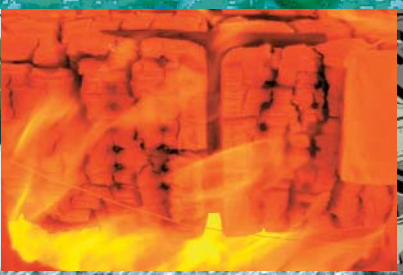
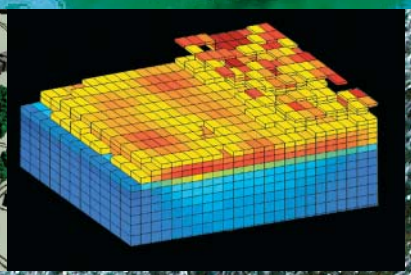
# Department of Civil, Environmental and Geomatics Engineering

## Annual Report 2002





ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

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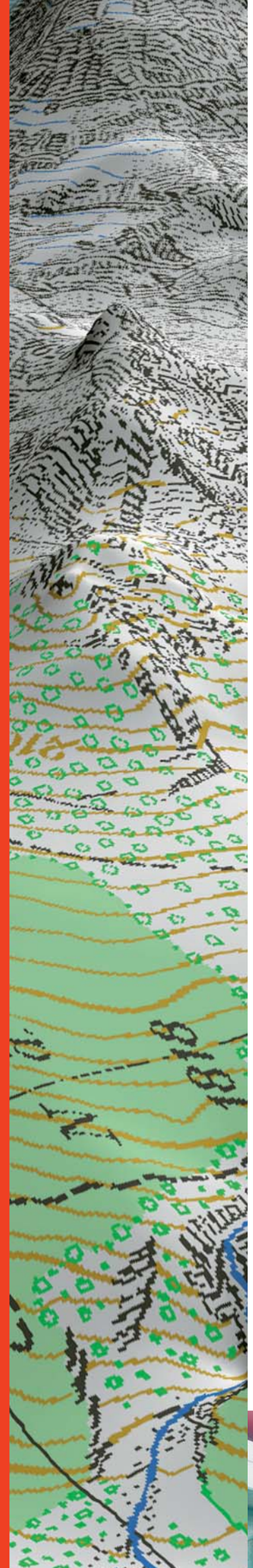


# Preface

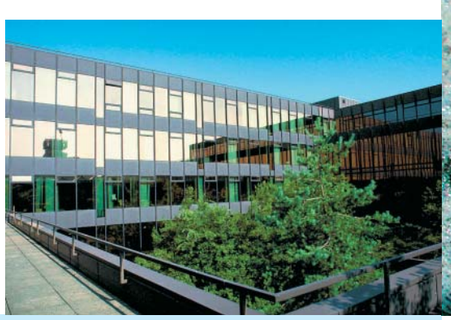
Man-made infrastructure and nature are in increasingly severe competition: The global population is still growing – luckily a little bit slower than forecast – and the needs of society and the economy to expand the infrastructure are multiplying all over the world. As a consequence, the natural resources are shrinking constantly to a level that gives serious concern. Neither economists nor natural scientists or sociologists were able until now to formulate feasible solutions to achieve a sustainable balance between the competing forces.

Our department is convinced that these crucial questions will be the predominant challenge for civil, environmental and geomatics engineers in the future. It is our duty and prime goal to educate 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.

It is obvious that also our research focuses on the changing demands of society, the expanding infrastructure and their close interdependence with nature: Water supply and waste water management, transportation systems, efficient use of resources (space, buildings, materials, data, etc.), environmental protection, spatial development and natural hazards engineering are therefore the key issues in our research programs. They all foster scientific knowledge and practical solutions to enable mankind to survive on our planet.

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

# *Our Focus*



## Planning period 2004 – 2007

The year 2002 was to a large extent dominated by important planning activities and related decisions at various management levels. On the one hand, the Board of ETH (ETH-Rat) has outlined its strategic plan for the period 2004 – 2007, which based on an overall portfolio, that distinguishes between disciplines to be strengthened, those to be kept at their present level and others requiring reengineering or a cut-back in activities. According to the Board's view, the disciplines of civil, environmental and geomatics engineering ought to be subject to restructuring topics and economizing resources through a closer coordination with ETH Lausanne. As a consequence, our department has initiated in spring 2002 a thorough discussion with the Faculty ENAC (Environnement Naturel, Architectural & Construit) of ETH Lausanne, that led to an agreement called "coordinated competition". This agreement sets in place – at the level of postgraduate education and in research – specific fields of competence in civil engineering, which will be concentrated either in Zurich or in Lausanne.

At the level of ETH Zurich, the long-term planning 2004 – 2007 was driven by the ongoing cuts in resources available during this period and an ambitious process of balancing the sometimes differing positions of the management of ETH Zurich and those of the departments. The outcome for our department has resulted in reduction of our global annual budget ,which is partly compensated by the transfer of the chair of environmental planning into D-BAUG, and a relinquishing of two chairs. On the other hand, our research and teaching strategy dated May 2000 (see Annual Report 2001) was accepted and incorporated as baseline for the future development of our department.

## Number of students

In sharp contrast to the cut in our resources is the increase of incoming students to our department since the year 2000 (civil engineers +66%, environmental engineers +130%, geomatics engineers +65%). This trend illustrates in a convincing manner that young people are getting more and more interested in the mission of our department and the later professional opportunities.

## New curricula

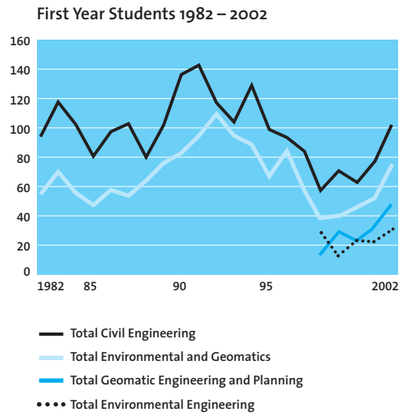
Besides the diverse planning activities, our department has put considerable efforts into the preparation of the forthcoming switch from the traditional diploma courses to the new bachelor/master system according to the Bologna model. We will start with the 3 year bachelor's program for civil, environmental and geomatics engineers in autumn 2003. In addition to the three basic master's programs lasting 1.5 years, we will offer a separate master's course in spatial and infrastructure development. Together with the Department of Architecture, two joint master's programs in urban design and planning and in project and facility management are in the pipeline. These master's programs and the extended PhD courses will form the basis of the new graduate school to be established by 2006.

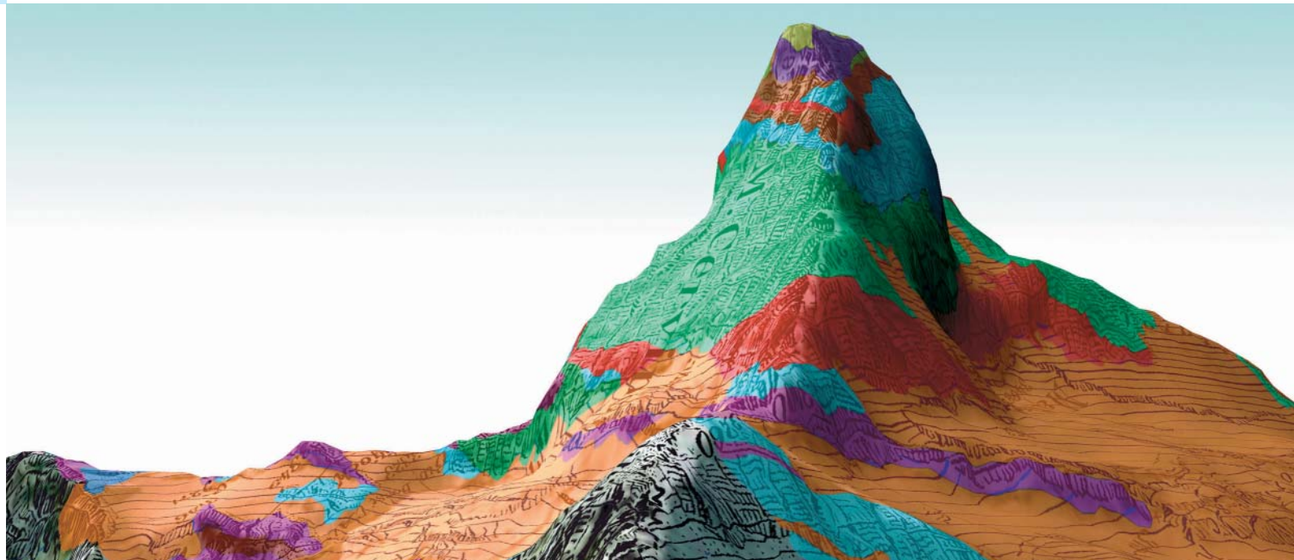
## A new star was born

While reengineering the former Institute for National- Regional and Local Planning (ORL) and transferring it to the new Network City and Landscape (NSL) under the supervision of our Department and the Department of Architecture, the need has arisen to think over the future role of the Institute for Rural Engineering (IfK). Checking all possibilities as well as the pro's and con's, the result was the forming of a new organisational entity called the Institute for Territorial Development and Landscape (IRL). This institute has been operating since October 2002 and for the time being is headed by Prof. Dr. Willy Schmid.

## Some critical thoughts about future

The world is changing at such a speed that sometimes we feel giddy and in the same way the ETH Zurich and consequently our department too is undergoing rapid change. Despite the many efforts to bring about change, our department will endeavour to maintain top quality in teaching and research. Universities cannot be compared to companies. Global budgets and benchmarks are also important for us, but our shareholders are students and society, not politicians or the short-lived CEO's of the global economy. Thus we are aiming for a good balance between change and consolidation. In academia there need to be periods of review and evaluation in order to check if the changes are really turning out to be successful or not. Nevertheless, if something needs to be improved, we will always tackle it with passion.



# Swisscodes

***A new set of structural design codes became effective in Switzerland as of January 1, 2003.***

**Peter Marti**

## Background

Within the European Committee for Standardisation (CEN) European Standards (EN) for structural design, execution of construction works, construction products and testing have been elaborated since 1989. Publication of the EN Eurocodes is scheduled for the period 2002 to 2006. After the date of availability of the approved EN Eurocodes a national calibration period of two years and a subsequent coexistence period of a Eurocode package of three years are foreseen; within the coexistence period, conflicting national standards must be withdrawn and national provisions must be adapted to make sure that all parts of the related package can be used without ambiguity.

## Swiss structural design codes of the Swiss Society of Engineers and Architects (SIA)

The project "Swisscodes" aimed at developing a complete, consistent and user-friendly set of structural design codes, compatible with the Eurocodes and considering specific national requirements. The Swisscodes are published in German, French and English. They replace the existing Swiss structural design codes and allow for the transition to the Eurocodes at the appropriate time.

The Swisscodes provide basic requirements for all types of structures, including buildings and bridges. They comprise eight documents, i.e. SIA 260 (Basic Principles of Structural Design), 261 (Actions on Structures), 262 (Structural Concrete), 263 (Structural Steel), 264 (Composite Steel-Concrete Structures), 265 (Structural Timber), 266 (Structural Masonry) and 267 (Geotechnical Design). Seismic design provisions are integrated into these documents rather than being treated in a separate document as in the Eurocodes.

