

*Department of **Civil,** **Environmental** and **Geomatic Engineering***

Annual Report 2003



ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Table of Contents

| | |
|---|----|
| Preface | 3 |
| Our Focus | 4 |
| Soil-Structure Interaction | 6 |
| Transport Infrastructures | 8 |
| High-Tech Geodetic Systems for Global Atmospheric and Space Geodetic Research | 11 |
| Highlights | 14 |
| Structures | 14 |
| Infrastructure Systems | 16 |
| Resources | 18 |
| Geo-, Structural and Environmental Data | 20 |
| High-Tech Measuring Systems | 22 |
| Studying at the Department of Civil, Environmental and Geomatic Engineering | 24 |
| Facts and Figures | 25 |
| Addresses | 27 |



Preface

The Department of Civil, Environmental and Geomatic Engineering of ETH Zurich is on its way to becoming a leading research and teaching institution in the field of man-made infrastructures and their interdependence on natural resources and spatial development. We are convinced, that these topics will be the predominant challenge for civil, environmental and geomatic engineers in the future. Therefore it is evident, that our curricula and research focus on new technologies and processes contributing to a sustainable development of society, economy and nature.

It is our prime goal to teach and train our undergraduate and graduate students on the basis of science and ethics, so that they will be able to identify future problems far in advance, to develop smart solutions and to implement them successfully within the narrow constraints of an increasingly demanding and unstable social, economic and political environment. Despite the fact that the importance and the image of the basic sciences is still growing, we are proud to educate engineers to be the future problem solvers for the benefit of mankind.

But also in research we strive towards implementing our long-term strategy. This has a direct impact on the search for and appointment of new professors: Besides our traditional strengths in civil engineering, we are looking for a continual improvement of our competences in environmental and geomatic engineering in order to deal completely with the huge potential of our unique combination of disciplines. In addition, our department promotes interdisciplinary research projects launched by several professors with the allocation of additional resources, such as PhD positions and seed money. All these efforts aim at leadership in engineering at an internationally acknowledged scientific level.

Hans-Rudolf Schalcher
Prof. Dr. sc. techn.
Head of Department



Our Focus

Implementation of our strategy

During the year 2003 we started to implement the long-term strategy of our department, which aims at focusing more precisely on man-made infrastructure and its interdependence with natural resources. This strategy is fully in line with the strategic plan of the Board of ETH (ETH-Rat) for the period 2004–2007 that designates infrastructure, natural resources and sustainability as key issues for the future.

Implementing an academic strategy corresponds on the practical level to shaping the profiles of new professorships accordingly. Therefore our department has decided during the last year to

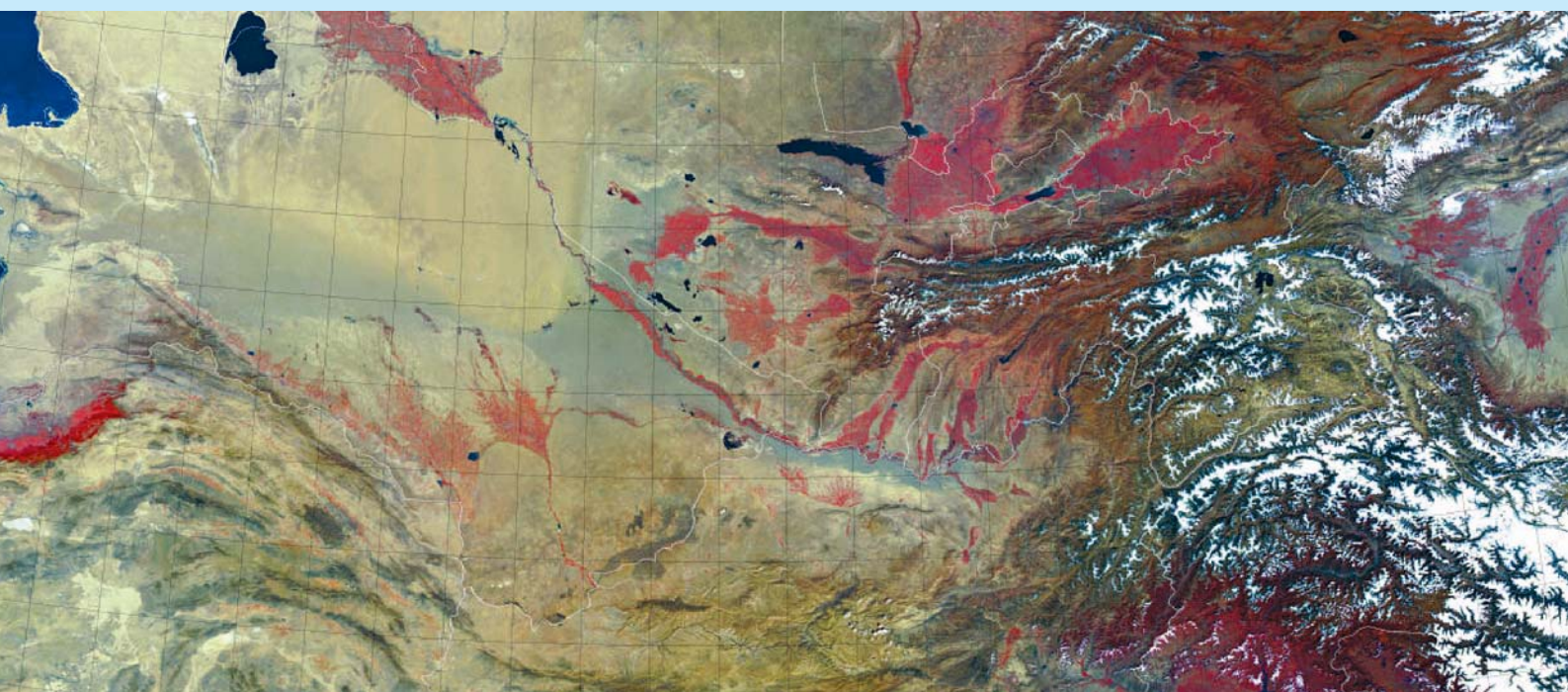
search for two new full professors in the fields of spatial development and of solid materials management and waste disposal technology.

A crucial problem for our department has emerged from the top down decision of the Board of ETH Zurich not to replace the faculty position in computational science in civil engineering, to become vacant in 2004. The loss of such a basic competence will create serious threats to teaching and research in civil, environmental and geomatics engineering. Thus we risk losing attractiveness for Swiss and foreign students at the graduate level, especially for PhD students.

The ongoing financial restrictions imposed by the Swiss Government are a further hindrance to the successful implementation of our strategy for the years 2004–2007. This situation doesn't allow us a rapid adjustment of our scientific focus and of the corresponding organisational structure demanded by rapid global changes.

Strengthening the links with industry

The Holcim Foundation for Sustainable Construction, established in 2003 and located in Zurich, has decided to sponsor an assistant professorship for sustainable construction to be based in our department. The search for the suitable person in accordance with the general guidelines of ETH Zurich will start in early 2004 and the position will be financed from 2005 until 2010. This generous endowment by one of the world's largest cement, concrete and aggregate producers earns our thanks and illustrates how the collaboration between universities and industry could develop in the future.





The new tenure track system works

Two years ago ETH Zurich established a tenure track system for assistant professors. Our department took the chance immediately and applied for tenure of the professor for risk and safety. After a thorough evaluation by the tenure committee of ETH Zurich, our application was approved by end of 2003. We congratulate Prof. Dr. Michael Faber and welcome him as a full professor in our department.

Student intake

The positive trend since 2000 regarding the number of new students has turned out to be robust. In autumn 2003 168 students started their undergraduate studies in our department. Luckily, 25% of them are female. This proves that the various attempts to attract more women to an engineering education show the anticipated result. While the number of beginners in civil engineering and

in geomatics engineering has remained more or less stable, environmental engineers have shown a big increase to 60 new students.

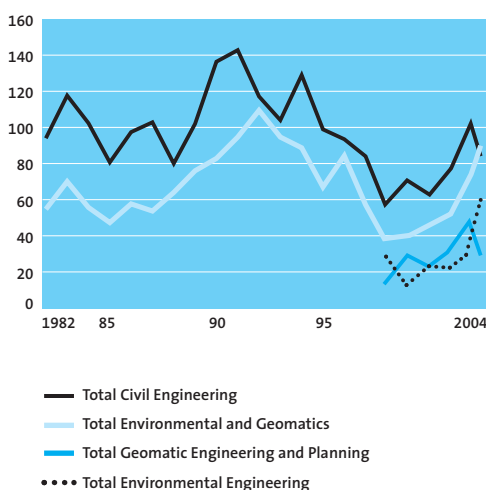
The Bachelor program has started

Our department has started to implement the new study model according to the Bologna Declaration in autumn 2003. With the beginning of the winter semester 2003/04 we are offering bachelor programs in civil engineering, environmental engineering as well as in geomatics and planning. These programs last three years and are completed with a bachelor thesis. It is the ruling

policy of ETH Zurich, that the bachelor degree doesn't mean professional competence. The bachelor degree is considered a prerequisite to entering the master programs and as a qualified platform for student mobility.

The master programs of our department will start in autumn 2006. They are still at the stage of fine tuning. It is planned to offer such programs in civil and environmental engineering as well as in geomatics and planning. In addition there will be master programs in "spatial development and infrastructure systems" and in "natural hazards engineering". Together with the Department of Architecture we plan to develop jointly two master's programs in the fields of "urban and landscape design and planning" and of "technology and management in construction".

First Year Students 1982 – 2004



Soil Structure Interaction

Sarah Springman, Jan Laue

Soil Structure Interaction (SSI) inevitably plays a rôle for any structure that cannot be founded directly on or in rock, and hence SSI must be considered for a vast range of civil engineering structures. This subject remains one of fascination both in industry and in research, largely because of the challenges associated with working across the thematic divide and understanding the effect of the structure on the ground, and vice versa under increasingly more demanding spatial and societal conditions.

Modern attempts to codify conceptual and actual design have been aided by the recent development of the thematic Swisscodes, under the leadership of Professor Peter Marti, with further contributions being made by Professors Thomas Vogel (actions), Mario Fontana (steel, timber, composites, fire) and Sarah Springman (geotechnics). This has formalised the process across the Swiss civil engineering world, enabling a common philosophy and technical language to be adopted across all disciplines, aiding communication and design activity, with the intention of leading to optimally safe and economic structures. The adoption of the potentially cost saving observational method has also been introduced within the geotechnical design process, together with rules for

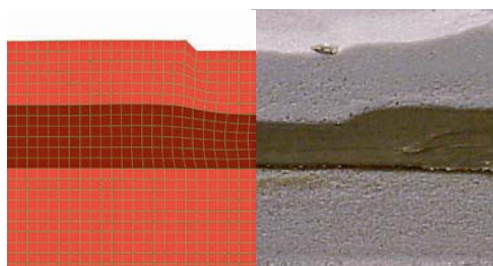
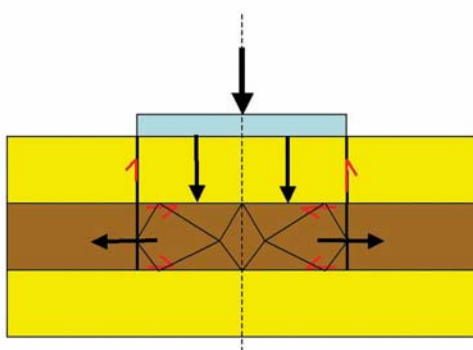
the acceptance of risk. In this respect, new design methods related to Soil Structure Interaction may also be established based on results from physical model testing.

