commerical environmental information services increasing their data processing and visualization capabilities. Implementing the mobile 3D-client running in the mobile phone user interface requires a potential customer having a need to distribute visualized environmental data to large group of users. Potential customer could be for example a municipality willing to distribute water quality information to citizen swimming in the sea areas that are threaten by toxic blue green algae blooms. The service could also be offered in co-operation by companies and partners providing software functions (city, environmental institute, mobile phone operator). Further development is anyway needed to create 2D/3D-model and software to visualize monitored sea water data in the mobile client. Potential impact of the system showing sea water quality in real time is happier citizen and decrease in number of people exposed to toxic algae blooms.

University partners involved with environmental research will exploit the prototype in-house in education, especially on field trips. In that context, a handheld device can be use as a tool to show how the environment can be managed. Moreover, using cells phone, it can be possible during a field trip to add a lot of new data and annotation or in an easy way to integrate new manual observations, which may localize potential pollution and other inputs to a river, risks in an alpine catchment, etc. The communication capability of the system can also be used in field work to exchange data, images or such.

The research system prototype enables end-users to analyse environmental processes and their effects in their actual context, by providing interactive visualizations of quasi real-time sensor data shown at mobile display devices. A dense information space is built up: the system binds sensor data and the actual environment in a unified manner, thus creating the actual context for the data. The methods, the spatial analysis tools, allow end-users to analyse in particular those processes and events that cause environmental degradation. Till date, many of the processes are not well understood because of the complexity involved. The system is expected to aid in better understanding these processes. Of particular advantage is system mobility and usage of multiple cameras dispersed at the observed site: users can analyse the data from multiple perspectives, getting a better understanding of the outlined problem area.

The system is not only interesting for the end-users in mind in this project – there are multiple system innovations that are certainly applicable in other fields of research too. The majority of the system will be made open source and as such can also be accessed by researchers from related fields like computer graphics, human-computer interaction, database systems and robotics.

This outcome is further elaborated in project publications:

Nurminen, A., Kruijff, E., Veas, E. HYDROSYS - A mixed reality platform for on-site visualization of environmental data. To appear in Proceedings of the 10th International Symposium on Web and Wireless Geographical Information Systems, Springer Lecture Notes in Computer Science, 2011.

Veas,E., Kruijff, E., Grasset, R., Schmalstieg. Mobile interfaces for environmental sensor networks. Publication under submission.

Veas, E., Kruijff, E., Mendez, E. HYDROSYS - first approaches towards on-site monitoring and management with handhelds. eEnvironment 2009, Prague, 2009.

S1 Support for analysis of complex environmental processes to mitigating environmental degredation by spatial analysis tools on mobile platforms

The consortium will continue to disseminate information about their on-going work, results and papers analysing the perceived value of the HYDROSYS system and on-site modelling and management.

The research prototype will be exploited in- house in education, especially on field trips. In that context, a handheld device can be use as a tool to show how the environment can be managed. Moreover, using cells phone, it can be possible during a field trip to add a lot of new data and annotation or in an easy way to integrate new manual observations, which may localize potential pollution and other inputs to a river, risks in an alpine catchment, etc. The communication capability of the system can also be used in field work to exchange data, images or such

This outcome is further elaborated in project publications, including:

Nurminen, A., Kruijff, E., Veas, E. HYDROSYS - A mixed reality platform for on-site visualization of environmental data. To appear in Proceedings of the 10th International Symposium on Web and Wireless Geographical Information Systems, Springer Lecture Notes in Computer Science, 2011.

Kruijff, E., Mendez, E., Veas, E., Gruenewald, T., Simoni, S., Luyet, V., Salminen, O., Nurminen, A., Lehtinen, V. 2010. HYDROSYS: on-site monitoring and management of environmental processes using handheld devices. To appear in: Anand, S., Ware, M., Jackson, M., Vairavamoorthy, E. GeoHydroinformatics: Integrating GIS and Water Engineering. CRC Press.

S1.1 Techniques for observing and handling events on the field by closely relating dense visualized sensor data with the actual environment thus placing data in its context

The mobile platform developed within Hydrosys enables referencing sensor data with their place of origin (sensor station). This can be a big advantage for an end-user when entering a previously (for the end-user) unknown site which is already equipped with sensors. This can help the user to identify the data and sensors which are available and help to improve the site-management.

This outcome was exploited during the project will be exploited in-house in association with the use of the research system prototype.

S1.2 Advanced interactive visualization techniques that may exploit on-site access to simulation results

Accessing simulation results is currently part of the office work flow. The mobile platform developed in Hydrosys enables to access simulation data while being on site and to very quickly visualize them. This is an advantage especially in extended field campaigns (which last for several days) where model results can provide additional information and help to decide how to plan/perform further action.

This outcome was exploited during the project will be exploited in-house in association with the use of the research system prototype.

S2 Office-only workflows complemented for monitoring and management, improving the understanding of on-site monitoring and management activities

On-site monitoring and modelling of environmental processes is a central and novel feature of the HYDROSYS project. Complementing environmental management workflows, whose associated information processing is traditionally strongly office-only, with on-site data and information requires education of end-users. Consortium members plan to present vision, ideas and results of the project in several venues.

This outcome is further elaborated in project publications, for example:

Antti Nurminen. 2009. Maps in Mobile Services. Presentation at the Cartographic Society of Finland (SKS) and ProGIS Autumn Seminar 29.9.2009, Helsinki.

Antti Nurminen. 2009. Mobile 3D Maps. Keynote at SIGGRAPH Finland Autumn Event "Syysgraph 2009", 27.10.2009.

S2.1 Support for interdisciplinary communication and cooperation between office and on-site workers, aiming at improved prediction and decision-making, and solution finding and checking

Direct communication between office and on-site workers is an important requirement in many environmental applications, especially when the specialist (e.g. engineer) is not able to be directly on-site. Currently the communication is problematic and usually addressed via telephone calls. An example could be the failure of a meteorological station: the problem is very difficult to solve from the office. The end-user (who is not an expert in electronics) goes to the site and builds up a connection (skype, video) with the electronics expert in the office. Such the point of view of the user on-site is transferred to the expert and the expert can easily guide the person on-site in order to solve the problem. Similar applications on a simple tool (e.g. on a smartphone) could have large potential for future station and sensor setup and maintenance.

This outcome was exploited during the project will be exploited in-house in association with the use of the research system prototype.

S3 An integrated and unified data pipeline for data acquisition, storage and processing, and mobile visualization

The premise of the system consists of a common platform that integrates data acquisition from static and mobile sensors in the field, data storage and processing of the sensor data, and the final data visualization and analysis functionality provided at the mobile devices. The platforms are tuned to the varying end-users needs regarding functionality / tasks in the field. The usability and results obtained using the data, processing, and visualization pipeline are planned to be reported.

This outcome is elaborated in many publications of the project, for example:

Mathias Bavay, Thomas Egger, Laurent Winkler. 2010. MeteoIO: A Meteorological Data Pre-Processing Library for Numerical Models. Presentation at the European Geophysical Union General Assembly, May 2nd to May 7th 2010, Vienna, Austria.

Aberer K.: Swiss Experiment - From Wireless Sensor Networks to Sensor Data Management; Invited Talk at DMSN Workshop, July 2009.

S3.1 Introduction of new sensor network installations and data acquisition methods

This outcome is dealt with detail in the A series of outcomes.

S3.2 Support for accessing detailed, quasi real-time sensor data in field

This outcome is dealt with detail in the B and C series of outcomes.

S3.3 Information shared with and between a wide variety of end-users advancing sensor network based systems

This outcome is dealt with detail in the C series of outcomes.

S4 A strongly user-centered approach to specifying, developing, using, and testing a system with end-users and other specialists

This outcome has described in report D2.2 and it was already exploited during the project when working with end-users (see reports D8.*). The improved methodology will be exploited in-house in future projects and in scientific publications.

A0 Techniques to support the setup of sensors and gathering of dense environmental data

Next to the usage of existing sensor technologies, the project introduces and develops ways to set sensors up, and several new kinds of sensor data acquisition methods.

To analyse environmental processes on-site in a meaningful way, it is required to have dense and recent data sets available. Accurate data is often not available, being timely outdated or in low spatial resolution, hence, new data acquisition or refinement (update) is generally required. Next to the usage of existing sensor technologies, the project has introduced and developed ways to set sensors up, and several new kinds of sensor data acquisition methods. The usage of an unmanned aerial vehicle in updating and refining existing digital terrain models (DTMs), and to capture both normal and thermal images, was introduced. Additionally, sensor placement aids were provided that aid in setting up sensor networks quicker and easier, especially in remote sites.

This outcome is further elaborated in project publication:

Jeung H., Sarni S., Paparrizos I., Sathe S., Aberer K., Dawes N., Papaioannou T. G., Lehning M.: Effective Metadata Management in Federated Sensor Networks; SUTC, Newport Beach, CA, March 2010. Presented at SUTC 2010 by H. Jeung.

A1 A blimp-based site reconstruction system for refining the resolution of digital terrain modules, and the generation of high-resolution imaging

This outcome can be exploited to improve the data acquisition capacity of a monitoring service product. Such a system can complement or replace current methodology in surface water quality mapping based on mobile onboard measurements and interpolation. The blimp based monitoring system can increase the density of observations using the onboard thermal and optical cameras and lead to economical benefits when mapping large surface water areas.

A system was created which uses the aerial imagery gathered by the blimp to refine and improve the resolution of digital terrain models. A higher resolution model of a site improves the accuracy of simulations produced. The user will also benefit from recent high resolution imagery of the site and some visualizations require textured 3D models to overlay sensor data. The blimp system can deliver both the high resolution digital terrain models and the required aerial imagery. A visual reconstruction of a scene is typically done using Bundle Adjustment or SLAM algorithms. The HYDROSYS system uses these and take advantage of the further information provided by the low resolution digital terrain model (DTM) available and the other sensors on board the blimp. Producing a visual reconstruction requires an estimate of the camera position when each image is captured. The localisation system developed for the blimp (A1.1) produces such an estimate using all the available sensors on board. Furthermore a blimp is able to provide overhead footage during campaigns, which is useful to get a good overview of the problem area.

