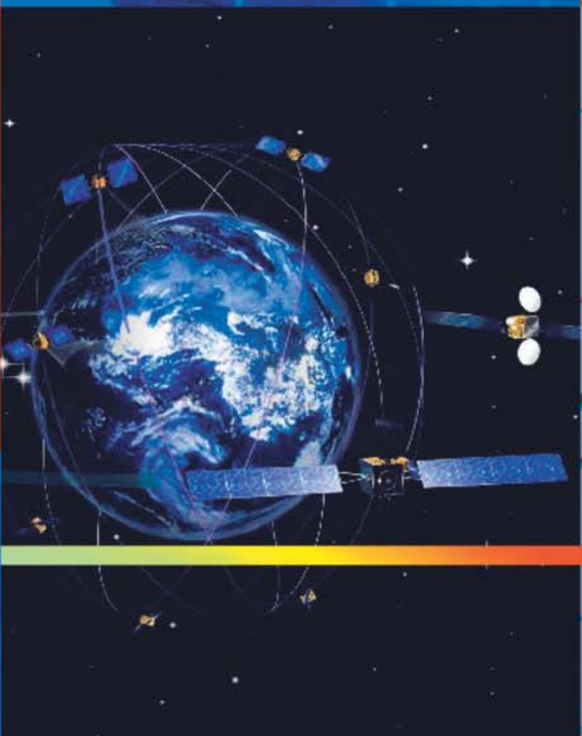
Department of Civil, Environmental and Geomatics Engineering

Annual Report 2000



ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

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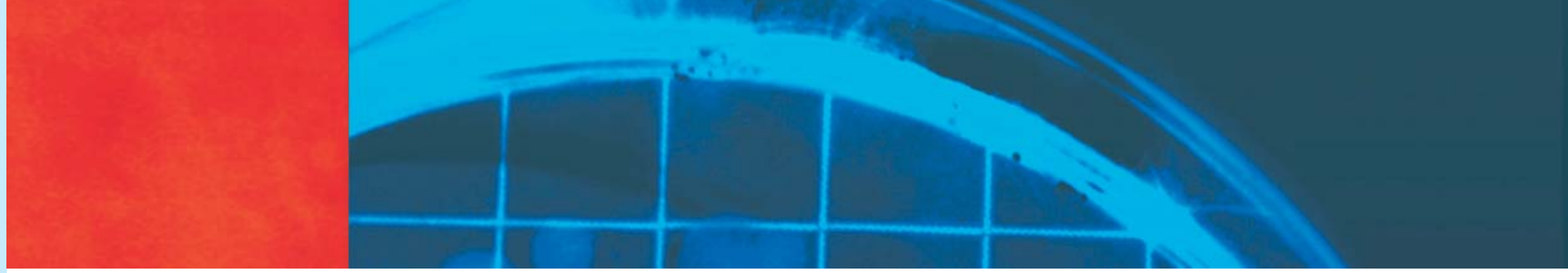
Preface

In the world today the speed at which change occurs is rapidly increasing, not only with respect to technology, economics and society, but also in science and education. Thus the Swiss Federal Institute of Technology (ETH) Zurich is also undergoing a constant evolution. Against this background the ETH Zurich carried out a major restructuring of its organisation at the end of the 20th century. As one of the important consequences of this, in October 1999 the former Departments of Civil and Environmental Engineering (D-BAUM) and of Geodesy (D-GEOD) merged to form the new Department of Civil, Environmental and Geomatics Engineering (D-BAUG). In addition, our department acquired extensive logistic and administrative autonomy. This means that we now work with a global annual budget concerning finances, personnel and space.

We regard these substantial changes as a welcome challenge. It is not only a reason for an internal streamlining of our organisation but also for reconsidering and if necessary reshaping our research and teaching focus and activities. The merger of the three disciplines of civil, environmental and geomatics engineering offers new perspectives and reveals considerable synergies in the field of the sustainable development of our natural and human resources. We aim to tackle these challenging tasks in the dual role of scientists and engineers, who analyse future developments and problems, evaluate appropriate solutions and implement them in an increasingly complex world of politics and economics.

By means of this strategy, we intend to strengthen our position as researchers and teachers at a top university level and to expand our diverse contributions to the global scientific and human communities. Furthermore, this strategy offers to our students, scientific staff and professors an attractive environment for efficient learning, effective teaching, outstanding research and multiple personal achievements.

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



Our Focus

The Vision

To make the best use of the vast potential of the new Department of Civil, Environmental and Geomatics Engineering at ETH Zurich, we formulated new strategies for research and teaching in spring 2000, based on the following vision:

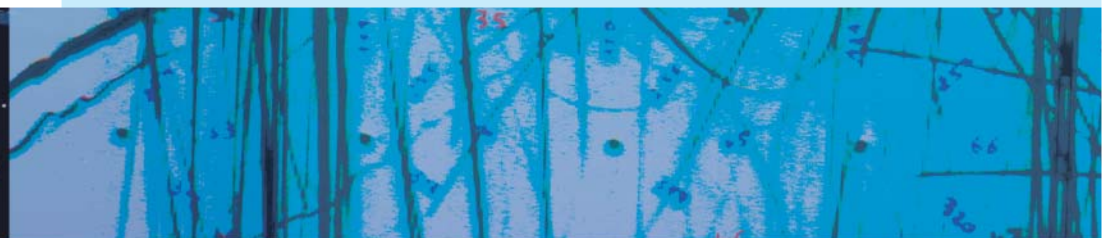
"Our Department belongs to the leading teaching and research organisations worldwide at university level in the fields of civil, environmental and geomatics engineering and their interaction. The main focus is on the life-cycle responsibility for man-made and natural resources with emphasis on safety, ecology, design and economy as well as on the related socio-economic planning and decision processes."

Research

In order to ensure national and international leadership in research, we focus our activities and resources on the following five strategic areas:

- Design, dimensioning, construction and rehabilitation of complex and outstanding **structures,** such as buildings, bridges, tunnels, dams and protective structures.
- Planning, realisation, operation, maintenance and rehabilitation of **infrastructure systems** (traffic, water supply, water and solid waste disposal, protection against natural hazards, energy production and distribution, communication, precision navigation).
- Management of **natural and man-made resources** (space, soil, water, air, building materials, built infrastructure), land use and land development as well as material life-cycle considerations (exploitation, use, recycling and disposal).
- Collection, processing, administration, interpretation, analysis and visualisation of **data** related to geodynamics, environment and built infrastructure as basic information for planning, simulation and control of environmental, industrial and infrastructural processes, of socio-economic processes as well as of land use and land development.
- Development of **innovative high-tech measuring systems and evaluation algorithms** (plane and satellite based sensors for surveying and geodynamics, industrial measuring techniques, control of technical systems, monitoring of man-made and natural objects and processes).

Due to their interdependence, these five strategic research areas form a thematic unity and an indispensable prerequisite for the three curricula in our Department. To underline this unity and to make use of the inherent synergy potential, we are in the process of defining so-called research focuses. In these focuses interdisciplinary research efforts will be initiated, which involve several professors from our Department. Over the coming years we also intend to increase the number of PhD students.



The Curricula

In our Department the teaching focuses on three curricula:

- Civil engineering
- Environmental engineering
- Geomatics engineering

In 1998 and 1999, respectively, the three curricula were thoroughly restructured with the principal aim of reducing the number of mandatory lectures and to increase the students' freedom to choose their own programme of studies.

The first year, which is more or less identical for the three curricula, is devoted to mathematics, information technology and the natural sciences. The second year concentrates on the fundamentals in the three fields. The disciplinary studies start with the fifth semester and lead to the diploma. This part of all three curricula is based on the European Credit Transfer System (ECTS) and allows the students individual choice from a wide range of lectures and projects. In addition, it facilitates considerably the international mobility of students. Their professional education is complemented by a substantial programme in social sciences.

At the present time we are gaining experience with our new curricula with a view to the permanent improvement of the teaching and learning processes. Increasingly, new IT and web-based educational techniques are being introduced into the classroom, a development which will receive further impulse from the recently started school-wide project "ETH World".

Despite the fact that our Department has gone to considerable effort to increase the attractiveness of the three curricula in recent years, the number of students has remained constant at the very low level of approximately 100 beginners. This unacceptable situation is forcing us to expand our public relations activities in general and especially in the secondary schools.

The near future will bring us further changes and new challenges. Following the signing of the Bologna Protocol by the Swiss Government, we have already started discussions on the introduction of the anticipated Europe-wide Bachelor and Master System at university level. This fundamental change offers many opportunities, but also dangers, and will lead to a completely different structure of our curricula. As mentioned at the beginning, change is the only constant, even in the academic world.