Regarding construction products and testing, the Swisscodes generally refer to relevant EN standards. Seven supplementary documents (SIA 261/1 through 267/1) which can be revised on a short-term basis, depending on the EN development, contain such references as well as test methods not covered by ENs. Regarding execution of construction works, the Swisscodes are restricted to requirements of common interest to all parties involved in the construction process. EN execution standards and ongoing SIA work on the removal of code specific contract requirements from the technical standards (NVB) have been taken into account.

## Project organisation

Apart from the SIA, project partners included the Coordination of the Federal Construction and Properties Services (KBOB), the Association of the Swiss Contractors (SBV), the Association of the Swiss Cement Manufacturers (Cemsuisse) and other public and private organisations. Individual agreements between the SIA and each of the other project partners determined their contributions to the project.

The elaboration of the Swisscodes was directed by an executive committee consisting of Prof. Dr. Peter Marti (Chairman), Dr. Paul Lüchinger, Prof. Dr. Viktor Sigrist and Dr. Ulrich Vollenweider. 42 mandated experts were responsible for the drafting of the eight codes and their revision based on comments received from public review. The total cost of the five-year project amounted to seven million Swiss francs. One third of the total amount was covered by voluntary work; the balance was paid by the project partners.

## Implementation

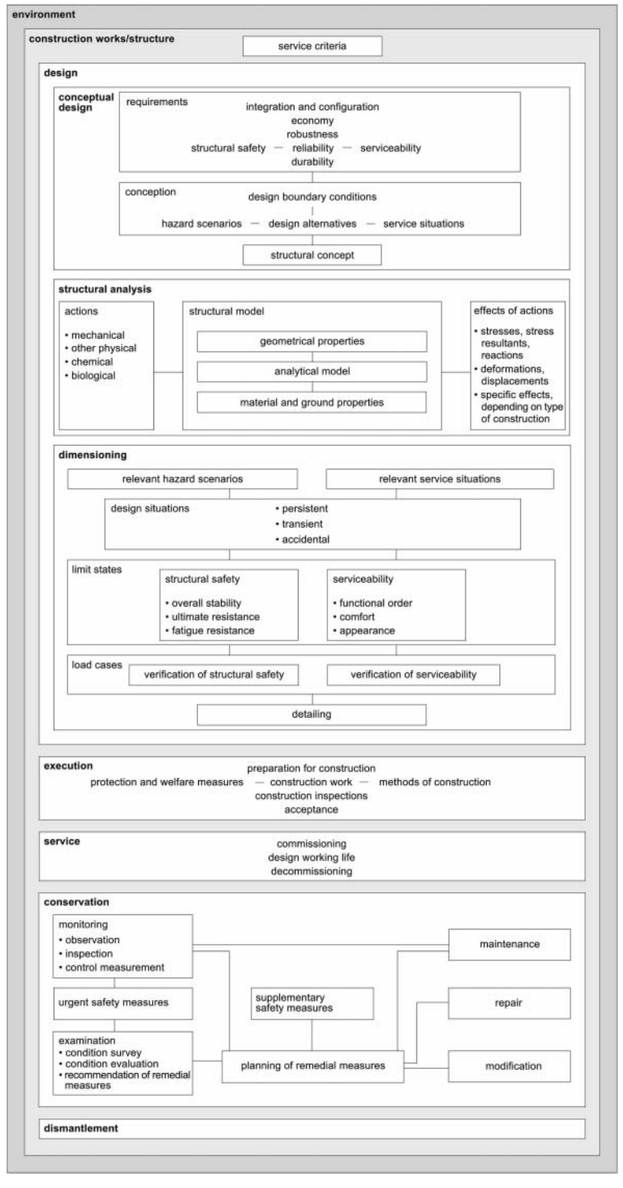
As part of the project "Swisscodes", trial applications were arranged for a number of selected construction projects. The trial applications provided comparisons with the existing Swiss and European standards and enabled a final check of the Swisscodes. Training courses for practitioners will be held in 2003. A special project directed by Prof. Dr. Otto Künzle was established for this purpose.

## Basic principles of structural design (SIA 260)

SIA 260 contains a comprehensive list of definitions of terms used in SIA 260 through 267. A figure is used to illustrate their interrelationship along with the characteristic steps of a planning process. SIA 260 is unique in its emphasis on conceptual design. A separate chapter is dedicated to relevant principles.

## Concluding remarks

The development of the Swisscodes was supported by major owner, designer, contractor and material supplier organisations as well as by the ETH. The substantial voluntary contribution of the mandated experts, the members of KTN and its associated committees and of all individuals who reviewed and commented on the draft Swisscodes should also be emphasised. The project "Swisscodes" created considerable interest among practitioners for the ongoing European standardisation process. With the Swisscodes they will have at their disposal concise documents that embody the latest European developments and continue the Swiss code tradition.




**Terms used in the Swiss structural design codes.**

# *Mining the Urban System: Exploration in Environmental Engineering*

**Peter Baccini, Thomas Lichtensteiger, Hans-Peter Bader, Susanne Kytzia**

**Mining of secondary resources in a Swiss town**
(Messe Basel, Foto Tozzo Tief- und Strassenbau AG)

## Introduction

In the time frame of the 21st century urbanisation is a global project. The urban systems of the developed world, mainly installed in the second half of the 20th century, do not meet the physiological criteria for sustainable development. The **environmental management of the first generation** (1970 – 2000) has been quite successful in

- protecting and restoring environmental compartments on regional scales,
- reducing significantly specific material fluxes,
- increasing the eco-efficiency of products.

It is based on the following concepts and principles, implemented in laws and ordinances:

- Emission Limits (threshold values, based on toxicology),
- Polluter Pays Principle,
- Principle of Precaution,
- Promotion of best available technologies.

The main goal of all actors is to achieve "legal compliance". The corresponding engineering tools are concentrated in the cleaning technology and in the increase of resource efficiency. All this did not significantly reduce the consumption of essential and non-renewable resources on a global scale. This is mainly due to the growth of urban systems, which overcompensates the efficiency gains. The **environmental management of the second generation** (after RIO 92) will have to focus on the resource management of urban systems. There are no "sustainable goods and processes". "Sustainable urban systems" might be possible on a regional scale, that is in regions with several million people and an average population density of several hundred inhabitants per square kilometre. To be classed as sustainable, any development of those systems would have to take into consideration the limitations of global resources. Regional studies are the essential links between the global models and the local and functional models ( www.se.ethz.ch).

## Growth and Steady State of the Urban Stocks

In the "Network City Switzerland" a new stock of "secondary resources" (exemplified by gravel, iron, copper, wood) has reached a quantity and quality comparable to primary resources. While the population growth is near the end of logistic growth, the per-capita growth of the construction stock is still in the period of strong linear growth (Fig. 1). In the 20th century, the mass stock of buildings grew to a level of about 200 tonnes per capita (Fig. 2). Within the total built urban system (buildings and infrastructure), the stocks per capita of various materials (e.g. copper and timber) are of the same order of magnitude as the known stocks of primary resources on a global scale (Table 1, page 10).

From a physiological point of view, an urban system of the "20th century" type, exemplified by the Swiss Lowlands, has the following main characteristics: the settlement stock, the energy demand and the type of energy transformation are the key factors to gain a "status of sustainability". From an engineering point of view, it follows that a transformation to a "sustainable status" is only possible by a reconstruction of the urban system. The building technology and the transportation system must be adapted to low energy demand.

## Material Management at the Level of Saturation

An urban system in growth (Fig. 3a) shows a mean stock increment of 1–3% per year, mainly from primary sources (e.g. gravel, clay, timber, metal, glass etc.). During this period, the secondary resources were not able to satisfy the overall demand. In this case, most of the engineering activity is found in the so-called production branches. If the population stabilises and the per capita consumption reaches the growth limit (a quasi steady-state situation, see Fig. 1), the urban stock becomes the main mining site and the secondary resources are the important source for the further transformation of the urban infrastructure (Fig. 3b). This means that the waste management process becomes much more important in the primary and secondary sectors of the urban economy. There are already some regional examples for this type of material management, e.g. paper, glass, iron, for which the consumption flux shows relatively low growth rates and small stock increment. In these cases the secondary sources have become the dominant ones, due to economic reasons. However, with regard to the overall fluxes, their quantitative contribution is still very small.

## The reconstruction of the energy household

The transition from the actual energy management of urban systems to a "sustainable status" comprises two steps: a) the redesign of the supply, i.e. the substitution of non-renewable by renewable energy carriers and b) the restructuring of the urban system to reduce significantly the energy demand. These two steps are illustrated for the urban system Switzerland in the combination Highlands–Lowlands interaction (Fig. 4). The present situation corresponds to a 6000-Watt society that depends mainly on external fossil fuels. There are only small interregional exchanges, due to complementary functions of different climate and ecosystems. During the last 30 years, the specific energy demand for house heating (MJ/m2.y) was reduced significantly. However, the efficiency gain was overcompensated by the growing demand for transportation.

In the case of a 2000-Watt society, the regional urban system doubles its solar energy production by a factor of two. By this it can reduce the demand from external resources by a factor of 20. Furthermore, the Highlands, at present an economically weaker region, become an important energy producer for the Lowlands. For this scenario,

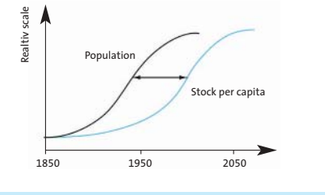



**Fig.1 Logistic growth of population and material stocks per capita in the transformation from a developing to a developed status. In the urban systems of European countries, these two processes have a time-delay of one to two generations**

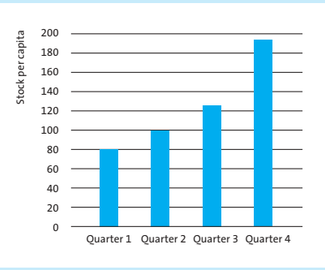



**Fig. 2 Mass development of buildings in Switzerland in the four quarters of the 20th century (in tons per capita). At the beginning of the 21st century, the stock per capita is approximately 200 tons per capita**

(Source: Henseler G., Baccini P., 2003, Materialzusammensetzung im Bauwerk Schweiz, unpublished results from ARK'04 2000, Professur für Stoffhaushalt und Entsorgungstechnik der ETH Zürich, CH-8093 Zürich).