Refining a coarse Digital Elevation Model (DEM in the followings) and delivering a DEM (DTM) with a higher resolution is extremely relevant for 3-dimensional numerical modelling, where the topography of the study area is the basis for all the computation; in fact equations describing physical processes are discretized over a 3-dimensional grid and solved iteratively. The values obtained by solving the equations are associated with a grid cell, therefore, the finer the grid resolution the more accurate and smother the process mimic. Scientists who study natural process dynamics and technicians from municipalities need to locate hazardous areas on municipal lands, will strongly benefit from the improved DEM resolution. First, being able to investigate small scale phenomena with higher accuracy, and second being more precise in taking actions when needed. On the other hand, high resolution DEM can slow down analysis due to the large amount of data that needs to be transmitted and elaborated. This aspect has been accounted for and tackled using fully automatic, state-of-the-art model selection techniques available in this field. This allows to generate irregular grids representing the surface with higher detail, where required, and lower detail, where no data is available. Once produced, high resolution DEM can be useful for several other applications, including engineering designs, water resource management, leisure activities, such as hiking, skiing and mountaineering. The new algorithms developed for the aerial visual reconstruction are also of interest in the computer vision and robotics communities.

A1.1 Blimp flight control methods

In relation to A1, a control system is needed to allow a blimp to perform its tasks of producing a high resolution DEM and gathering real-time thermal imagery: hence, a system is needed to control the actual movement of the blimp in the field. The HYDROSYS system uses the sensors available on board the blimp to track its position within the environment. Several possible modes are possible for this control system. The most direct one allows the user to manually control the blimp. Other possible modes will allow the user to specify a region of interest that the blimp can direct its cameras to focus on or the blimp can be sent on a sensor sweep to autonomously gather the data needed to produce a visual reconstruction of an area of the test site. When using the blimp, the user will need to take into account the weather conditions. In strong winds, the blimp could be lost if the control algorithm is unable to maintain a high enough speed into the wind. In such a situation, it is advisable not to launch the blimp– in emergency situations though, the blimp can be flown since it holds some safety mechanisms that will land the blimp when needed.

Apart from their key use in controlling the blimp In this project, the navigation algorithms developed will be of interest to the robotics community.

The blimp developed for the project provides a perfect platform for developing new aerial vision techniques and will greatly increase the capabilities of the group in this respect. It also provides an opportunity for collaboration with the Marshall Aerospace company. This collaboration will be pursued to develop more sophisticated capabilities for the blimp system.

A1.2 A mobile sensor system acquiring thermal data to be fused with other sources

The blimp payload includes a thermal camera. Thermal data from this camera is recorded and made available to the user on the ground. Since the system knows the position of the blimp and has a 3D model of the terrain, it is possible to register the thermal data onto the 3D model to observe live temperature measurements for locations of the site currently being monitored. These temperature readings can also be recorded and fused (validated) with other data to provide measurements for simulations of the site

New computer vision algorithms were developed for using the thermal imagery. These provide useful information for the 3D reconstruction process or the blimp localisation since the thermal camera can observe features which are not visible to the optical camera. Since thermal imagery has very rarely been used in the field of computer vision, and this is a challenging task. However, the results for visual reconstruction and blimp localisation are sufficient even if the thermal imagery is not used. Also, the registration of the thermal imagery onto the terrain model will be accomplished even if the thermal camera images are not used in the reconstruction process.

The dense thermal imagery obtained from the aerial vehicle will provide far richer thermal measurements across a site than was previously available using discrete ground sensors, improving interpretation of thermal data and potentially providing input for actual simulation (which requires pre-processing). In addition, any new vision algorithms developed for the thermal camera are of interest to the computer vision community.

Algorithms form an important part of this outcome. This is a part of knowledge UCam will exploit in further work.

Results of work during the project has been disseminated in the following paper.

Olaf Kahler, Neill Campbell, Ed Moore, Ed Rosten. Direct Recovery of Adaptive Dense Meshes from Image Intensities. Britis Machine Vision Conference. 2011. Submitted.

A2 A sensor placement module supporting the installation of sensors in the field

The interfaces for sensor placement can potentially safe time when sensors are installed at more remote locations, since its functioning can be checked immediately.

In order to get dense information from sites under observation, it is often required to set up larger sets of sensors or sensor stations. Depending on the site at hand, this can become a more tedious task. Some sites are not very well accessible or at remote locations, and previously defined sensor placement positions (based on data available in the office) might be inaccurate due to changes in the environment. Furthermore, in order to get sensor readings over the network, an actual network / telephone connection needs to be available, which is not always the case. All these issues may require additional setup time and potentially multiple trips to modify sensor placement. Next to the setup of static sensors, users may want to take manual probes with a mobile sensor while in the field, for which initial feedback on the readings is useful.

Both the setup of static sensors and the taking of manual probes can benefit from feedback on where to put a sensor, and the quality (correctness or suitability) of the actual readings being produced. HYDROSYS provides methods to accommodate these. Once a sensor placement position is provided (planned in the office), a user can be directed towards its location in the field by providing directional cues on the handheld display. Once arrived at the location, the user will need to evaluate if the location is still useful to install a sensor, hence checking the physical characteristics of the place: the environment might have changed in comparison to the information available in the latest digital terrain model used for planning. Once the sensor is installed (for static sensing or for a manual probe), it is useful to get initial feedback on the correctness, which can be provided by running an initial simulation loop. Hereby, the sensor placement takes advantage of the on-site simulation functions available through the research prototype system. Under the premise that previous data is available from the site, sensor readings can be checked by evaluating the visualization produced using a krigging of the data coming from the new sensors over the sensor network GSN. If the readings are completely off, either the sensors are not working properly, or the model is producing bad results. To check this one can compare the results produced by the model with the data given by the sensors previously installed. Once suitable data is received, the user can perform an additional check on the other sensor sanity information, such as the available power.

In case a new location needs to be found for placing the sensor, the same mechanisms can be used. Furthermore, for the site at hand, network coverage maps are available that can be accessed to secure a position that has actual network access. These techniques are particularly useful for those users (including companies) that install sensors at less accessible sites, or want to quickly deploy a sensor in the field, for example with the purpose to get an initial and rough overview of the processes on site: The methods will allow users to more quickly deploy sensors in the field at meaningful positions. In general, the methods will be interesting for those interested in quasi real- time simulation.

A3 A remotely controlled camera framework for multi-viewpoint analysis

The usage of both static and dynamic cameras has shown to be of great interest to both hydrologists and environmental scientists, and other end-users that use multi-camera systems.

See also C2.1

This outcome is elaborated in publication:

Veas, E., Mulloni, A., Kruijff, E., Regenbrecht, H., Schmalstieg, D. Techniques for View Transition in Multi-Camera Outdoor Environments. In Proceedings of Graphics Interface 2010 (GI2010), 2010.

A4 Mobile sensors for measuring moisture, temperature and oxygen content in water

The mobile sensor can be a very useful tool to make quick measurements, getting immediate feedback on the screen. It has been a wish from a larger number of end-users, thus, it can be expected that take up rate can be higher. Similar systems could also be useful for more complex sensing scenarios, for example by coupling simple simulation loops.

B0 Techniques to support the storage, processing and distribution of environmental data gathered from on-site data acquisition and external sources

Based on an existing sensor network system, several extensions will be developed that provide for specific functionality required for the on-site monitoring campaigns. The methods introduced will handle the quasi-real time data from the sensors, check the data through advanced filtering methods and prepare the data for the mobile devices by pre-processing it.

This outcome (and also other Bx outcomes) can be integrated to existing data services or components. Especially implementing online simulation products combined with real time monitoring services have a significant marketing potential in several application areas. These services could be carried out in co-operation with a simulation provider.

Once data is received from the sensors onsite, it will need to be stored, processed and distributed to the end-user display devices. The HYDROSYS system provides specific functionality required for the on-site monitoring campaigns. The methods handle the quasi-real time data from the sensors, check the data through advanced filtering methods and prepare the data for the mobile devices by pre-processing it. Furthermore, access management is introduced to cover for possibly private (or sensitive) data access. To advance the analysis in the field, an important aspect is the integration of simulation functionality from within GSN, advancing the prediction possibilities of the user. Finally, to both gather and distribute data from and to the site, the project introduces the usage of self-powered WIFI bridges, enabling fast access to the data storage at those sites that normally exhibit network coverage problems.

This outcome is elaborated in publications:

N. Bonvin, T. G. Papaioannou, and K. Aberer. An economic approach for scalable and highly-available distributed applications. In Proc. of the 3rd IEEE International Conference on Cloud Computing, Miami, FL, July 2010. Presented at CLOUD 2010 by N. Bonvin.

Zhou Y., Salehi A., Aberer K.: Scalable Delivery of Stream Query Result; In proceedings of the 35th International Conference on Very Large Data Bases (VLDB), July 2009.

Wu J., Zhou Y., Aberer K., and Tan L.: Towards Integrated and Efficient Scientific Sensor Data Processing: A Database Approach; In proceedings of the 12th International Conference on Extending Database Technology, 2009

B1 Methods for handling quasi real-time sensor data within the sensor network

Environmental monitoring is becoming important for analyzing the processes involved with the creation of hazardous events. Understanding these processes is a complex task requiring dense and real-time monitoring of the environment. Quasi real-time sensor data streams submitted from multiple mobile sensors that monitor an area of interest have to be continuously combined, processed, analyzed and visualized. Moreover, scientists may require to compare or combine real-time streams with archived ones and apply on them some complex processing. The methods developed in the project help to efficiently collect and combine real-time data coming from multiple mobile sensor stations through connectionless communication channels with archived data. This process has an important trade-off between the freshness of sensor data and the latency introduced by synchronizing sensor data sources that may have different rates or different update time. The project also has provided methods to support complex spatial, temporal and value-based querying of this data in real-time. This output is also useful for the developers of data stream processing middleware systems.

The methods developed in the project aim to efficiently collect and combine real-time data coming from multiple mobile sensor stations through connectionless communication channels with archived data.

This outcome is elaborated in publication:

Jurca O., Michel S., Herrmann A., Aberer K.: Processing Publish/Subscribe Queries over Distributed Data Streams; In proceedings of the 3rd ACM International Conference on Distributed Event-Based Systems, 2009

B2 Filtering methods for data quality control

Inherently sensing devices introduce some measurement error within a manufacturer bound. Furthermore, the accuracy of these devices is very sensitive to their positioning and their interaction with the environmental heterogeneity, changes and processes. Moreover, the wireless medium, through which the sensor measurements may be transmitted, is highly error-prone inducing packet loss, packet reordering and latency. As a result, sensor data streams may contain outlier measurements and data holes (i.e. missing values). The new data filtering and quality improvement methods improve the quality of sensor data streams by removing outlier values and filling missing ones based on regression models and employing long-term historical data. Also, methods for monitoring the confidence on sensor data based on probabilistic models has been investigated. This outcome will be of particular interest for environmental scientists that employ these data in physical models that assess the probability of hazardous environmental phenomena. It can be exploited to facilitate monitoring of the “health” of sensor data and sensors in real-time against failures. This output will be useful for database developers to enhance the quality of the data stored. Scientists may not always trust the output from automated data quality improvement methods. This problem could be alleviated by the proposed approach. Another problem is the quality monitoring of sensor data. To this end, the research conducted to this area will be published to high-end conferences in database systems.