Resources

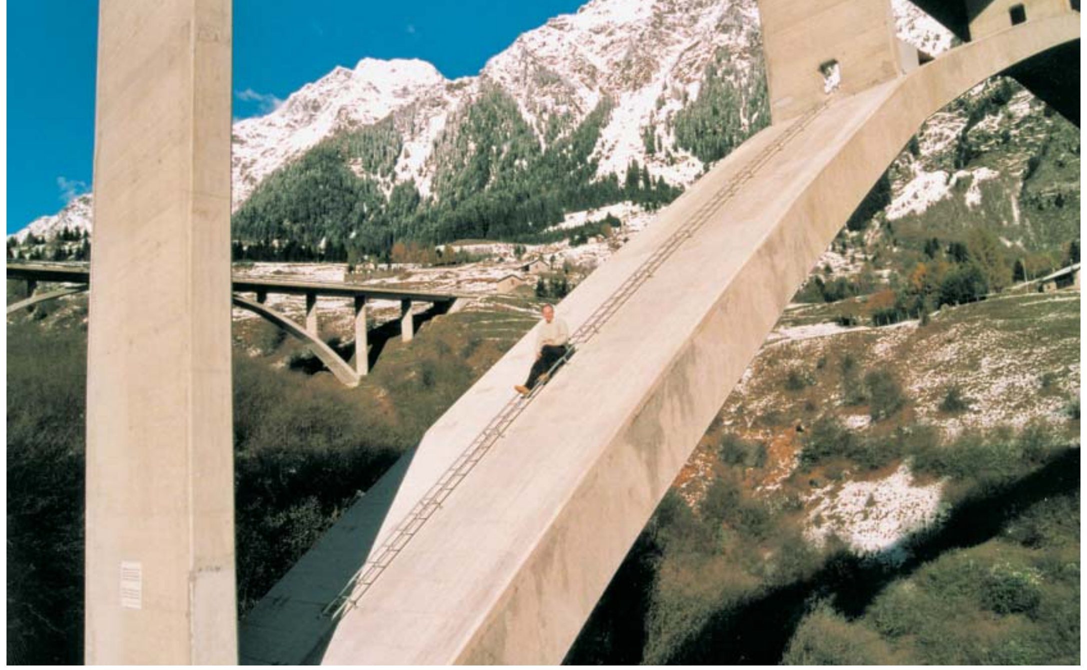
Our disposable resources, such as ordinary credits, positions and space, for the year 2000 have been nominally constant since 1998. This reflects the present situation of the Federal Treasury of Switzerland as well as the long-term planning policy of the Board of the Swiss Federal Institutes of Technology. This strict policy demands tough controlling and makes it difficult to initiate new projects or to enter new fields, unless the necessary means are compensated for elsewhere.

Concerning research funds, this stringent financial situation is exacerbated by the fact that the Swiss construction industry is just emerging from a serious recession lasting 10 years and that nowadays the newly constituted Universities of Applied Sciences (Fachhochschulen) are also demanding more government support.

Hard times produce creativity and innovation! At the moment our Department is involved in intensive discussions on a possible reallocation of the resources at our disposal in order to implement our new strategies in research and teaching more efficiently and quickly. There is still a long and risky path ahead of us, but the first steps are exciting and give us cause for hope.

Conservation of Highway Bridges

Thomas Vogel, Hans Böhni, Gerhard Girmscheid



Bridge stock in Switzerland

The Swiss national highway system is owned by the cantons but strongly supported by the Federation including more than 3'300 bridges with a total length of 265 km. 27'000 bridges with a total area of about 17 km2 belong to the national, cantonal and communal road systems and to the railway network, representing a replacement value of more than 40 billion SFR.

Fig. 1 shows the age distribution of the national highway bridges, most of them built of concrete and 80% (related to the bridge deck area) prestressed.

Standards, actions and hazards

To save resources the first bridges were built without emergency lines, which restricts flexibility in actual repair phases.

Since the early beginnings of the construction of the national highways, traffic has increased tremendously resulting in both larger and more frequent loads. With the implementation of the bilateral treaties with the European Community the legal vehicle weight has increased from 28 to 34 tons in 2001 and will reach 40 tons in 2005. The level of the axle loads does not change but their frequency leading to more wear to deck layers, expansion joints and waterproofing.

The internationally important connections include tunnels through the Alps with access ramps reaching up to 1400 m in height. Therefore climatic conditions range from Mediterranean to almost arctic climate. De-icing salts were used first at the beginning of the sixties but the consequences for bridge design and detailing awoke only gradually. Some roads have been placed in zones that have been avoided by earlier rail and road planners and experience has to be gained on how nature reacts with hazards like avalanches, floods and landslides.

Deterioration processes, monitoring and prevention

Chloride induced corrosion of rebars is one of the main causes of damage to reinforced concrete bridge structures. Chlorides from de-icing salts enter into the porous concrete structure and cause localized corrosion attacks on the originally well-protected passive reinforcing steel. Localized corrosion processes on passive metals usually consist of an initiation step followed either by rapid repassivation (metastable pitting) or stable pit growth (propagation stage). In the case of unalloyed steel rebars the transformation from metastable pitting to stably propagating local corrosion attacks is primarily influenced by environmental factors such as chloride concentration, and the pH or oxygen content of the adjacent electrolyte in the pores. Therefore the environmental exposure of concrete structures is of decisive importance for the durability and the service life of reinforced concrete constructions.

A new monitoring system has been developed where both chloride and resistivity sensors as well as corroding rebar probes are cast into concrete cores. These cores are fixed into the structure at different locations of bridge structures. A permanent recording of important corrosion parameters allows studying the effect of changing exposure conditions in the cover zone of real structures over an extended period of time. It permits determining the time periods of enhanced as well as low corrosion activity in order to predict the long term corrosion behaviour of concrete structures (Fig. 2). It will also give us a better insight into the actual processes occurring during the corrosion of the reinforcement and it will lead to the design of new, more durable constructions and repair methods.

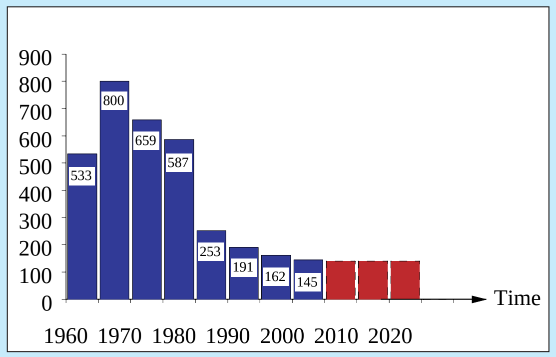


Figure 1: Number of highway bridges of the national network including forecast until 2015 (from Donzel, IABSE Congress 2000, Lucerne)

Figure 2: Corrosion propagation over time of corroding rebar probes in an edge beam and in the underside of a bridge deck.

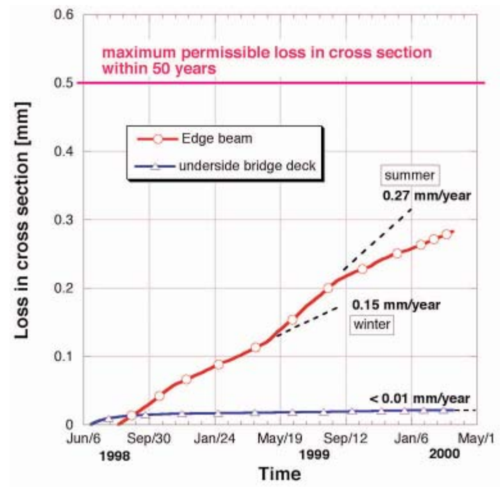


Figure 3: Hydrodemolition on a bridge deck

Repair procedures

Although more refined methods like cathodic protection, electrochemical chloride extraction and re-alcalisation may be feasible in special cases, restoration of concrete bridges usually means removal of carbonated or chloride contaminated concrete to a predefined depth without damaging subgrade and loosening reinforcement.

Hydrodemolition is one of the most sparing concrete removal procedures affecting neither sound substrate nor bond between concrete and reinforcement. By varying water pressure and flow rate the removal depth can be defined. The application ranges from heavy equipment (Fig. 3) with a pressure of 150 MPa and a flow of 2 l/s for large depths to manual equipment with 250 MPa and 0.4 l/s respectively.

Figure 4: Protective tent on a bridge status

Rehabilitation during operation

To choose a rehabilitation method for a bridge, not only achievable effects but also the influence of operational conditions has to be considered.

The actual traffic rates do not allow for re-routing on the opposite lanes and rehabilitation has to proceed during full operation of the road. The reduction to one lane may also lead to an undue reduction of traffic flow. To prevent long traffic jams a partition of the construction site in length may be appropriate. Often additional measures are taken to guarantee a short construction period not influenced by weather conditions with little hindrance of traffic (Fig. 4).

Conservation strategies and costs of rehabilitation measures

Due to big influence on the traffic several structural members should be rehabilitated simultaneously even if they age unequally and their optimal intervention points differ. To fulfil economical restraints some aging damages are accepted to postpone and concentrate rehabilitation measures to an optimal time (25 to 30 years after commissioning). The optimum of costs can be obtained by adjusting cost profiles of structural elements and the whole structure. A rehabilitation gets considerably more expensive when the carbonation or the chloride front reaches the reinforcement and thus the concrete cover does not protect the steel anymore. The second leap in costs occurs when pitting corrosion or superficial corrosion together with concrete spalling requires a replacement or an adding of reinforcement. Costs depend on the structural element and less on the structural system of the bridge. For instance, both box girder bridges and arch bridges show a similar distribution of costs amounting 1000–1500 CHF/m^2 (Fig. 5). To choose the appropriate strategy increasingly indirect costs like traffic delay costs are also taken into account.

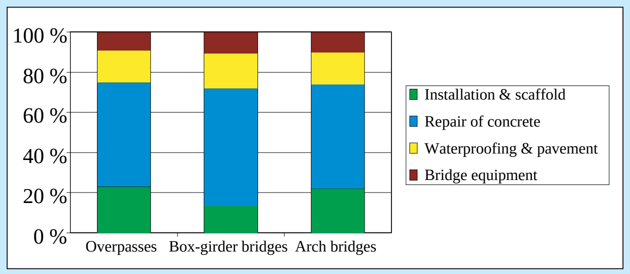


Figure 5: Distribution of costs for rehabilitations of bridges

Environmental data: A strategic resource for environmental engineers

Lorenz Hurni, Willi Gujer, Alessandro Carosio

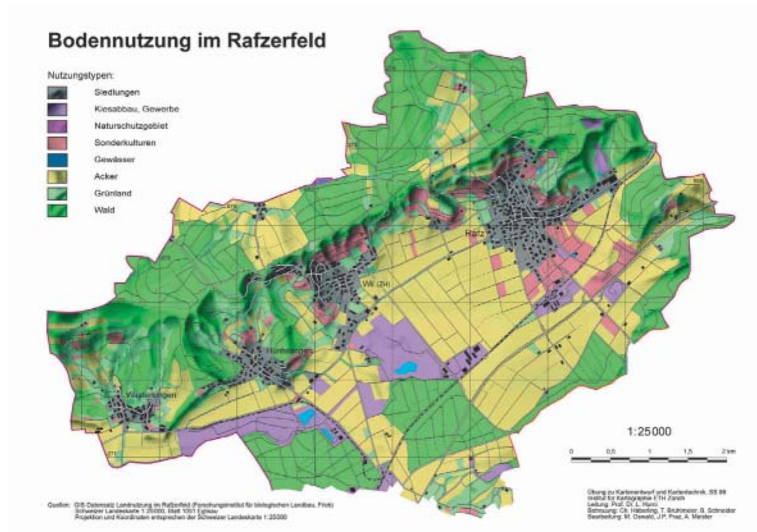
During the recent years an ever intensified use of natural resources has brought about a conflict zone between ecology, society, politics and economy. Population growth in developing countries as well as growing and partially controversial demands in industrial and service-oriented countries create increasingly complex problems. The necessity for efficient and sustainable management and utilisation of resources is becoming widely accepted in science, politics and economy. We now face the necessity to implement sound and effective solutions and processes. With respect to technology, this is a demanding task for the scientific community as well as for engineers working in industry and administration. Environmental engineering research in the department is developing the technical framework and supports its application in consulting contracts. In addition this know-how is the basis for teaching in lectures and case studies.

