Geoengine –The University Of Stuttgart International Master Program With More Than 6 Years Of Experience

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Key words: International Master of Science program, Geomatics Engineering

SUMMARY

In 2006 the University Stuttgart implemented an international master program for geodesy and geoinformatics. At the start it was designed as a three-semester program including one semester for the master thesis. It attracted an increasing number of students from all over the world; starting with only 5 students in fall 2006, the 7th generation now started with 29 students last fall 2012. This is a considerable number for a geodesy related master program and directly illustrates the attractiveness of the program.

This contribution reflects our experience with this international student community of the last more than 6 years. Recently the program was slightly modified as a consequence of this experience and of discussions with the students. It is now extended to a four-semesters program to not only improve the attractiveness of the program but also being fully compatible to other master programs at university level with typically 2 years study period . The new two years program provides one additional semester in order to deepen knowledge and to allow for additional elective modules. The new design of the program starting in fall 2013 will be outlined as well.

Geomatics Engineering (GEOENGINE) is designed as a compact Master of Science program for international students from academia, government agencies or geomatics engineering companies. It provides advanced education and practical training to those students who wish to widen their perspective and expand their knowledge on numerical techniques for acquiring and modeling geospatial data. Therefore, the GEOENGINE master program provides profound knowledge focused on positioning, navigation and telematics. The compulsory modules cover topics like Advanced Mathematics, Geomatics Methodology, Geodesy, Engineering Geodesy, Remote Data Acquisition, Representation of Geodata, Law and Culture. Special focus is given to practical adaption of the knowledge within the Integrated Fieldwork which is carried out in the surrounding area of Stuttgart. Additionally, the elective modules Satellite Geodesy, Navigation, Geo-Telematics and Multisensor Integration may serve as access to research areas that may then be deepened in the master thesis.

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1. INTRODUCTION

Geodesy, Geo-Informatics or Geomatics has a long tradition in Germany. The International Association of Geodesy (IAG) traces its roots back to 1861, when general J.J. Baeyer organized formal international cooperation between Middle-European countries to determine the size and shape of the Earth. The Central Bureau, which was set up as executive body in 1866 was led by F.R. Helmert after Baeyer's death in 1885.

Student education in Germany is realized at two levels: Universities of Applied Science (Fachhochschule) and Universities (Universität). Until recently both levels had the diploma as a first degree, where Universities show a more scientific education level and their graduates could continue their research for doctor of engineering (Dr.-Ing.). In general the German University level never distinguished between surveying and geodesy; the two domains are integrated and taught in one degree. The diploma system was changed due to the European Bologna process (starting with the signing in 1999 of the Bologna declaration by Higher Education Ministers from 29 European countries) that is aiming at a formal unification of the university landscape in Europe and therefore in Germany too. This leads to a three-step education: Bachelor, Master and Doctor (PhD). The consecutive Bachelor and Master degrees are considered to be equivalent to the former German diploma degree. This shift from Diploma to Bachelor and Master is accomplished at all German Universities and Universities of Applied Science. At the University of Stuttgart a consecutive 3-year Bachelor and a 2-year German Master program has been introduced accordingly, where the first students under the new system have just entered the second semester of the Master. The three plus two year configuration is the standard agreed to by all German Research Universities teaching Geodesy and Geoinformatics as well as by the leading nine German Technical Universities (TU9).

This new structure of the degrees offers more flexibility to students to change the University between Bachelor and Master, both at national and international level. The latter is only possible in the case English is the medium of instruction, since German is only known by a few students worldwide. Some of the German Geodetic departments establish International Master Courses to attract international students and to give national students the opportunity to study in English language, thus providing an easier access to the international market. The University of Stuttgart started the international Master program GEOENGINE in fall 2006. The other German Universities offering similar Geomatics courses in English language are the Technical University Berlin with "Geodesy and Geoinformation Science", the Technical University Munich with "Earth-oriented Space and Science Technology" and "Land Management and

Tenure" and, jointly, the Technical Universities Munich, Dresden and Vienna (from Austria) with the joint Master "Cartography". In addition, two Universities of Applied Science offer international Master courses, too.