This outcome is elaborated in publications:

S. Sathe, H. Jeung, K. Aberer. Creating Probabilistic Databases from Imprecise Time-Series Data. ICDE, 2011.

H. Jeung, S. Sarni, I. Paparrizos, S. Sathe, K. Aberer. An End-to-End System for Cleaning Sensor Data: Model-Based Approaches. Submitted to Information Systems journal, Elsevier, 2011.

B3 Access management methods for securing data on the sensor network

Several sensor network deployments exist and more are expected to occur in the near future. Environmental scientists that collaborate and belong to different institutions want to have a unified interface for accessing multiple sensor deployments. However, the access rights of different scientists to the data provided by the different deployments are different. Proper authorization of data access is of crucial importance for environmental scientists but also for other end-user, such as municipalities. The project provide s mechanisms for fine-grained control for data stream access supporting ACL rights. The underlining mechanisms were implemented in test systems based on existing database access control approaches.

B4 Integrated simulation and modeling functionality supporting the selection and generation of simulations from within the GSN sensor network

Environmental physical models, such as Geotop and Alpine3D, assess the probability of hazardous environmental phenomena based on environmental data. Currently, environmental data are downloaded through web interfaces (in the best case) or manually collected from the flash disks of the sensors using portable storage media. Moreover, data has to be properly formatted and then inserted to the physical models for processing. This procedure is time-consuming and costly. Similar cases occur when environmental scientists want to evaluate some assumptions through simulations or analyze the data with complex visualizations.

The project has developed a method and demonstrated its use in fully integrating physical models and simulation functionality with GSN. Therefore, not only the above procedures can be fully automated, but also the models are now able to employ real-time sensor data. The project provides the functionality to apply arbitrary R scripts to combinations of real-time or archived data. The impact of this task is important both for scientists, who can now build several scenarios and understand complex environmental dynamics better, and technicians supporting decision-makers in decision-making processes.

The HYDROSYS system can be extended to any other contexts where the process under investigation has to be studied through a model that needs to be fed in real-time with field data. The output of this task will be of particular interest for the e-science community, but also for the developers of data stream processing middleware.

Several GSN software components resulting from the project were or will be published as FOSS. These extend significantly the use scope of GSN and open many exploitation avenues for environmental information infrastructures.

The outcome is elaborated in publication:

T.G. Papaioannou, S. Sarni, K. Aberer, S. Simoni, M. Parlange, M. Bavay, and M. Lehning. Automated Model-driven Simulation and Visualization of Field Sensor Data. In European Geosciences Union General Assembly 2011, Earth & Space Science Informatics, 2011.

B5 Pre-processing functionality to support the handling of complex data on handheld display devices with limited performance, and C1.2 Graphics optimization methods for low-performance platforms

Handling of complex data on low-performance devices is of particular interest at a deep-system level. Optimizations are of particular interest for low-performance platforms such as UMPCs or tablet computers.

Raw data sets are not suitable for direct use on mobile devices, and need to be optimized and arranged to device friendly form. Mobile 3D map applications developed at TKK have always aimed for optimization of data and data representation. The HYDROSYS data sets are incorporated to this in-house development with a possible software release. TKK approach here is similar to the COLLADA standard for digital 3D assets, where a standard defines the form of raw data sets, but which are processed to useful formats suited and optimized for each application. TKK demonstrates and leverages this view actively in other standardization bodies such as the Web3D Consortium, which oversees the development of the X3D standard.

HYDROSYS may use of different kinds of mobile devices that only have limited processing capacities, both for processing data (CPU) and graphics. In order to interact with the graphics on the mobile platforms, sensor data needs to be optimized at two stages: the data is pre-processed before it is sent over the network, and optimized during display time.

Pre-processing optimization takes place at different levels, from the moment the data is received on the SmartClient till it is sent to the mobile devices. Once the data is queried and received at the SmartClient the first step is to transcode the information from the exchange format (GML) onto the graphics specific format. This allows to reduce unnecessary transport information to a more compact display specific format such as Open Inventor. During the generation of graphical primitives the data may be further filtered, for example, the density of a DEM point cloud can be reduced to lower resolution sampling (e.g. from a 10cm LiDAR

DEM sampling to a more manageable 20 meters display DTM model with the associated simulation results).

Data filtering does not always infer a quality loss (as in the case of data reduction) but it may also involve a partitioning of data depending on user location, i.e. only the data associated with the current user's location is sent to the mobile clients. The amount of filtering (patch sizes) can be configurable depending on the location and current task. The final step for pre-processing is the transmission of the data to the mobile devices. Here too, an optimization step has been developed. This involves converting the data to a binary format that reduces the network consumption, although it does not directly affect the graphics performance.

After data has been successfully received at the mobile devices, further optimization is necessary. These techniques are characterized by being tightly couple with the user's intrinsic information and decisions such as viewing angle, occlusions and current task. Level of detail techniques (LOD) allow the system to use the graphics resources unevenly, by reducing the quality of lower important data patches. Possessing heavily occluding features, such as the DTM, allow the system to determine the visibility of objects and whether or not they can be excluded from the display. The rendering of graphics is also tightly coupled with the hardware restrictions of the mobile devices. In the case of both the UMPC and mobile phones, a special care has to be taken on the management of texture units. Typically, the usage of textures enables the system to boost performance by mimicking more complex data, in reality, however, this heavily depends on the capabilities of the graphics devices. In general, this level of optimization is based on the graphics API upon which we're based: OpenGL. By fitting our graphical data structures to the specific needs of OpenGL (such as by using Vertex Buffer Objects, and by minimizing state changes) the performance has been increased.

The developed techniques are generally useful for low-performance platform developers and computer graphics scientists.

B6 Improved physical models representing complex physical processes

Within the complex structural framework the project has encompassed sophisticated physical models able to mimic physical processes such as avalanche triggering, rainfall run-off and infiltration, surface and subsurface flows, flood generation, etc. These models are 3D, distributed, dynamical and physically based, meaning they contain equations that describe, at every time step, physical process for every cell in which the study area is divided into. These models are often rich in tuning parameters, (which are usually difficult to be given a physical meaning). In the HYDROSYS system they can be fed with measurement data and take advantage of the different type of data available to deliver reliable results. In essence, HYDROSYS system allows the use of complex physical models thanks to its capability of providing in real-time several data from field sensors. The understanding of natural phenomena will benefit from such an approach, where "black boxes" are removed and processes are described by mathematic equations. The high computational load is the paid off. Appropriate machines and clusters with an adequate number of processors can be used for such a task to avoid too long processing time.

During the project several improvements existing process models were made. (See B4).

This outcome is elaborated in publication:

Mott, R. and Lehning, M.: Meteorological modelling of very high resolution wind fields and snow deposition for mountains, J. Hydromet., doi:10.1175/2010JHM1216.1, in press.

Simoni, S. Porporato, A. Padoan, S., Parlange, M., Different sensitivity of streamflow components to spatial variability in complex topography, in preparation.

Simoni, S., Porporato, Padoan, S. and Parlange M. Different sensitivity of streamflow components to spatial variability in complex topography. EGU 2010, Vienna, Austria

B7 Extended network capacities through WIFI bridges

HYDROSYS system may handle a multitude of sensors combined with simulation results, which means that the HYDROSYS mobile devices have to be capable of dealing with relatively large data sources. Sending this data to the field requires high bandwidth to function effectively, otherwise, the frustrated scientist/practitioner is left waiting for their data to download and in the worst case, this data is then outdated.

Some of the sites in the project have good mobile coverage, meaning that for many tasks the UMTS/HSPA networks could be used for data transfer. The speed of this system varied according to the area, but was up to 3.5 Mbits/s download and 1 Mbits/s upload. Though 3.5 Mbits/s is relatively high speed, it will be beneficial to cover these areas with a 2.4GHz wireless network, or at least hotspots where the user could retire to in order to quickly download to download large volumes of data: extremely high network speeds could be provided and data costs could be cut.

Using the developed technology, even at sites that have no network connection, a limited bandwidth can be achieved. There are two possibilities: a multi-hop (more expensive) WIFI network can be used to transport traffic between either a fixed connection in the village or the high speed mobile coverage and the site; alternatively, the WiFi bridge device may be placed in an area of GPRS coverage for a single hop (cheaper), though slow network connection. These hotspots can be made large (though close to the GPRS coverage), with a sector antenna or small and further reaching with a directional antenna.

WiFi links are a rapidly 'up-and-coming' technology in the mountain regions. Previously, 900MHz radio links have been used for data transfer, but the data rate on these is slow. Low power computing technology has now made autonomous WIFI nodes a real possibility. SWITCH (the Swiss university network company) are currently doing research in this area and are in close contact with WSL for knowledge transfer in both directions. Knowledge on this area of technology development will be integrated into this rapidly developing industry and will be of particular significance for research institutions throughout Switzerland. Further distribution of this infrastructure within Europe is also possible.

C0 Techniques to support the interaction with in-context visualizations of environmental data, to analyse (monitoring), predict and discuss effects of environmental processes with co-workers, to come to possible solutions mitigating environmental degradation (management).

The research prototype system encompasses a range of functionality to support the tasks involved in monitoring and managing environmental processes. This functionality is centred on the interaction with in-context data visualizations, that is, the data representations that are directly related visually to the locations they refer to. Different kinds of visualizations can be generated, based on sensor type and visualization method (numerical, graphs and overlays/maps), and are optimized to for example direct the attention of the user to a specific area or event. The visualization is optimized to support the limited graphics possibilities of the hardware platforms.

The dependency on in-context visualization requires accurate localization of users using the handheld computer (around 1m accuracy), which is provided through a hybrid tracking system that can rely on an additional support vehicle holding a high-accuracy localization system.

The functionality to support the user's actions consists of several modules that are integrated into a single user interface. Depending on the handheld platform (handheld computer or cellphone), the user accesses the full or a more limited set of functions. These modules support the selection of data and visualization formats, and allow the access to simulation services. The data can be viewed from different angles, by either walking around the site and receiving data visualizations adapted to the users viewpoint, view a 3D model from different sites, or observe videos from remote video cameras. The functionality enables to analyse the data, outline its problems, make predictions, and possibly find solutions. These processes can occur in a cooperative manner, by supporting communication and data exchange between different users in the field and in the office. Users can thereby note down their results in an effective way using geo- referenced notes.