Data acquisition

Reliable data is an important operational and strategic resource for all projects and processes in the environmental domain. Such data consists of different thematic, semantic, qualitative as well as quantitative aspects. Frequently, environmental information is accompanied by geometric components which provide the spatial reference and describe the extent (area, line, point, etc.). The geometric information also contains the mutual spatial relations (neighbourhood, hierarchical dependencies) which are necessary for environmental modelling. For the acquisition, processing, management, analysis, process modelling and presentation, there are numerous interdisciplinary methods and technologies available. Collaboration in the department with related disciplines such as civil engineering, transportation sciences, metrology, Geo-Information Systems (GIS) and visualisation is vital and offers invaluable cross-fertilization. Such collaboration allows environmental engineers to base their work upon advanced technologies and methods with interdisciplinary support.

Monitoring Programs

Numerous environmental problems and tasks are spatially related and spatially relevant. Frequently phenomena and processes relate to large areas or – to express it in cartographic terms – to small and medium scales. An example is environmental planning leading to sustainable spatial development. Several permanent monitoring programmes, such as remote sensing applications, provide a more or less constant flow of data, which consists of various observation parameters. However, very often terrestrial data acquisition leads to thematic environmental data, which is not geographically complete but project-related due to various constraints. The development of interdisciplinary comprehensive overviews, comparisons and analyses in the environmental domain is still in its infancy. Nevertheless, the necessity of the analysis of qualitatively different but related environmental data is widely recognised and is the subject of different international research activities.

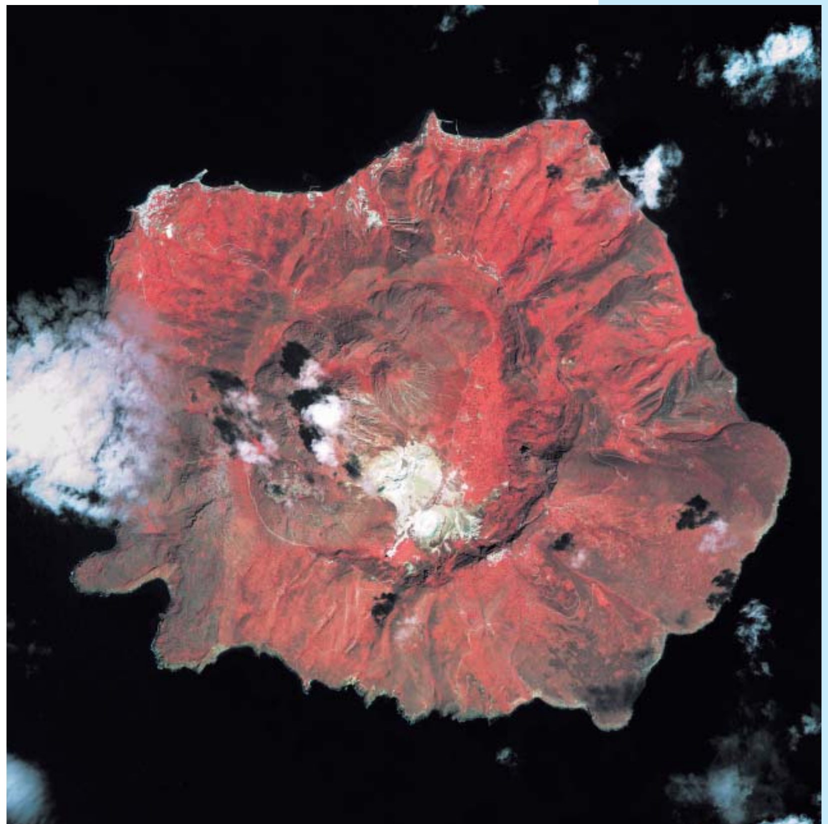


GIS-based landuse map Rafzerfeld

Dormant Ag. Stefanos crater on the volcanic island Nisyros, Greece. Within the EU-project GEOWARN an interdisciplinary monitoring network is being developed.

EU-project GEOWARN

An example is the current EU-project GEOWARN with participation of our department (www.geowarn.org). In two test areas in volcanically active areas in Greece and Italy, geological, volcanological, geophysical, geo-chemical, geodetic and topographic data are acquired, homogenised, analysed and graphically and mathematically correlated, some of them even in real-time. In the case of volcanic activity, a special user-friendly interface will support the public, politicians, and civil protection officers to take decisions and support measures. This example indicates the importance of the application of special geodetic measurement techniques, Geo-Information Systems (GIS), cartographic visualisation and new Information Technologies (IT) to support the whole workflow from data acquisition up to the presentation of user-friendly refined information. The synergies between the domains of civil , environmental and geomatic engineering are evident. They form one of the strengths and internationally renowned core competence of our department.



1 meter high resolution image of Nisyros island in Greece

Navigation

Hans-Gert Kahle, Alain Geiger, Kay Axhausen

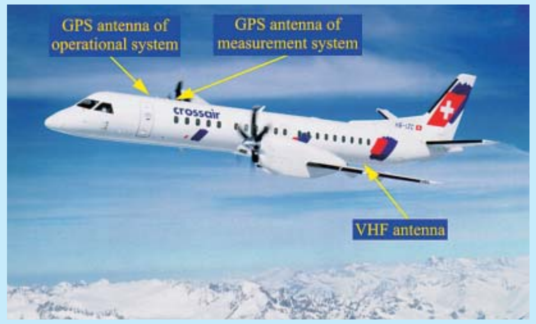


Figure 1: Testbed on experimental flight over the Alps. The operational system has been augmented with a precise reference measurement system for comparison and cross-checking. The VHF was used to receive the real-time differential GPS corrections from the reference station on ground (from Crossair and Scaramuzza).

Hardly anything can distract Japanese tourists from concentrating on the display of their hand-held mapping device, which will finally lead them to the Grossmünster. Will have road maps and travel guides been obsolete in future? In National Surveying the future has already become the present. The entire field of positioning and navigation is undergoing a revolutionary development. Satellite-based navigation has reached a stage at which it looks almost indispensable for numerous applications in everyday life. This has become possible by the integration of satellite radiowave techniques and information technologies. Potential applications range from analysis of commercial locations through intelligent transport systems to geodynamics. What is the position of the Department D-BAUG within this high potential future-oriented field of research and development? What do its recent activities look like and what are its future directions?

GPS-based techniques for approach and landing

The original goal of the US Navy and Air Force to provide a continuous global service for positioning of submarines and aircrafts has been realised in the so-called Global Positioning System GPS. In civil aviation particular requirements, the so-called "required navigation performance" have to be fulfilled before GPS is allowed as a stand-alone system. These include accuracy, reliability, availability, integrity and continuity of the system. Also GPS-based techniques for approach and landing have to be certified following corresponding standards of the International Civil Aviation Organisation (ICAO). The feasibility of GPS-based approaches has been evaluated and the potential of applications has been studied at the Department D-BAUG.

Co-ordinated by the Swiss Federal Office of Civil Aviation (FOCA), the Geodesy and Geodynamics Lab of ETH, Swisscontrol (now Skyguide), Crossair, Telematica and the Swiss Federal Office of Topography participated in the trials (Fig. 1). In particular, the effect of rugged terrain in Switzerland was studied. Also critical turns at low altitude were considered and tested during real flights. A central topic was the question, how fast, accurately and reliably errors could be detected and appropriate warnings communicated. A mean horizontal deviation of 0.7 % of the value allowed was achieved. In using additional sensors, such as altimeters, satellite systems could fulfil future navigation requirements for approach and landing also in difficult terrain (Fig. 2), such as the airport Lugano-Agno. With the results obtained, a valuable scientific basis for developing concepts of future navigation applications has been achieved.

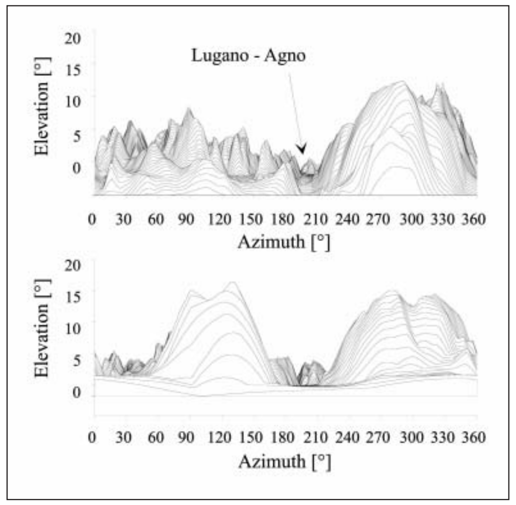


Figure 2: Digital terrain model giving an impression of the ruggedness of the terrain. The view is along the approach flight path towards the runway at 1.8 miles (top) and 0.6 miles (bottom) from touch-down (from Scaramuzza) digital terrain data from Swiss Federal Office of Topography)

Figure 3: A glimpse of the surveyed Unteraar glacier… However, the scientists can hardly afford to enjoy the view.