Recent SSI research within IGT has focused primarily on either excavations in or embankments on highly anisotropic soft lacustrine deposits (Diss. Trausch Giudici, Messerklinger, Weber) or foundations subjected to both static and dynamic loading. Determination of both the serviceability and ultimate limit states has become important as a function of the respective deformation and failure mechanisms. The soil models are often inadequate for accurate prediction of structural deformations related to excavations and the mechanics background to the classical calculation methods for shallow foundations are questionable, whereby assumptions are made about homogeneity isotropy. These and other uncertainties were covered by large global factors of safety in earlier design practise. Key issues in the research revolve around the relative geometries and stiffnesses of

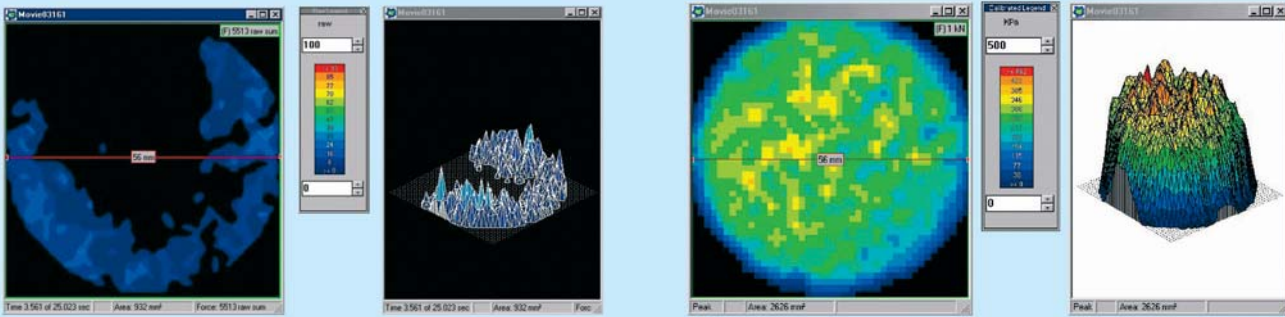
the structural and soil systems so that the effect of soil strata can be taken into account more realistically for future complex systems.

Investigations of the response of shallow foundations on layered soils to uniform vertical loads have been carried out at diploma thesis (Ducksch, Herzog, Glanzmann, Tanner) and doctoral level (Diss. Nater) using combinations of analytical methods, as well as physical and numerical modelling. Current design methods are inadequate because they do not allow for the extrusion mechanism in the clay layer, and may lead either to an under- or an over-estimation of bearing capacity or settlements at working load. The Figure below shows a comparison between results obtained from testing a 56 mm diameter rigid footing in the IGT/ETHZ Geotechnical Centrifuge at 25 times earth's gravity, simulating a 1.4 m diameter footing. This event has also been modelled numerically at full scale using a finite difference approach with a Mohr Coulomb yield criterion, including stress dependent increase of undrained shear strength and strain dependent stiffness within the yield locus.

Modern measurement techniques adapted from biomedicine have aided the determination of the interaction between the foundation and ground, showing the evolution of the bearing pressure as



Extrusion of soft material between two stiff layers (sand/clay/sand) due to the vertical loading of a 1.4 m diameter foundation: (left) failure mechanism, (center) result from finite difference numerical modelling, (right) centrifuge physical modelling



Load distribution under an axisymmetric footing on sand under applied normal stress of c. 225 kPa (right) and at an earlier stage under 49 kPa (left).

the soil response evolves from small elastic strains to increasingly plastic flow. This will be used in future for examining the different load-deformation distribution across the footing when a more flexible structural system is adopted.

A further dimension is added by the incorporation of cyclic or dynamic loads, either due to semi-repetitive events based on known loads (e.g. temperature induced changes in strut loads in excavations, infrastructure for high speed trains) as well as less easily predictable events, for example those due to earthquakes. IGT has recently been involved in a multidisciplinary project (with U. of Bogazici, Istanbul, D-ERDW, ENAC/EPFL) related to microzonation according to the risk of site amplification (of the signal at bedrock), slope instability and liquefaction. In the latter case, the rapid loss of stiffness and strength occurring in certain potentially liquefiable soils (typically sands and silts) has caused significant structural distress, whereby the

feedback between soil and structure becomes uniquely linked as liquefaction proceeds from partial to full, where no effective stress can be mobilised between soil particles.

A new dynamic hollow cylinder device (R'EQUIP/ETH Fond) will enable soil response to be determined from a typical soil element due to a combination of dynamic and structural loading (Diss. Buchheister), depending not only on soil conditions, but also on the initial stress conditions. These vary for a soil element located under the centre of a structure and another element at the side of the foundation before a seismic event, causing significantly different responses and effects on the structure. Two dimensional effects related to the acceleration of the earthquake can also be considered. This project will then provide soil condition indicators to feed into a new generic risk analysis tool, which will be developed in a D-BAUG research group led by Prof. Michael Faber and including Professors Hans-Rudolf Schalcher, Armin Grün, Alessandro Dazio and Dr Jan Laue. Methods for

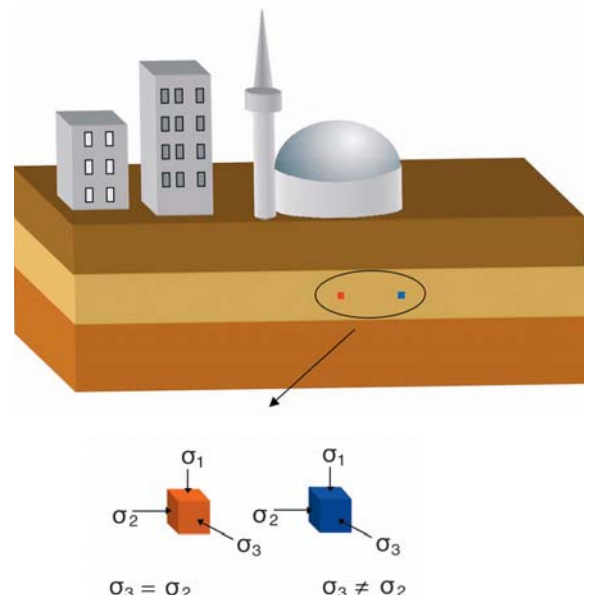
making deterministic assessments of actual risk will be developed as well as generic procedures for taking uncertainties into account over a time period including pre-, during and post-earthquake.

These aspects, and important new developments in Soil Structure Interaction, are incorporated in teaching at all levels, from the basic and obligatory courses through to the selected topics, which may include Design and Construction in Geotechnical Engineering, Modelling in Geotechnics (consisting of constitutive, physical and numerical variants) or Soil Dynamics and link in to advanced courses offered in Structural Engineering, including Structural Dynamics together with many SSI-focused semester and diploma projects.

Collapse of a mosque during the Kocaeli-earthquake in Turkey (1999)



Influence of location of soil element on in-situ load distribution, with implication for subsequent stress paths due to earthquake loading (Example from Microzonation Project in Turkey).



Transport Infrastructures

K. W. Axhausen, H. P. Lindenmann, J. Wichser

Understanding – measuring – forecasting – operating

These four aspects of infrastructure engineering will be the focus of this contribution. They stand pars-pro-toto for the life cycle of an infrastructure from the need identification, planning, design, construction, to operation, maintenance and evaluation. Research focusing on infrastructures in the Department is much broader than presented here this year, as active research is going in areas such as water resources, hydraulic engineering, bridge design and monitoring, geotechnics, navigation, GIS or urban service provision. The examples will be drawn from the Institute for Transport Planning and Systems (IVT) and will sketch the range of the three groups making up the Institute: transport planning, transport systems (public transport) and transport systems (road traffic).

Understanding: Human activity spaces and innovation in location choice

One can understand transport demand models as models of daily life in as much as they predict the when and where of a population's activities for an average day. Travel and traffic are only the results of these activities, excepting those where the movement is the purpose of the activity, e.g. walking the dog, jogging or a pleasure drive with the car. Current state-of-the-art models approach daily life as a set of decisions, which are dependent on each other. The relevant statistical models account for the dependency of the choices, but also for the taste differences of the different people in these choices. What they do not properly account for is the dependency over time. How much structure and habit do the choices of a person exhibit over time?

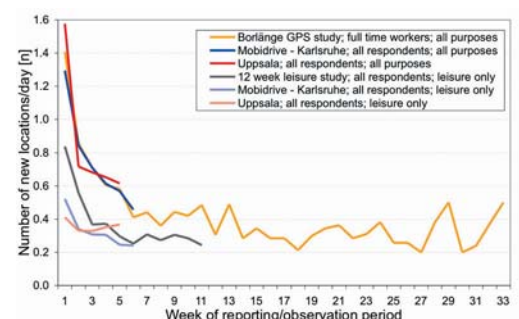
If, indeed, there are strong habits and visible structures, then choice models will have to account for them in the future. Recent work at the IVT has addressed both aspects, but only the question of spatial structures will be discussed here. The IVT has currently the largest set of longitudinal travel diary data sets available for its research, for most of which it designed the survey itself. In each of these from 35 to 365 days long datasets the destinations of the travelers are geocoded allowing an analysis of the spatial distribution of these destinations.

While biologists have worked with similar data for animals for some time, these new datasets open up possibilities that transport researchers never had before. In the first instance, we developed a set of measures to characterize the size, structure and orientation of the activity space of an individual, i.e. the area which a person is actually using. The main driving force behind the size is the number of activities a person performs, which in turn can only be very partially explained by the obvious socio-demographic characteristics of the traveler. Beyond the size of the activity space we can identify the number of distinct locations which a per-

son visited during the reporting period. The ratio of the number of activities to distinct locations varies around 4 per activity, but the distribution of visits per location is heavily skewed. Normally, the 10 most heavily visited locations make up 80% of the activities. On the other hand, people continuously add places to their repertoire of places visited. While it is possible in each survey to identify the places (classified by both geocoded location and purpose of visit), which had not been visited before, we had included only in one survey the question, if this visit was the first ever visit to the place. The ratio was about 1 to 10. Figure 1 summarizes the relevant results for three surveys. Given the way the new places are identified it is not surprising that the number goes down in the first part of the reporting period, but what is surprising is the steady stream of new locations and places even after a number of weeks of observation.

Both results are a challenge to current choice modeling approaches, as they indicate a strong serial dependency in the choices: both the preference for a small number of core locations, as well as the wish for variety for its own sake demonstrated by the continuously added new locations.

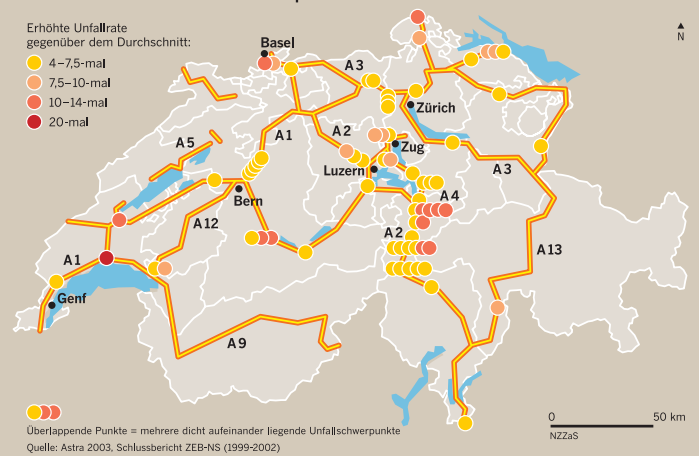
Number of new places visited over the reporting periods of three surveys



Die 70 schlimmsten Unfallschwerpunkte auf den Schweizer Nationalstrassen

Erhöhte Unfallrate gegenüber dem Durchschnitt:

- 4-7,5-mal
- 7,5-10-mal
- 10-14-mal
- 20-mal



Current accident black spots on the Swiss motorway network.

Source: NZZ am Sonntag, 7.12.2003

Measuring: Current condition of the national motorway network

The IVT directed the work behind the first full-scale assessment of the condition and safety record of the Swiss national highways (federally funded), by and large its motorways (Zustandserfassung und -bewertung Nationalstrassen Fahrbahnen (ZEB-NS)). This effort was motivated by the need for the national and the regional governments to improve their knowledge about the pavement performance and safety levels, as well as the maintenance and long-term financial needs of the aging primary road infrastructure. This is especially crucial as both levels need to plan for future expansion and extension of the network at the same time.