Both user interfaces and graphics representations are perceptually optimized to ease the potential load on the user to deal with complex data and quite some functionality, all displayed and used on a small display.

C1 Visualization techniques for showing complex and multivariate environmental data in their actual context

Within the context of HYDROSYS, around 25 different sensor data types that differed both in representational method, and complexity was visualized. The sensor data varied and came at different frame rates, in different formats, and in multiple dimensions, for example, temperature readings are uni-dimensional and come at roughly 0.1hz, while wind direction is three-dimensional and comes at roughly 20hz, while some sensors are of proprietary technology and come encoded in special formats ranging from text outputs to voltage readings.

The visualization techniques developed for HYDROSYS provide to the user a concrete representation of the abstract data delivered by the sensors and simulation. This visualization aims at helping the user understand the data that typically comes just as a collection of numbers. The final techniques run in the low-powered mobile outdoor devices. Users can see the data delivered by sensors and simulation in a near real time fashion while they are on the field. While on the one hand sensor data can be seen as a single geo-referenced label, simulation on the other hand is a point cloud dispersed around a large area.

Simulation data is more complex and dense and may be a performance bottle neck for the mobile clients. Furthermore, data may not always be physically visible and might be occluded (such as sub-surface soil moisture) which will require extra tools for visualization. Data to be visualized may not always be fast changing as is the case of sensors, but it may be roughly static, as in the case of Digital Elevation Models. Methods to cover these limitations have been developed.

Data visualization is a large area of research. It typically is a slow process of high quality image generation from an abstract data source, such as in volume visualization of MRI data. Our work focused on fast generation of highly representative image from abstract data. The limitations of this type of visualization are higher, as images have to be generated within 0.06 seconds after data is available. This includes not only incoming sensor and simulation data, but also tracking and video information. Such fast generation of graphics allows the system to present to the user an augmented view of the world that closely relates its current physical state, called in-context visualization.

This kind of data visualization allows contrasting digital information coming from sensors with the current real state on site.

Labeling generation is a promising solution for single sensor data visualization. However, this incurs in a problematic situation when multiple sensors are in the field of view of the user. Labels are typically thought of as containing textual information on the sensor values, but this is not the only type. Graph-like representations can also be placed inside labels or annotations, further techniques such as glyphs with color codings (e.g. red circle means damaged sensor, green means healthy) were investigated throughout the course of the project. Overlapping, cluttering are just some examples of the possible issues. Visualization of simulation data can be done by mesh generation of a DTM overlaid with textures representing simulation values. This is a useful technique but limited, as overlaid information can only be uni-dimensional.

Three dimensional simulation data visualization is more complex as it cannot be simply overlaid as a texture in which case 3D primitives generation will be explored. Comparison of data is also in the HYDROSYS toolset, to help the user contrast information coming from different simulation results (see C1.1).

The generation of images from abstract data is dependent in multiple factors, many of which are related to the users themselves. Appropriate techniques of visualization need to consider the cognitive load imposed on the users. For example, lagging effects from low refresh rates may cause motion sickness, as the imaging device (camera) might physically move faster than the presented graphics on the screen. Inaccurate overlay of tracked information may cause a misunderstanding on the scene, where sensor data is presented in the wrong physical position on the screen. This and many other perceptual problems were tackled by HYDROSYS (see C3).

The developments can be very useful for computer graphics scientists and developers that develop for limited performance platforms.

C1.1 Focus and context techniques: Attention-direction techniques for focusing the user on specific events, and occlusion management

Visualization techniques for complex data are published as part of a systems paper on the HYDROSYS system (part of S1). Further publications are expected on perceptual factors of the focus and context techniques under development, and a cooperative sensor data visualization paper with other partners. One dissertation has been based on its results. The new techniques are made available as software release.

TKK's mobile 3D map interface is designed to emphasize local salient cues for better orientation in the environment. The methods will be published in scientific conferences. Human factors on attention in natural environments are researched and also published. Exploitation of these results in larger scale is considered commercializable, and demonstrations given to companies that show interest on navigation systems, such as Navteq, Nokia and Google. Cooperation with these companies already exists and will be deepened.

Attention direction techniques are used to guide the user's eye sight to areas that the system has detected as being of interest. For example, sensor health reports, location of other users in the environment, and user defined metrics. Users could tell the system to direct their attention to sensors that exceed certain threshold; this could be useful to explore areas with potential landslides or patches in a river where pollution is above healthy levels. Attention direction techniques provide a tool to let the user know of important areas in the image.

The techniques developed by HYDROSYS deal with the limitations imposed by the low-powered mobile devices. The performance of the attention direction techniques were tested in real outdoor environments in order to steer their development. The techniques not only focus on the underlying digital data being observed, but they deal also with environmental factors (e.g. Contrast of snow) to better direct the user's attention. During the project, we tested a set of techniques for attention direction based on Visual Saliency.

The field of human attention based on visual graphics is vast. Person's attention is a complex process rooted in physiology (such as the cones and rods in our eyes) and in culture and experience (such as fears). Naive techniques for attention direction would consider simple overlays to be sufficient to solve the task, but this would ignore the problematic of visual cluttering and of the complex background information provided by the camera feed. Sound is often cited as another source for attention direction, but its potential is limited as direction itself is hard to achieve (i.e. one can generate a sound coming from the computer, but one cannot easily direct the user to a particular location of the environment exocentric from the computer itself).

These problems are exacerbated when one considers the limited computational resources at hand and the difficult environmental situations in which the users will use the system. Proposed solutions for these situations are mainly based on management of colour (and visual saliency) but also explore further techniques throughout the project.

This outcome is elaborated in publications:

Veas Eduardo, Mendez Erick, Steven K. Feiner, Schmalstieg Dieter. Directing Attention and Influencing Memory with Visual Saliency Modulation. In Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI2011)

Mendez, E., Feiner, S., Schmalstieg, D. Focus and Context in Mixed Reality by Modulating First Order Salient Features. In Proceedings of the ACM International Symposium on Smart Graphics, 2010.

Mendez, E., Schmalstieg, D., Feiner, S. Experiences on Attention Direction through Manipulation of Salient Features. In Proceedings of the IEEE Virtual Reality Workshop on Perceptual Illusions in Virtual Environments (IEEE VR 2010), 2010

Erick Mendez, "On the use of Context for Augmented Reality Visualization". PHD, TU Graz, 2011.

C1.2 Graphics optimization methods for low-performance platforms

The core of TKK's research is in optimizing 3D graphical representations for mobile devices. This includes preprocessing of data (B5) using perceptual means (C3). These developments will be further published in scientific conferences.

See also B5.

C2 Advanced interfaces for handling more complex functionality for on-site analysis on small-screen handheld display devices

The HYDROSYS user interfaces cover a wider scope of functionality than currently available interfaces. The interfaces are promoted as the front-end of the research prototype.

Two different kinds of handheld devices were used during environmental monitoring and management during the project: a handheld computer with additional sensors, and a cell phone. These devices are mobile (portable) – users need to take them to the field without being limited by the weight or ergonomics of the device. However, the size of the devices implies that users can only view and interact with content on small screens. Typically, small handheld computers have a screen of around 5 inch, mobile phones more or less just 3 inch. In addition, only either small controls (like a mini keyboard and joystick) or a pen is available to interact with the content, which is quite different from interacting with normal desktop computers. At the same time, the requirements are high. A solution is not to show the functional depth always: most of the functionality is not directly seen by the user, but needs to be learned or communicated by other means. Also different users require different functionality (see C0).

The project specifically focused providing all the needed functionality in an apt way – ignoring the limitations of the system would likely lead to only partially usable systems. Approaches tested include the usage of different interaction modes and associated structuring of functionality, the definition of functional sets by using user profiles, and the structuring of functionality according to the workflow of the user. The user interfaces developed particularly take care of using methods that match the used input control method at hand. The development of the techniques was supported by a range of human factor studies and user evaluations. Noticeably, the user interfaces include screen management techniques to avoid that the "menus" are cluttered and possibly overlap the data being observed. These techniques relate to C3 perceptual optimization, which tackles optimizing the integration of visualization and user interfaces.

Furthermore, several innovative modules were or will be made available that allow for multi-viewpoint analysis, simulation support in the field, and making geo-tagged, sharable notes. Additionally, specific focus is put on providing a robust platform for outdoor analysis with mobile devices, by creating a new kind of handheld augmented reality construction.

The lessons learned from developing the techniques, and the techniques themselves can be useful for any developer making more complex mobile applications for small- screen devices, and as such affect among others cell-phone, MID (mobile internet device) and UMPC (Ultra mobile PC) developers. Furthermore, several of the techniques we will develop will be applicable in general for augmented reality applications.

Figure. Toolbar for data exploration.

This outcome is elaborated in publications:

Veas,E., Kruijff, E., Grasset, R., Schmalstieg. Mobile interfaces for environmental sensor networks. Publication under submission.

Nurminen, A. 2009. Mobile 3D City Maps, Doctoral Dissertation. Helsinki University of Technology

Upcoming PhD from Eduardo Veas on Mobile interfaces for Outdoor Augmented Reality.

C2.1 Techniques for handling dynamic multi-camera setups used for multi-viewpoint analysis and A3 A remotely controlled camera framework for multi-viewpoint analysis

The HYDROSYS system may deploy a number of static and dynamic cameras. Mounted under the blimp, at the sensor stations, at a quickly deployable pan-tilt unit, or at the handheld devices, cameras can be accessed while users observe the site at hand. The camera footage will allow the users (especially those using the handheld computers) to get a good overview of the identified problem area: by viewing from different angles, and possibly controlling the camera itself (blimp, pan-tilt), the problem area can be observed from different sites, avoiding possible object occlusions and creating a better understanding of the spatial relationships between all objects in the scene.

To use the different camera footages an user needs an understanding of where the cameras are in relation to the her and what possible common objects of interest can be seen. Basically, the user needs to understand the relationship between herself, the cameras, and the site being observed. Apt techniques aiding that understanding were developed. They help the user not to become confused while accessing the different cameras: the user may have limited knowledge on the site and location of the cameras. The consortium developed techniques that provide spatial cues communicating the spatial relationships between the user, camera and site. These techniques can be both aimed at providing a general overview (like map-related techniques), or by integrating location and directional cues while switching between ("travelling") different cameras. The development of techniques was supported by several human factors studies and user evaluations that specifically focus on spatial awareness.