Surveillance of glaciers

Navigation-related research at D-BAUG has also focussed on airborne surveillance of glaciers which is ultimately of interest in collecting information on changes of ice masses in connection with possible global warming (Fig. 3). In 2000 the feasibility was studied of utilising airborne laser scanning techniques for determining surface elevation changes of glaciers, with particular emphasis on remote firn areas where no texture is visible. An airborne system consisting of laser, GPS, gyro and an inertial system, has been constructed, in real flights tested and improved.

The Unteraar glacier, Bernese Alps, Switzerland, had been selected as test area because valuable ground truth information was available there. The key problem involves bringing together all the necessary elements for geo-referencing the laser data (Fig. 4), whereby the quality of each contributing part has to be monitored regarding accuracy and systematic effects. Using the laser scanning solution a height accuracy of 0.3 m was obtained. The areas covered were located between 2500 and 3400 m above sea level. For the period 1998–1999 a surface elevation increase of up to 4 m was measured. This height increase can be related to the immense amount of snowfall during the winter of 1998/99. With this work national know-how in airborne laser altimetry has been gained for the first time. The results were used as an input for flow modelling of the glacier carried out by VAW.

A National Aerogravimetric Map

Airborne techniques gain more and more interest not only in geodesy and photogrammetry but also in geophysics. Precise satellite navigation enabled the determination of the regional gravity field over Switzerland by aero-gravimetry. The dynamics of flight path has been precisely calculated based on the GPS determination of the trajectory. Pioneered by D-BAUG this technology was studied and developed in a co-operative effort with "Lacoste-Romberg" and the flight service of the Topographic Office. As a result the first national aerogravimetric map of a country has been established (Fig. 5). A new project has recently been started to develop methods and technologies to directly determine the absolute value of gravity on board an aircraft. This technologically highly demanding project also requires a more sophisticated analysis of the satellite data.

Automatic Control and Steering

Similar methods to the ones developed for airborne trajectography are applied in engineering surveying. Examples are the dynamic road mark out and road survey or the automatic control and steering of construction engines. A study at D-BAUG demonstrated the feasibility of completely determining the kinematics of the 6 degrees of freedom for a ropeway. The high resolution of the measurements allows extraction of the translational and rotational oscillations, which occur in the case of emergency stops.

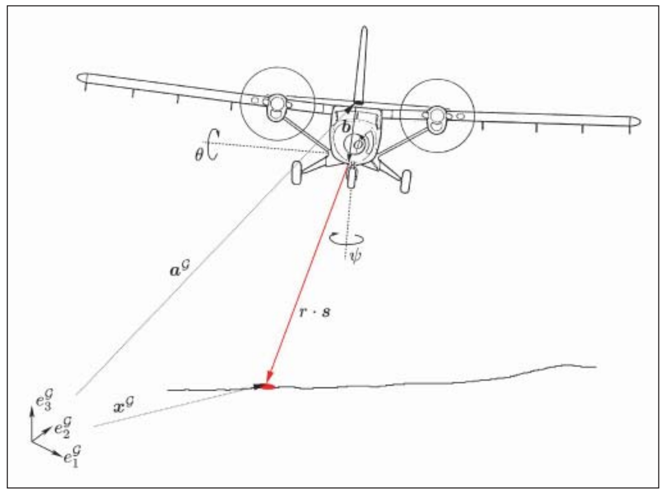


Figure 4: Georeferencing: To refer the measured target (laser distance in red) to an Earth-fixed coordinate system both the position and the altitude of the aircraft have to be known. They are determined by combining GPS with an inertial system (INS).

Figure 6: Galileo: Constellation (30 satellites) and spacecraft. This will soon become reality (from ESA).

Route Guidance Systems

GPS-based systems, often combined with mobile telephony, open new perspectives for users, operators and planners of transport infrastructures. In combination with other navigation instruments they offer the road user a viable alternative to the traditional road atlas. Such static route guidance systems are becoming increasingly dynamic with the relevant information about delays and detours provided by the integrated telephone or in-car radio on the fm band. This information is based on measurements provided by external sources and by the vehicles themselves. The data must be processed and appropriately adjusted by the road operator to avoid undue swings in the system's performance and in its demand. The development of suitable algorithms will be a central task for the researchers at D-BAUG. GPS systems can also be used to capture the behaviour of travellers outside the car. Combinations of GPS, GSM and palm-top computing systems allow today a detailed recording of the time-space paths of travellers, including pedestrians and cyclists. This mostly passive tracking increases the duration over which such observations are acceptable to the respondents and will provide new insights into the dynamics of travel behaviour.

Galileo: a new European GPS under Civil Control

The large spectrum of applications, the potential for growth, and the considerable socio-economic impact of satellite navigation led the EC and ESA to develop a new global satellite system under civil control. This new system, named Galileo, is planned to be in operation before 2008 (Fig. 6a). In conjunction with advancements in the miniaturising of electronic components and the rapidly expanding communication technology, new future-oriented applications can be envisaged. We will see an increasing integration of navigation, information and communication. It is anticipated that the immense market in navigation will be taken over by mobile phone applications, to the amount of 75 percent, within the next 15 years.

Information, mobility, information's mobility: infomobility

Navigare necesse est!

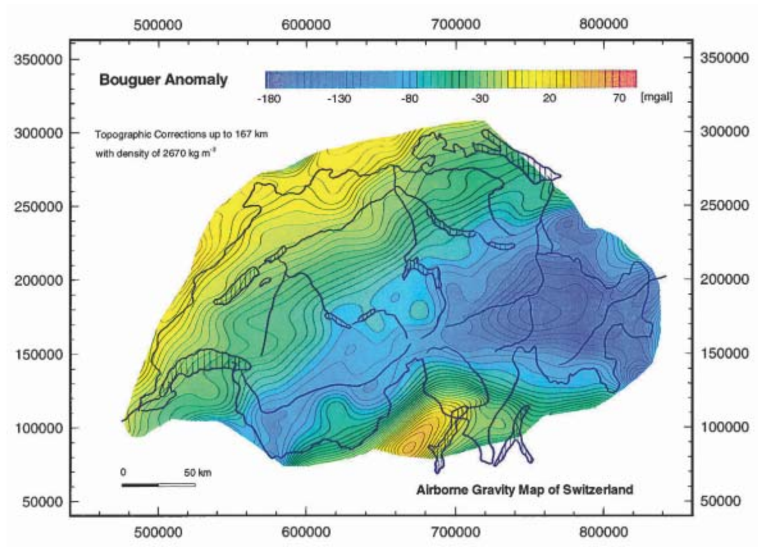


Figure 5: First national aero-gravimetric map (from Klingelé et al.): Deviations from the "normal values" in mgal. 100 mgal corresponds to 0.0001 of g (g: value of the attracting acceleration due to gravity, approx. 9.81 m/s2).

Highlights

Structures

Deformation of rebars during pseudo-dynamic testing (Thesis Klaus Thiele)

An innovative deployable system

Deployables are characterized by their dual functionality as load-bearing structures or mechanisms. At the beginning of this work, the structural possibilities in the design of hybrid deployables, consisting of components with and without bending stiffness, were highlighted in a morphological investigation. Subsequently, through a comprehensive patent and literature search, the set of existing hybrid deployables has been established.

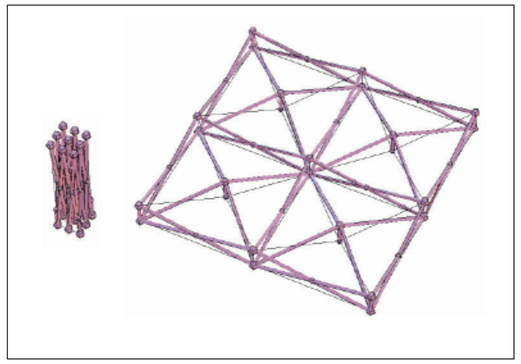
On this basis, an innovative deployable system was developed, which, by the externally prestressed cross-bracing of its orthogonal scissor-grid, has for substantial advantages over existing systems regarding its kinematics, statics and the possible variety of forms. The transition from mechanism to load-bearing structure is reversible and occurs in a self-acting manner at the end of deployment. By means of prestress and camber, the deformation behavior of the load-bearing structure can be controlled. The novel deployable allows for the design of plates as well as of cylindrical and spherical shell structures.

The problems related to the manufacturing of hybrid deployables were shown and solved in the course of designing and building a prototype of the novel system at the Institute of Structural Engineering (IBK, Group of Prof. Peter Marti, Thesis Gerhard Rückert). It has an extension of 25 m² and is made from aluminium rods and steel cables. By testing the prototype, the novel system's improved kinematic and static capabilities have been verified.

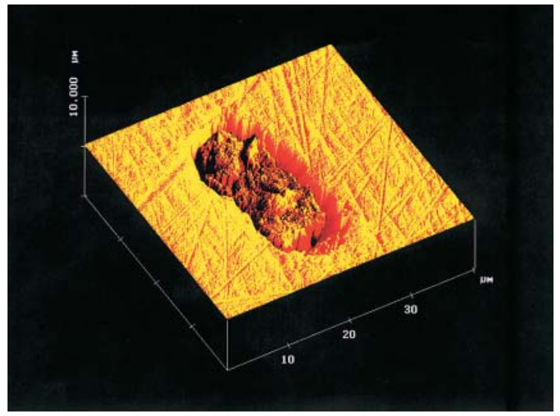
Earthquake research

Unlike other countries, Switzerland was spared a major earthquake in recent decades. Nevertheless, Switzerland cannot be considered safe from earthquakes. The major earthquake of Visp in 1855 and especially the devastating earthquake of Basle in 1356 which can be compared with the earthquakes of Northridge in 1994 and of Kobe in 1995 prove the contrary. At the Institute of Structural Engineering (IBK, Group of Prof. Hugo Bachmann), studies on Reinforced Concrete structural walls were conducted to adapt the general rules of seismic design to the situation in Switzerland concerning construction style, materials and seismicity. These studies include cyclic static tests, tests on a shake-table, pseudo-dynamic tests and numerical analysis. One main goal of these studies is developing seismic design rules that are easy to use for structural engineers.