In a series of major measurement campaigns since 1998 a range of variables were measured to describe the conditions of the roads: grip, horizontal and vertical roughness, structural strength and finally the accident record of each segment of the network. The segment lengths varied between 100 and 500 meters. To allow comparability the conditions were graded between 1 and 5 (very good to not sufficient) following the Swiss code

SN 640 925. The generally good to very good conditions reflect the high level of investment and maintenance afforded by the continuous funding of the road system, as provided for in the Swiss constitution, which details a share of the fuel tax income for this purpose.

For the analysis of the safety record all accidents for the last five years were geocoded to allow an analysis of the accident black spots in the network. While the safety record of the motorways is impressive in terms of accident rates per 10^6 vehicle-km, there are localized problems, which need further attention.

The ZEB-NS provides the owner of the national highways with the information necessary for its planning and budgeting of the maintenance and rehabilitation of its network and for the investment in an improved safety performance. An update is planned for the period 2004/05.

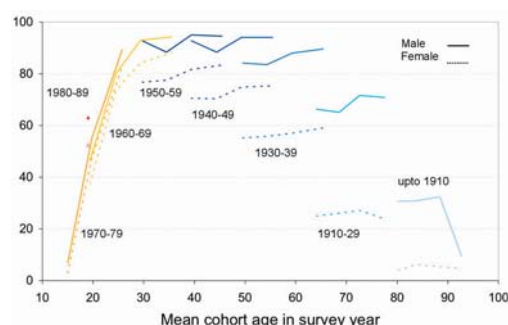
Forecasting: Swiss travel demands in 2030

The Federal Office of Spatial Development (Bundesamt für Raumentwicklung; ARE) is regularly updating its long term perspectives of Swiss travel demand. As part of the current renewal the IVT was asked to provide a forecast of the number of persons owning mobility tools in 2030 and of the average number of kilometers of travel they will demand.

Mobility tools is a summary term for vehicles (cars, motorcycles, etc.), public transport season and discount tickets, which a person or household acquires to enable its travel. These are longer term decisions, with which the household determines its short term marginal cost of travel. Daily modal choices are then fairly obvious for the traveler. It is therefore crucial to understand how persons choose these tools, if one wishes to forecast the demand for travel by mode, as the IVT had been asked to do. A set of sequential choice models was estimated to explain and predict the share of owners of the different mobility tools as a function of the usual socio-demographic variables, but also a detailed description of the location of the household and the speed on the regional transport system.



Pavement condition on the Swiss motorway network



Share of car driving license holders by age-cohort and sex among Swiss residents



Horizontal transfer device

Source: Tuchschnid AG, Frauenfeld

The driving license is the precondition for the access to cars. Inspection of the current share of license holders by age and sex shows what change can be expected in the next thirty years. With the departure of the pre-war cohorts the number of license holders will substantially increase and the current difference in ownership rates between men and women will disappear.

The models for the travel demand were based on the series of national travel surveys since 1984 and used the same person, location and network variables as the ownership models. In addition, a time trend was included to capture the unobserved structural changes of the last twenty years. We are aware that such a simple approach has its dangers, but nothing more complex was possible in the given timeframe.

A national average does not do justice to the variability of conditions in the country or to the differences between the various groups of persons, in particular the age cohorts. Therefore the IVT performed the forecasts separately for each municipality and each age group by sex within them. A special software tool was developed to support the large computational effort involved in this numerical task. Additionally, for each forecast of a business-as-before scenario error bands were estimated to give the user an understanding of the uncertainty of forecasts over such a long period.

Operating: Horizontal transshipment between rail and truck

Combined freight traffic employing both rail and truck stages is currently handicapped by the costs of the transfer of the container from rail wagon to truck. Regarding the labour costs, it is the investment in the dedicated infrastructure of cranes, tracks and access which creates problems for the widespread provision of terminals. Continuing previous work, the IVT was involved in the 5th framework-funded InHorTra consortium, which designed, built, tested and evaluated three new horizontal transfer devices. These devices reduce the cost-base of a terminal considerably, which makes smaller scale terminals servicing smaller catchment areas feasible.

The IVT contribution was focused on the development of freight service concepts, which would make full use of the possibilities of the new devices. Drawing on much experience with railroad simulation systems (see www.opentrack.ch) it developed tools to simulate the new services and the operation of the terminal to suggest further possible improvements.

The new terminal concept can make a noticeable contribution to the politically-desired shift to rail-based freight by lowering the costs of the operation and by reducing the access- and egress cost of the shipper to the terminal, while maintaining or even improving service through shorter and more reliable terminal times.

Outlook

The provision of a welfare-enhancing traffic infrastructure is a central task for each industrialized country, especially for a densely populated one like Switzerland. The IVT contributes to the further development, operation and maintenance of these networks by its research into all aspects of the infrastructure lifecycle: need identification, planning, design, construction, to operation, maintenance and evaluation.

High-Tech Geodetic Systems for Global Atmospheric and Space Geodetic Research

Marc Troller, Alexander Somieski, Beat Bürki, Alain Geiger and Hans-Gert Kahle

Water Vapor, Atmosphere and Geodesy

Tropospheric water vapor plays an important role in atmospheric and space geodetic sciences, especially in the evolving field of space geodesy. It is the most variable parameter of major constituents in the atmosphere. Water vapor is one of the important greenhouse gases and involved in the decomposition of the ozone layer. Atmospheric humidity has a strong impact on the refraction of microwave signals emitted by GPS satellites. This results in an overestimation of the distance between satellite and receiver. The so-called path delays enable the determination of the amount of atmospheric water vapor, which is usually expressed in terms of the integrated precipitable water vapor (IPWV). The goal of the project described here is to develop methods to determine the content of the atmospheric water vapor as well as its spatial distribution on a continuous base and with high accuracy and reliability.

Methods of Measuring Water Vapor

Two kinds of approaches exist to assess the water vapor content: either the IPWV along a signal path or its distribution by measurement at specific locations. The IPWV can be determined with GPS, radiometers, solar spectrometers and space-borne systems (METEOSAT). Measurements at specific locations are usually carried out with radiosondes, which provide vertical profiles and serve as a basis for determining the 3 D distribution. The new approach, which we have pursued, is using the IPWV to resolve the spatial structure with high temporal and spatial resolution (GPS tomography).

Integrated Water Vapor Content

The radiometric determination of IPWV is based on intensity measurements of radiation, which is emitted by H₂O-molecules due to thermal excitation. The technique utilizes the relation between water vapor abundance and thermal radiation emitted at the 22.235 GHz spectral line. Several prototypes of these instruments have been developed at the Geodesy and Geodynamics Labora-

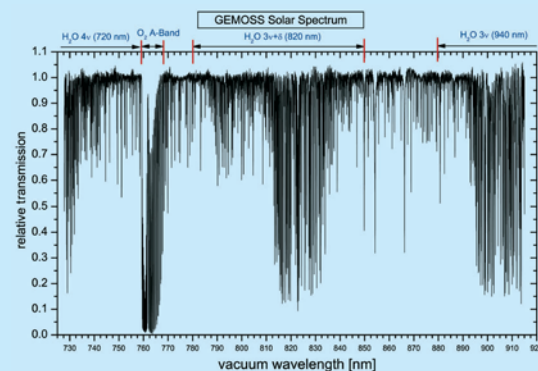
tory (GGL) of the Institute of Geodesy and Photogrammetry (IGP). Figure 1 shows the new radiometer WVR2000.

Solar spectrometers utilize the absorption of the solar radiation traversing the atmosphere due to water molecules. A portable field-capable type was developed at GGL in cooperation with the Institute of Spectrochemistry and Applied Spectroscopy (ISAS, Berlin): the GEodetic MOBILE Solar Spectrometer (GEMOSS). It resolves single water absorption lines in the range between 730 nm and 910 nm. Since GEMOSS acquires up to 4 solar spectra per minute containing numerous absorption lines, a high accuracy of IPWV can be achieved. A measured solar spectrum with hundreds of absorption lines mainly from water and oxygen molecules is shown in figure 2. A total absorption of solar radiation due to oxygen molecules is visible near 760 nm, whereas water molecules absorb strongly at around 820 nm and 900 nm.

Fig. 1: The new Water Vapor Radiometer WVR2000 installed at ETH HÖNGGERBERG.



Fig. 2: Solar absorption spectrum (730-910 nm) measured by the Geodetic Mobile Solar Spectrometer (GEMOSS). The integrated water vapour content in direction to the sun is retrieved by quantifying the amount of absorption of sun radiation.



A dedicated field campaign ESCOMPTE (expérience sur site pour contraindre les modèles de pollution atmosphérique et de transport d'émissions) was performed to measure atmospheric gases in the air-polluted region of Marseille. A network of 16 GPS-receivers, the radiometer and solar spectrometer as well as radiosondes were deployed. Figure 3 shows a time series of IPWV over a range of 5 days. A significant variation of the IPWV was detected by all techniques with good agreement.

GPS Tomography and 3D Water Vapor Information

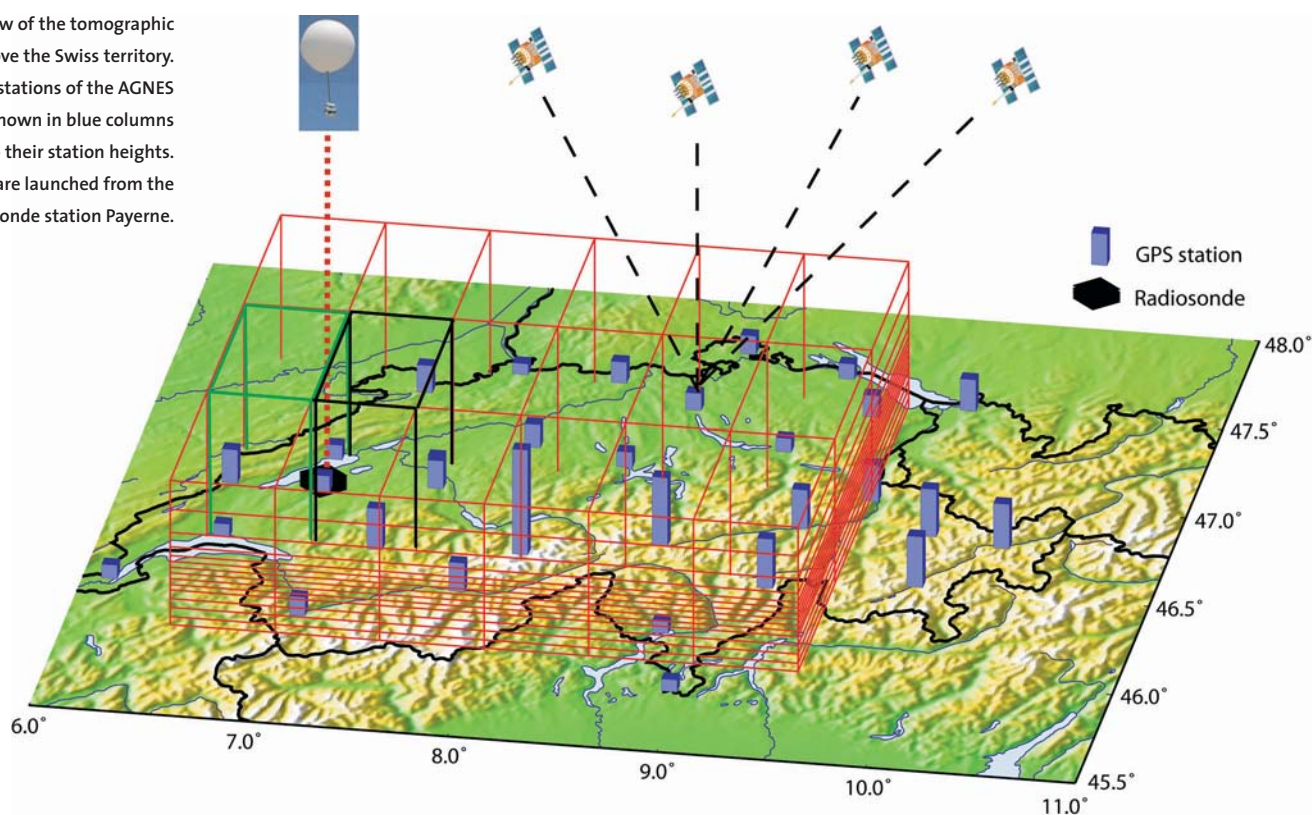
In GPS tomography, the structure of the atmosphere is elucidated. The signal emitted by the GPS satellites propagates through the atmosphere and arrives at the GPS receiver after a time lag which corresponds to the distance satellite - receiver. The elapsed time depends also on the physical parameters of the ionosphere and troposphere. The water vapor in the atmosphere causes systematic delays, the effects of which are exploited in GPS tomography. Since horizontal measurements are not possible, and because the number of GPS satellites and receivers are limited, boundary conditions have to be introduced in the adjustment

procedure to achieve the desired result. Promising results of profiles of water vapor were obtained with a high temporal resolution and at every location within the area of the GPS receivers.