Geomatics Engineering (GEOENGINE) at the University of Stuttgart was designed as a three-semester master program for international students. Currently it is changed into a four semester course. The authors will come back to this in a following section. GEOENGINE focuses on an extensive theoretical background knowledge supplemented by application related topics. This way it assures its attractiveness to external students. The main driver of GEOENGINE is the Geomatics Department at the University of Stuttgart that consists of four institutes: Institute of Geodesy (GIS), Institute of Engineering Geodesy (IIGS), Institute of Navigation (INS) and Institute for Photogrammetry (ifp). The Geomatics Department at the University of Stuttgart is part of the faculty of "Aerospace Engineering and Geodesy".

2. DEVELOPMENT OF GEOENGINE

2.1 General outline of GEOENGINE

Geo-Information is the basis for various planning and decision processes and is of fundamental importance for sustainable development and stewardship of available resources. Moreover, the need for spatial data infrastructures as well as the realization of reference frames is important in various countries. This is the reason that the Master course GEOENGINE aims at teaching theories and methods for acquisition, management, analysis and interpretation of geodata. After successfully completing the master course the students are enabled to react to new challenges of the fast changing geodetic technologies. This will help to solve the problems in their home countries and therefore qualify them to take leading geomatics positions in industry and government as well as to compete for academic positions.

The GEOENGINE program provides an advanced education and training for students with a qualified Bachelor of Science degree (or comparable) in Geodesy, Photogrammetry, or Surveying Engineering. Graduates from equivalent programs may be accepted subject to individual assessment carried through by the admission board. This way, GEOENGINE also attracts people who already have finished other Bachelor studies (e.g. civil engineering or electronic engineers, computer scientists, physicists) to gain expertise in the promising field of Geomatics Engineering. Besides the Bachelor degree, English language proficiency has to be proven at the level of 80 points for the internet-based TOEFL test or equivalent. If the candidate's complete education has been conducted in English, TOEFL can be replaced by an official certificate of the home university confirming that the language of instruction is English. Most application documents can be uploaded online via http://www.geoengine.uni-stuttgart.de/application/application.html.

The entire Master Program is studied in English. From now on it will take two years (four semesters) including a one-semester thesis research. The annual enrollment is typically about 30 students, mainly international ones.

2.2 Development

In 2006 GEOENGINE was implemented at the University of Stuttgart with the first students starting in fall. In this first year GEOENGINE attracted 17 applications, of which 12 were admitted and 5 actually began (compare figure 1). That was a small number for the first year. Nevertheless the authors were satisfied, since the time for promoting the new program was obviously too short. Figure 1 clearly outlines that the enrollment is rising from year to year. In fall 2012 the number of 29 students was reached. The number of applications is rising too. The maximum is reached for 2012 with 80 applications. In spring 2013 more than 100 applicants submitted their materials for the course intake fall 2013. Some interesting relations are within the data. The percentages of the admitted student with respect to the applicants are between 70% and 80% showing that the quality of applicants is more or less comparable from year to year. Another important fact is that for all the years approximately 40% of the admitted students came to Stuttgart and start their studies. This is an almost constant value, so that the expected number of starters can be calculated directly after the admission process. This ratio is a typical value for international geodesy and geoinformatics master courses in Germany (Cramer, 2011). It is mainly visa problems, lack of financial support and personal reasons that prevent admitted students to finally travel to Stuttgart.

The number of graduations is below up to now, since the first years show low numbers of starters. Notice, that it is the students from generation 2006 graduating in year 2008.