Center of the prototype



Initial and final configurations of the system's kinematic simulation



Initiation site of local corrosion

Early stage of pit corrosion on a stainless steel rebar:

Pit initiation occurs at the steel /impurity interface. The main impurity of stainless steel are MnS inclusions. Atomic Force Microscopy (AFM) investigations at the Institute of Building Materials (IBWK, Group of Prof. Hans Böhni, Dr. Thomas Suter) reveal that trenches, formed at the interface, act as potential initiation sites for stable pitting. The surface of a polished steel probe is scanned with a tip thinned to atomic dimensions. The measured forces on the tip are transformed into an image of the topography showing the steel surface, the MnS inclusion (ca. 20x10 μm) and the initial stage of the pit corrosion. If the concentrations of aggressive agents, such as chloride, reach a critical value inside a trench pit, propagation of the corrosion results. The study shows how processes at the molecular level can damage entire structures.

ETHZ Geotechnical Drum Centrifuge

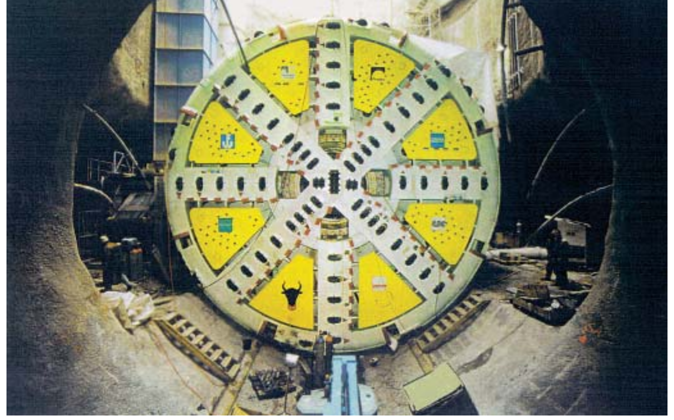
The 2.2 m diameter, 880 g-tonne ETHZ Geotechnical Drum Centrifuge (IGT, Group of Prof. Sarah Springman) was commissioned this year. Soil samples, typically of sand, silt or clay, are prepared in either the annular drum ring (with masses up to 2 tonnes) or in smaller strongboxes placed diametrically opposite each other. These samples constitute a test bed on and in which experiments may be performed to investigate a whole range of soil structure interaction problems, including many with a natural hazards theme.

By rotating the drum, a radial acceleration of many times gravity is applied to the soil samples, so that stress conditions in these small-scale models will represent full-scale field behaviour, according to certain modelling laws. Models made at 1/100th full scale and accelerated under 100 times gravity will be equivalent to a field prototype, whereby a 200 mm model depth represents 20 m in the field. Similar scaling advantages present themselves when modelling diffusion problems such as embankment construction on soft clay or pollution migration, whereby 1 day of modelling in the centrifuge at 100 gravities represents 27 years of field behaviour.

Development and manufacture of mechanical actuation tools for construction procedures, the application of loads and measurement purposes have been carried out in-house together with the development of a sophisticated data acquisition system. Several diploma projects have already been carried out and the first research proposal has been funded. Successful multi-disciplinary research collaboration will be strived for.

View into the Geotechnical Drum Centrifuge

Infrastructure Systems



Front of the tunnel-boring machine

The final and improved solution for the Saltina Bridge in Brig-Glis – a raisable bridge. (Photo taken during the flood of October 2000 by André Burkard, Brig-Glis)

Tunnel Construction below buildings and roads

The 9.4 km long twin track tunnel Zurich-Thalwil is being constructed for Rail 2000. The most demanding section from the constructional point of view is driving the tunnel at a shallow depth below buildings and roads over a stretch of about 700 m. These exceptional geometrical conditions are further complicated by difficult geological and hydrogeological circumstances, since the tunnel lies under the groundwater table and passes through highly permeable gravels. The tunnel boring machine of the type "hydro-shield" has an excavation diameter of 12.3 m. Face support was provided by a viscous fluid under pressure. However, in the present case, due to the unfavourable interaction of different factors, instability at the working face leading to the development of a crater at the ground surface could not be completely excluded. Therefore, additional conceptional and constructional measures to guarantee the safety of residents and road traffic users had to be implemented.

To solve the demanding problems the services of the Institute of Geotechnical Engineering (Groups of Proff. Kalman Kovari and Rita Hermanns Stengele) were called upon already at the planning and design phases. Besides establishing the safety concept this activity included statical computations and laboratory investigations in order to select the most suitable fluid for the face support.

Stakeholder analysis in water supply systems

A shift of focus is essential if water supply systems are to be optimized and further developed. Emphasis needs to be placed on the characteristic behavior of stakeholders (engineers, politicians, consumers, etc.) and the resulting effect on the supply infrastructure. In this project, the prevailing interests, strategies of action and interactions among stakeholders were disclosed in a participatory process together with stakeholders. These rules of behavior were validated based on an agent-based computer model, which showed up the deficits of current supply strategies. With the simulation of future scenarios of development, measures were identified which help to increase the flexibility of water utilities. The project at the Institute of Hydromechanics and Water Resources Management (IHW, Group of Prof. Willi Gujer, Thesis Donald Tillman) is indispensable for the optimization of water supply systems.

Urban Transport in China

In 1998, the China Council for International Co-operation on Environment and Development (CCICED) has commissioned a "Transport Working Group" (TWG) of four international experts to develop, in co-operation with local, regional and national policymakers, objectives, principles, measures and implementation strategies for sustainable transportation systems in China.

The representative of the Institute for Transportation and Railway Engineering (Prof. H.Brändli, IVT) has special responsibility for public transportation. The limiting factor for the development of urban transportation in densely populated areas is the available space. For this reason public transport is the only realistic option in large cities. Starting in the year 2000, measures ranging from the allocation of special bus lanes on existing roads to the planning of underground rail transport systems were initiated.

Virtual railway laboratory: OpenTrack

One result of the research project Object Oriented Modelling in Railways, carried out at the Institute of Transportation, Highway- and Railway-Engineering (IVT, Group of Prof. H. Brändli), is a virtual railway laboratory called OpenTrack, which can provide answers to various questions of railway operations by simulation. The network data is described by double vertex graphs. The other input data contains information about the rolling stock and the timetable. During the simulation, which is an interactive process, all the train movements are calculated under the constraints of the signalling system and the timetable. After a simulation run, the collected data can be analyzed and visualized. OpenTrack is now used by railway administrations, the railway industry, consultant companies and universities.

Flood Protection of Brig-Glis

The floods in the Saltina River in September 1993 and October 2000 show how the engineering sciences can provide the basis for sound flood protection measures. In 1993 the intense sediment yield caused aggradations in the Saltina River flowing across the town of Brig-Glis. The river was completely blocked up at the Saltina Bridge, and the town of Brig-Glis subsequently flooded.

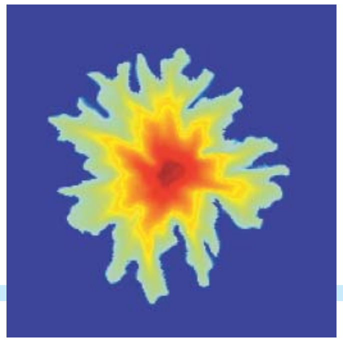
A hydraulic model was built at VAW (Group of Prof. Hans-Erwin Minor) to investigate the cause of the obstruction at the Saltina Bridge. The model also served to design first measures to improve the situation at the bridge. In parallel, a numerical model was used to quantify the sediment transport and the morphological changes in the Saltina River during floods. This model also served to design the sediment retention measures upstream of Brig-Glis. Two flat river reaches were created by excavation. Thus, in October 2000 the passage of sediment was limited and aggradation in the downstream reaches prevented.

Sketch of stakeholder interactions

Public transport in China's megacities

Open Track logo

Resources



Numerical simulation of air expanding in a water saturated porous medium (blue: water, red: air, scale of order cm)

Site of borehole measurements in permafrost (Thesis Lukas Arenson)

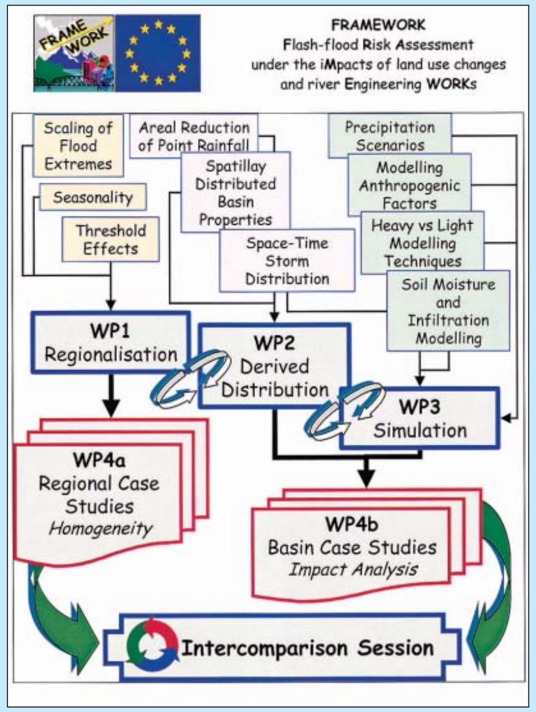
FRAMEWORK:

Flash-flood **R**isk Assessment under the i**M**pacts of land use changes and river **E**ngineering **WORK**

The objective of the FRAMEWORK EU-project was to evaluate the sensitivity of flash-flood risk assessments to anthropogenic influence, including man-induced changes of the runoff generating and propagating mechanisms and climate fluctuations. The achievement of the goal required the project to be organised in a sequential structure. First, it was necessary to develop methods for estimating flood risk that can explicitely account for anthropogenic changes, so contributing also to improve the present level of flood estimation techniques. Subsequently, the methods were applied to investigate the impact of changes, mainly concentrating on the effects of land use changes on flood runoff generation. Partners of the Institute of Hydromechanics and Water Resources Management (IHW, Group of Prof. Paolo Burlando) are Politecnico di Milano as coordinator, Technische Universität Wien, University of Newcastle upon Tyne, Universidad Politecnica de Valencia, Technische Universität Darmstadt and Università di Bologna.