A dedicated field experiment of GPS tomography was conducted within Switzerland. The GPS national reference network AGNES of swisstopo was used for this study. It consists of 29 GPS stations, equally distributed over Switzerland. A 3-dimensional box model dividing the atmosphere into discrete cuboids was introduced in the adjustment system (Figure 4). External data, such as radiosondes, have

Fig. 4: 3D view of the tomographic box model above the Swiss territory.

The GPS stations of the AGNES network are shown in blue columns according to their station heights. Radiosondes are launched from the radiosonde station Payerne.



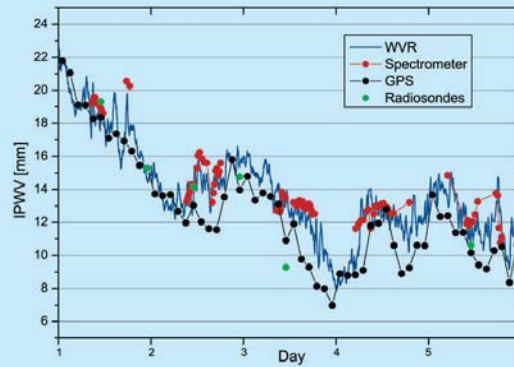


Fig. 3: Time series of IPWV during 5 days. In addition to the GPS receiver network, radiometer, solar spectrometer and radiosondes were deployed.

been used for the validation. They are usually launched twice a day from the station at Payerne. Figure 5 shows a radiosonde profile and two profiles obtained from GPS tomography for two nearby columns. The tomographic solutions fit the radiosonde profile very well. The statistical evaluation shows, that, together with additional information, a sufficient accuracy of the water vapor determination can be achieved. A cross section of the tomographic box model is depicted in figure 6. The rapid change of water vapor distribution in horizontal direction is clearly seen.

Concluding Remarks and Outlook

Geodetic systems are successfully applied for estimating the water vapor of the atmosphere. GPS, radiometers and mobile solar spectrometers achieve a high accuracy and reliability for the determination of integrated water vapor. They provide long-term series of the total amount of water vapor for several applications, both in space geodesy and in the field of climate and atmospheric

research. The spatial distribution of water vapor is successfully obtained by the method of GPS tomography. An accuracy equivalent to radiosondes can be reached. However, the spatial and temporal resolution of the tomographic approach is much higher and provides nearly continuous information. With the development of GALILEO and improvement of GPS, a considerable increase of accuracy can be expected. Geodetic measurement systems will, therefore, contribute substantially to recent issues of space geodesy, climatology and atmospheric science.

The ETH-funded project GEMOSS is conducted in cooperation with Prof. Hans Richner of the Institute of Atmospheric and Climate Sciences. We are grateful for funds provided under the ETH research grant No. 00860/41-26475/AW/ML.

With this research topic, Marc Troller and Alexander Somieski participated at the Prix du Jeune Entrepreneur de la Section Suisse des Conseillers du Commerce Extérieur de la France. For further information reference may be made to ETH-Life (<http://www.ethlife.ethz.ch/articles/KahleGPS.html>).

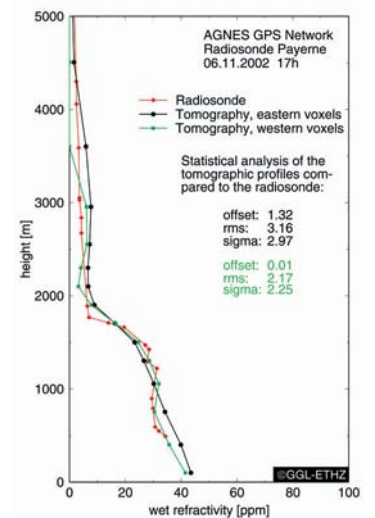


Fig. 5: Comparison of a radiosonde profile vs. two tomographic determinations. The tomographic profiles are from the box column near the radiosonde station Payerne (indicated in green and black color in figure 4).

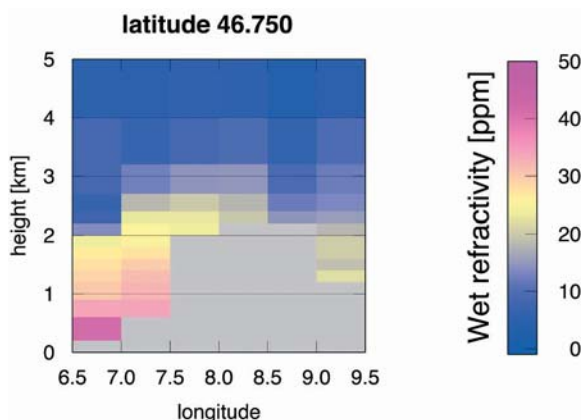


Fig. 6: Cross section of the tomographic box model.

Structures



New Material Development: Hybrid Fibre Concrete

New materials may open the road to new structural applications in civil engineering. Over the last few decades not much improvement has been made in designing new types of concrete, but the last decade has shown significant progress in the field (IBWK, Group of Prof. van Mier). Recent developments have shown that, specifically, the tensile strength of concrete can readily be improved by adding the right 'fibre cocktail' to the concrete. A fibre cocktail comprises of fibres of different size (and or shape), and/or of different types of fibre. Large amounts of short fibres tend to increase the strength of the material, whereas a relatively small amount of long fibres is capable of improving the ductility of the material. These are exactly the two material properties of concrete that have given rise of substantial durability problems in applications involving concrete. The flexural tensile strength reaches values up to 80 MPa, which is 12 times higher than the bending strength of plain concrete. In addition, the deformations at the onset of global fracture exceed 0.3 mm, with a rather interesting plastic response. The materials are designed to be self-compacting,

which implies that placement becomes relatively easy and straightforward, even without vibrating. The future might perhaps see concrete structures without conventional steel reinforcement.

Squeezing Rock in the Gotthard Base Tunnel

In some long stretches in the northern part of the new Gotthard railway tunnel, rocks of low strength and high deformability such as kakiritic phyllite are expected. The critical zone is approximately 1.1 km long, the depth of cover amounts to 900 m. The existence of groundwater under high pressure favours the development of squeezing. In the critical zone, high initial pore water pressures of up to 90 bar are expected.

In order to establish the mechanical characteristics of the kakiritic rocks, a comprehensive laboratory testing programme on intact rock specimens was carried out (IGT, Group of Prof. Anagnostou, Thesis of Martin Vogelhuber). A new apparatus

was developed in order to control and monitor the pore water pressure and the water content during testing. Despite the complex structure of the kakiritic phyllite, remarkably consistent results were obtained. Specimen pre-saturation and maintenance of a sufficient back pressure proved to be essential for obtaining reliable and reproducible parameters. In order to take into account the pore water pressure, the squeezing rock is modelled as a porous medium according to the principle of effective stress. This approach reduces the prediction uncertainties regarding the ground response to the tunnelling operation.

Remaining structural capacity of broken laminated safety glass

Glass constructions with structural function require the verification of both the load carrying capacity (LCC) and the remaining structural capacity (RSC) of broken glass. The RSC is under theoretically and experimentally investigation at the Institute of Structural Engineering (IBK, group of Prof. Vogel, Thesis of Alexander Kott), as part of the European COST action C13 "Glass and Interactive Building". The load transfer mechanism in broken

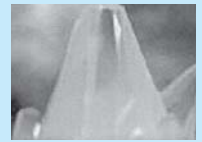
Example of the slump flow of self-compacting hybrid fibre concrete.



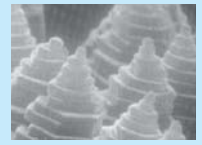
Tunnel cross section in squeezing rock



Scale deposits in tunnel drainage systems (left) and effect of polyaspartic acid on the crystallisation of calcium carbonate (right)



Crystal of calcium carbonate



Calcium carbonate Crystal with polyaspartic-acid inclusion

Broken pane of laminated safety glass with PVB foil as tension reinforcement still transferring load.

glass can be explained by applying yield line mechanisms and stress field theory. The PVB foil works as tension reinforcement and the upper broken glass layer carries the compression forces. The ultimate failure, which leads to the collapse of the structure, occurs when the compression zone in the yield line fails when the compression strength of glass is reached. Four point bending tests combined with impact tests demonstrate that the different glass types, the type of initial failure and the specimen dimensions determine the post-breakage behaviour. The developed mechanical models can be considered in future codes, which will help the engineer to design glass structures complying with the required safety standards.

The EasyStatics E-Learning Project: A Virtual Structural Design Laboratory

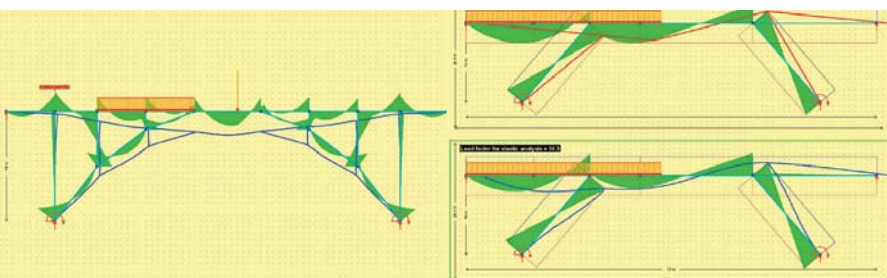
Architects and civil engineers need to understand how the structures they design are going to carry loads. They have to know how design parameters influence deflections, section forces, stability,

dynamic behaviour, ultimate resistance, etc. Computers compute all this, but their users must be able to properly model real-life structures and to extract relevant information from computer results. As easy to use as paper and pencil, as intuitive as a hand calculator, the program EasyStatics teaches these non-trivial but today essential skills (IBK, Group of Prof. Anderheggen, Thesis of Claudia Pedron). Acting as a virtual structural laboratory, EasyStatics helps students in civil engineering and architecture to develop the feeling and intuition needed for structural design in a highly motivating way. The aim of the accompanying e-learning project is to build an environment in which teachers can freely produce their own lectures, demonstrations and student exercises utilising EasyStatics's power and flexibility. More information is found on www.easystatics.ethz.ch.

Stabilizing water hardness in tunnel drainage systems lowers maintenance costs

Operators of drained tunnels are faced with the problem of cost-intensive maintenance measures to counteract the phenomenon of scaling in tunnel drainage systems. The enrichment of the descending seepage/ground water with carbon dioxide is a principal natural cause for the formation of scale. The stabilization of water hardness by adding polyaspartic acid is investigated by IBB (Group of Prof. Girmscheid, Thesis of T. Gamisch, funded by the German Railways (Deutsche Bahn AG). By adsorbing the hardness-forming ions in the drainage system, polyaspartic acid prevents, disrupts or delays the formation of hard scale. This active agent of hardness stabilization is a nature-related substance, which is fully decomposed by microorganisms and regarded as environmentally unproblematic. As an overall result, the right use of hardness stabilization in connection with constructional modifications can result in longer maintenance intervals and a substantial reduction of cleaning work in pipes, which in turn leads to considerable extension in the life cycle of the tunnel drainage system, to lower maintenance costs, and to increased availability of the traffic routes.