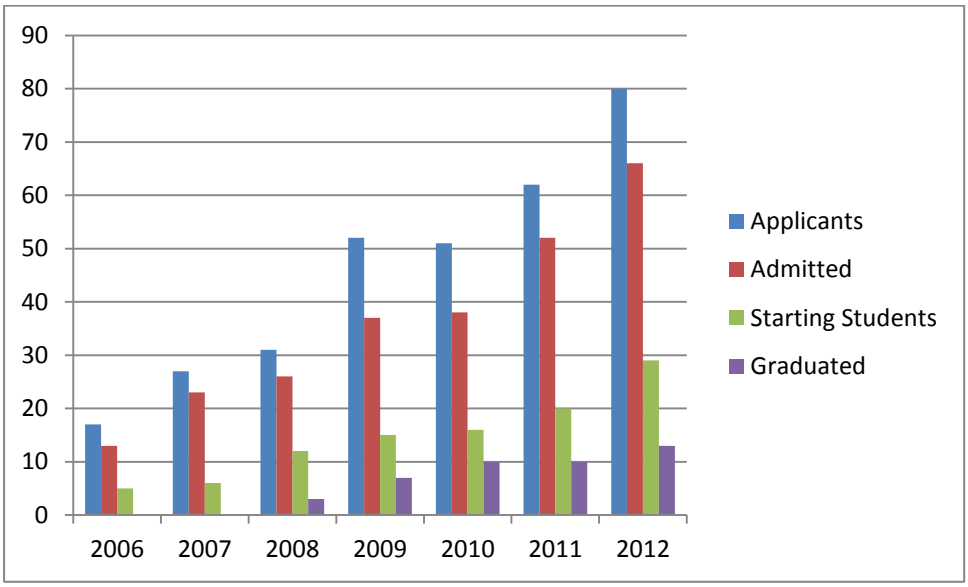
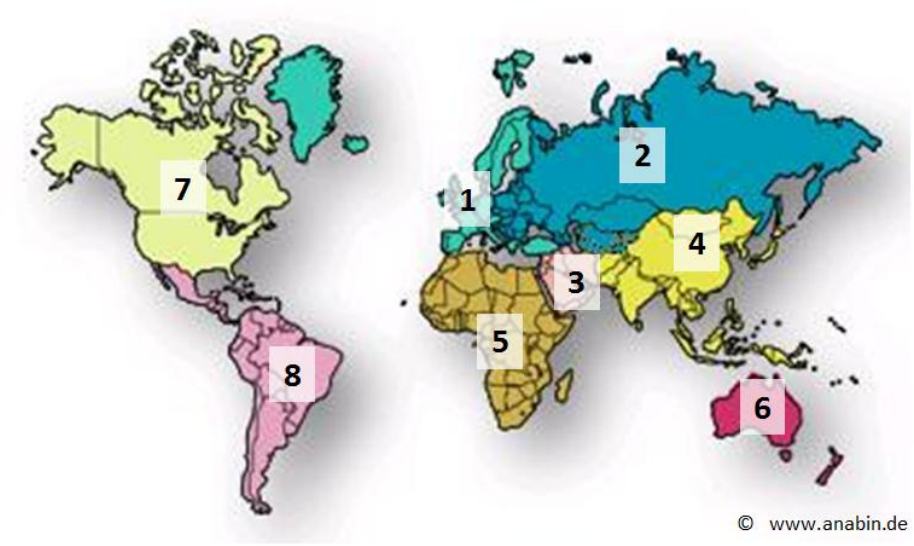


Figure 1: Applicants, admitted, starting and graduated students for GEOENGINE per year

2.3 Internationality

GEOENGINE was designed as an international master course. Therefore the authors analyze

the countries of origin of the students. Surprisingly, within these seven years of experience only one German student was registered, which is a first perfect proof for its internationality. The second step is to look into the worldwide distribution of the countries of origin. Here the authors follow a division of the world given by anabin data base ("Informationsportal zur Anerkennung ausländischer Bildungsabschlüsse", figure 2). The regions of origins identified are: West-Europe, East-Europe and Russia, the Near East, Asia, Africa, Australia, North-America and South-America.