The development of these techniques is beneficial for researchers: relating to surveillance systems used for a diversity of purposes, the techniques extend the generally used system techniques for "static" setups and users that know their setup well through experience. Currently, there is much interest for mobile camera setups, especially in the field of robotics, that may profit from our techniques.

The usage of both static and dynamic cameras has shown to be of great interest to both hydrologists and environmental scientists, and other end-users that use multi-camera systems. Currently, TU Graz is exploiting the camera control framework through research collaboration and a possible future project proposal with University College London, through publication, and by possible ways of a proof-of-concept for a sensor company. The module will be released as part of the open source software architecture.

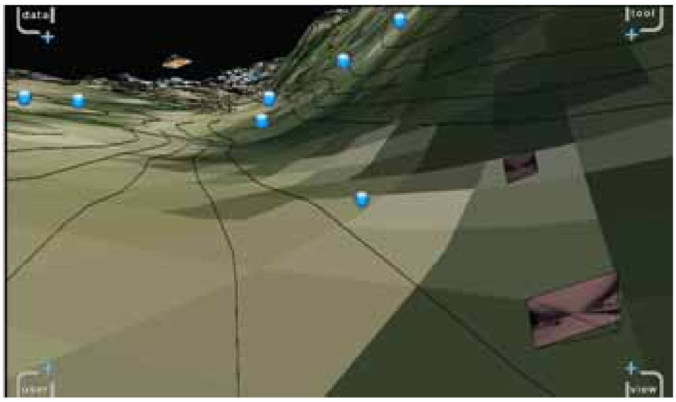

Figure. Multi-view management.

This outcome is elaborated in publication:

Veas, E., Mulloni, A., Kruijff, E., Regenbrecht, H., Schmalstieg, D. Techniques for View Transition in Multi-Camera Outdoor Environments. In Proceedings of Graphics Interface 2010 (GI2010), 2010.

C2.2 Lightweight methods for geo-referenced annotation of events or solutions

TKK is developing a data model for semantic segmentation of the environment. This model, along with the segmentation information, facilitates fast association of annotations, not only to geographic coordinates, but to semantic contexts. As this association is done at annotation creation time, the link is stored along with the annotation to a database. Subsequent searches do not need to apply costly data mining techniques but can rely on the existing associations. In effect, this solution transfers the load of data mining from a post process (associations searched when data is needed) to a pre process, to the moment of creation of the annotation. This system will be demonstrated to GIS communities and commercial GIS software companies after publishing it in scientific conferences.

One of the potentials of visualizing data on site is the collaboration among users. Having many users on site browsing the simulation and sensor data in their surroundings can generate large amounts of useful logging of events. HYDROSYS will enable users to easily create content on site about current events. This takes place in many levels, from image capturing of the scene to text comments for later analysis. The mobile devices for on-site analysis will all be equipped with a tracking device and an image capturing device. This enables the creation of geo-referenced visual logs by the users. Each image will not only be a snapshot of the current view of the camera but will possibly include contextual information about its position, viewing direction, tracking quality, user who took it, and current viewed profile. Be it to record damaged sensors or potentially interesting climatic events, the advantages of image capturing are clear. But the recording of images is not always sufficient; users may find the need for a more explicit logging method. For that purpose HYDROSYS system includes a tool for the recording of text annotations. The annotation will be in the form of simple text boxes in which the user records geo tagged information. This tool allows collaboration among users and more detailed information on events. Furthermore, it enables the sharing of ideas and revisiting of details while back at the office.

Figure. The cell phone annotation interface.

The geo-referenced labelling and annotation methods are submitted for publication (see C2). Furthermore, they will be made available as software release.

C2.3 An ergonomic and robust handheld outdoor augmented reality setup

The sites observed by HYDROSYS system users may be at remote locations with possibly harsh conditions. Whereas most observations tend to take place during “normal” weather conditions, the devices used for on-site monitoring and management potentially still need to cope with lower temperatures, dirt, and water (snow, rain). In addition, to improve the user acceptance, device setups need to be robust to be taken around. In particular the device setup for augmented reality visualization (the handheld computer setup) needs to be protected by these external influences. The setup requires the connection of additional sensors (such as a camera, and location / orientation sensors) to provide high-quality in-context graphics visualization. The project developed prototype casings that integrate and protect the computer and the sensors. The casing allows for ergonomic pose during operation and a good weight distribution, to avoid strain. Additionally, the encasing is portable to be taken around easily, or stashed away. Such a construction is currently not available either at research institutions or commercially. Nevertheless, outdoor augmented reality applications is increasingly focused upon – both researchers, but also professional field workers from other application areas (such as engineering) have shown interest and may profit from the knowledge gathered.

The ergonomic handheld is promoted to be used by other projects through collaborations. Currently, another project at TU Graz has started using the construction for a field worker application. Previous prototypes have also found interest by other research institutes – TU Graz has continued to look into possibilities to make the 3D model available for others, or see if an external company wants to produce small companies. Further contact will also be sought with hardware developers for field worker devices, since discussions before and during the project have shown potential interest. The current models for producing the handheld construction and its various components are made available for public usage.

The ergonomic and robust hand-held outdoor augmented reality setup will greatly increase the augmented reality capabilities within the consortium and will be used in-house after the HYDROSYS project to develop new augmented reality systems and test new techniques.

Figure. The final modular handheld system.

This outcome is elaborated in publication:

Veas, E., Kruijff, E. Handheld Devices for Mobile Augmented Reality. In Proceedings of the 9th ACM International Conference on Mobile and Ubiquitous Multimedia (MUM2010), 2010.

C2.4 Simulation support during on-site analyses

An important outcome of the project is the testing of on-site simulation in practical use: HYDROSYS aims to provide near-real time simulation-results to be available for the user while being in the field.

A simulation can be triggered either from a desktop in advance of a field trip or remotely, with a handheld device while being on-site. This supports scientists and technicians on- site who need to check the ground-truth against model results to follow the evolution of the current scenario.

Usually a simulation will be started in advance (e.g. the day before you plan to go to the field). While the simulation is running and while being on-site the simulation-runs are permanently updated with the most recent input data coming from the sensing stations in the area. It therefore should be possible to get near real time data when being on-site. Simulation results can than be visualized on the handhelds. The information obtained from the model output can now help the user to decide weather and which spots might be interesting for further (more detailed) analysis (e.g. manual measurements) or sensor placement. Since distributed models are in general computationally demanding, and the data load required is large, the use of such models in operational context is still restricted in terms of calculation effort and time.

C3 Perceptually optimized visualization and user interface techniques

A 3D user interface enables navigating in virtual environments. 3D environments are emerging to mobile platforms, but the main obstacle in their success is the user interface. This component will be published on scientific papers and frequently used in demonstrations to leverage mobile 3D applications in general, and continued to be used for in-house development.

While using the handheld devices, users need to interpret complex data sets, and simultaneously use a potentially larger set of functions. Users need to interpret different kinds of visualised data, and possible compare different sets to come to a conclusion (interpretation or prediction). With the limited display size of the handheld devices, handling both the visual data and the functions may cause cognitive load that limit the usefulness of the system. As a result, the project provides tailored visualization and interface methods that filter and structure the content and functionality at hand: the techniques are based on perceptual optimization to avoid confusion and cognitive overload; hence, the techniques actively tackle visual data management of both the visualizations and the user interface. This specifically counts for the augmented reality system, inhabiting a wide functional set and more complex visualizations than the cellphone platform.

Throughout the project the development of graphics was steered by user tests that hint at the better ways of presenting information. The end result pays attention to basic elements such as colour, brightness and depth of field to present a coherent data view. A typical weakness of competing methods is to heavily enhance the virtual graphics overlaid on the real world, which leads to a disconnected view of real and virtual and may deviate the attention of the user from the important areas, a problem known as the transparency of the media.

Within the development of the techniques, particular attention was given on how to relate the sensor data to its actual context, balancing the communication of visual features of both sources to create a coherent view. Hereby, techniques such as overlay- background colour adaptation, depth filtering, and specific x-ray like techniques were developed and tested. The usage of the visualization techniques directly depends on the screen management associated with the display of the user interface. The user interface may occlude specific visual information that is associated with performing a certain task, or users may want to adapt perceptual qualities of the visualization itself based on personal preference. Furthermore, specific techniques such as depth filtering are likely directly related to a control in the user interface.

The techniques are not only useful for the particular application framework at hand, but beneficial for developers in the field of augmented reality in general. Supported by the planned validation outcomes, we expect that people interested in computer graphics, perception and user interfaces will also benefit from the results.

As part of the developments and multiple validations, TU Graz will continue to write publications on perceptually optimized visualization and user interface techniques and is looking for further project possibilities. The techniques (integrated in the visualization and interface modules) are made available as software release.

This outcome is elaborated in publications:

Kruijff, E. Swan II, E. Jr., Feiner, S. Perceptual Issues for Augmented Reality Revisited.

Accepted for publication at the The IEEE International Symposium on Mixed and Augmented Reality 2010, Seoul, South-Korea, 2010.

C4 A hybrid tracking system for accurate localization of users on-site

In order to create in-context visualizations, apt localization of users needs to be guaranteed. A hybrid tracking system was developed to track the pose of the user's hand-held augmented reality setup. This pose information is crucial for correctly rendering the augmented reality data on the screen: the in-context visualization methods are depending on accurate localization of the user. Furthermore, the user can easily note their own location within the site when making observations.

This hybrid tracking system fuses measurements from a variety of sensors within the hand-held unit. These sensors include gyroscopes, magnetometers and accelerometers providing inertial measurements, a GPS sensor, and a camera. This camera provides information on the pose of the device by tracking the horizon in the image and matching it to that provided by the terrain model produced in A1. Additionally, the tracking system benefits from the ultra wide band position sensing developed in C4.1. When fused, all of these measurements provide an estimate of the unit's pose accurate to 1m. If any one of the sensors fail (poor GPS reception for instance) the accuracy will be reduced, but the basic tracking functionality continues operation. In these instances, the user can be informed of the failure through the visualisation system. The user can then take steps to improve the tracking (by moving closer to the UWB tracking stations for instance).

Accurate real-time tracking systems are useful in a number of different applications. In particular, our system is of interest in the fields of augmented reality and robotics. The source code for the hybrid tracking system will be released making all new techniques developed available to the wider community. New computer vision algorithms developed in this project are released in the open source computer vision library CVD. The underlying general numerical algorithms developed for the project are released in the open source numerics library TooN. Also the algorithms needed to build visual maps from the blimp (A1) and the hybrid tracking system are available to the public.

