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
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 (Cemuisse) 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 characteristics, 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.
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 (after KO 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 of 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 increase. In those 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 Highland–Lowlands interaction (Fig. 4). The present situation corresponds to a 4000-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/Watt) 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,
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 for landuse limitations). In consideration of the present structure of operational costs, it is evident that measures aiming at growing resource efficiency are insufficient to significantly improve the ratios 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.

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 degradation. 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, disaster recovery and infrastructure improvements in these fields will result in a growing productivity, which is necessary to trigger the process of urban renewal and to maintain economic growth in the envisioned steady state of the urban stock.

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 visualisation. The resulting problems often cope with the sheer amount of data (up to several terabyte) 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.
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 3D and 2D spatial data for presentation on the Internet. Research topics include cartographic tools on the Internet, cartographic relief representation, 3D visualization of GIS-based spatial 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 volcano sites 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.geo-warn.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 and cultural-environmental aspects as well as humanmade space. This spatial context— referred to as “environment” and “object” of all activities of the Chair for Landscape and Environmental Planning— provides a major basis for (i) the integration of environmental considerations into the (spatial) planning process and the implementation of sustainable land use patterns and management, (ii) the informed decision-making in the context of infrastructure planning and spatial development, and (iii) 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 decision-making in 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 perceptible by a specified group of (non GIS experts) participants, in order to support these joint decision-making processes.

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 stereoscopic screen and a group of people may interact with the system simultaneously.
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. Fortana) 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 fire resistance of structural timber elements.

Fire resistance – breakthrough for multi-storey timber buildings

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.

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 Tamaz Ulagi). 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 ("Vororm SIA 166: Klebewehrung"). 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 for 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 of Geotechnical Engineering (Group of Prof. Amann). The industrial project partners were the firms Solexperf, Schwerzenbach, and KSE, 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 and archivage 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.

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 alternatives of action (IBK, Group of Prof. Gornisch, project of Jan Barthol). 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.ibk.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.

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, VABE, 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 target reliability and 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)
Impact of motorway construction on accessibility patterns in the Swiss “Mittelland” 1950 (top) and 2000 (bottom).
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 KIT 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 of 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 3D 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 reliable 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 is 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 (HW, Group of Prof. Kirzelbach, thesis of Martin Thümler, 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.

Geophysics and Geodesy in Botswana

The Okavango Delta is an inland delta in and Botswana, famous for its wildlife. The delta lies 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 (HW, Group of Prof. Kirzelbach, thesis of Peter Bauer, IGP, Groups of Prof. Ingensand and Prof. Gran, thesis of Krishna Talukar). 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 – leads 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 Okavango Delta is an inland delta in and Botswana, famous for its wildlife. The delta lies 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 (HW, Group of Prof. Kirzelbach, thesis of Peter Bauer, IGP, Groups of Prof. Ingensand and Prof. Gran, thesis of Krishna Talukar). 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 – leads 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.
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. Humi, 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.

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. Humi, 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. Geo-data 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 ISO191xx) 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 ISO191xx 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 ISO191xx 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.
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 radio wave 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 3–20 ppm for the wet refractivity (http://www.ggl-baug.ethz.ch/research/wg56/).

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 a 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 tachometer (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 tera 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 Cruder 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 900 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 GAIAODS, the first successful measurements were carried out on the island of Crete (Greece) to calibrate the JASON altimeter satellite.
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 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 consolidated at the end of the course was surveying. The theoretical knowledge subjects was very large. One part of the basic including mathematics and mechanics. The range of two parts. The first two years of the course cover.

Thesis in Canton Grisons, which was a welcome first year in a week-long practical surveying course. After completing the two pre-diploma courses the change from the theoretical part.

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.

Unfortunately, it was not until the final year of study that we were given the opportunity to specialize 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 organizational tasks facing the engineer could be tackled by means of exercises.

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Staff (including part-time employees)

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

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Secretariate: Sigrid Schönherr
Secretariate

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