- **Grp. 1:** West-Europe
- **Grp. 2:** East-Europe & Russia
- **Grp. 3:** Near/Middle East
- **Grp. 4:** Asia
- **Grp. 5:** Africa
- **Grp. 6:** Australia
- **Grp. 7:** North-America
- **Grp. 8:** Middle- & South-America

Figure 2: Worldwide regions of origin of GEOENGINE students

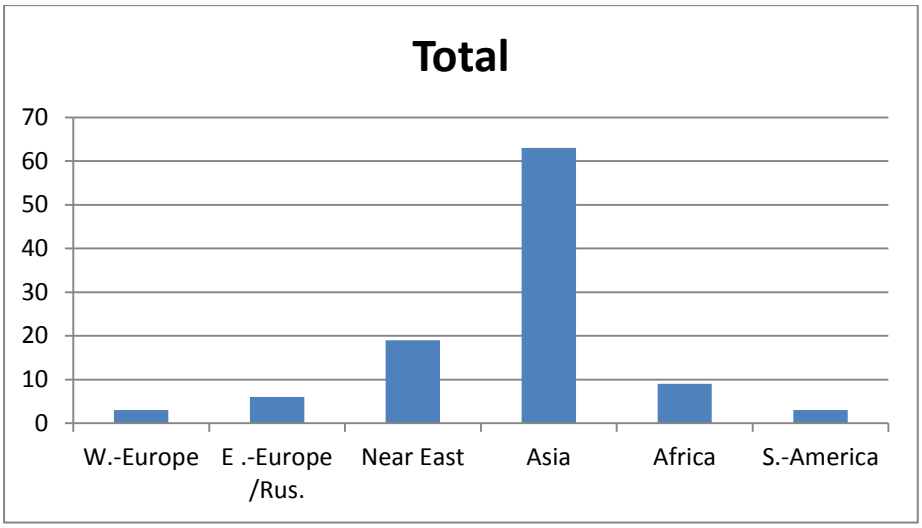


Figure 3: Total number of GEOENGINE students according to regions of origin

Figure 3 shows that obviously more than 50 % of the students are from Asia. Within this group most of the students originate from China, which is due to a large extent to a cooperation agreement between the University of Stuttgart and Wuhan University, which is the most important university to educate geodesy students in China. Further important student numbers are from India and Pakistan.

The region of origin that ranks 2nd is the Near East, which accounts for around 20 % of the total GEOENGINE student population. Here Iran is the most important country of origin. Enrollment from all other regions is low till now. The authors currently try to attract more students from the other regions of origin. Obviously no students from North-America and Australia found their way towards Stuttgart so far. Nevertheless GEOENGINE has proved to be truly international. Figure 4 shows the development for the 7 GEOENGINE generations. Again Asia, meaning to a large amount China, is representing the most frequent region of origin through all the years. The Near East bar is rising since winter semester 2008/09 (WS 08/09) up to the last year, where the difference to the Asian bar is reduced. The numbers always refer to the number of students at the beginning of each study year, which is always in fall / winter semester.