Macroscopic parameters for two-phase flow

In a number of engineering applications air is injected into water-saturated porous or fractured media. Among these are the pressure testing of fractures, air sparging as a remediation technology for volatile hydrocarbons, and the aerobization of bioactive sand filters used in water treatment. A project conducted at the Institute of Hydromechanics and Water Resources Management (IHW, Group of Prof. Wolfgang Kinzelbach, Thesis Insa Neuweiler), looked into the problem of transferring the results of small scale laboratory experiments to the larger field scale. This procedure is called upscaling and has been successfully carried out in single phase flow. Here, the upscaling methods are generalized to two-phase flow of air and water. On the small scale, capillary and viscous effects can lead to fingering instabilities depending on parameters such as flow velocity, mobility ratio etc. It is shown that these processes cannot be upscaled. However, in all cases of stable displacement it is found that a new dispersion term can take into account the effect of the small scale heterogeneous structure of the medium.



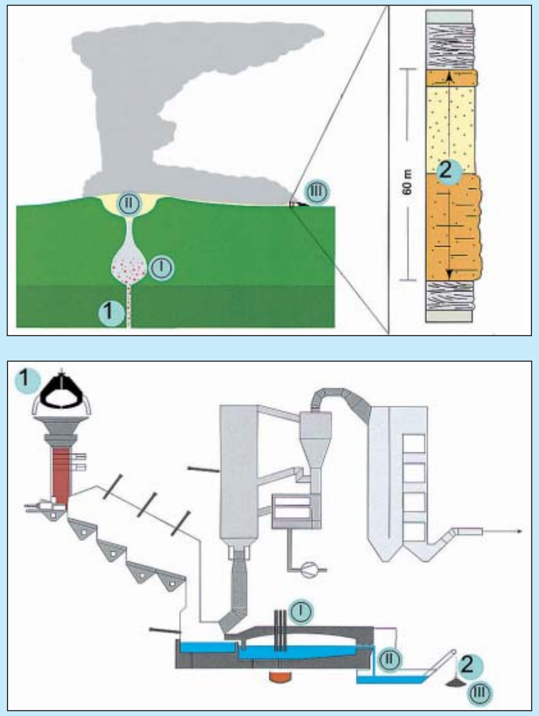
Structure of the EU-Project FRAMEWORK and links among its Workpackages (WP)

Natural and Technical Petrogenesis of Pozzolans – A Contribution to the Design of Secondary Raw Materials

Purified siliceous granulate with pozzolanic properties can partially substitute Portland cement which is produced from lime and marl. Such pozzolanicity was already known in Roman times. In the research conducted at the chair of Resource and Waste Management (S+E, Prof. Peter Baccini, Thesis Peter Krušpán), synthetical pozzolanic products of a new pyrometallurgical waste treatment process are compared to geogenic analogues in order to understand the petrogenesis of pozzolans.

The figure illustrates the petrogenesis of pozzolanicity by volcanic processes (upper part) and by pyrometallurgical waste treatment (lower part). Number 1 indicates the source material, number 2 the pozzolan. The petrogenesis follows the 3 steps "melting" (I), "cooling and fragmentation"(II) and "weathering and diagenesis" (III). Based on the volcanic model the pozzolanic reaction of the siliceous waste treatment product could be increased by up to 50% by fine fragmentation of the melt (step II) and zeolitisation of the glassy matrix (step III). The approach selected can be applied generally to the design of secondary raw materials.

The combination of competencies (from natural and technical processes) is an excellent example of environmental engineering for long-term resource management.



Petrogenesis of pozzolanicity by volcanic processes and by pyrometallurgical waste treatment

Alpine Permafrost Research

The VAW has been active in alpine permafrost research over the last 15 years, focussing primarily upon determining the extent of permafrost in Switzerland, with a special interest in rock glaciers where extensive surface and some borehole measurements of temperature and deformations have been carried out during this period. Ongoing measurement and monitoring is being carried out Europe-wide for the Permafrost And Climate change in Europe (PACE) project. More recently, IGT put together an ETH Mini Poly Project with VAW and the Institute for Geophysics to investigate the stability of rock glaciers; a major concern in view of possible temperature increases. 6 further boreholes were drilled in 1999 and 2000, and used for insitu determination of the frozen material properties, extraction of cores for laboratory testing of strength and creep properties using triaxial apparatus developed and manufactured by IGT, cross-hole geophysics and monitoring of temperature and deformation. A follow up project concerning the numerical modelling for predicting the transient evolution of the surface of rock glaciers and, in particular, the rate-of-advance of the frontal lobe, is now underway. A full-system model, developed at VAW, is compared with data from a zeroth-order model and demonstrates that the results obtained from both approaches converge.

Geo-, Structural and Environmental Data

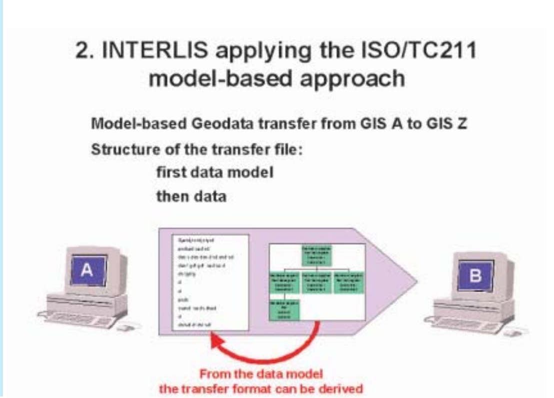
75 years of cartography at ETH Zurich and a major step forward into multimedia cartography

The Institute of Cartography at ETH Zurich was founded in 1925 by Professor Eduard Imhof. It is therefore the oldest academic cartography institute worldwide. On October 6, 2000, about 280 staff members, former members and friends celebrated the 75th anniversary of the institute at ETH Hönggerberg. In a festive colloquium, the history and evolution of the institute as well as current research and teaching projects were presented. The presentations were followed by a visit to the institute's facilities. On January 25, 2000, the newest edition of the "Atlas of Switzerland" was presented at a press conference. This new multimedia product was programmed entirely by the atlas group (Prof. Lorenz Hurni) at the institute and was published in close collaboration with the Federal Office of Topography and with the Federal Office of Statistics. With over 11'000 copies sold within the year 2000, the atlas has been remarkably successful. The project will continue during the next years with support from the Federal Board of Institutes of Technology.

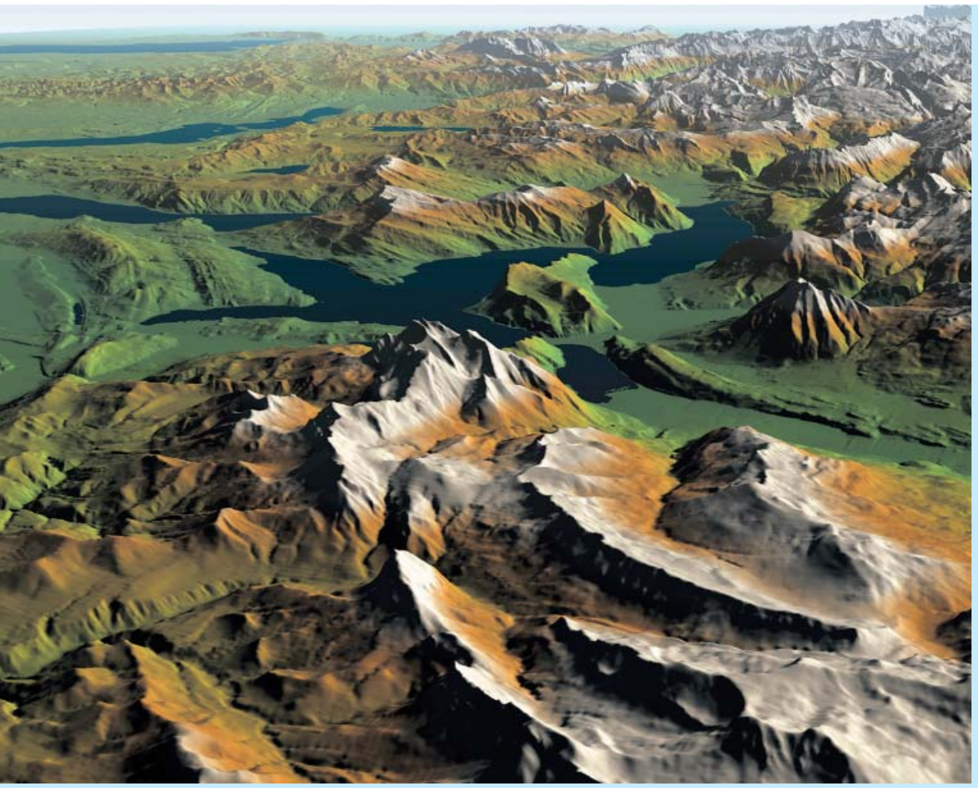
Swiss Object Oriented Modeling for GIS Interoperability

Interoperability among Geographic Information Systems (GIS) needs a chain of essential tools fitting each other seamlessly from the object oriented (OO) model of a GIS application to the transfer format of the corresponding data. Together with Swiss software development companies the Institute of Geodesy and Photogrammetry (IGP, Group of Prof. Alessandro Carosio) has managed to complete the tool chain from the OO graphical conceptual schema language UML to the web-based transfer format XML for the first time worldwide. This has been achieved by the OO extension of the Swiss transfer mechanism INTERLIS and by the realization of an UML to INTERLIS converter as well as a powerful INTERLIS compiler.