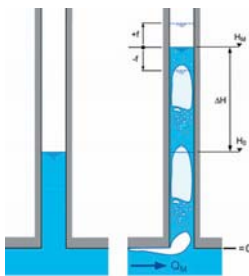
Graphic interface of EasyStatics



Infrastructure Systems

De-Aeration of a Diversion Tunnel of a Large Scale Hydroelectric Scheme

One of the intakes of the Jökulsà Diversion Tunnel of the Karahnjúkar Hydroelectric Scheme is subjected to a transition from free-surface to pressurized tunnel flow due to the varying water level in the main reservoir of up to 75m. In order to avoid damage in the main conduit as well as in the hydraulic equipment, the air entrained into the pressurized flow has to be removed through vertical drill-holes of 0.5m diameter leading the air to the ground surface. The air entrainment and the de-aeration system were studied in physical models at the VAW (Group of Prof. Minor). Special attention was paid to possible scale effects in the two-phase flow model, which includes a rather slow concurrent horizontal two-phase flow with a small void fraction in the diversion tunnel and a highly turbulent and highly aerated vertical flow with an almost stagnant liquid in the drill-holes. In a first phase, the capacity of the drill-holes, the corresponding two-phase flow patterns and the additional rise of the water level in the drill-holes had to be assessed, as icing in the vicinity of the ground surface would endanger the functionality of the chosen system severely.



Additional rise of the water level ΔH .

The IGT Circular Pavement Test Track

The circular test track allows the simulation of the loading and the weather conditions that affect roads during their service life at full scale. The time scale of the loading conditions can be shortened, in comparison with experimental tracks constructed within the existing road infrastructure, because the number of loading cycles can be increased significantly within a given time period. The specifications of the test track include a circular trapezoidal concrete pit (medium diameter: 32 m) that allows the groundwater level to be adjusted and controlled, a loading system consisting of three arms, each of them fitted with driven truck twin wheels, a load adjustable from 50 kN to 80 kN (corresponding to truck axle loads between 100 kN and 160 kN), variable speed up to 80 Km/h (i.e. between 100,000 and 150,000 load cycles per month). The test track is built for accelerated full-scale tests and comparisons of different pavement structures in order to find appropriate design methods and construction procedures. Examples of tested material include recycled road construction materials, stone mastic asphalts, stress absorbing membrane interlayer, thin overlays and natural stone paving. Skid resistance can be measured, and weigh-in-motion (WIM) systems can be tested and calibrated (IGT, Dr. Markus Caprez).

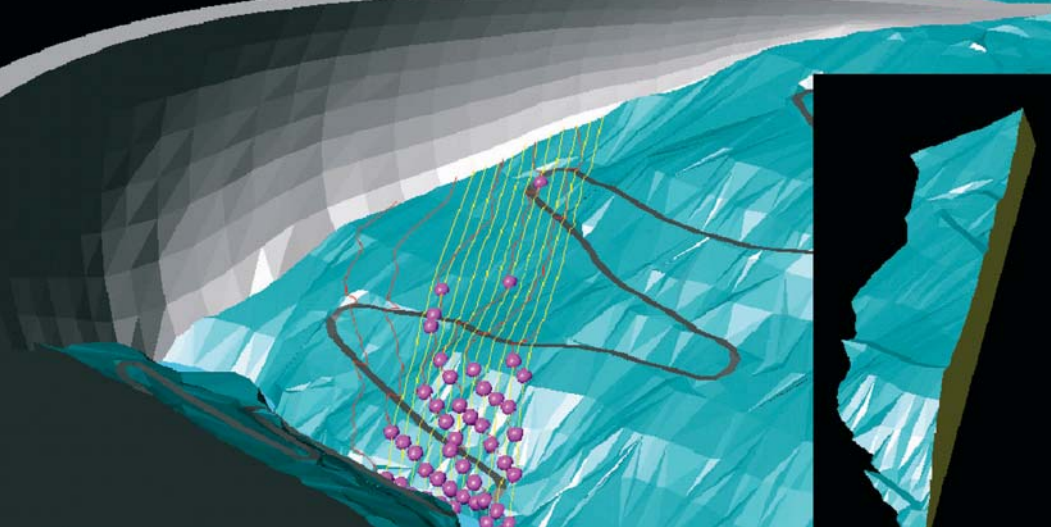
Stability of Foundations and Slopes in Rock based on a Digital Terrain Model

The CAD-based program AutoBlock enables one to analyze the stability of potential sliding blocks in a digital terrain model (IGT, Group of Prof. Anagnostou, Dr. Peter Fritz, Stefan Bergamin). These blocks are endangered by sliding along known planes of weakness or by separating from them. Additionally, foundations or parts of the ground to be excavated may be superimposed. For each block, which, based on kinematic considerations, may fail, the factor of safety against sliding is computed using the limit equilibrium method. AutoBlock is an add-on to the popular program AutoCAD and exploits its possibilities and its power (e.g. for 3D-visualizations). It provides all the tools required for representing and visualizing the results and facilitates a stability analysis with any number of potential sliding blocks. Thanks to these tools and by exploiting the services of AutoCAD, AutoBlock enables engineers to over-view and handle the geometry of the discontinuities in the ground and to determine potential sliding blocks with a minimum of expense and a maximum of accuracy.

Arm of the test track showing the water tanks for loading the truck twin wheels



Hydraulic jump in the model tunnel, entraining air into the pressurized part of the tunnel.



AutoBlock model with trace lines and outcropping points of potential sliding blocks (Valle di Lei arch dam)

Estimating Infiltration into Urban Sewer Systems: A full-scale Experiment

Traditional methods for determining infiltration into urban sewer systems are subject to considerable uncertainties due to their underlying assumptions. In the context of an EU project, supported by EAWAG, a new method based on stable isotopes as a natural tracer system, has been developed (IHW, Group of Prof. Gujer, Thesis of Markus Gresch). As a pre-condition to this approach, a difference in the isotopic composition between drinking water, which ends in the sewer system and local groundwater, which is a major source of infiltration, must exist. This can be found if drinking water originates from a catchment area that is situated significantly higher than the investigated urbanized area. This method was tested in a city-wide full-scale experiment carried out in Rüm- lang, where a major part of the drinking water usually comes from the Lake of Zurich. The entire water supply system was changed to assure that only water from the Lake of Zurich was delivered during the test. Substituting all interfering contributions of local water sources to the drinking water network by lake water was tedious but resulted in a successful comprehensive measuring campaign in the main sewer with the objective to quantify the infiltration in the upstream sewer system.

Development of Deep Underground High Level Radioactive Waste Repositories

The thermo-hydro-mechanical (THM) processes in the near field of a thermal source were studied within an EU-Project for the development of deep underground high level radioactive waste repositories (IGT, Dr. Rita Hermanns Stengele, Dr. Michael Plötze, Dr. Günter Kahr). The THM processes in both the bentonite buffer and the host rock clay formation after a medium-term (18 months) heating phase at 100°C under saturated conditions were identified. A heating tube with a diameter of 10 cm was installed in a 7 m deep borehole of diameter 30 cm. The gap between the heater and the clay host rock was backfilled with compacted bentonite blocks. The THM response in both the buffer and the rock will be monitored in-situ. Subsequently the buffer and part of the surrounding host rock will be excavated for characterisation in the laboratory. The evolution of THM processes in the barrier system is monitored and analysed. The experiment is carried out at the Mont Terri underground laboratory. The goal is to produce a validated model of coupled THM processes in an engineered barrier system composed of compacted bentonite blocks, in a vertical borehole in the Opalinus clay formation, with adjusted parameters and with special emphasis on the host rock-buffer interaction.



Part of the excavated bentonite buffer after heating (with instrumentation)



Infiltration of groundwater into a leaky sewer pipe. In Switzerland an overall average of around 40% of the dry weather flow is contributed by infiltration of "clean" water. (Photo: Entsorgung und Recycling Zürich)



The VisuLands Project

The management of land is increasingly decided at a local level, with trends across Europe of greater public participation in landscape planning processes and empowerment of local administrations to determine resource exploitation and development. Yet, understanding of the consequences of landscape planning decisions is generally poor among the public and their elected representatives. The VisuLands Project analyses public preferences and land manager aims for present landscapes and scenarios of future land use to produce a set of new visualization tools that enable public participation in landscape management (IRL, Group of Prof. Schmid, Thesis of Olaf Schroth and Ulrike Wissen). It uses relationships between visual qualities and other landscape functions such as biodiversity, cultural heritage, amenity and sustainable production to support a sound stewardship of the rural and peri-urban landscape, and an increased understanding of change. These tools should assist planners and the public in assessing the outcome of landscape planning strategies. This includes the development of quantitative indicators of landscape change and the use of landscape preference models. The tools are tested in co-operation with local stakeholders of the Entlebuch UNESCO Biosphere Reserve. The Entlebuch's cultural landscape is of (inter-)national significance because of the natural scenery and the habitat functions for plants and animals. In addition, it is a valuable resource for tourism as well as for agriculture. In this context, the visualization tools are tested in public development forums as well as with local experts.

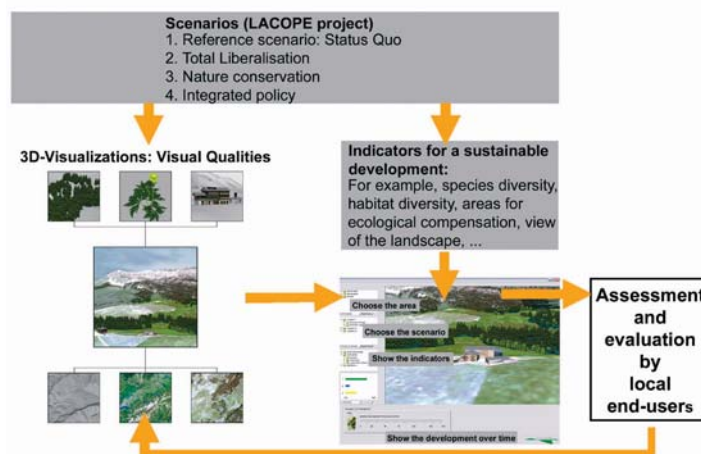
Upscaling and Effective Properties in Heterogeneous Aquifers

Natural porous media such as aquifers and soils are heterogeneous. As small scale heterogeneity cannot be considered explicitly in practical design and management, several strategies have been devised to take into account the unresolved sub-scale. One of those is the introduction of effective parameters on the large scale. These are functions of the stochastic properties on the small scale (e.g. mean, variance and correlation function). The procedure has been quite successful in linear problems. Successful upscaling implies that on the large scale the same transport equations apply as on the small scale with the coefficients replaced by their upscaled effective values. In nonlinear transport things change dramatically. We investigated nonlinear adsorptive transport according to a Freundlich isotherm as a prototype of nonlinear interaction (IHW, Group of Prof. Kinzelbach, Thesis of Jiva Dimitrova Micha). If the exponent of the isotherm is assumed to be a spatially stochastic variable, the large scale transport equation no longer

has the same form as the small scale equation. The isotherm on the large scale has to be modified. The new isotherm was derived using the technique of homogenization. While in the linear case the dispersion coefficients are properties of the aquifers alone, they also depend on concentration in the nonlinear case. If the Freundlich exponent can be assumed constant, upscaling is possible to the extent that an equivalent adsorption capacity can be defined. However, the dispersion coefficient cannot be localized and has the form of a spatial integral.