**Typical stock of secondary resources in a Swiss town** (Luzern Nord, Foto T. Lichtensteiger)

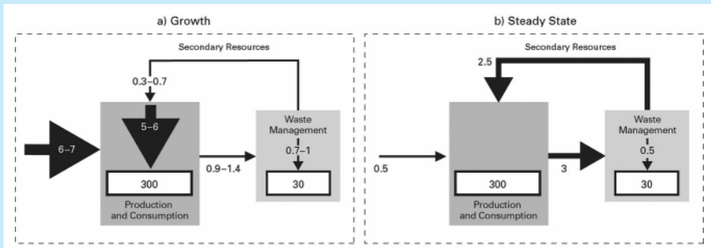



**Fig.3 Material management scheme for an urban system in the a) growth phase and b) steady state phase. The flux units are in tons per capita and year; the stocks in tons per capita**

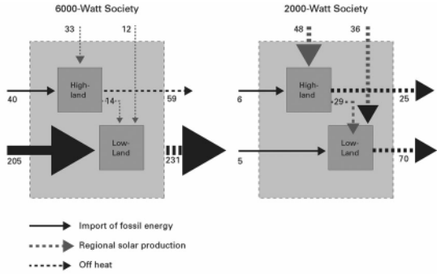



**Fig. 4 Comparison of energy household of a 6000 Watt-Society (status quo) with a 2000 Watt-Society (sustainable status), exemplified with the Highlands-Lowlands urban system of Switzerland. Energy fluxes in TWh per year. In the status quo the allochthonous and non-renewable energy source amounts to 84%. The solar energy support from the Highlands to the Lowlands is small (6%). In a 2000 Watt-Society, the import of non-renewable energy is reduced by a factor 20. Its share in the overall demand is only 12%. The Highlands become an important supplier with 40% of the Lowlands' demand**

(source: Hug F., Baccini P., 2002, Physiological Interactions Between Highland and Lowland Regions in the Context of Long-Term Resource Management, Mountain Research and Development, Vol.22, No.2, May2002:177–185).

# *Geoinformation for Sustainable Development*

**Alessandro Carosio, Christine Giger, Lorenz Hurni, Willy Schmid**

## Introduction

At the UN Conference on Environment and Development in Rio de Janeiro in 1992, a major resolution was passed to focus on reversing the impact caused by environmental deterioration. The Agenda 21 resolution establishes measures to address deforestation, pollution depletion of fish stocks, and management of toxic wastes, to name a few. The importance of geographic information to support decision-making and management of these growing national, regional, and global issues was cited as critical at the 1992 Rio Summit, and by a special session of the United Nations General Assembly in 1997 to appraise the implementation of the Agenda 21.

Business development, flood mitigation, environmental restoration, community land use assessment and disaster recovery are just a few examples of areas in which the associated decision-makers are benefiting from geographic information. In this context the idea arose of simplifying the access to geographic information for all interested groups, which may include scientists, professionals, politicians as well as private persons. It became obvious that associated infrastructures (i.e. Spatial Data Infrastructures or SDI) had to be developed, that support information discovery, access, and use of this information in the decision-making processes.

Today, we regard an SDI as a means of hosting spatial data and attributes as well as sufficient documentation (metadata), in order to enable the retrieval, access, integration, and presentation of geographic information on the Internet.

## Challenges for Research in Geoinformation Science

In order to develop an SDI we have to face the necessity of integrating spatial data of different kinds (e.g. photos, maps, descriptions, satellite imagery, raster and vector data, etc.) and sources (e.g. official surveying, environmental agencies, private utility suppliers, telecommunication, etc.). The data has to be integrated and linked to appropriate software in order to provide easy-to-use means for information retrieval, analysis and visualization. The resulting problems often cope with the sheer amount of data (up to several terra bytes) and its complexity. One aspect of that complexity originates in the fact that different information communities specify fairly different models for the same object in reality depending on their notion and with regard to their specific application and point of view. The integration of spatial data from different information communities is usually non-trivial because of the different semantics and corresponding data models involved. So, even if we ask the seemingly easy question "What is a street?", we will receive quite different answers (data models) according to the membership of a specific information community. For example, (1) a resident of a big city would possibly associate noise, pollution, and a line on a map, or (2) an official surveyor regards a street as part of a tessellation, consisting of parcels, specified as polygon areas in an official co-ordinate system, or (3) someone developing a car navigation system would describe a street as part of a path, which has to be calculated and is specified by connected line segments.

**3D-Visualization of a Landscape in Ticino.**
Data source: © Swiss Federal Office of Topography

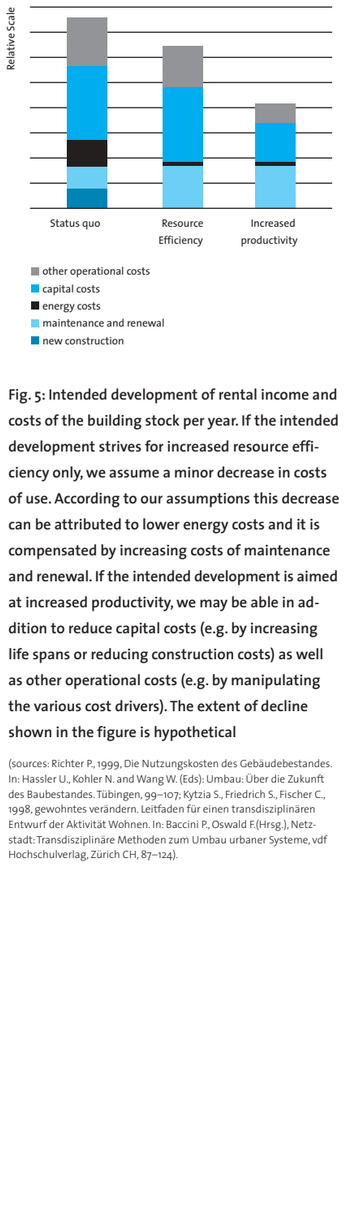



**Fig. 5: Intended development of rental income and costs of the building stock per year. If the intended development strives for increased resource efficiency only, we assume a minor decrease in costs of use. According to our assumptions this decrease can be attributed to lower energy costs and it is compensated by increasing costs of maintenance and renewal. If the intended development is aimed at increased productivity, we may be able in addition to reduce capital costs (e.g. by increasing life spans or reducing construction costs) as well as other operational costs (e.g. by manipulating the various cost drivers). The extent of decline shown in the figure is hypothetical**

(sources: Richter P., 1999, Die Nutzungskosten des Gebäudebestandes. In: Hassler U., Kohler N. and Wang W. (Eds): Umbau: Über die Zukunft des Baubestandes. Tübingen, 99–107; Kytzia S., Friedrich S., Fischer C., 1998, gewohntes verändern. Leitfaden für einen transdisziplinären Entwurf der Aktivität Wohnen. In: Baccini P., Oswald F.(Hrsg.), Netzstadt: Transdisziplinäre Methoden zum Umbau urbaner Systeme, vdf Hochschulverlag, Zürich CH, 87–124).

only known and in practice realised technologies were applied. For economic and social reasons such a reconstruction takes at least 50 to 60 years.

## Economics of an Urban Stock in Steady State

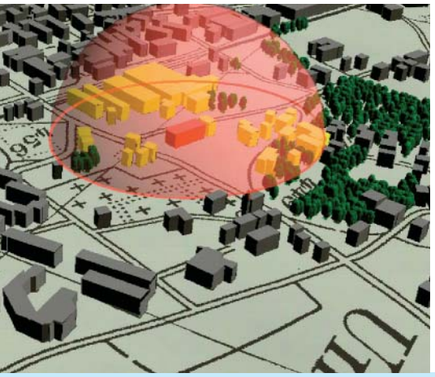
Economically, an urban stock in steady state is only desirable if it is accompanied by a decoupling of economic and physical growth. Decoupling requires a growing productivity of buildings and infrastructures per unit of mass or area. It is vital for two reasons. Firstly, return on investment in real estate should keep up with alternative investments (e.g. bonds) because social security currently depends on it (e.g. pension funds). Secondly, we may encounter social problems in distributing the available property (for housing) and/or limitations in economic development (for service industries). Productivity growth in the urban stock is currently restricted by low rates of renewal. A significant growth in productivity can be achieved by technological progress, as was experienced in agriculture throughout the last century. New building technologies and design concepts are generally available. Yet, their implementation is delayed because the urban stock is currently renewed at slow rates. With a demolition rate of 0.5% of the building mass per year, the theoretical life-span of buildings amounts to 200 years. Buildings are refurbished and structurally modified at higher rates. These kinds of modifications, however, are insufficient to obtain gains in energy efficiency as envisioned in the previous sections. This reveals the need to encourage investment.

At present, low expectations of productivity growth discourage adequate investment in the urban stock. To overcome this situation, it is crucial to better understand the structure of life-cycle costs and rental income as well as their determinants (e.g. business environment, location, building conditions). Considering the present structure of operational costs, it is evident that measures aiming at growing resource efficiency are insufficient to significantly improve the ratio between costs and revenue (see Fig. 5). The share of energy costs in a building's total life-cycle costs is too small. Efforts in urban renewal have to put an additional focus on capital costs, other operational costs as well as rental income per unit. Significant improvements in these fields will result in a growing productivity, which is necessary (1) to trigger the process of urban renewal and (2) to maintain economic growth in the envisioned steady state of the urban stock.

| | Global reservoirs for 8 billion people | Stocks in develop. urban systems | Consumption rates in developed urban systems |
|---|---|---|---|
| **Territories** | **ha/capita** | **ha/capita** | **ha/cap. & year** |
| **Agriculture** | **0.5** | | |
| **Forestry** | **0.3** | | |
| **Settlement** | | **0.03** | **0.0001** |
| **Timber** | **$m^3$/capita 50** | **$m^3$/capita 10** | **$m^3$/cap. & year 0.4** |
| **Oil** | **GJ/capita 800** | **GJ/capita 40** | **GJ/cap. & year 100** |
| **Copper** | **kg/capita 300** | **kg/capita 300** | **kg/cap.& year 10** |

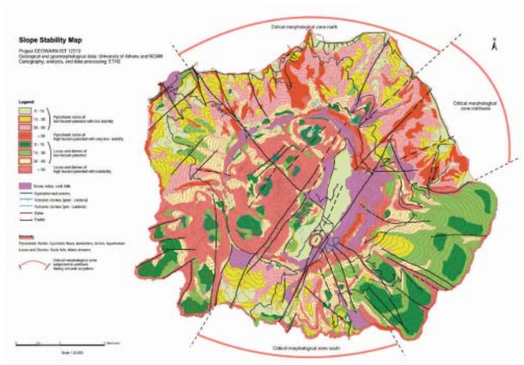
**Table 1: A selection of estimated resource reservoirs per capita for a world population of 8 billion, compared with corresponding stocks and actual consumption rates in developed urban systems. The data, giving only orders of magnitude**

(sources: Buitenkamp et al. 1992,"Action Plan Sustainable Netherlands"; Campbell C.J. 1997,The Coming Oil Crisis. Multi-Science Publishing Company&Petroconsultants. Amazonbooks; Global 2000, 1981, The global 2000 report to the president, Washington D.C.; Zeltner Ch., Bader H.-P., Scheidegger R. , Baccini P., 1999, Sustainable Metal Management Exemplified by Copper in the USA, Regional Environmental Change 1 (1), 31–46).



**Analysis of integrated Vector and Raster data in a 3D GIS.** Data source: © Swiss Federal Office of Topography

**Access to the Spatial Data Infrastructure by using GPS-enabled mobile devices**




**EU-Project GEOWARN: Result of GIS analysis: Slope stability map based on slopes and types of volcanic deposits**

In an SDI our goal is to integrate the data originating in different information communities, and to make that data available to the public as well as to experts and stakeholders. The only possibility to cope with the effect is to provide formal descriptions of the models as well as deterministic algorithms to map the different models onto each other. The Chair for Geographic Information Systems and Theory of Errors and the Chair for Geoinformation Technologies developed tools for specifying, processing, and integrating data models and descriptive data (metadata). These tools provide useful and usable means to retrieve, access, integrate, analyze and present data from different sources in the context of an SDI. Research topics cover, e.g., data transfer between Geographic Information Systems (GIS), automatic data acquisition for GIS, knowledge-based visualization, geographic data retrieval through meta information systems, and software architectures for SDI.