C4.1 A quickly deployable and movable high-accuracy tracking setup extension

The HYDROSYS tracking system setup is an important extension in the HYDROSYS framework since it enables the real time tracking of people on a given area around the vehicle while taking measurements on the site. In conjunction with the location engine running on a station onboard the vehicle, the sensors mounted on a fixed setup compute an accurate position. Depending on the terrain and on the required time and accuracy of the on-site measurements, there are three kinds of setups. The vehicle-only setup will be used for a quick deployment in order to increase the accuracy of the GPS and inertial positioning. This setup is especially advantageous for the application when a frequent or quick change of the operation area is required. Furthermore, detailed investigation of the terrain requiring a higher accuracy can be achieved through an extension of the vehicle setup with movable tripods. This heterogeneous setup offers also the advantage in increasing the flexibility of the vehicle setup for difficult terrain relief, where the movement of the vehicle is rather limited.

For rough terrains, which are not easily accessible by the vehicle, the tripod-only setup offers a great advantage of flexibility and coverage, as the sensors could be moved freely on the site.This outcome could be exploited in future collaboration with other parties. The projects may consider environmental monitoring and management but they also may consider problems faced by police, fire and rescue, and other services .

4.2 Exploitation by partner

Graz University of Technology

With future exploitation in mind, TU Graz has promoted the system prototype (S0) to selected institutes active in the field of hydrology and environmental sciences in Austria. Dissemination will continue among the hydrological institutions in Austria, extending the previous contacts to for example the ZAMG and the Institute of Urban Water Management and Landscape Water Engineering at TU Graz. After the projects end, TU Graz intends to extend its scope to worldwide efforts – at current, activities are being pursued to install the system in New Zealand, in cooperation with HITLab / University of Canterbury and NIWA. The results will also be viewed from a wider field of view – the scope of multiple methods can be of high interest to the wider geosciences domain (such as more technical construction-technical applications), as well as other survey applications that make use of large sensor networks (from search and rescue missions to “humane” security systems).In cohesion with accepted paper publications, TUG is looking also at promoting the system among researchers (in particular the A and C outcomes) through demonstrations at large conference venues – ACM CHI 2011 has been a perfect venue for this purpose, and interesting follow ups are expected. As part of its teaching tasks, the TU Graz will continue to demonstrate its technologies within an educational context, in lectures and “open lab nights”.

The interfaces for sensor placement (A2) can potentially safe time when sensors are installed at more remote locations, since its functioning can be checked immediately. TU Graz will continue talking to the undisclosed sensor company to see how the module could be beneficial- talks continue after the project’s end. The module will be released as part of the open source software architecture.

The usage of both static and dynamic cameras has shown to be of great interest to both hydrologists and environmental scientists (C2.1), and other end-users that use multi-camera systems. Currently, TU Graz is exploiting the camera control framework through research collaboration and a possible future project proposal with University College London, through publication, and by possible ways of a proof-of-concept for a sensor company. The module will be released as part of the open source software architecture.

The ergonomic handheld (C2.3) is promoted to be used by other projects through collaborations. Currently, another project at TU Graz has started using the construction for a field worker application. Previous prototypes have also found interest by other research institutes – TU Graz has continued to look into possibilities to make the 3D model available for others, or see if an external company wants to produce small companies. Further contact will also be sought with hardware developers for field worker devices, since discussions before and during the project have shown potential interest. The current models for producing the handheld construction and its various components are made available for public usage.As part of the developments and multiple validations, TU Graz will continue to write publications on perceptually optimized visualization and user interface techniques (C3) and is looking for further project possibilities. The techniques (integrated in the visualization and interface modules) are made available as software release.

HYDROSYS results were used to achieve considerable optimizations in software framework Studierstube, which is an in-house open-source project coordinated by TUG. The updates will become available through the normal channels – Studierstube is used in several research projects within EU and worldwide.

Details of confidential intentions are in the internal report.

Ecole Polytechnique fédérale de Lausanne

Ecole Polytechnique fédérale de Lausanne brought into the project the contribution of two groups: Laboratory of Environmental Fluid Mechanics and Hydrology and the Distributed Information Systems Laboratory.

At EPFL two groups join the project, namely the Laboratory of Environmental Fluid Mechanics and Hydrology (EFLUM) and the Distributed Information Systems Laboratory (LSIR). EFLUM is active in a variety of hydrologic and atmospheric boundary layer research topics including evaporation, soil erosion, atmospheric turbulence, watershed hydrology, urban micrometeorology and snow processes. Combinations of experimental techniques are used typically in the field including Lidar, Sodar/RASS, embedded wireless sensors (SensorScope), distributed temperature sensing (fibre optics) and fast response meteorological sensors. On the other hand, LSIR is a highly experienced partner in the field of distributed system architectures, having a solid background on sensor network systems and associated themes.

EPFL is an academic institution and thus its exploitation intentions are naturally focused on academic merits and education of students. However, there are also strong intentions to collaborate with end users and disseminate the research results to end users and environmental companies. These intentions can be specified as following:

- Based on a meeting already held with end users, the EFLUM intends to arrange an on-site demonstration to illustrate the capabilities of the HYDROSYS system (real-time communications, augmented reality, etc). The targeted end users are cantonal and local administration, and especially private environmental companies.

- While keeping the exact nature of collaboration with environmental companies undisclosed and without giving any names, it is an intention at EFLUM to exploit the results of this project (improved capabilities for doing risk mapping, creating engineering designs, coupling online simulation with real-time sensor data, managing infrastructure, etc) in collaboration with such companies. These companies are often doing environmental studies mainly asked by the administration. They provide expertise in various areas such as natural hazards, setting up sensors and analyzing data. Generally these companies are quite small (a few people working there) and are dedicated to study, outline or manage environmental problem (example: doing a map of potential risks on the specific municipalities). The nature of the collaboration can be development of knowledge and capabilities or it can be development of a new application.

- LSIR plans to maintain online platform accessible to the public for the deployments of HYDROSYS and provide access to sensor data and access-controlled simulations with physical models. LSIR will produce several demos and online-live demos on the results of this project and especially on sensor data cleaning and sensor data simulation.

- LSIR intends to exploit sensor data streams produced in HYDROSYS to investigate research challenges and publish original work in data compression, data cleaning and data processing for a large number of streams and queries.

The increased in-house knowledge and experience of EFLUM will be exploited in developing projects with other universities, other countries or within Switzerland with cantonal administration. EFLUM is very interested in applying the improved GSN software and the data fusion developed within the project.

EFLUM intends to exploit the simulation results to as a scientific paper and to better develop in-house knowledge regarding hydrological risk.

The follow section provides an overview of the initial exploitation plans of EPFL on the research project outcomes.

S1 A research system prototype: The research prototype will be exploited in-house in education, especially on field trips. In that context, a handheld device can be use as a tool to show how the environment can be managed. Moreover, using cells phone, it can be possible during a field trip to add a lot of new data and annotation or in an easy way to integrate new manual observations, which may localize potential pollution and other inputs to a river, risks in an alpine catchment, etc. The communication capability of the system can also be used in field work to exchange data, images or such.

Several software components resulting from the project have been and/or will be published as FOSS. These include

- RemoteWrapper. This component was updated to link together multiple GSN instances and thus make the fusion of archived remote data with real-data possible.
- CSVWrapper. This component was updated to read archived data from CSV files to GSN. It allows full flexibility of parameterization and it is robust against errors contained in the CSV files.
- RVirtualSensor. This new component allows for the communication of GSN with an R server, so as GSN is able to apply R scripts to real-time or archived sensor data.

As a result of HYDROSYS, the GSN platform was improved by LSIR with various new capabilities (such as mobile sensor support, spatial queries, web service interfaces, network interfaces, visualization interfaces, access control, etc.), which enhances the maturity of the platform to render it one of the dominant middleware technologies for data sensor aggregation, processing and publishing. This open-source platform is going to be used by LSIR on various new project initiatives in Switzerland and internationally as a stable infrastructure to advance and facilitate environmental monitoring capabilities. Collaborations with environmental scientists, sensor vendors and municipal authorities are viable towards the provision of end-to-end added value environmental monitoring services and new applications.

Several improvements to the physically-based numerical models ALPINE3D and GEOtop were made during the project. The improvements were directly be exploited by WSL and EPFL.

Details of confidential intentions are in the internal report.

WSL Institute for Snow and Avalanche Research SLF

Institute for Snow and Avalanche Research (SLF) belongs to the Swiss Federal Research Institute on Forest, Snow and Landscape (WSL). WSL/SLF operates under the Board of the Swiss Federal Institutes of Technology. WSL/SLF conducts basic and applied research on the environment, sustainability, and risks from natural hazards. It also provides consulting, advisory and training services to federal and cantonal governments, the forestry, environmental protection, the tourist sector, industries, and the public. As a national research institute WSL also an interest and intention to exploit the datasets and information generated in the Alpine scenario. In the first step the outcomes are exploited in-house to improve the knowledge on the targeted issues and in the second step this knowledge is exploited as scientific publications.

An explicit intention in this respect is a study into the wet-snow avalanches using data which has been gathered during the project from Dorfberg. The meteorological station, which had been set up for three winters at Dorfberg performed regular high quality measures of different meteorological parameters like air temperature, wind speed, wind direction, relative humidity, radiation, snow depth and snow characteristics like snow temperature on different levels or humidity of the snowpack in high temporal resolution. Sensorscope stations at Dorfberg have beed used to measure air and snow temperature, wind speed and direction and volumetric water content of the snowpack. Additionally manual measurements such as snow stratigraphy, stability and infiltration rates of melt water have been carried out regularly. Time-lapse photography of the slope is used to obtain avalanche occurrence and airborne thermal image-data collected by the blimp to recognize spatial patterns of the thermal regime of the snow surface. These data have been collected over a period of three (winter) field seasons. In combination this is a unique dataset for wet-snow avalanche research.

HYDROSYS helped to gather, organize, visualize and interpret these data (outcomes S2, S4, A, B, C). In this context HYDROSYS has helped to achieve more detailed insights on wet-snow avalanche formation. The knowledge on this highly complex topic is expected to be significantly improved in further analysis of the data. The research has already resulted in several scientific publications. Even if we are far from fully understanding the complex processes interaction in the area of wet-snow avalanche research a significant step forward was made with the help of HYDROSYS.

WSL intends to continue exploiting the collected data in analysis and method development. A significant impact on safety and economic issues is expected as increased knowledge will help to prevent damage. Related tasks like avalanche warning or hazard mapping is expected to benefit from the knowledge which has been and is being generated. The Dorfberg data has been used to support a PhD-student for his dissertation on wet-snow avalanches. Several publications in peer reviewed scientific journals, and contributions to conferences (talks and poster presentations) have been produced out of this research (see below).