Thanks to a generous sponsoring from the Swiss Federal President A. Ogi and an enormous effort of a small group of experts supported by a PR agency, a perfect presentation of these research results in the areas of modeling and semantic interoperability has been a success in Reston USA. GIS researchers and experts, who are developing SQL3 and SQL MM, OpenGIS and the Geo-standards of ISO, showed great interest in the results.



Model-based geodata transfer

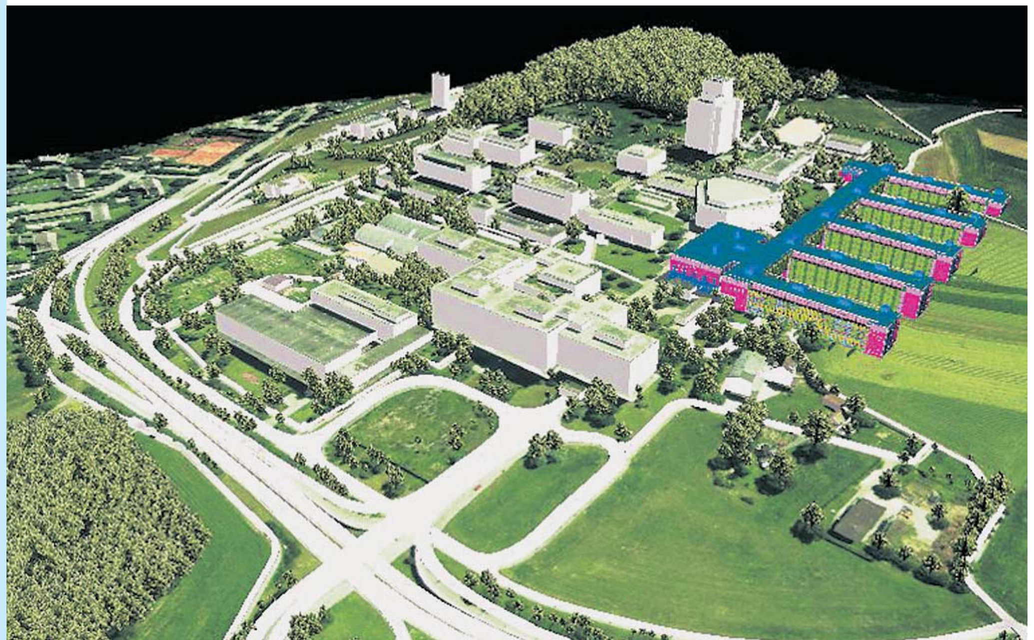


Virtual view of Lake Lucerne

3-D City Modeling

The Institute of Geodesy and Photogrammetry (IGP, Group of Prof. Armin Grün) has made significant progress with its research topic "3-D City Modeling". The fully automated methods of building and road extraction have been further developed with focus on the task of automated map updating on a project supported by the Federal Office of Topography Bern. The software of the semi-automated approach of "CC-Modeler" has become operational to such an extent that an ETH spinoff company CyberCity AG was founded with the goal of marketing and further development of this software. CC-Modeler can now be considered to be the most advanced approach in high resolution 3-D city model generation worldwide. Modeling examples not only include city models but historical and archaeological sites as well. Major current users of the datasets are city authorities, planners, telecommunication companies, chemical engineering plants and car manufacturers. The research work of our group in this area was honored by the U.V. Helava Award 2000 (recipients M.Sinning-Meister, A. Gruen, Hanbin Dan) of the ISPRS, which is awarded only every four years.

3-D model of the ETH Campus Hoenggerberg



High-Tech Measuring Systems

Experimental setup of the solar spectrometer for remote sensing of atmospheric water vapour

Monitoring absorption and radiation of water molecules in the troposphere

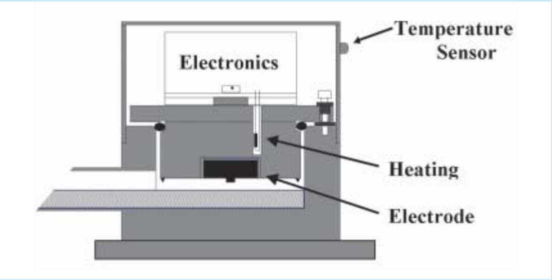
A new instrumental approach (solar spectrometer) for remote-sensing of water vapor is based on high-resolution absorption measurements of solar radiation. The photo shows the telescope and pre-monochromator of the solar spectrometer jointly developed by the Institute of Geodesy and Photogrammetry (IGP, Group of Prof. Hans-Gert Kahle, Thesis Bernd Sierk), and the Institute of Spectrochemistry and Applied Spectroscopy in Berlin. Also seen is the prototype of a newly designed microwave radiometer system, which measures the radiation of the atmosphere at 23.8 and 31.5 GHz. Both methods are complementary to each other and form integral parts in the mitigation of tropospheric refraction effects in high-precision GPS positioning and satellite radar altimetry.

A new Hydrostatic Level System (HLS) for permanent height monitoring of the neutron light source at the Paul Scherrer Institute (PSI)

A newly designed high-precision Hydrostatic Level System (HLS) has been developed to monitor the vertical position of the quadrupoles at the Paul Scherrer Institute (PSI) with an accuracy of a few microns. This development is the result of a co-operation of Edi Meier and Partners in Winterthur, Stanford Linear Accelerator (USA) and the Institute of Geodesy and Photogrammetry (IGP, Group of Prof. Hilmar Ingensand).

The basic function of the HLS-sensor is the determination of the level of a fluid, representing the local reference horizon, by measuring the capacity between the fluid surface and the internal electrode. The circuit of the neutron light source has a length of 560 m and is sectorized into 48 girders carrying the quadrupoles. Each girder is controlled by 4 HLS-sensors and can be levelled individually by electric devices. For permanent monitoring a total of the 204 sensors send their signals via CAN bus system to a central computer. The HLS is in operation since November 2000.

Sensor of the Hydrostatic Level System (HLS)



Experimental setup of the gravimetric system installed in an airplane

Towards an airborne absolute gravimetric system

The new Airborne Absolute Gravimetry system (AAG), developed at the Institute of Geodesy and Photogrammetry (IGP, Group of Prof. Hans-Gert Kahle, Thesis Henri Baumann), combines three powerful techniques: Laser interferometry, Global Positioning System (GPS), and INS (Inertial Navigation System), to measure absolute gravity in an aircraft. A laser interferometer and a highly stable frequency standard are used to determine the free-fall acceleration of a test mass relative to the aircraft. GPS is used to determine flight path accelerations and to precisely position the aircraft in an earth fixed coordinate frame. The INS in combination with GPS is used to correct the measurements for tilts of the apparatus and to remove low frequency non-gravitational accelerations. The AGG instrument will be the first system worldwide for measuring absolute gravity in an aircraft. The new instrument will substantially improve geodetic research. It will also have important impact on global change studies by providing a high-precision reference model for the Earth's gravity field over oceans and ice covered areas.

Studying at the Department of Civil, Environmental and Geomatics Engineering

GPS calibration in the surveying course in Sedrun, Switzerland

Studying at the Department of Civil, Environmental and Geomatics Engineering offers a very broad education. The small number of students allows very close contact among the students and as well as with the teaching assistants and the professors. A healthy number of excursions and field courses completes the subject material and also helps to promote contact between different groups within the university.

Studying is fun!

The wide variety of teaching areas in the basic curriculum provides a diversified education. Each lecture contains new challenges, the teaching areas ranging widely from geology to ecology and from physics to information technology. Project work in the most popular subjects is guaranteed in the specialised study blocks. Highlights of the study programme are the surveying and geodesy courses (for civil and geomatics engineering), the laboratory work (for environmental engineering), the various excursions and also the mandatory practical training (for environmental and geomatics engineering). The small number of students in each semester allows individual support. The atmosphere is friendly and informal.

Strong comradeship among the students

The students in each semester maintain close cooperation. The agreeable atmosphere is mainly established by the two student organisations GUV (for geomatics and environmental engineering) and AIV (for civil engineering). The organisations support the students by selling collections of old examination papers, etc. Some of the highlights for the students are the numerous excursions and traditional activities, like organised card games, a fondue evening, to name but a few. Additional services such as e-mail-accounts, storage space for homepages on the Web, mailing-lists, etc. are also provided.

Studies completed – what now?

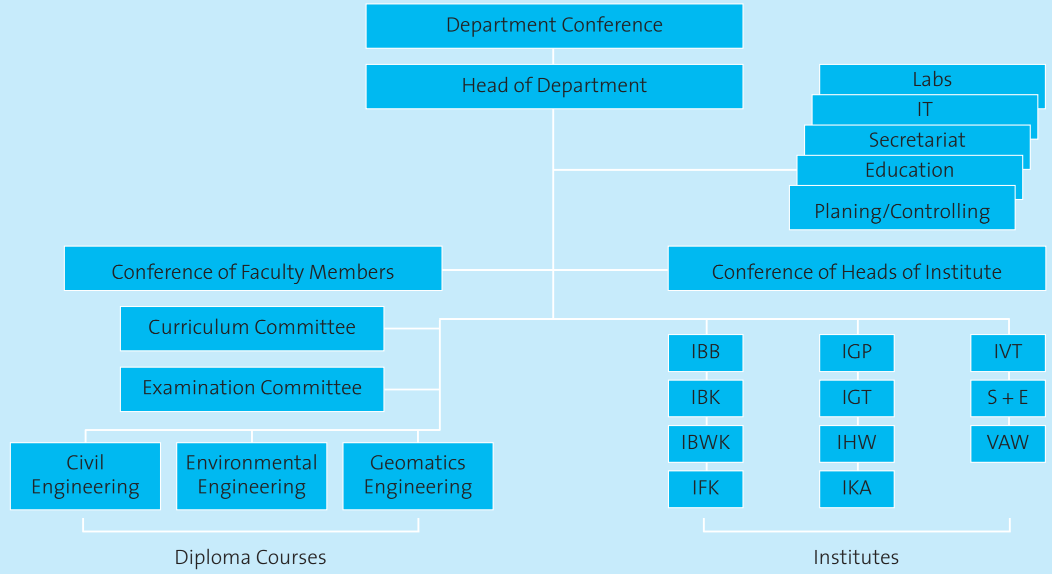
The graduate engineer is in demand as a specialist in the classical areas ordnance surveying, urban and regional planning, construction planning and ever increasingly in new fields like geo-informatics, system development, development aid, navigation, power maintenance, telecommunications, insurances, banks and consulting. The economic boom of recent months has also created a need for more jobs in engineering, which are only just being filled with the current number of students.