## Advanced Presentation Methods for Spatial Data

Due to the amount of information and the inherent complexity of spatial data there is a need to provide suitable visualization methods in an SDI. The Chair for Cartography therefore is developing new methods to support expert cartographers in preparing 2D and 3D spatial data for presentation on the Internet. Research topics include cartographic tools on the Internet, cartographic relief representation, 3D visualization of GIS-based glacial data, an interactive multimedia Atlas information system, the development of cave mapping tools, and distributed publishing of interactive maps on demand. Depending on specific applications it may also be necessary to provide advanced methods to support the mutual understanding of experts and the public. For example, dormant volcanoes situated in regions of high geodynamic unrest represent a constant threat. Surveillance studies of volcanoes require the monitoring of geodetic, seismic, and geochemical data. A web-based software that combines this data with topographic information, satellite images, and multimedia information is a suitable tool that could use up-to-date data and information services on the basis of an SDI. The software then allows an interactive comparison of various data sets from different information communities, and thus gains new insights into the internal processes of volcanic regions. The ease of the graphical user interface in combination with the versatility of different cartographic representations and functionalities allows one to analyze the different data sets and to obtain data correlations in order to better investigate volcanic hazards (www.geowarn.org).

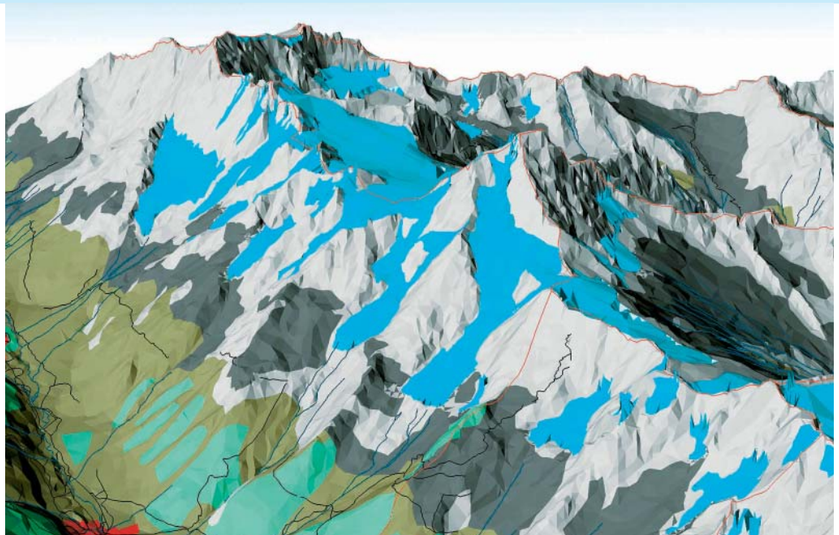
## Geoinformation to support the Informed Planning Process by 3D GIS

According to the general concept of sustainability, "environment" is a comprehensive entity, encompassing our natural, social, economic, administrative-political and cultural environment – the living space of humans. This living space – in its interactive context – is the "object" of all activities of the Chair for Landscape and Environmental Planning. Geographic (spatial) information provides a major basis for (1) the integration of environmental considerations into the (spatial) planning process and the implementation of sustainable land use patterns and management, (2) the informed decision-making in the context of infrastructure planning and spatial development, and (3) the development of planning tools and instruments relying on state-of-the art (computer) technology, facilitating spatial and environmental decision-making and monitoring.

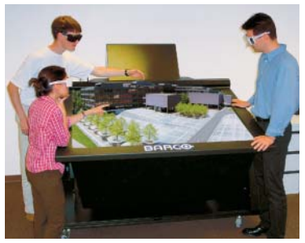
The management of land is increasingly decided at a local level, with trends across Europe of greater public participation in landscape planning processes and empowerment of local administrations to determine resource exploitation and development. Yet, understanding of the outcomes and consequences of landscape planning decisions is generally poor among the public and their elected representatives. This led to the development of visualization tools to enable public participation in the management of landscape change. Relationships between visual qualities and other landscape functions are used, 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.

In agglomerations the growth of population and increasing living standards has led to a serious lack of disposable space. To avoid conflicts, participatory planning strategies were developed, integrating experts, stakeholders and lobbyists in the decision-making process. For these processes it is indispensable to make spatial and time-related information perceptive by a specified group of (non GIS experts) participants, in order to support their joint decision-making process.

The Chair for Geographic Information Systems and Theory of Errors has a long tradition in developing methods to support 3D GIS, such as topologic 3D data modelling and the integration of raster data and 3D objects into geo-databases. For mutual understanding in a participatory process, the use of 3D information and visualization is known to be a suitable support. Therefore, the Chair for Geoinformation Technologies is developing an immersive environment, which is based on 3D GIS functionality (analysis, presentation and interaction with spatial information) and can be used by a group of people who discuss a specific problem or carry out a given planning task. All information can be visualized on a large 3D stereo screen and a group of people may interact with the system simultaneously.



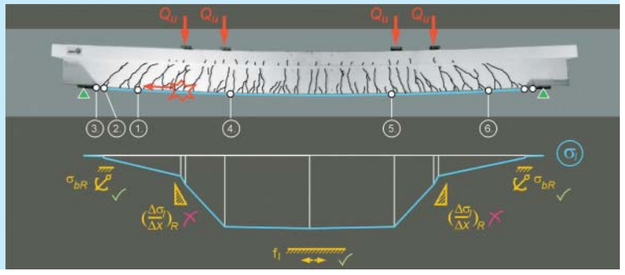
**Perspective view of the glaciated Bietschhorn area (seen from northwest) with simplified glacier extension of 1973, realised with ARCVIEW extension 3D ANALYST (by ESRI).** Terrain and topographic data DHM25, ©Swiss Federal Office of Topography, Wabern; testdata of glacier contours from CH-INVGLAZ, ©Department of Geography, University of Zurich.



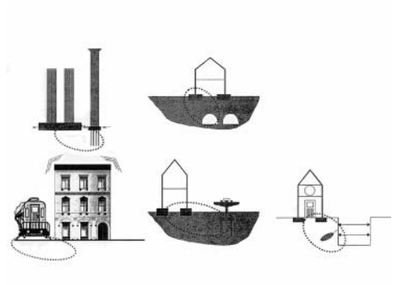
**Participatory planning utilizing 3D GIS and a stereoscopic visualization enviroment**

**Scene of an urban Park in Zurich, modelled in two different conditions of seasons and vegetation, based on GIS data (thesis of Isabella Mambretti, IRL).**
**a) The park depicted in spring with vegetation enclosure**
**b) The park depicted in winter without vegetation enclosure**

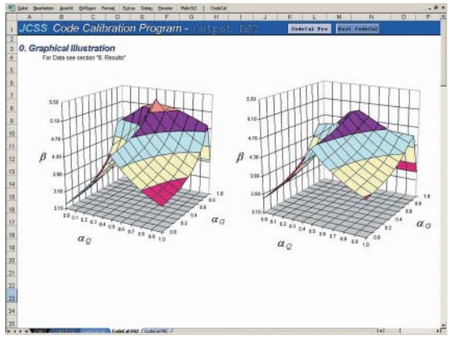
# Structures




Reinforced concrete beam with externally bonded reinforcement: failure analysis



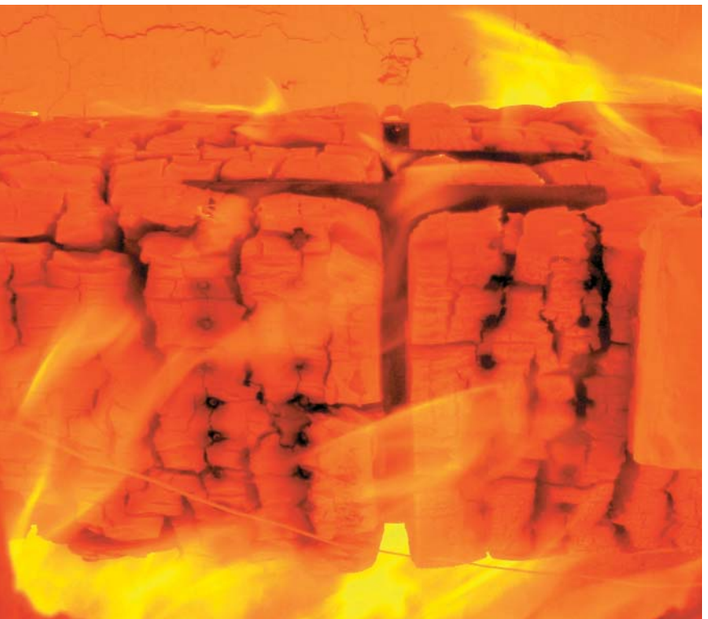
Sustainable use of underground space in urban areas
after Kjekstad NGI, 2000, Chairman COST C7




Software for calibrating the safety of structural design codes

## Fire research – breakthrough for multi-storey timber buildings

The introduction of the new Swiss fire regulations by the State Fire Insurance Companies will lead to a remarkable breakthrough for multi-storey timber buildings and open up a large new market for timber. Based on our research results and our collaboration within the technical committee of the Swiss fire regulators, the use of wood for structural elements in timber buildings will be extended from presently two to six storeys. To guarantee fire safety in such buildings a large joint research and education project was launched by the timber industry and timber associations with a financial volume of over 5 million CHF over a period of 5 years. IBK (Group of Prof. Fontana) was commissioned to carry out two of the core research projects in the field of fire behavior and fire resistance of structural timber elements and timber connections. The aim of these projects is to develop and experimentally verify design models for 60 minutes fire resistance. The fire tests are being performed in close collaboration with EMPA. The research projects benefit from our experience and previous research projects in this field and will provide basic data on the fire behaviour of timber for a fire of long duration. The results will also form the basis for a new SIA documentation on the fire safety of timber buildings.



Fire resistance of structural timber elements

## Design Guidelines for Reinforced Concrete Beams with Externally Bonded Reinforcement

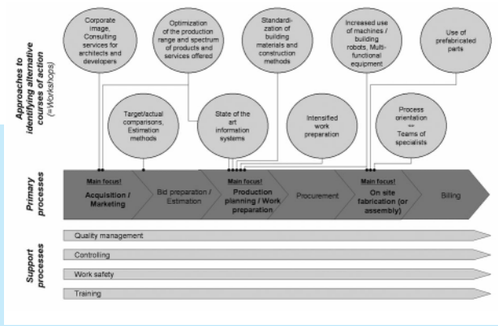
Experimental investigations on concrete beams with externally bonded plates show that the most common failure mode is due to delamination of the plate. This failure occurs normally within a fraction of a second, and is therefore very difficult to study. In order to determine appropriate design guidelines, the delamination phenomenon was examined experimentally at the Swiss Federal Laboratories for Materials Testing and Research (EMPA) and theoretically at the Institute of Structural Engineering (IBK, Group of Prof. Vogel, project of Tomaz Ulaga). An innovative method based on potential drop measurements on conductive stripes across the reinforcement was used to monitor the crack propagation process. This provided an indication of the origin of the crack and its velocity, which was in the range of 600 m/s. The theoretical findings support the experimental observations in terms of the crack origin. The results demonstrate that plate delamination can be prevented if the following design aspects are considered: the shear stresses at the plate-concrete interface must be limited and the anchorage resistance must be verified. These findings will be integrated in a design concept which is part of a new Swiss code on externally bonded reinforcement ("Vornorm SIA 166: Klebebewehrung"). The document will be published in 2003.