A second outcome of the project was to test the concept of on-site modeling. HYDROSYS aimed to provide the possibility of both triggering simulations from the field using real-time data input and visualizing the simulation results on-site. (outcome C2.4). In order to archive this goal the physical process models Alpine3D and Snowpack have been improved and adapted in the way, that they can run more operationally and provide results in near real-time. The efforts which were made to improve the models do now enable to apply them in a operational context. This will help that they can go into broader application in scientific and practical purpose. More non-experts and scientific partners of the WSL are now able to run the model for their studies.

As a side outcome of the project TKK aimed to develop a mobile cable-less sensor station to measure the highly important parameters snow moisture content and snow temperature. At the current state the sensor could not yet be tested in real application. Such tests are planed for the next winter season. If the sensor performs well, it will be further applied: It could be considered if the Swiss avalanche observers should be equipped with such a strait forward and easy to handle tool. Such a tool is currently not available but would be beneficial.

WSL has also a general interest and intention to exploit the results in their collaboration and dissemination activities with external institutions. To monitor possible deformation, tilting and settling of infrastructure built in retreating permafrost, changes in inclination of the building walls have to be monitored at the Gemsstock. Cable car-buildings and pylons have to be surveyed regularly by an engineering company and additional manual measurements of the geometry of the cable car station are taken by an employee of the cable car company on a monthly basis in order to detect potential deformations: data series on wall inclination have been collected manually over the past and have been archived on paper only.

The handheld devices developed in HYDROSYS aimed to improve this process (outcome S, C2): Inclination is measured automatically by placing the device at fixed benchmarks. Previous measurements can be directly visualized (onsite) and first interpretation on deformation can be obtained very quickly. The concept of on-site visualization and analysis of data showed to be very valuable in that task. Unfortunatelly at the current state the consortium is still struggling with the accuracy of the inclination sensor (Inertia cube orientation sensor): Currently the sensor does not provide the high level of accuracy which is required for the safety concerns in the scenario. More efforts on calibrating the sensor in a way that measurements, accurate enough for the end-user purpose can be obtained, are ongoing. If the required accuracy can be reached, more on-site testing of the system is going to be performed and a operational or even commercial exploitation of the system can be considered. If the task works out successfully, options for the further development of the device for monitoring infrastructure in a more general way might come up.

Details of confidential intentions are in the internal report.

Aalto University

Aalto University is a new university in Finland. Aalto assumed the role of TKK as a partner in HYDROSYS (The acronym TKK is still used in this document, however). Aalto brought into the project the contribution of two groups: Ubiquitous Interaction (UIx) and Environmental Planning and Management (EPM, now Environmental Informatics EI). UIx conducts research in the areas of mobile and ubiquitous interfaces and near future interactive systems. UIx works with ethnographies, quasi-experiments, interaction design, prototyping, field trials in real settings, and new technologies. Current research tracks include social and psychological aspects of using ubiquitous technologies, formats for collective creation of media and impact on group behaviour and practices, and designing for fluent interaction with multiple devices. A particular research track has entered the domain of mobile 3D maps, developing optimized 3D rendering techniques suited for mobile devices, and then applying the aforementioned methodologies in real world navigation tasks.

The EI group researched and developed tools for management of water in semi-urban environment in HYDROSYS. The group, which experienced several major changes while the project run, was led by prof. Ari Jolma and draw resources from geoinformatics, water engineering, environmental engineering, and environmental informatics groups in TKK and now in Aalto. The group worked most closely with Luode and HIIT but had also close interaction with Graz, LSIR, EFLUM and other HYDROSYS partners. The group also worked closely with the designated end users and other possible future exploiters of HYDROSYS results. Aalto has a long history carrying out water-related research focusing on water management and decision support with innovative methods and technologies, utilization of hydrologic and spatial data, hydrological processes, and measuring hydrological processes at different scales.

Aalto is an academic institution and thus its exploitation intentions are naturally focused on academic merits and education of students. However, there are also strong intentions to collaborate with and disseminate the research results to end users. TKK organized several field campaigns with Luode, which consist of sensor deployments, collecting data for monitoring, management, and environmental design. The environmental modelling activities run in parallel to these campaigns aiming at models being available for the final system prototype. The campaigns were arranged so that they contributed to solving real environmental management problems and thus interested end users. The intention is to exploit the research process itself in environmental problem solving by delivering valuable and focused environmental data and knowledge products (results of modelling and use of the system) to end users. In parallel, the outcome of the research process is a valuable experiment in modelling, which will be exploited in scientific publication(s) of the EI team.

The EI group gained more knowledge and expertise in observation of semi-urban water systems, measurement of small urban streams, many aspects of modeling, environmentally sensitive hydraulic engineering, specific software, and especially in developing comprehensive information systems for specific hydrological systems. The group will exploit the knowledge and expertise it gained in future research in the field, publications and dissertations, and collaboration.

The EI group will specifically use the system (outcomes S0, S1, S2, A0, B0, B4) in future collaboration with water engineering group of Aalto and other groups in developing and researching shared environmental information systems. The EI group is exploiting the knowledge and experience gained in HYDROSYS for further advancing the state of art in distributed environmental modeling. EI has started a project “Distributed Environmental Modeling”[4], which is a collaboration network with links to iEMSs and OGC.

The HYDROSYS project and research has contributed significantly to I. Ferencik's (a doctoral student in EI) doctoral dissertation.

Outcome-oriented exploitation

The follow section provides an overview of the initial exploitation plans of TKK (both UIx and EI) on the research project outcomes.

S0 the research prototype is intended to be exploited in-house in future research, education, and as a part of a collaboration platform with end users (water management administration, municipalities, infrastructure and engineering companies). For example the Real Estate Department of the City of Helsinki has long been a collaborative partner, with an aim of integrating the official survey data sets to a mobile 3D map interface. In HYDROSYS, this is being materialized with the Korkeasaari case area. Furthermore, the resulting system will be exploited as presentations and associated materials at expert workshops and seminars, including the entire Finnish GIS field, including events organized by the Cartographic society of Finland and ProGIS, to leverage the potential of mobile GIS applications with near real-time updated content, and 3D interfaces for more intuitive visualization of environmental content. Potential for commercialization of the system will be evaluated during the project.

Outcomes related to the environmental monitoring and management processes (S1, S2, S3, S4) , of which S1 is a pure knowledge outcome describing the current situation and the potential of HYDROSYS themes are intended to be exploited in collaboration with / to be disseminated to end users (presentations and associated materials).

S3 A unified data pipeline: The research will yield a data pipeline from survey data to a 3D representation running on mobile devices, including near real time sensor data. This process will be elevated to promote data standardization activities and openness of survey data management software. One practical issue is integration of Bentley’s Microstation CAD data sets onto the pipeline. Microstation is a large software utilized commonly by municipalities in management of survey data sets, but suffering from closed file formats and poor support for data interchange. Should HYDROSYS succeed in taking these data sets into the pipeline, relevant parts would be made into software releases.

[4]http://geoinformatics.tkk.fi/dem/

B4 simulation and modeling functionality integrated into GSN: This outcome is intended to be exploited as a key in-house knowledge and capacity at TKK/EI. Dissemination-oriented exploitation intentions include both publication of scientific papers and software releases. Longer term exploitation intentions include commercialization with selected partners.

B6 Improved physical models: This outcome is intended to be exploited by the TKK/EI mainly in collaboration with other research groups in the field and environmental engineers and managers. It also contributes to the in-house knowledge and capacity of TKK/EI and will be exploited in publication of scientific papers.

Both outcomes B4 and B6 are key components of a PhD thesis to be written within the project at TKK/EI.

B5 Pre-processing: raw data sets are not suitable for direct use on mobile devices, and need to be optimized and arranged to device friendly form. TKK's mobile 3D maps have always aimed for optimization of data and data representation. The HYDROSYS data sets are incorporated to this in-house development with a possible software release (S2.1). TKK's approach here is similar to the COLLADA standard for digital 3D assets, where a standard defines the form of raw data sets, but which are processed to useful formats suited and optimized for each application. TKK demonstrates and leverages this view actively in other standardization bodies such as the Web3D Consortium, which oversees the development of the X3D standard.

C1.1 Attention direction: TKK's mobile 3D map interface is designed to emphasize local salient cues for better orientation in the environment. The methods will be published in scientific conferences. Human factors on attention in natural environments are researched and also published. Exploitation of these results in larger scale is considered commercializable, and demonstrations given to companies that show interest on navigation systems, such as Navteq, Nokia and Google. Cooperation with these companies already exists and will be deepened.

C1.2 Graphics optimization: The core of TKK's research is in optimizing 3D graphical representations for mobile devices. This includes preprocessing of data (B5) using perceptual means (C3). These developments will be published in scientific conferences.

C2.2 Lightweight methods for annotations: TKK is developing a data model for semantic segmentation of the environment. This model, along with the segmentation information, facilitates fast association of annotations, not only to geographic coordinates, but to semantic contexts. As this association is done at annotation creation time, the link is stored along with the annotation to a database. Subsequent searches do not need to apply costly data mining techniques but can rely on the existing associations. In effect, this solution transfers the load of data mining from a post process (associations searched when data is needed) to a pre process, to the moment of creation of the annotation. This system will be demonstrated to GIS communities and commercial GIS software companies after publishing it in scientific conferences.

C3 Perceptually optimized visualization and user interface techniques: A mobile 3D user interface for navigating in virtual environments. 3D environments are emerging to mobile platforms, but the main obstacle in their success is the user interface. This component will be published on scientific papers and frequently used in demonstrations to leverage mobile 3D applications in general, and continued to be used for in-house development.

Details of confidential intentions are in the internal report.

University of Cambridge

The HYDROSYS team at the University of Cambridge specialises in computer and robot vision. It has experience in using cameras and other sensors for tracking and localisation which can be used in robot navigation and augmented reality applications. In the HYDROSYS project, contributes to several key project outcomes, the blimp capable of autonomous control (A1.1) for producing high resolution visual maps (A1) which can be fused with thermal imaging (A1.2), and the hybrid tracking system (C4) for the hand-held augmented reality setup (C2.1).

The work on the HYDROSYS project has increased the knowledge of the group through the development of new algorithms to meet the challenges posed by both the high resolution mapping from the blimp (A1) and hybrid tracking of the augmented reality setup (C4). It also gained new experience in developing algorithms which are able to utilize images from thermal cameras (A1.2).