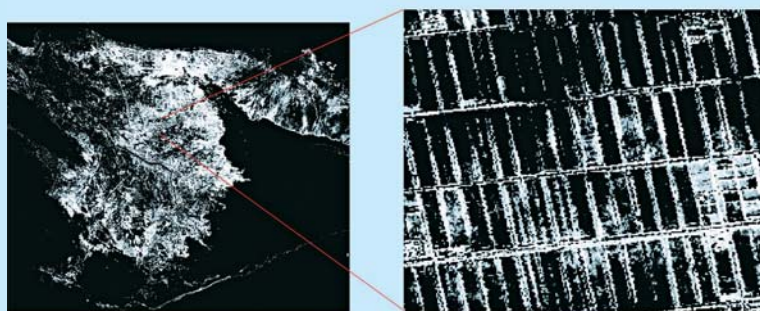
Water Management in an Arid Area (Xinjiang Project)

The project, supported by D-BAUG funds, looks into water management in an arid area of China. In the Yanqi plain of Xinjiang large scale irrigation with river water has led to a groundwater table rise and soil salination. It has also caused a salinity increase in the downstream Lake Bostan. We are investigating several countermeasures (IHW, Group of Prof. Kinzelbach, Thesis of Philip Brunner) including irrigation from groundwater, which



VisuLands project workflow

The heterogeneous structure of a gravel aquifer shows up in a gravel pit



Salinity distribution from remote sensing data

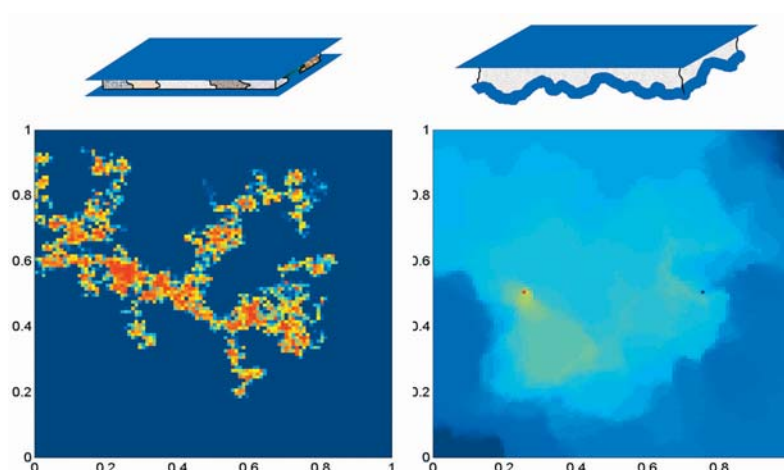
should keep the water table down, water saving irrigation and direct diversion of water to the downstream. To judge their effectiveness, these measures will be simulated in a regional model combining surface water and groundwater. The model requires inputs which are not easily obtained in an environment with a poor scientific infrastructure. We are exploiting therefore remote sensing data. As the salination depends on the distance of groundwater tables from the surface, a digital terrain model is an important input. It was obtained from stereo radar satellite images combined with accurately measured fix points. Another input, which is required for calibrating the final model, is a salinity map of the top soil. Here also remote sensing can be applied. From multi-spectral data a typical spectrum for completely saline pixels was defined. The degree of closeness to this spectral fingerprint determines the degree of salinity. Extensive field work on the ground was performed to determine the actual salinity of a number of training pixels. The satellite

signal correlates well to observed soil salinity in the first 30 cm. The map was successfully calibrated with actual ground measurements and will play an important role in future model calibration.

Experiments in Fractured Media

Nuclear waste disposal has to address the problem of gases produced by decay and corrosion. In a fractured host rock the gases may migrate together with the water, leading to a two-phase flow. Up to now little is known about this type of flow, especially when the fractures are filled with fault gouge material. This was the motivation for carrying out two-phase flow experiments in single fractures in the Grimsel Rock Laboratory (IHW, Group of Prof. Kinzelbach, Thesis of Ivan Lunati). The research was done in cooperation with NAGRA, ANDRA and UPC. To produce a two-

phase flow, a well-doublet was installed in the studied fracture. Air was injected in one well and a water-air mixture was extracted from the other one. After the air "bubble" stabilized, the system was ready for gas tracer tests to determine the volume of air contained in the fracture. Numerical simulations were conducted at IHW to interpret the data obtained in the experiments. Three conceptual models of the fracture space were proposed in the simulations. While they did not differ significantly in the breakthrough curves at the extraction well, the respective air distributions in the fracture were extremely different. As these could not be observed in the field, a laboratory experiment was performed on a core from the Grimsel drift. The two-phase flow was visualized by neutron-radiography at the Paul Scherrer Institute. The first images obtained indicate that the air distribution has a structure consisting of blobs connected by fine threads. This behavior fits the model of a fracture which is filled with fault gouge of spatially varying grain size distribution.



Computed air distribution in a dipole flow field for two hypothetical models containing fault gouge material:

- a Parallel-plate fracture containing heterogeneous fault gouge material (left) and
- a Rough-walled fractured containing homogeneous fault gouge material (right)

Geo-, Structural and Environmental Data

Conflict Management GIS

Space is a limited resource and requires planning processes. Commercial Geo Information Systems (GIS) support these procedures by acquisition, maintenance, analysis and visualisation of spatial data only. In order to achieve a common and widely accepted solution, affected people have to be integrated in a participatory process aiming at overcoming underlying conflicts. At IGP, Group of Prof. Giger, a Conflict Management GIS (COMAGIS) was developed, which is based on a commercial GIS, which was enhanced by additional functionalities:

1. A usable interface according to the users' mental model, and a high-end visualisation system based on Virtual Reality enables laymen to fully participate equally to experts.
2. Executing all interactions based on this system, all interaction data are stored and can be used as a protocol.
3. Interpreting these interaction data provides information if really all participants worked together in a solution-oriented and constructive way.

COMAGIS supports users' perception and analyses the interaction data in order to raise the probability to achieve a common solution to the given planning task.

Advanced User Interfaces for the Handling of Spatial Data

Thanks to the trend towards mobile applications and devices, new applications like mobile GIS, portable tourist guides or supporting systems for emergency response are being developed. These systems simplify the use of computing systems and Geographic Information in highly mobile (e.g. field data collection) as well as in urgent situations (e.g. disaster management). Research at IGP, Group of Prof. Ch. Giger, uses the latest advances in spatial cognition sciences for developing new user interfaces for handling spatial data in such systems. The interface is based on speech recognition and enables the user to do without keyboard and mouse. Special functionalities like the selec-

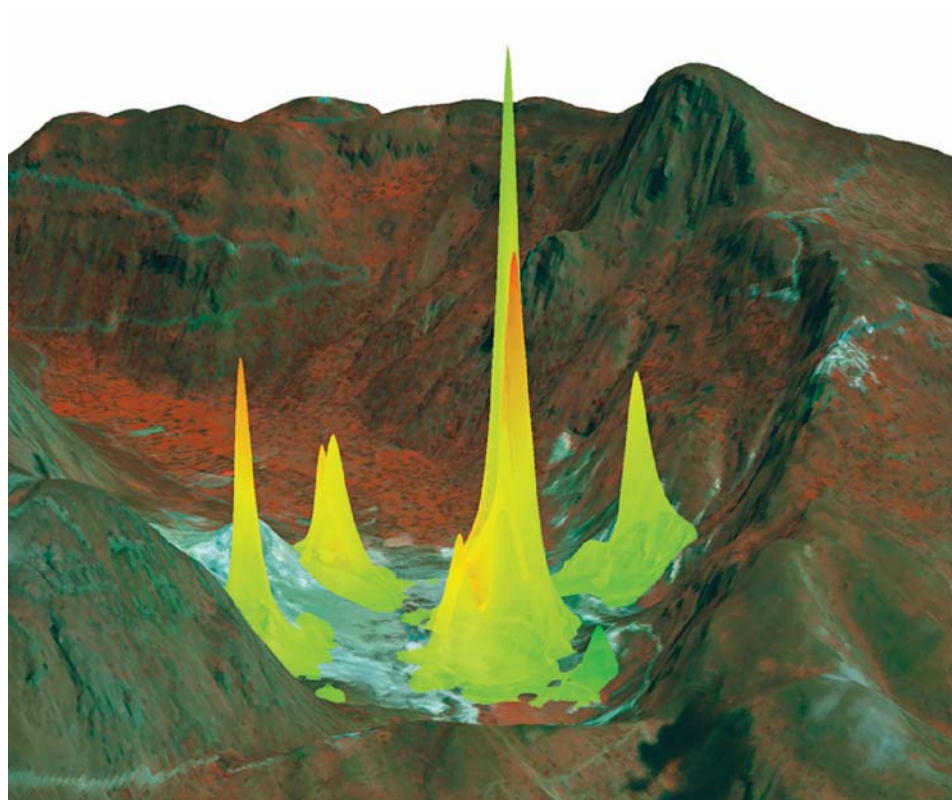
tion of spatial objects or object spaces require sophisticated algorithms and the consideration of many different influences. The results of such research are user-centered, intuitive interfaces that are tailored to spatial questions and easy to use. They also provide a framework for later user interface design in totally new spatial environments that use technologies like Augmented Reality and Wearable Computing.

EU-project GEOWARN

The European Union-funded international GEOWARN project provided an internet-based expert tool to visualise and analyse research data in order to aid the forecasting of natural disasters, as well as scientific analysis. The volcanically active European regions of Nisyros (Greece) and Campi Flegrei (Italy) were chosen as pilot sites. Geophysical, geochemical, geodetical, geological,



Advanced user interfaces in use with wearable GIS allow real-time access to complex spatial information and analysis



Topographic 3D map of the region of Greifensee (Switzerland), seen from the east. The symbolised vector-based digital landscape model VECTOR200 was combined with the digital elevation model DHM25 (Data: © Swisstopo, Wabern).



demographic and geographic data of various types, resolutions and formats (raster data, grid data, time series data, etc) from 8 teams in four European countries were unified in a single database. This database can be accessed by GIS software for expert visualisation, analyses, and hazard assessment, as well as by the internet-based Atlas Information System (AIS) -type software, allowing interactive multi-level access for user-friendly visualisation, crisis management, education and outreach. The AIS software platform was custom-programmed at the IKA, Group of Prof. Hurni, and its user interface was designed as a component-based framework for interactive maps. GEOWARN was invited to contribute to the World Organisation of Volcano Observatories (WOVO) global data management effort (WOVOdat)."

Design Aspects for 3D-Maps

Today, cartographic theory of 3D maps has some important deficits. Mainly, there are no design principles for the user-friendly symbolisation and expressive visualisation of map objects. A PhD project at the IKA (Group of Prof. Hurni, Thesis of Christian Häberling) aimed at deriving a preliminary set of such design principles for 3D maps. A first inventory of design variables relevant for map concepts and production was assembled, and 3D map examples were created from sections of vectorial landscape models and digital elevation models. The 3D map examples covered the five independent design variables, i.e. observation angle,

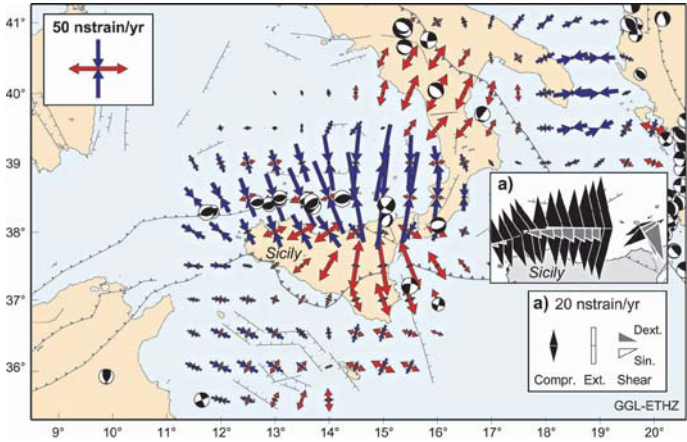
observation distance, direction of illumination, sky structure, and fog effects. The quantitative ranking and the comments of experts from different fields within geomatics were interpreted for optimising the degrees of abstraction and dimension. As conclusions nineteen theses for design principles were formulated. In particular, the familiar map-like symbolisation of map content finds great acceptance. An almost natural representation of map objects should not be attempted. In future, 3D maps will find increasing application, especially in tourism, planning and education, particularly when provided with extensive functionality for interactive use. The proposed design principles – in addition to the general availability of vector-based geo-data sets and of powerful computational resources – will facilitate the production of this attractive type of map-related representations.