## COST C7 Action "Soil Structure Interaction in Urban Civil Engineering"

The COST C7 Action "Soil Structure Interaction in Urban Civil Engineering" had as its aim the exchange of geotechnical experiences between universities and civil engineering practice throughout Europe and the preparation of recommendations for future urban planning. The accompanying Swiss research project was directed by the Institute for Geotechnical Engineering (Group of Prof. Amann). The industrial project partners were the firms Solexpert, Schwerzenbach, and RSE, Zurich. The research work consisted of the preparation of a state-of-the-art report on the planning and control of urban geotechnical measures and urban tunnelling in ground water as well as the evaluation of case studies in Switzerland. The action showed that in urban planning strategies geotechnical aspects and relevant information have to be taken into account early, in order to avoid damage and reduce costs. In the education of architects and civil engineers an awareness of the problem of soil-structure interaction should be awakened more than has been the case in the past. Finally, it is to be expected that the sustainable use of underground space in urban areas in the future will become of great economic importance (http://www.bygg.ntnu.no/geo/costc7/web00/).

## Industrial Construction in Small and Medium-sized Enterprises (SMEs)

Numerous workshops, which were based on empirical research, have been conducted with the active participation of the Swiss construction industry focusing on potentials of industrial construction and on appropriate alternative courses of action (IBB, Group of Prof. Girmscheid, project of Jan Bärthel). Initially, it was necessary to define what was actually meant by industrial construction. Robots are not the first step towards industrial construction but industrial construction is rather the possible final result of an industrially-structured organization. On the basis of empirical findings, 29 alternative courses of action for industrial construction in SMEs were developed using theoretical support and logical thought processes. The alternative courses of action are enhanced by tools for the company-specific evaluation of the same and by working aids for their implementation in companies (e.g. checklists, flowcharts and summaries with key information). The project findings (www.ibb.baug.ethz.ch/publikationen) aim to assist SMEs in strengthening their competitive ability and are therefore being integrated into advanced training schemes, starting in spring 2003 in the training centre of the Swiss Contractors' Association and aimed at entrepreneurs and senior construction managers.




Industrial construction in small and medium-sized enterprises (SMEs)

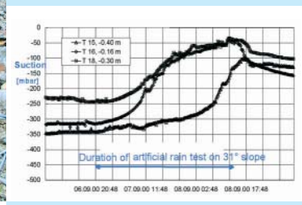
## New – More Safe, Cost Efficient and Sustainable Approach to Structural Safety in Codes and Regulations

In 1971 the Liaison Committee which co-ordinates the activities of six international associations in civil engineering (CEB , CIB, fib, IABSE, and RILEM), created a Joint Committee on Structural Safety (JCSS), with the aim of improving the general knowledge in structural safety. Continuous efforts by JCSS over more than 25 years have recently been synthesized to form the basis for a new safe, cost efficient and sustainable approach to the codified design of structures. The JCSS-recommended procedure for implementing the new approach into the codified and regulated design of structures is described on www.jcss.ethz.ch. The approach is presently being incorporated into the Excel-based CodeCal software, publicly available upon request. Following the new approach facilitates the design of structures with a significantly enhanced targeting of the safety of structures and consequently a far more rational use of building materials, consequently providing a basis for significant societal cost savings. This remarkable achievement is the result of the large efforts devoted by a varying group of internationally recognized experts in structural reliability theory on the formulation, development and homogenization of methods of structural reliability and optimization. One of the most obvious first applications will be in connection with the forthcoming adoption of the Eurocodes by the individual European Community member states. (IBK, Group of Prof. Faber)

# Infrastructure Systems

The site (12m x 8m)

Tensiometers for measuring suction




Loss of suction during rainfall

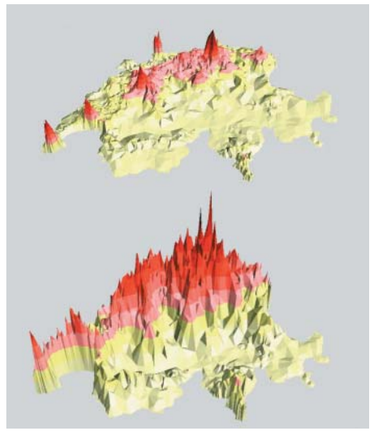
## Transport System Development and its Impact on Spatial Use in Switzerland

In the context of the projects COST-Action 340 and NFP 48, the Institute for Transport Planning and Systems (IVT, Group of Prof. Axhausen) is analysing the joint long-term development (ca. 1850-2020) of the tightly interwoven transport and spatial systems. Changing the accessibility (the number of persons accessible, weighted by a function of travel costs) between the various regions is the key impact on the regions resulting from transport system development (infrastructure, transport services). Accessibility is the link explaining the connection between transport- and spatial development. On the basis of road- and railroad networks, accessibility changes can be calculated for each municipality in Switzerland since 1850. The figures show the impact of motorway construction on accessibility patterns in the Swiss "Mittelland" between 1950 and 2000. The primary beneficiaries of the motorway network are not the urban centres, but rather the areas in between, where accessibility has improved tremendously as a result of motorways. The merging of the agglomerations between the cities of the Swiss "Mittelland" (Zwischenstadt) is the observable effect. Project information and partners are given in

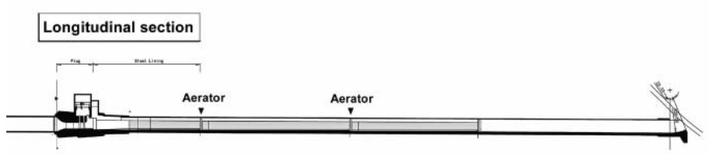
www.ivt.baug.ethz.ch/vrp/projekte_cost340_d.html
www.ivt.baug.ethz.ch/vrp/projekte_nfp48_d.html

## Two-Phase Flow in Bottom Outlets

Common design criteria for bottom outlets stipulate free surface flow in the tailrace tunnel in order to avoid unpredictable conditions concerning air pressure and air discharges as well as pressure fluctuations in a possibly pressurized air-water discharge. Nevertheless, these criteria cannot always be attained for different reasons, e.g. subsequent heightening of dams. Another aspect possibly leading to flow conditions other than free surface mixture flow may be an unavoidable influence from the tail water. A current research project at VAW (Prof. Hans-Erwin Minor, thesis Urs Keller) financed by the Fund for Projects and Studies of the Swiss Electricity Utilities (PSEL), focuses on the consequences of such unfavourable conditions in terms of the above mentioned parameters as well as possible discharge limitations. Field measurements and physical model tests such as those on the bottom outlet of the Gojeb Hydropower Project (Ethiopia) have contributed to these investigations. In the specific case of the Gojeb Bottom Outlet, negative consequences of the influencing tail water and imminent shockwaves downstream of the gates almost filling the whole cross-section could be ruled out. Nevertheless, additional knowledge on the related pressure impact on the tunnel lining will allow a more specific design.



Impact of motorway construction on accessibility patterns in the Swiss "Mittelland" 1950 (top) and 2000 (bottom)




Model study of the two-phase flow in bottom outlets

## Rheology of Debris Flow

In various mountainous zones debris flows endanger villages and infrastructure. Numerical modelling is becoming an increasingly important tool for the definition of risk areas and the investigation of prevention measures. Numerical models that simulate the flow and deposition process of viscous and viscous granular type debris flow rely on rheological models. Thus knowledge of the rheological behaviour of the whole debris flow mixture (fine to very large particles) is a prerequisite. However, due to the geometric constraints of conventional rheometric devices only the fine material part of the whole debris flow mixture could be analyzed so far. At VAW (Prof. Minor, thesis Markus Schatzmann, in collaboration with Institute of Food Science) a project focuses on a novel rheometric system that allows the analysis of the rheological behaviour of mixtures containing fine and medium size particles. One of the potentials of the new system is its extension to a large scale device whereby an important part of the whole debris flow mixture could be analyzed.

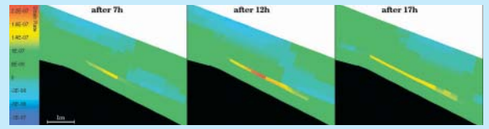
Deposits depend on the rheology of the debris flow

## Slope Instability in Moraines

Many alpine slopes remain stable only because the soils, mainly moraines, are partially saturated. In this case, the pressures in the void space are suctions, and these contribute to the effective stresses within, and hence the strength of the soil matrix. As resaturation occurs during rainfall events, these suctions will be eliminated gradually and replaced by positive pore pressures, causing significant loss of strength. This leads to shallow planar slips that can also develop into debris flows. Field tests have been carried out at two sites, which have been instrumented and subjected to artificial rainfall for periods of up to one week (IGT, Group of Prof. Springman, thesis of Philipp Teysseire). An extensive range of in situ and laboratory tests has been carried out to establish the relevant properties of the soil. An appropriate constitutive model has been selected and is being adapted for future numerical analysis with the aim of producing recommendations for evaluating risk in terms of slope stability.

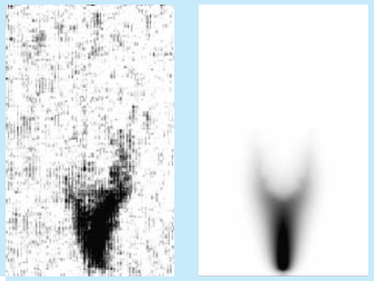
## Numerical Modelling of the Alpine Snowpack

Most predictions of avalanche hazard risk today are based on decisions made by experienced experts and statistical methods. The exact physical processes (structure of snow cover, temperature dependence, weak layers, topographic situations, material behaviour, etc.) which lead to an avalanche are thereby not fully taken into account. These highly nonlinear processes can be modelled using modern numerical methods. The IBK (Group of Prof. Anderheggen, thesis of Martin Stoffel) is developing a specific Finite Element simulation software in a joint research project with the Federal Institute for Snow and Avalanche Research. Research topics in this project are the numerical modelling of the visco-elastic behaviour of snow, especially the treatment of weak layers with almost no resistance to friction and the implementation of an N-directional material model to simulate the failure of snow. The temperature simulations of the ice-matrix and the surrounding air are separated to account for the dependence of the physical behaviour of snow on temperature. A graphical interface to a GIS system is to be developed as well as a front-end to display the results of the simulation.




Development of strain rate between an old snow layer and new snow. After 12h an avalanche is very likely around the red cell.

# Resources



Flow in a porous medium around a region clogged by bacterial growth, visualized by a dye tracer. Left: experimental observation. Right: result of the modelling.