Marc Troller

Marc Troller got his Diploma Degree in Geomatics in Spring 2000

Practical training in development aid in Faisalabad, Pakistan

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. Faber, M. Fontana, P. Marti, T. Vogel
Institute of Building Materials (IBWK): Proff. H. Böhni, F. Wittmann
Institute of Geodesy and Photogrammetry (IGP): Proff. A. Carosio, Ch. Giger, A. Grün, H. Ingensand, H.-G. Kahle
Institute of Geotechnical Engineering (IGT): Proff. P. Amann, R. Hermanns Stengele, K. Kovari, S. Springman
Institute of Hydromechanics and Water Resources Management (IHW): Proff. P. Burlando, W. Gujer, W. Kinzelbach
Institute of Cartography (IKA): Prof. L. Hurni
Institute of Land Improvement and Water Management (IfK): Prof. W.A. Schmid
Institute of Transportation, Highway- and Railway-Engineering (IVT): Proff. K.W. Axhausen, H. Brändli
Laboratory of Hydraulics, Hydrology and Glaciology (VAW): Prof. H.-E. Minor
Resource and Waste Management (S+E): Proff. P. Baccini, S. Kytzia

Faculty

Retirements:	Prof. Karl Dietrich	Transportation Engineering	30.3.2000
	Prof. Dr. Hugo Bachmann	Structures	30.9.2000
Appointments:	Prof. Dr. Michael H. Faber	Assistentprofessor for Risk and Safety	1.4.2000
	Prof. Dr. Christine Giger	Assistentprofessor for Geo-Information Systems	1.6.2000
	Prof. Dr. Susanne Kytzia	Assistentprofessor for Regional Resource Management	1.12.2000

Students (Academic Year 1999/2000)

	Students						Doctoral Students	
	1st year	2nd year	3rd year	4th year	Total	Diplomas	Total	Graduates
Civil Engineering	60	51	80	82	283	59	90	16
Environmental Engineering	28	12	32	16	88	21	20	1
Geomatic Engineering*	14	26	38	44	122	36	35	3
TOTAL	**102**	**89**	**150**	**142**	**493**	**116**	**145**	**20**

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

Staff (including part-time employees)

Institute	Professors	Senior Staff	Assistents, PhD-Students	Technical Staff	Administr. Staff	Total
D-BAUG		4		4	4	12
IBB	2	2	13	1	3	21
IBK	6	5	34	4	4	53
IBWK	2	3	29	5	4	43
IGT	4	13	25	14	4	60
IHW	3	7	23	3	3	39
IfK	1	3	15	1	1	21
IVT	3	13	21	4	4	45
VAW	1	16	41	16	3	77
IGP	5	12	34	2	6	59
IKA	1	3	12	2	2	20
S+E	1	2	7			10
Total	**29**	**83**	**254**	**56**	**38**	**460**

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

NDS/NDK	ORL	Regional Planning
NDS/NDK	VAW	Hydraulic Structures (together with LCH of EPFL)
NDK	IGP, IKA	Spatial Information Systems
Short Course	ORL	GIS in Regional Planning
	IVT	Stated Preferences in Transportation
	IVT/SBB	Integrated Public Transport
	IBK	Risk and Safety: Fire Safety Engineering

Workshops, Symposia, Congresses

Event	Institute	Date
SCART: Science and Art, Symposium 2000 and Exhibition	IHW	February 28 to March 3
Workshop on Stepped Spillways	VAW	March 22 to 24
Workshop on Interuniversitäre Partnerschaft Erdbeobachtung und Geoinformatik	IGP	Mai 4 to 7
Swiss Railway-Bridges, Exhibition of the Society for the Art of Civil Engineering	IBK	May 6 to September 30
UNESCO course on Groundwater Recharge Estimation in Arid Environments organized and held by IHW at Niamey, Niger	IHW	July 7 to 11
Congress of International Association for Bridge and Structural Engineering, Lucerne	IBK	September 18 to 21
Annual Meeting of the German Clay and Clayminerals Society	IGT	August 30 to September 1
Meeting of Young Scientists of the Hydraulics Laboratories of German-speaking Universities	VAW	September 20 to 22
Internationales Symposium Betrieb und Überwachung wasserbaulicher Anlagen, at the Technical University Graz	VAW	October 18 to 20
Sino-Swiss Management Training Programme, Gansu Extended Programme 2000		
Workshops on Spatial and Environmental Planning in Xian and Lazhou in Kunming, China	ORL	September 10 to 15
Workshops and Presentations in Zurich	ORL	November 8 to 10
International Workshop on Reliability and Risk Based Inspection Planning	IBK	December 14 to 15

Honours

Dr. h.c. Franz Knoll	Honorary Doctorate of the ETH Zürich
Prof. P. Amann, Dr. Edelmann and Dr. Hertweck	Telford Price
Martina Sinning-Meister, Prof. Armin Grün, Dr. Hanbin Dan	U.V. Helava Award 2000
Marc Honikel	Young Author Award
Dr. Emmanuel Baltsavias	Presidential Citation
Joost Meyboom	Ernst & Sohn Award at the International PhD Symposium in Civil Engineering
Martin F. Bäuml, Christine Hollenstein, Thomas Jäger, Marc Roland Troller	Medal for the best Students of ETHZ

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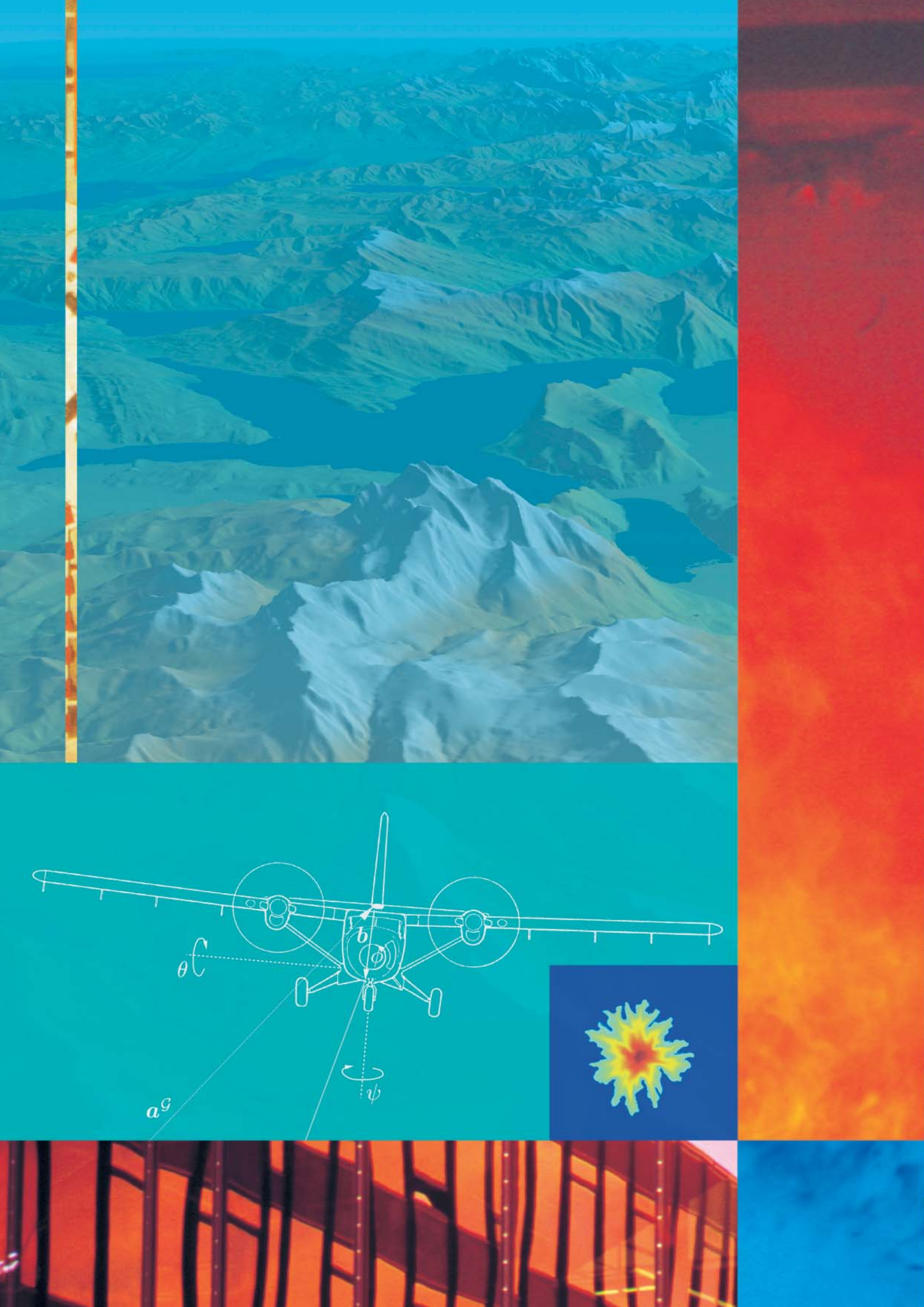
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