GPS Results and Seismo-Tectonic Processes in Southern Italy

Southern Italy is a key area for understanding the tectonic processes in the collision zone between the African and Eurasian plates. With the results of new GPS measurements carried out between 1994 and 2001, the GGL (Geodesy and Geodynamics Lab, IGP, Group of Prof. Kahle) presented completely new findings for this area. Central Italy, Corsica, Sardinia and the Tyrrhenian Sea move like the Eurasian plate. There is no indication that the opening of the Tyrrhenian Sea is still active. In contrast, the African plate motion extends across Maltese and southern Italian islands to southern and western Sicily. The compression between the African and Eurasian plates is concentrated along a 50 km narrow belt to the north of the Sicilian coast and reaches 60 nstrain/yr (= 60 ppb per year). Location and direction of this large compression is in general agreement with fault plane solutions of earthquakes. Due to the large velocities in northeastern Sicily and the Eolian islands, the interior of Sicily is under extension. Furthermore, we could confirm the compression between Italy and Greece as well as extension across the southern Apennines, which have been the site of numerous large-scale earthquakes in the recent past.

Nisyros caldera, Greece: 3D-representation of IKONOS orthophoto overlaid with representation of CO2 flux (height) and surface temperature (colour).

Geodetic strain field and seismicity in southern Italy



High-Tech Measuring Systems

3-D Terrestrial Laserscanning of the Benedictine Abbey of Einsiedeln

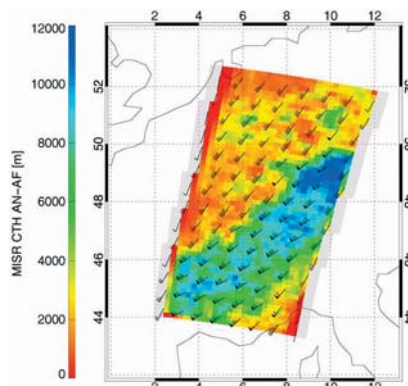
In collaboration with the Institute for History and Theory of Architecture (gta), Prof. Dr. W. Oechslin, the facade and the interior of the famous Abbey of Einsiedeln have been scanned with the new technology of 3-D Laserscanning (IGP, Group of Prof. Ingensand). The benefit of this new laser technology is to capture 3-D coordinates of the construction within a few minutes. In conjunction with intensity values of the reflected laser beam it is possible to generate a full geometric model of the building. As a result of this campaign the unknown and complex geometry of the different construction stages of this building could be uncovered and documented.



3-D Laserscanning data allow the survey of historical buildings

3D Cloud Mapping and Tracking with Satellite and Terrestrial Images

Cloudmap2 is an EU project with 7 partners in 6 European countries for the estimation and validation of macroscopic (e.g. cloud-top height) and microscopic (e.g. cloud droplet radius) cloud parameters and water vapor distributions for Numerical Weather Prediction Models. The role of the IGP (Group of Prof. Gruen, Thesis of Gabriela Seiz) is to estimate cloud-top and -bottom heights and wind speeds from satellite and ground-based sensors. The cloud-top heights are derived from multi-view satellite scenes from AATSR, MISR and ASTER, using Meteosat images for wind correction. The cloud-bottom heights are estimated from stereo images acquired by a self-established ground-based sky imager system consisting of 3 digital cameras with wide-angle lenses. In both cases the photogrammetric processing includes camera calibration and orientation, image preprocessing, point measurements with our cloud-adapted multi-photo matching algorithm, quality control and further postprocessing. For validation, the derived cloud heights are compared to other ground-based (cloud radar, ceilometer, IR camera) and in-situ (radiosonde) measurements. Our self-developed terrestrial system is currently used in measurements campaigns in England and the USA.



Development of a new Digital high-resolution Aerial Camera

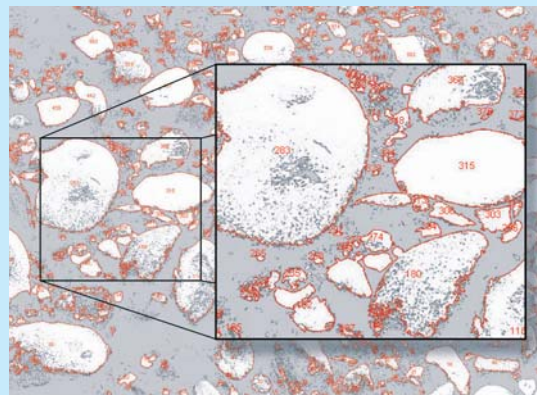
The development of a new generation of high-resolution digital aerial cameras is currently a major topic in photogrammetric system development worldwide. The STARIMAGER SI-200 is such a new camera, based on the principle of CCD Three-Line Scanning, developed and manufactured by STARLABO Corp., Tokyo. IGP (Group of Prof. Gruen) is currently doing extensive research work in cooperation with STARLABO with the aim of developing new methods for the automated and semi-automated processing of Three-Line Scanner data. Under a research and development contract we are also designing, developing and testing new software for a variety of processing tasks, including graphical user-interface for image handling in mono, stereo and image triplet mode, model orientation and image triangulation with fully automated tie point measurement, automated Digital Surface Model generation, different modes for image rectification, ortho-image generation, mono-plotting and feature and object extraction, with focus on 3D city and road network modeling (for more information see www.photogrammetry.ethz.ch). Originally designed for the modelling of line structures (roads, rivers, railways, etc.), this system can be used in many other applications as well, as for instance in natural and man-made hazards damage monitoring, for 3D city modeling, car navigation, traffic control, and for general data collection for GIS.

Cloud-top heights and motion results from satellite views, 03 Aug 2000



Grain size distribution of the subsurface of the Töss-river

Development of the airborne absolute gravity meter system



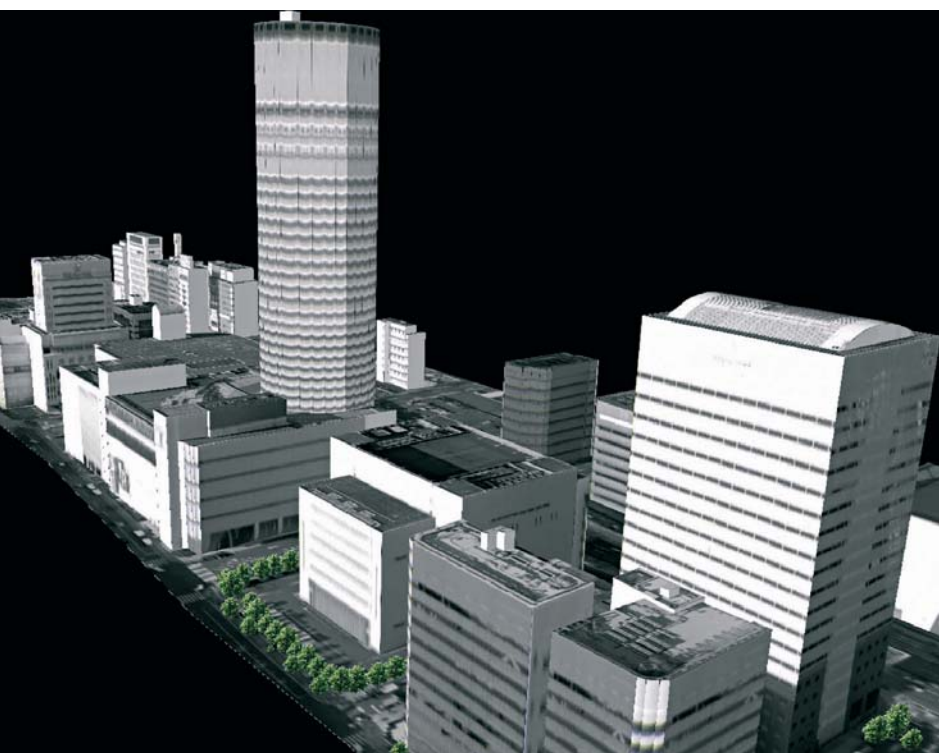
First Airborne Absolute Gravity Measurements, Worldwide

In recent years global change has become of concern for mankind. In this context precise knowledge of the Earth's gravity field is of major importance in order to establish the physical reference surface needed for monitoring global sea level changes. There is a large uncovered wavelength domain, which can only be filled with airborne techniques. Until now, airborne gravity surveys were carried out with relative techniques using spring-type gravimeters. These suffer, however, from correlated measurements, instrument drift

and frequency response of the spring. Our project, pursued at the IGP (Group of Prof. Kahle, Thesis of Henri Baumann, supervised by Prof. Klingelé) is concerned with the development of an absolute gravity measuring system which is based on the interferometric principle. INS, GPS and mechanical as well as mathematical filters are used to mitigate the disturbing accelerations significantly. It allowed for the first time the retrieval of absolute gravity under flight conditions with a resolution on the order of 6×10^{-6} g. The promising results achieved may open up a new era in airborne gravimetry.

Grain Size Analysis for Coarse River Beds using Digital Image Processing

Quantification of the grain size distribution of river beds remains an issue of large importance for a wide range of river engineering problems. A new procedure was empirically derived from flume experiments performed at the VAW (Group of Prof. Minor), using digital image analysis. The proposed method represents a fast, easy and inexpensive alternative to determine the grain size distribution of the subsurface of coarse river beds. In a first step, a photograph is taken of a dry bed section from an appropriate height. The following step converts the photograph into a quasi-binary image, which is suitable for an automated extraction of grain size data. The programme scans the image to identify and analyse objects. Besides other information, the longest and shortest axes of the recognised objects are measured. The analysis with automated object recognition resembles a point analysis of the surface layer. Thus, an appropriate conversion model was developed to determine the volumetric distribution of the subsurface layer. The method was tested with independent flume and field data, resulting in promising approximations to the reference grading curves of the subsurface.



3D hybrid city model of Yokohama, produced with CyberCity modeller in semi-automated mode from STARIMAGER SI-200 images



Image strips of STARIMAGER SI-200 over Yokohama (Insert: zoom-in)

Studying at the Department of Civil, Environmental and Geomatic Engineering (D-BAUG)

The quality and the profit of the studies at D-BAUG only becomes obvious when one has completed one's studies and the first projects in practice. During the seemingly innumerable lectures, exercise courses, excursions and workshops one easily forgets that these new important inputs (from each meeting) develop the student's knowledge and experience until he or she gains the engineering diploma. One first becomes really conscious of what has been achieved at the diploma celebration, when the head of department calls you "dear colleagues".

But, no pains no gains! The studies are not a bed of roses, particularly during the basic semesters and the exams. Amazingly however one meets many of the unloved propaedeutic subjects again during the specialization studies, in the semester projects or the diploma thesis or in practical training.

Yes, practical training! For me it represents the highlight of my years of study. My stays in Munich and Vienna allowed me to put to use the technical knowledge and methods of problem solving acquired and provided the chance for intercultural exchange. That will influence me for life. Unfortunately,

the mandatory practical training of 16 weeks has been removed from the curriculum with the conversion to the Bachelor/Master system; a terrible loss.

The transfer from the basic studies (1st–4th semesters) to the specialized studies (5th–9th semesters) was in one way a continuous transition, formally however it was radical, with the implementation of the new credit system. Being the first class to experience this, it was sometimes quite difficult to obtain our credits. On the other hand, the options to attend elective courses were almost boundless. In my branch of study "Geomatic engineering" we were offered a pretty wide range: from geophysics to regional economics, from river engineering to computer vision. Specialization in the fields of study and the work as a student assistant in various institutes made personal contact to professors and assistants possible. This contact gave the studies a kind of humanity and quality of life.