## A New Tool for Investigation of Contaminated Sites

The change from an abandoned industrial site to a residential area requires a site investigation to assess whether the location is contaminated or not. If necessary, a remediation plan needs to be developed based on this data. Currently, such investigations can be cost-intensive, time-consuming and imprecise. This uncertainty resulted in a KTI research-cooperation called "New Technology for Exploration of Contaminated Sites (NTECS)" (IGT, Group of Prof. Hermanns Stengele, thesis of Peter Wotschke, in collaboration with the Institute for Geophysics (University of Leipzig) and the company ABB). The task of the first project phase was to investigate the stratigraphic sequence of a test site and to quantify the volume of undisturbed subsurface structures and the infill. Based on this data the excavation costs can be calculated. In a further project phase a chemical analysis will be integrated to assess type and amount of contamination to calculate the expense of remediation. Two geophysical methods for tomographic site characterisation were used. A 3-D resistivity tomogram of the subsurface was generated using measurements of a multi-electrode system. In addition, cross-hole radar measurements were performed between boreholes. The measurements provided a quick and liable tool to image the subsurface and to place effectively cost-intensive drillings. The results of these four technologies showed a high degree of similarity and created a detailed image of the subsurface. They allowed a calculation of bedding volumes and excavation costs.

## Modification of Porous Media by Bacterial Growth

Bacteria play a decisive role in the self-purification of polluted aquifers. Under suitable growth conditions they can clog the pore space of a porous medium. This effect – also known as "bio-clogging" – not only reduces the porosity but also the hydraulic conductivity of a water saturated medium. It therefore has to be taken into account in any bioremediation measure. Bioclogging has been observed in laboratory experiments, the measured data, however, could not be reproduced by numerical models up to now. Experiments were performed, which visualized the complex interaction of bacterial growth with a two-dimensional flow field (IHW, Group of Prof. Kinzelbach, thesis of Martin Thullner, in cooperation with Prof. Zeyer from the Institute of Terrestrial Ecology). The growth process was quantified using methods of microbiological analysis. It was shown that the extracellular mass of the bacteria contributed significantly to the clogging. A new modelling concept was developed, based on the simulation of pore networks. With this new approach it was possible to reproduce in a satisfactory way not only our own experimental results but also the results of other research groups.

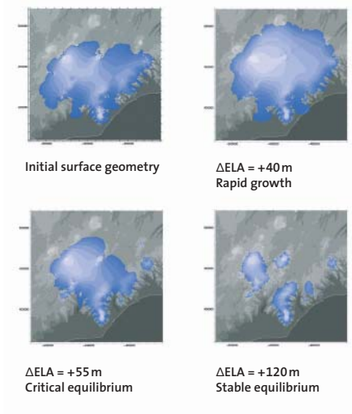
GPS campaign in Botswana

## Geophysics and Geodesy in Botswana

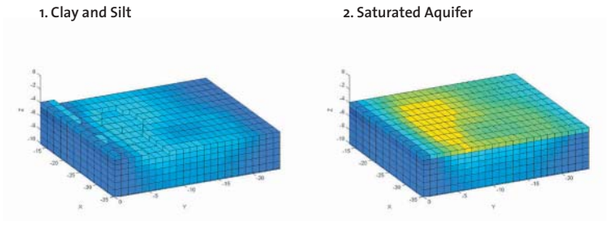
The Okavango Delta is an inland delta in arid Botswana, famous for its wildlife. The delta lives off the floods of the Okavango River, which takes 3 months to cross the delta. To understand and model the flooding pattern a very accurate digital terrain model is necessary. The modelled flood can then be compared to the actual flood as observed by satellite imagery. For management purposes the consequences of variations in flow due to human interaction can be estimated with this model. The field work in 2002 focused on geodetic and geophysical data (IHW, Group of Prof. Kinzelbach, thesis of Peter Bauer, IGP, Groups of Prof. Ingensand and Prof. Grün, thesis of Krishna Taluktar). In the course of a three weeks GPS campaign 45 points were measured with three geodetic GPS receivers. The post-processing of the GPS data in combination with an appropriately modelled regional geoid – based on 7 reference points of the national geodetic network of Botswana – lead to a point accuracy of 3 dm for all 45 points. The resulting coordinates allow the orientation of the aerial images and thus form the geodetic reference frame for the calculation of a digital terrain model.

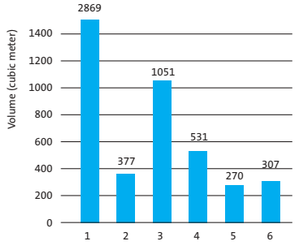
## Flow Dynamics of Vatnajökull Ice Cap, Iceland

The flow dynamics and the stability of the Vatnajökull ice cap in Iceland are analysed with a numerical ice flow model developed at VAW (glaciology group, thesis of Gudfinna Adalgeirsdottir). The basis for the numerical modelling are the radio-echo sounding data of the bedrock topography of Vatnajökull, surface elevation, velocity of the ice, and mass balance measurements provided by Helgi Björnsson at the Science Institute, University of Iceland. The data are used to select the model parameters to describe the flow of Vatnajökull. Several numerical schemes to solve the flow field equations are tested. It is shown that a commonly used method (alternating direction semi-implicit) is not mass conserving due to ice free points within the ice cap. It is necessary to use an upstream scheme to ensure mass conservation. A non-linear regression model that describes the mass-balance distribution of Vatnajökull during the years 1992–2000 is developed. The regression model uses six adjustable parameters, the slope, direction and the equilibrium line altitude (ELA, separation line between accumulation and ablation areas), two altitude mass-balance gradients and a maximum value of the surface mass balance. It is found that the temporal variation of the observed mass-balance distribution can be accurately described through annual shifts of the ELA. Model computations forced with the mass-balance model show that the ice cap is very sensitive to climatic changes and can respond in an unstable manner by unlimited growth. The Vatnajökull ice cap is presently very close to this critical size (figure). Smaller ice caps and alpine glaciers are not as sensitive to climatic changes.



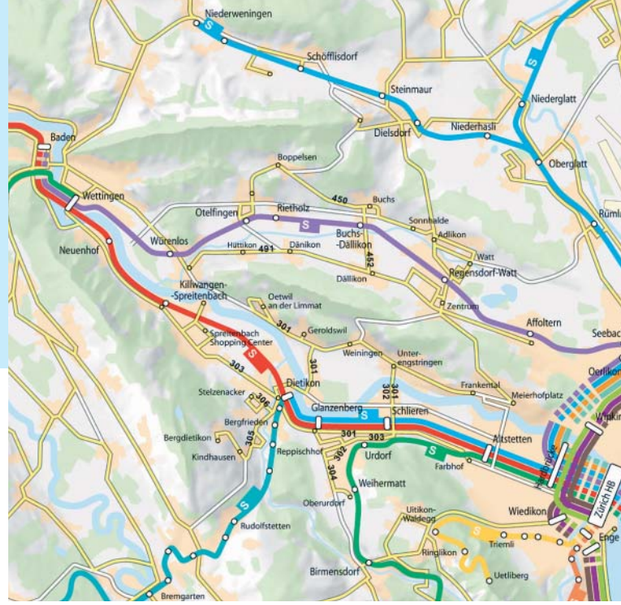

Future volume and geometry change of Vatnajökull ice cap as a function of equilibrium line altitude (ELA) increase. These changes correspond to a temperature increase of 0.3, 0.5 and 1 degree C if no change of precipitation occurs.




Subsurface volumes estimated from geophysical tomography

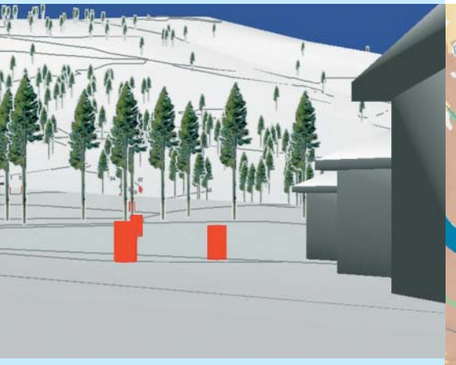
# Geo-, Structural and Environmental Data




Automatic generation of schematic maps for public transport systems

## Planning with Virtual Alpine Landscapes and Autonomous Agents

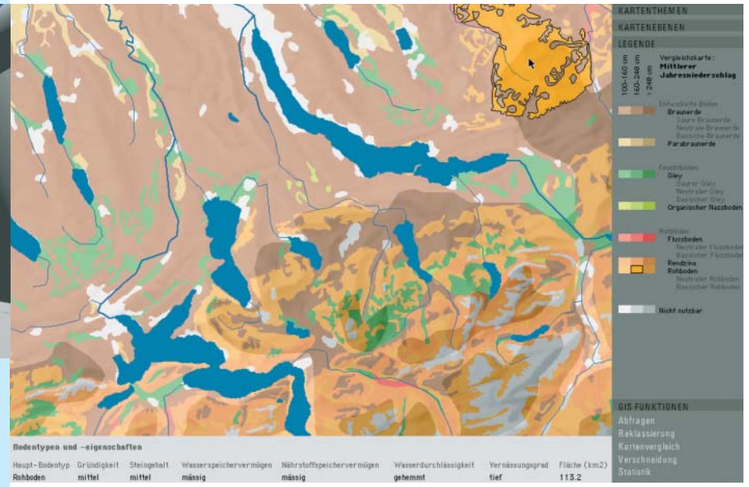
As part of the NFP 48 project, we are developing a prototype planning system which uses real-time 3D visualisation and autonomous agents to predict the responses of 'virtual' and real tourists to changes in the real landscape (IRL, Group of Prof. Schmid, thesis of Duncan Cavens, in collaboration with the Institute of Scientific Computing, Group of Prof. Nagel, thesis of Christian Gloor). Using the Gstaad region as test case, a detailed 3D model is being developed that will allow tourists to evaluate various proposed tourism developments. While traditionally these tourists have been real people, we are exploring the use of computer agents as surrogates for human subjects, in order to be able to feasibly test a greater range of proposed landscapes and to evaluate the interactions between individuals. A primary contribution of our research is enabling the agents to 'see' their environment and make decisions based on their visual perceptions, as well as on more traditional model data such as slope, available destinations and desired trip length.



Evaluation of tourism developments based on real-time 3D visualisation

## GIS Functions in Atlas Information Systems

Due to technological changes in cartography, traditional paper atlases have increasingly been replaced by digital atlas information systems (AIS) over the last 20 years. AIS offer both user-friendly interfaces and high-quality multimedia visualisation techniques, yet they still lack the functionality to perform spatial analysis. The Institute for Cartography (IKA, Group of Prof. Hurni, thesis of Barbara Schneider) investigates how GIS analysis functions can be integrated with AIS, and how these functions can be rendered accessible to a broad range of expert and non-expert users. The research showed that the following GIS functions are suited to AIS: measurements, queries, reclassification and aggregation, graphical and geometrical overlay, analysis of surfaces, network analysis and statistics. The scientific approach was realised by developing the application AGAIS (Analytical Geographic Atlas Information System) based on the existing software platform of the "Atlas of Switzerland". The study showed that GIS functions can be successfully integrated with AIS. These functions, however, must be carefully chosen, considerably adapted, and simplified so that atlas users can understand them by intuition. Complex spatial analysis, so far mainly performed by GIS specialists, is now available to a broader range of users.