Several of the techniques developed during the project are suitable for publication at academic conferences or in research journals. In particular, UCam team has submitted the method for building high resolution visual maps from the blimp (A1) for publication at a computer vision conference. The horizon tracking method, for which a significant amount of development has been done in the hybrid tracking system (C4), will be published in a computer vision conference after some required performance improvements. The entire autonomous blimp system will be described for a publication at a robotics conference (A1.1).

The new computer vision algorithms developed for this project have been released in the open source computer vision library, CVD. The underlying general numerical algortihms developed for the project have been released in the open source numerics library TooN. Also the algorithms needed to build visual maps from the blimp (A1) and the hybrid tracking system (C4) are available to the public.

The ergonomic and robust hand-held outdoor augmented reality setup (C2.3) hasl greatly increased the augmented reality capabilities of our group and will be used in-house after the HYDROSYS project to develop new augmented reality systems and test new techniques.

The blimp developed for the project provides a perfect platform for developing new aerial vision techniques and will greatly increase the capabilities of the group in this respect. It also provides an opportunity for collaboration with the Marshall Aerospace company. This collaboration will be pursued further to develop more sophisticated capabilities for the blimp system (A1.1).

Details of confidential intentions are in the internal report.

Luode Consulting Oy

Luode Consulting Oy is a company that specializes in waterway research and measurement technology, and plans and implements individualized monitoring programs. Business idea of Luode is to offer full comprehensive monitoring services for the needs of various customers operating in water sector. Luode staff consists of experienced specialists in water research. Research topics in hydrology, oceanography and hydrobiology, during both open-water and winter periods, are in Luode's field of expertise. The company is profiled as a high quality service provider which is based on professional staff and latest technology. Luode is active in developing environmental monitoring products and implements the latest high quality products on service selection of the company. Luode sees future marketing potential also in HYDROSYS final prototype and in its components.

As a commercial company the exploitation intentions of Luode focus in developing its own knowledge and capacity for being able to develop sellable products and services. Luode has an explicit intention to exploit the outcome of the project in developing its environmental monitoring products and services.

Luode is expressly intending to exploit the outcome S0, the complete prototype, in developing a comprehensive service for supporting its customers' decision making processes. Luode sees potential in exploiting the outcome in a future sellable system that combines and visualises all data that is needed for example to support decision making in urban planning. Such a system could also be used by the company in commercial educational material and workshops.

Luode also intends to integrate HYDROSYS complete prototype S0 to company's service targeted for general public in order to respond in increasing data processing and visualization needs of customers. Implementing the mobile 3D-client running in the mobile phone user interface requires a potential customer having a need to distribute visualized environmental data to large group of users. Potential customer could be for example a municipality willing to distribute water quality information to citizen swimming in the sea areas that are threaten by toxic blue green algae blooms. The service could be carried out in co-operation of Luode and a partner providing software functions (city, environmental institute, mobile phone operator). Further development is anyway needed to create 2D/3D-model and software to visualize monitored sea water data in the mobile client. Potential impact of the system showing sea water quality in real time is happier citizen and decrease in number of people exposed to toxic algae blooms.

In addition to complete prototype, individual outcome components can be integrated to Luode services. To improve data acquisition capacity, outcome A1, a blimp equipped with tracking system and sensors could be integrated to monitoring service product selection of Luode. System could potentially complement or replace current methodology in surface water quality mapping based on mobile onboard measurements and interpolation. The blimp based monitoring system could potentially increase density of observations and lead to economical benefits when mapping large surface water areas. The system could be carried out in co-operation with Luode and blimp operator.

Outcomes B0, B1, B2, B3 and B4, data storage, processing and distribution components could be integrated to existing Luode data service or components could be offered to customers as an alternative option. Especially implementing online simulation products combined with real time monitoring services have a significant marketing potential in several application areas. These services could be carried out in co-operation with Luode and simulation provider.

Luode intends to exploit the knowledge outcome of the project as scientific papers to increase its credibility as a science and technology based company. Specific innovations it intends to exploit in patent applications.

Details of confidential intentions are in the internal report.

Ubisense

Ubisense is a leading provider of precise real-time location systems (RTLS). The company was founded by engineers from AT&T Laboratories Cambridge combined with a veteran team of entrepreneurs. The Ubisense staff consists of experts in advanced radio-location technologies, radio communication systems and senior software engineers who provide integration services to our customers.

As a commercial company the exploitation intentions of Ubisense focus in developing its own knowledge and capacity for being able to develop sellable products and services. Ubisense intends to exploit the project outcomes as such, but also as a background when starting or entering into new projects, which aim to develop systems and applications with similarities to the HYDROSYS system.

Ubisense's unique UWB hardware in combination with a comprehensive distributed software platform is allowing companies in many different industries to monitor and improve processes and to drive improvements.

Ubisense will be exploiting the outcome C4.1 (A quickly deployable and movable high-accuracy tracking setup extension) of the project in future collaboration with other parties, but the exact nature of the collaboration and names of partners can't be disclosed at this point. The projects may consider environmental monitoring and management but they also may consider problems faced by police, fire and rescue, and other services.

An explicit future exploitation scenario in the domain of cognitive systems and robotics could be following. Firefighters, policemen or soldiers want to send robots for assessing a dangerous building or area. A vehicle/truck with Ubisense sensors will stop somewhere in front of the entry of the building and the robots equipped with tags will get an accurate position and continue moving into the building (where no localisation sensors are installed). These robots have inertial navigation sensors and need only to get an initial correct and reliable position at the entry of the building (where GPS may fail). The scenario requires new approaches towards endowing robots with advanced perception and action capabilities. In particular, this target outcome could address 3D sensing, motion and affordance perception, and benchmarking for navigation and autonomy. Therefore, the outcome of C4 (A hybrid tracking system for accurate localization of users on-site) could bring a background of experience.

Ubisense also intends to exploit the outcomes of C4 in assessing and improving the localization for outdoor applications with closely spaced sensors. This is a challenge since an increase in the range over which a good accuracy is reached is needed. Ubisense has now experience rather for the indoor field with sensor distance of almost 10-15 meters and range of around 20-30 meters. The HYDROSYS project is the first application where the vehicle setup with closely spaced sensors and a requirement for good accuracy over high range is assessed.

Details of confidential intentions are in the internal report.

4.3 Strategic outlook

The consortium has assumed a continuous and structured approach to dissemination and exploitation. The main steps and directions are

- to develop and strengthen the in-house knowledge and capabilities,
- publish research results quickly in conferences and in high-quality periodicals,
- collaborate with academic partners, focus on exploiting the results,
- inform the public and disseminate to public use, and
- use the SME university synergy present in the consortium to make ground for new products and services.

Above the general structure of exploitation was laid out. In the first level the results are used internally, to increase in-house knowledge and capacity. In-house knowledge and capacity is the foundation on which higher level activities rest. Activities to seek and establish collaboration with external institutions form the second level of activities. The third level of activities consist mainly of publishing those results that are deemed worthy of it and/or ready for it. Publishing is done in many levels, the most immediate ones as verbal communication with close end-users, and the most elaborate ones as articles in high quality journals or as books. Often high-quality publications, i.e., those ones that are most widely used as foundations of new work, are based on a longer research track and/or involve authors actually working in several projects. On the fourth level of disseminating research results we see scientists delivering directly to external institutions or companies. In some cases these companies are university spin-offs. In the case of consortium companies, activities in this level may for example be releases of new products.

The project consortium publishes HYDROSYS research results in increasingly high-quality and varied forums. Also there are collaboration efforts going on and in some cases bearing fruit. EPFL for example is reporting very promising collaboration efforts with South-African counterparties.

During the third year an effort was made to advance to the highest level in dissemination and exploitation, namely delivery of research results out of the academia into companies, or indications of planned new products or services. As these as mostly sensitive information it is reported in the internal part of the exploitation report.

The strategic approach to dissemination and exploitation activities adopted by the consortium was to form it as a continuous process throughout the project and maintain the momentum in key matters after the project. This approach supports the long-term impact and sustainability of the project results. The activities are considered and organized at three levels: local and regional (focusing our end-users), national (focusing national experts, professional associations and meetings), European (focusing European institutions, meetings and organisations), and international (focusing highest level international societies, conferences, journals, and other). The project addresses some highly specific research challenges and develops solutions those. In the same time, integrative work is carried out in the project to develop insights and solutions to broader issues, or issues that cover a broader set of contexts.

A part of HYDROSYS was concerned with the transfer of scientific knowledge to the public. This was and parly will be achieved through scientific publications, forecasting and prediction tools, data dissemination through the web portal and also through public participation techniques (example: field trips, environmental education, and workshops). Moreover, on-site monitoring makes HYDROSYS visible to the research community as well as to the public. The developed extensions to the GSN systems are accessible to the relevant research and development community and eventually end-users. This allows follow-up projects to use these extensions similarly as HYDROSYS relies on development done in previous projects. The vast majority of the developed extensions will be of general purpose, i.e. their applicability and usefulness is not limited to HYDROSYS. Those include in particular the data querying, data security, data modeling, data quality and data control components.

Exploitation of the project outcomes are also discussed in report D6.3 from the point of view of application of the HYDROSYS system to environmental monitoring and management.

5 Conclusion

The HYDROSYS research project run from June 1, 2008 until the end of May 2011. The project developed many outcomes the most important one being the complete research system prototype. This report describes all dissemination actions throughout the project and reveals the non-confidential exploitation that already took place and the intentions of the consortium.

A major part of the dissemination consisted of focused communication with end-users, including the advisory board members. The communication took place both indoors in workshops and outdoors on-site. The project outcomes have been described in extensive and detailed reports, many of which are public, and in numerous conference presentations, posters, scientific papers and articles in professional magazines etc.

The consortium has gained a substantial amount of new in-house knowledge, capacities, and know-how, which it has exploited and will exploit in future research, development, collaboration, and other business. The project has contributed to new environmental data sets and new free and open source software. The project has collaborated with other projects, notably with the SwissEx project, resulting in mutual benefit.

The project has communicated about itself in public media, publicity materials distributed in many occasions, and through the web. Information about the project and its outcomes is easy to find. The outcomes of the project are available and they can be exploited by the research community and by the industry.

6 Abbreviations

DFKI German Research Center for Artificial Intelligence

EPFL Ecole Polytechnique fédérale de Lausanne

FFG Austrian national research funding agency

HITLab Human Interface Technology Laboratory

ICT Information and Communication Technology

SensorML Sensor Markup Language

SwissEx Swiss Experiment project

TKK Helsinki University of Technology (Now a part of Aalto University)

TUG Technische Universität Graz

UCAM University of Cambridge

UCL University College London

UNISA University of South Australia

WSL Swiss Federal Institute for Forest, Snow and Landscape Research