From the beginning of our studies the contact and social life among students was excellent. Thanks to the student associations and their financial support by the alumni great events like ski weekends, the annual ice hockey match, the famous Jass competition or legendary parties can be funded. All these happenings promote bonhomie among the students. The student associations also place elected delegates in the different committees of the department. Regrettably not everywhere in these committees are the comments of the students taken seriously. On the whole, however the committees are a cooperative affair and are a useful preparation for later working life.

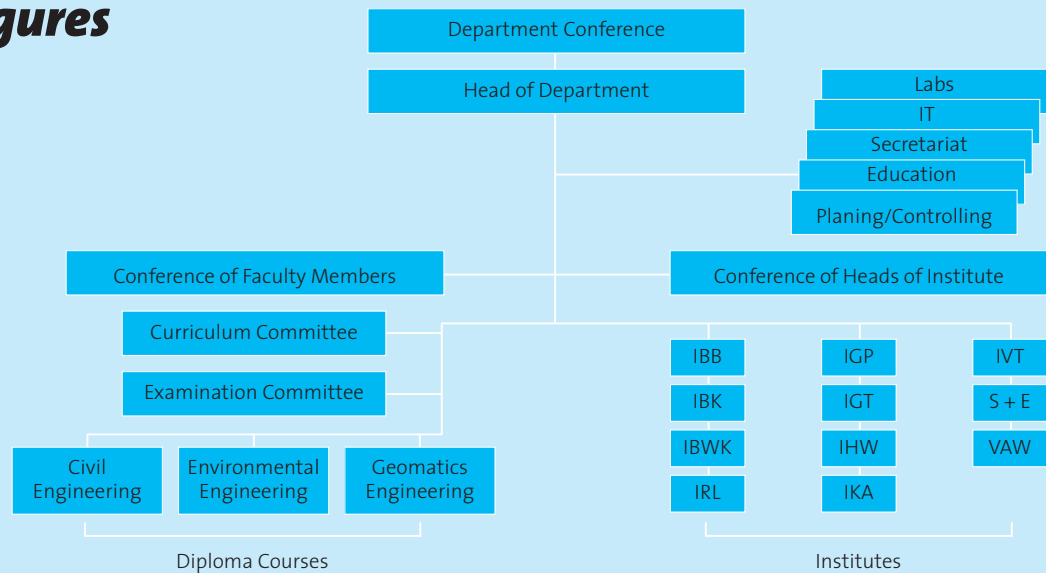
Before concluding I would like to mention one thing: Our studies are only as excellent as they are, because the state invests high sums of money in this university and its teaching. We graduates know how to value this dedication and would like to give sincere thanks to all the people who make such an education possible.

Hannes Schneeбели

Hannes Schneeбели got his diploma in Geomatics engineering in autumn 2003



Facts and Figures



Institutes

Institute for Construction Engineering and Management (IBB): Proff. G. Girmscheid, H.R. Schalcher
 Institute of Structural Engineering (IBK): Proff. P. Marti, E. Anderheggen, M. Fontana, T. Vogel, M.H. Faber, A. Dazio
 Institute of Building Materials (IBWK): Prof. J.G.M. van Mier
 Institute of Geodesy and Photogrammetry (IGP): Proff. H. Ingensand, A. Carosio, A. Grün, H.G. Kahle, Ch. Giger
 Institute of Geotechnical Engineering (IGT): Proff. S. Springman, G. Anagnostou
 Institute of Cartography (IKA): Prof. L. Hurni
 Institute of Hydromechanics and Water Resources Management (IHW): Proff. W. Kinzelbach, P. Burlando, W. Gujer
 Laboratory of Hydraulics, Hydrology and Glaciology (VAW): Prof. H.-E. Minor
 Resource and Waste Management (S+E): Prof. P. Baccini
 Network City and Landscape (NSL)
 Institute for Territorial Development and Landscape (IRL): Proff. W.A. Schmid, S. Kytzia, A. Thierstein
 Institute of Transport Planning and Systems (IVT): Prof. K.W. Axhausen

Faculty

| | | | |
|--------------|--------------------------------|----------------------------|--------------------|
| Retirements | Prof. Dr. P. Amann | Geotechnical Engineering | June 30, 2003 |
| | Prof. Dr. H. Brändli | Transportation Engineering | September 30, 2003 |
| | Prof. Dr. R. Hermanns Stengele | Geotechnical Engineering | March 31, 2003 |
| Appointments | Prof. Dr. G. Anagnostou | Geotechnical Engineering | October 1, 2003 |
| | Prof. Dr. A. Dazio | Structural Engineering | August 1, 2003 |

Students (Academic Year 2002/2003)

| | 1 st year | 2 nd year | 3 rd year | 4 th year | Students Total | Diplomas |
|---------------------------|----------------------|----------------------|----------------------|----------------------|-------------------|------------|
| Civil Engineering | 109 | 58 | 42 | 27 | 236 | 55 |
| Environmental Engineering | 38 | 20 | 24 | 25 | 107 | 18 |
| Geomatic Engineering* | 24 | 18 | 14 | 38 | 94 | 32 |
| Total | 171 | 96 | 80 | 90 | 437 | 105 |

(* Incl. Diplomas Rural Engineering)

| | Doctoral Students | | Diplomas | |
|---------------------------|-------------------|-------------------------------------|---------------------------------------|------------|
| | D-BAUG | Students in other Departments | Students from other Departments | Total |
| Civil Engineering | 69 | 1 | 3 | 73 |
| Environmental Engineering | 26 | 1 | 3 | 30 |
| Geomatic Engineering* | 36 | | | 36 |
| Total | 131 | 2 | 6 | 139 |

(* Incl. Rural Engineering)

Staff (including part-time employees)

| Institute | Professors | Senior Staff | Assistants, PhD-Students | Technical Staff | Administrative Staff | Total |
|--------------|------------|--------------|-----------------------------|--------------------|-------------------------|------------|
| D-BAUG | | 5 | | 5 | 4 | 14 |
| IBB | 2 | 2 | 14 | 1 | 3 | 22 |
| IBK | 5 | 4 | 39 | 5 | 5 | 58 |
| IBWK | 1 | 1 | 9 | 4 | 2 | 17 |
| IGT | 3 | 10 | 24 | 12 | 3 | 52 |
| IHW | 3 | 5 | 27 | 3 | 3 | 41 |
| NSL | | 7 | | 1 | 3 | 11 |
| IRL | 3 | 7 | 24 | 0 | 2 | 36 |
| IVT | 2 | 7 | 27 | 4 | 4 | 44 |
| VAW | 1 | 12 | 29 | 15 | 3 | 60 |
| IGP | 5 | 12 | 38 | 2 | 6 | 63 |
| IKA | 1 | 4 | 21 | 2 | 2 | 30 |
| S+E | 1 | 1 | 2 | | | 4 |
| Total | 29 | 77 | 257 | 52 | 39 | 452 |

Postgraduate Studies (NDS), Postgraduate Courses (NDK), Short Courses

| | | |
|---------------|-----------------|--|
| NDS/NDK | IHW | Hydrology and Hydrogeology (together with IATE/HYDRAM of EPFL) |
| NDS/NDK | NSL | Spatial Planning |
| NDS/NDK | VAW | Hydraulic Structures (together with LCH of EPFL) |
| NDK | D-MAVT, IBK | Risk and Safety |
| NDK | IGP, IKA | Spatial Information Systems |
| NDK | NSL | Space as a Factor of Decision Making |
| Short Courses | IBB | Bauunternehmensmanagement |
| | IBB | Bauinventarmanagement |
| | IBK/IGT/HBT/SIA | Einführungskurse zu den neuen SIA-Tragwerksnormen |
| | IHW | Probabilistic and Stochastic Approaches for Characterizing Hydroclimatic Processes |
| | IHW | Stochastic Tools for Groundwater Modelling |
| | IVT | Einführung in die Abschätzung und Prognose der Verkehrsnachfrage |
| | IVT | Forum Braunwald: Regionalverkehr zwischen Liberalisierung und Finanzproblemen |
| | IVT/SBB | Integrierter öffentlicher Verkehr |
| | IVT/DVWG | Liberalisierung und Privatisierung im Eisenbahnverkehr - aktueller Stand und zukünftiger Handlungsbedarf |
| | IVT/DVWG | Güterverkehr im erweiterten Europa |

Workshops, Symposia, Congresses

| Event | Institute | Date |
|---|--------------------|------------------------------|
| International Workshop "Validation of Cloud and Water Vapour Satellite Products", Zurich, Switzerland | IGP | January 27–28 |
| Milestones in Physical Glaciology from the Pioneers to a Modern Science | VAW | February 14 |
| ISPRS Workshop "Visualization and Animation of Reality-based 3D Models", Tarasp-Vulpera, Switzerland | IGP | February 24–28 |
| Turbulenzen in der Geomorphologie (Jahrestagung der Geomorphologischen Gesellschaft) | VAW | March 27–29 |
| 3. RailML Tagung | IVT | April 3 |
| Plenary Meeting ISO-TC 211 Geographic information / Geomatics | IGP | May 19–23 |
| 8th International Conference on Permafrost | IGT (Co-organiser) | July 21–25 |
| 10th International Conference on Travel Behaviour Research | IVT | August 10–14 |
| Hydrofractals'03 – International Conference on Fractals in Hydrosociences | IHW | August 25–29 |
| International Conference "Optical 3-D Measurement Techniques VI", Zurich, Switzerland | IGP | September 22–25 |
| 2nd Int. Seminar on Environmental Engineering Education (Int. Water Association) | IHW/EAWAG | Sept. 24–26 |
| Workshop on Benchmarking of Groundwater Models | IHW | October 15–16 |
| 6th International Conference on Precipitation in Urban Areas | IHW | December 4–7 |
| Ingenieurbetonbau, Exhibition of the Society for the Art of Civil Engineering | IBK | December 8, 04 – Jan. 15, 04 |

Honours

| | | |
|---|-----------|---|
| Prof. Dr. Peter Baccini | S+E | Honorary Doctor of the University of Neuchâtel. |
| Prof. Dr. Lorenz Hurni | IKA | Mitglied der Deutschen Akademie der Naturforscher "Leopoldina", (Halle/Saale) |
| Prof. Dr. Lorenz Hurni (Atlas der Schweiz) | IKA | Publikums- und Jurypreis für die beste Kartenpublikation in der Sparte Multimedia, Int. Kartographie-Kongress, Durban |
| Prof. Dr. Peter Marti | IBK | Honorary Member of the Swiss Society of Engineers and Architects (SIA) |
| Prof. Dr. Martin Funk | VAW | Titularprofessor ETH Zürich |
| Prof. Dr. Willi H. Hager | VAW | elected as member of the Council of the International Association of Hydraulic Research (IAHR) |
| Prof. Dr. Hansruedi Siegrist | IHW/EAWAG | Titularprofessor ETH Zürich |
| Dr. Lukas Arenson | IGT | T.L. Péwé Award for the Best Paper by a Young Author, 8th International Permafrost conference in Zürich |
| Helen Freimark | | KTW-Software Award |
| Dr. Kristian Kramer | VAW | Winner J.F. Kennedy Student Competition 2003, IAHR-congress Thessaloniki |
| Christian Marti | VAW | Winner SANW competition for young researchers |
| Dr. Hubert Meusburger | VAW | Alpiner Wasserkraftpreis 2003 der Arbeitsgemeinschaft Alpine Wasserkraft |
| Barbara Schechinger | IBK | Best Poster Contribution Award, German Society for Non-Destructive Testing |
| Andrea Thielen | IGT | F.C. Trapp-Prize, RWTH Aachen. |
| Markus Gresch, Hans Seelhofer, Roland Zeller | | Medal for the best Students of ETHZ |
| Markus Gresch, Roland Zeller | | Willi Studer Prize |
| Sandro Bay, Raphael Marty | | Baubetriebs-Förderungspreis |
| Ruth Freiermuth, Romano Hofmann | | Geosuisse-Prize |
| Barbara Karin Ebert, Hans Seelhofer, Regula Wicki | | Culmann Fund Prize |
| Yves Daniel Keller | | Maggia Preis |
| Simon Denoth | | Otto Jaag - Prize |

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