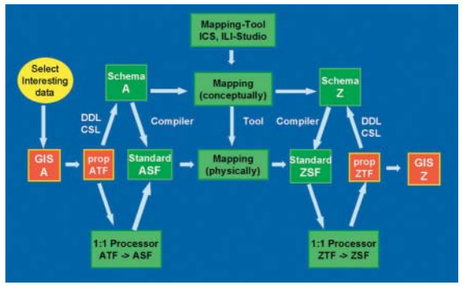

Integration of GIS functions in atlas information systems (AIS)

## Schematic Maps on Demand

Schematic special-purpose maps are designed to convey information of limited scope, such as diagrammatic representations of public transport networks. The rationale is that it is more important that users capture the basic structure of the network than to show accurately physical locations on the map. At present, schematic maps are entirely produced by hand or by purely graphics software. This is not only a time-consuming process, but requires a skilled map designer. The artist tailors the design to the prospective users and the potential queries they expect to be answered. Currently, there are no cartographic guidelines or orientation to help the design of schematic maps. Automatic generation of schematic maps may improve results and make the process faster and cheaper. More importantly, it would extend the use of such maps to a larger audience, especially to users of transportation systems of many more cities in the world. The Institute for Cartography (IKA, Group of Prof. Hurni, thesis of Silvania Avelar) aimed to study the generation of schematic maps on demand: a map is automatically generated in response to a selected set of constraints. The automatic generation of schematic maps from traditional vector-based, cartographic information was studied by using an optimisation technique, whereby the lines of the original route network are modified to meet geometric and aesthetic constraints in the resulting schematic map. Special emphasis was placed on preserving the topological structure of the line network during the transformation process.

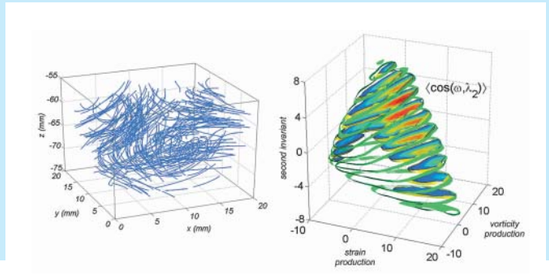
## Swiss Contributions to GIS Standards

For more than ten years it has become obvious that GIS technology cannot be based on local solutions. Think globally is the challenge. Geodata must be exchanged across political and technical borders. This is only possible if international standards exist which allow running interoperable systems. First on the European level (CEN/TC287) and then worldwide (ISO/TC211) the foundations of the necessary global harmonisation are now being built. The standards for GIS of the future are developed together with industry (Open GIS Consortium OGC). Switzerland is in the favourable position of holding a pole position in the domain of data modelling and of model-driven approaches. The figure shows the principle of the model-driven approach to semantic transformation. Switzerland not only possesses the conceptual instruments (defined by the standards series ISO19100) needed today, but furthermore these are implemented, operational and in daily use, and therefore offer worldwide samples appropriate as basic elements for international geo-standards. In this context the version 2 of the object-oriented data description language INTERLIS (fully compatible with the ISO19100 standards series) has been successfully completed and accepted as a Swiss standard in 2002 with relevant contributions of our group. The next plenary meeting of ISO/TC211 (responsible for ISO19100 geo-information standards) will be held in Thun, Switzerland. The GIS group of the IGP took over the leadership of CEN/TC287 (Geographic Information) on the European level this year. With H.R. Gnägi as chairman (IGP, Group of Prof. Carosio) the standardisation activities for Europe in the geo-data domain should be significantly enhanced.




Semantic Transformation by MDA

# High-Tech Measuring Systems



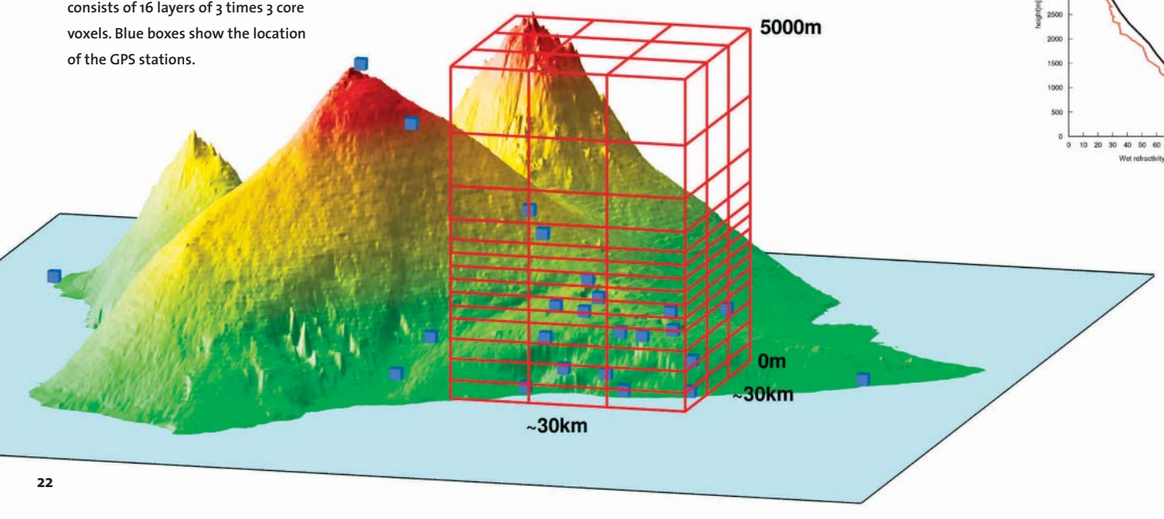

3D particle tracking velocimetry (PTV) in homogeneous isotropic turbulence

Alignment of the slab track using the track trolley

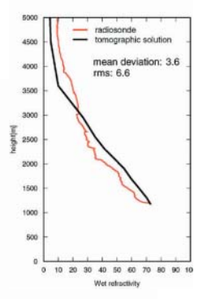
## Development of a New Method to determine the 3-dimensional Refractivity Field from GPS Double Difference Tomography

It is commonly accepted that GPS meteorology can be successfully used to model the refraction effect on radiowave signals traversing the troposphere. We developed an approach to estimate and model the spatial distribution of the tropospheric water vapour. A tomographic software package called AWATOS has been realized (IGP, Group of Prof. Kahle, thesis of Marc Troller). It is based on the assimilation of GPS double difference observations. These are allocated to a voxel model, which is defined according to the distribution of the GPS stations. Performing a least-squares adjustment, the refractivity of each voxel is determined. Tests of the software were performed, based on simulated and real data. A field campaign was initiated on the Big Island of Hawaii, which is ideal for test purposes because of an already installed dense GPS permanent network, associated with large height differences between the stations. The tomographic profiles of the real data sets were compared with 18 radiosondes launched during the campaign. The results obtained for continuous atmospheric conditions fit well. The statistical evaluation revealed an accuracy of around 5–20 ppm for the wet refractivity (http://www.ggl.baug.ethz.ch/research/wg56/).

Core of tomographic voxel model for the Hawaiian campaign. The model consists of 16 layers of 3 times 3 core voxels. Blue boxes show the location of the GPS stations.




Sample of a wet refractivity profile at station Volcano Village.




## Application of 3D PTV in Homogeneous Isotropic Turbulence

The full set of velocity derivatives was measured experimentally along particle trajectories in a turbulent flow (IHW, Group of Prof. Kinzelbach, thesis of Beat Lüthi). The flow was produced by continuous electromagnetic forcing at the walls. The particle paths are recorded by a 3D Particle Tracking Velocimetry (3D-PTV) technique, in which stereoscopic views of the particle positions from 4 camera positions are taken. The method was improved by three developments: An increase in the rate of image recording from 30Hz to 60Hz, application of a new 'spatio-temporal' tracking algorithm developed by the Institute of Geodesy and Photogrammetry (Group of Prof. Grün, thesis of Jochen Willneff), and the introduction of a weighted interpolation procedure to obtain the velocity derivatives. Characteristic properties of turbulent flows known from numerical DNS studies, such as the positive skewness of the intermediate eigenvalue of the rate of strain tensor and the predominance of vortex stretching over vortex compression are confirmed by the experimental data. The use of a new representation of the field of velocity derivatives in a space spanned by three invariants yields new insights into the dynamics of strain and enstrophy production. In particular, a mean cyclic evolution over intense regions of strain and vorticity and the important role played by viscosity in both, strain and enstrophy production can be observed. Another set of results deals with the evolution in time of material elements, such as material lines, surfaces and volumes. They reveal important differences between material lines and vortex lines and some characteristics of the rotation of material volumes associated with the properties of the Cauchy-Green tensor.

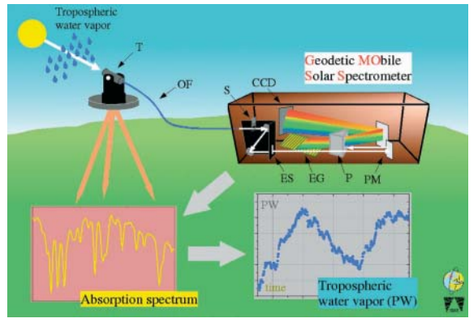
## The Development of an Alignment System for the Slab Track

On new railway lines, a novel construction technique is becoming widely accepted in tunnel sections. For the so-called slab track, sleepers are – in contrast to ballast tracks - embedded in concrete. The advantage of this method over conventional ballast tracks is the considerably lower maintenance costs. Paving over implicates that corrections to the track alignment are only possible with great effort. Thus, the alignment of the track has to be carried out extremely accurately. The Institute of Geodesy and Photogrammetry developed an alignment system for staking out the slab track (Group of Prof. Ingensand, thesis of Ralph Glaus). The system is based on an electronic tacheometer (distance and angle) and a track trolley. The track trolley serves as a platform for inclination sensors, odometers and a track gauge measuring system and was constructed by the HTA Burgdorf in collaboration with terra vermessungen AG, Zurich. The developed track alignment system combines the measurements of the involved sensors and computes correction values of the actual track with respect to the nominal track. These values are used by operators for the alignment. The system is being successfully used in the Zurich-Thalwil tunnel by Grunder Ingenieure AG for installing 15 kilometres of slab track. The project is financed by KTI (Kommission für Technologie und Innovation, Bundesamt für Berufsbildung und Technologie).

## Development of GEodetic MObile Solar Spectrometer GEMOSS I, Measuring Absorption of Tropospheric Water Molecules

The water vapour in the Earth's troposphere causes refraction of transatmospheric microwave signals and limits the accuracy of high precision GPS positioning and satellite radar altimetry. For remote-sensing of tropospheric water vapour a new GEodetic MObile Solar Spectrometer (GEMOSS I) has been developed by the Institute of Geodesy and Photogrammetry (IGP, Group of Prof. Kahle, thesis of Alexander Somieski) and the Institute of Spectrochemistry and Applied Spectroscopy (ISAS) in Berlin. GEMOSS I is based on an improved optical construction, which is permanently adjusted with high accuracy by 5 computer-controlled step motors. Within a single GEMOSS spectrum approximately 1900 water vapour absorption lines of sun radiation are measured in the wide range between 730 nm and 910 nm simultaneously. Furthermore, the optimized light sensitivity of GEMOSS I allows its deployment under low-level radiation conditions and increases the time period of data acquisition. Within the framework of the EU-project GAVDOS the first successful measurements were carried out on the island of Crete (Greece) to calibrate the JASON altimeter satellite.

Schematic overview over the Geodetic MObile Solar Spectrometer measurement system. The suntracking telescope (T) fixed on a tripod conducts the sunlight via optical fibre (OF) cable into the spectrometer, which consists of a shutter (S), entrance slit (ES), echelle grating (EG), prism (P), 2 parabolic mirrors (PM) and a CCD array (CCD). The processing of the absorption spectrum detected by the CCD array yields the amount of tropospheric water vapour



# Studies in the Department BAUG

I completed my studies in civil engineering in the Department of Civil, Environmental and Geomatics Engineering at the ETH Zurich in spring 2002. The civil engineering course can be divided into two parts. The first two years of the course cover the basic principles of the civil engineering, including mathematics and mechanics. The range of subjects was very large. One part of the basic course was surveying. The theoretical knowledge gained could be con-solidated at the end of the first year in a week-long practical surveying course in Thusis in Canton Grisons, which was a welcome change from the theoretical part.

After completing the two pre-diploma courses the third year of study was much more interesting, since the semester programme contained more specifically civil engineering subjects. Thus I read the basic lectures in hydraulics, geotechnical engineering, reinforced concrete, steel construction and in traffic engineering. In the reinforced concrete (R.C.) lecture I had the opportunity of deepening my knowledge in the topic of the deformation behaviour in tension zones under bending in R.C. beams with the aid of tests carried out oneself. In a group of six persons, in a first step we made a 3.5 m long R.C. beam. This allowed some of us to gain our first practical experience in the production of a R.C. element. In carrying out the test we could observe the structural behaviour of a concrete component and compare with our calculated prediction. The tests illustrated the use of the calculation models for the structural behaviour of R.C. beams treated in the lecture and show that with reasonable assumptions and models a good numerical result can be obtained.

After completing the third year of study the examination-free summer semester followed. I decided to devote this time to a practical training abroad. This I did in a large engineering firm in Copenhagen, Denmark. I could apply my basic knowledge in the fields of reinforced concrete and tunnelling and increase my knowledge with the firm's know-how. The visits to the sites of the Copenhagen subway highlighted for me the practical problems encountered in the engineering profession.

Unfortunately, it was not until the final year of study that we were given the opportunity to specialise in individual subjects. In order to train us to handle practical problems and to work in a team, we were assigned semester projects. Thus, besides constructional tasks also the organisational tasks facing the engineer could be tackled by means of exercises.

The diploma project forms the culmination of the course of studies. I myself chose my project in the Institute for Structural Engineering. My diploma work, besides the treatment of a theoretical problem, also involved the execution of tests in the large Structural Testing Laboratory at ETH Hönggerberg, Zurich.

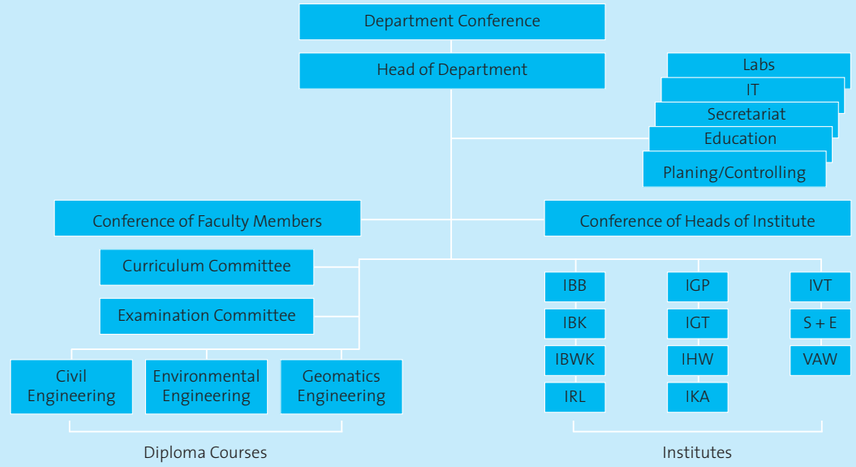
Apart from the treatment of actual civil engineering tasks, the course of studies also provided us with training in the solution of general problems.

Birgit Schilling

Birgit Schilling got her Diploma Degree in Civil Engineering in Spring 2002



# Facts and Figures




## Institutes

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

## Faculty

| | | | |
|---|---|---|---|
| Retirements | Prof. Dr. H. Böhni | Material Science | September 30, 2002 |
| | Prof. Dr. K. Kovari | Geotechnical Engineering | September 30, 2002 |
| Appointments | Prof. Dr. A. Thierstein | Regional Economics | October 1, 2002 |

## Students (Academic Year 2001/2002)

| | | | | | Students | |
|---|---|---|---|---|---|---|
| | 1st year | 2nd year | 3rd year | 4th year | Total | Diplomas |
| Civil Engineering | 75 | 42 | 28 | 60 | 205 | 65 |
| Environmental Engineering | 29 | 20 | 19 | 19 | 87 | 25 |
| Geomatic Engineering* | 21 | 13 | 13 | 31 | 78 | 28 |
| **Total** | **125** | **75** | **60** | **110** | **370** | **118** |

(* Incl. Rural Engineering in the 4th year)

| | | | | Doctoral Students | Diplomas |
|---|---|---|---|---|---|
| | D-BAUG | Students in other Departments | Students from other Departments | Total | |
| Civil Engineering | 84 | 1 | | 85 | 19 |
| Environmental Engineering | 30 | 1 | | 31 | 3 |
| Geomatic Engineering* | 44 | 2 | | 46 | 5 |
| **Total** | **158** | **4** | **18** | **180** | **27** |

(* Incl. Rural Engineering)

## Staff (including part-time employees)

| Institute | Professors | Senior Staff | Assistents, PhD-Students | Technical Staff | Administrative Staff | Total |
|---|---|---|---|---|---|---|
| D-BAUG | | 6 | | 5 | 4 | 15 |
| IBB | 2 | 2 | 11 | 1 | 3 | 19 |
| IBK | 5 | 5 | 32 | 4 | 5 | 51 |
| IBWK | 2 | 1 | 19 | 5 | 2 | 29 |
| IGT | 4 | 10 | 28 | 12 | 4 | 58 |
| IHW | 3 | 4 | 22 | 3 | 3 | 35 |
| IRL | 3 | 10 | 22 | 0 | 3 | 38 |
| IVT | 2 | 10 | 28 | 4 | 3 | 47 |
| VAW | 1 | 11 | 34 | 14 | 4 | 64 |
| IGP | 5 | 12 | 34 | 2 | 6 | 59 |
| IKA | 1 | 4 | 20 | 2 | 2 | 29 |
| S+E | 1 | 2 | 7 | | | 10 |
| **Total** | **29** | **77** | **257** | **52** | **39** | **454** |

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

| | | |
|---|---|---|
| NDS/NDK | ORL | Regional Planning |
| NDS/NDK | VAW | Hydraulic Structures (together with LCH of EPFL) |
| NDS/NDK | IHW | Hydrology and Hydrogeology (together with IATE/HYDRAM of EPFL) |
| NDK | ORL | Space as a Factor of Decision Making |
| NDK | IGP, IKA | Spatial Information Systems |
| NDK | D-MAVT, IBK | Risk and Safety |
| Short Courses | ORL | Weiterbildungsseminar Kommunikation-Moderation-Präsentation |
| | IGT | Advanced Geotechnical Analysis Using the Finite Element Method |
| | IVT | Forum Braunwald: Planung und Erstellung regionaler ÖV Angebote |
| | IVT/SBB | Integrierter öffentlicher Verkehr |
| | IVT | Netzmodelle – Theorie und Anwendung |
| | IVT | Angewandte Verkehrsplanung |
| | IVT | Neue Datensätze zum Verkehrsverhalten |
| | IVT | Verkehrssysteme Mischverkehr MIV/ÖV; Verkehrsflächenbewirtschaftung |

## Workshops, Symposia, Congresses in 2002

| Event | Institute | Date |
|---|---|---|
| 6. Alpine Glaciology Meeting | VAW | February 21-22, 2002 |
| ISPRS Workshop "Visualization and Animation of Landscape" | IGP | February 26-28, 2002 |
| Soil Structure Interaction in Urban Civil Engineering | IGT/COST Action C7 | March 7-8, 2002 |
| 2. Swiss Transport Research Conference | IVT | March 20-22, 2002 |
| JCSS Workshop on Reliability Based Code Calibration | IBK | March 21-22, 2002 |
| GEO-DACH-Meeting (TU Stuttgart, TU Munich, TU Graz, ETH Zurich) | IGT | June 13-16, 2002 |
| SVG Open / Carto.net Developers Conference | IKA | July 15-17, 2002 |
| Monte Veritá Symposium "Sedimentation and Sediment Transport" | IHW | September 2-6, 2002 |
| Internationales Symposium "Moderne Methoden und Konzepte im Wasserbau" | VAW | October 7-9, 2002 |
| Workshop on Reliability of Timber Strucures COST 24 | IBK | October 10-11, 2002 |
| SAFERELNET Workshop on the Homogenisation of Risk Assessement Across Different Industries and Countries in Europa | IBK | October 16-18, 2002 |
| Symposium "Critical Factors in Localized Corrosion IV - A Symposium in the Honor of the 65th Birthday of Hans Böhni" | IBWK | October 20-24, 2002, Salt Lake City |
| Workshop "Industrielles Bauen - eine Herausforderung für KMU" | IBB | October 30, 2002 |
| Symposium "Risikomanagement in Generalunternehmen" | IBB | November 19, 2002 |
| Workshop: Kombinierter Ladungsverkehr in der Fläche und auf kürzeren Distanzen. Haben die Bahnen eine Chance? | IVT | December 17-18, 2002 |

## Honours

| | |
|---|---|
| Prof. Dr. Armin Grün | Honorary Professor of the Yunnan Normal University, Kunming, China |
| Prof. Dr. Armin Grün | Honorary Member of the Japanese Society for Photogrammetry and Remote Sensing |
| Prof. Dr. Wolfgang Kinzelbach | Henry Darcy Medaille der European Geophysical Society |
| Prof. Dr. Sarah Springman & das IGT CALICE Team | Finalists, Media Prix 2002, (last 8 / 167 - Computer Aided Learning) |
| Dr. Martin Thullner | Medal of ETH Zurich for his thesis on bioclogging |
| Maria Patraki | Best Paper Award at the conference MAPINDIA 2002 at Bangkok |
| Pabio Remondino | Young Author Award, Syposium "Close range Photogrammetry - Long Range Vision" at Korfu |
| Sarah Jenny, Saskia Goes, Christine Hollenstein | Best student paper award, American Geophysical Union Fall meeting |
| Federico Cippà, Othmar Frey, Mathias Haldimann, David Naef, Matthias Thoma | Medal for the best Students of ETHZ |
| Federico Cippà, Christian Studer, Dominik Weiss | Hatt-Bucher Fund Prize |
| Mathias Haldimann, David Naef, Ralf Sigrist | Willi Studer Prize |
| Patrick Stillhart | Baubetriebs-Förderungspreis |
| Simon Haag | SVVK-Prize |
| Andreas Galmarini, Andreas Schwarz | Culmann Fund Prize |



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