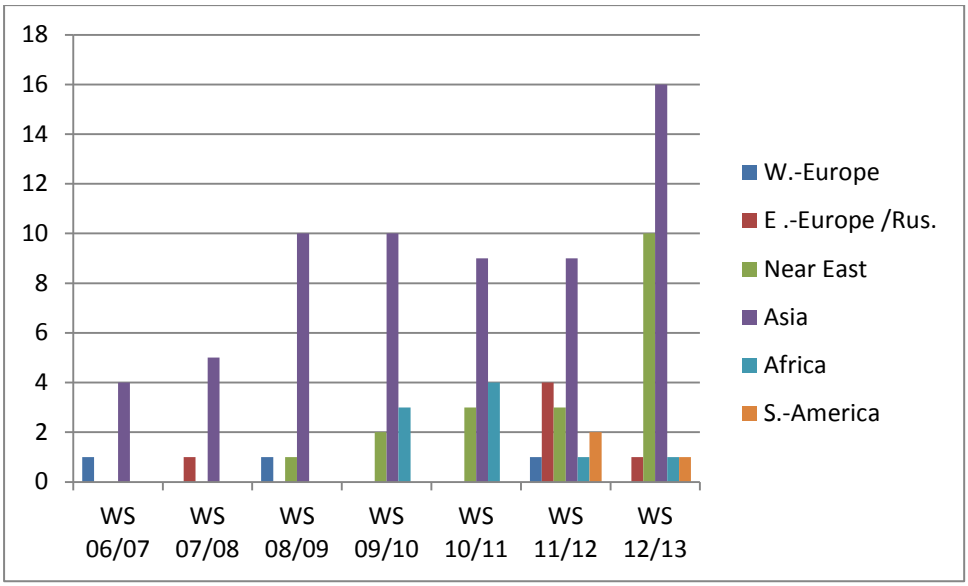


Figure 4: GEOENGINE students per study year according to regions of origin

3. GEOENGINE – PROGRAM REDESIGN

3.1 Reasons for the new program

Recently the program has been slightly modified as a consequence of discussions with the students. One main criticism of the GEOENGINE students was the high work load during the three semester course. This leads to problems delivering e.g. the master thesis within the agreed time. Another problem is the integration of students from different cultures and with different special background knowledge. Especially the 2nd point leads to problems, since some of the students have no problems to follow from the first semester, others have to catch up a lot of content. The short and condensed course program made it difficult to catch up completely within the study period. For the mathematical background this problem was already solved by the module Advanced Mathematics that takes into account the different mathematical knowledge levels. For the newly designed four semester course this is planned for other modules e.g. Engineering Geodesy too.

A further reason for reshaping the structure and extending the regular period of study was the demand for a three year bachelor followed by a two year master that is the standard for Universities in Germany. Especially the nine most important Technical Research Universities of Germany (TU9) have agreed on this consecutive scheme.

3.2 Structure of GEOENGINE

The international GEOENGINE program is offered annually, starting each fall in winter semester. It consists of three semesters of lectures and lab exercises. The final fourth semester is reserved for the master thesis. During the first three semesters, altogether 14 modules are offered, 10 of which are mandatory. Two of four courses have to be selected from an elective

part. All courses are credited conformal to the European Credit Point System (ECTS). The Master Program comprises courses up to the range of 120 Credit Points (CP).

It is worth to mention that studying GEOENGINE does not require to pay tuition fees. Only some minor student service fees of around 140 EUR per semester have to be paid. The program is fully accredited according to the European Standards and Guidelines for Quality Assurance in the European Higher Education Area. The original program accreditation, that was in place at the start of the program, has recently been superseded by an institutional accreditation at university level.

The lecture series is opened with a compact pre-course on German Language and Culture (6 CP). It conveys a basic knowledge of the German language as well as introducing into German culture and history. The other mandatory modules are focusing on advanced topics in Geomatics Engineering, namely Advanced Mathematics (6 CP), Geomatics Methodology (15 CP), Engineering Geodesy (9 CP), Geodesy (9 CP), Remote Data Acquisition (9 CP) and Representation of Geodata (9 CP). Besides this, a non-technical course in international and contract Law (3 CP) is supplementing this mandatory section of the program. Within the third semester additional elective courses in two of the four topics focusing on Multisensor Integration, Satellite Geodesy, Navigation or Geo-Telematics (9 CP each) can be chosen by the students. The final fourth semester is exclusively dedicated to the preparation of the master thesis (30 CP). The structure of the course is given in Figure 5.

Between the second and third semester the students attend a 10 days' Integrated Field Training (6 CP). This course is already a synthesis of knowledge acquired in previous modules. It enables students to team up with other students, to analyse real-life Geomatics Engineering tasks and to solve those tasks and problems using an engineering approach. The fieldwork is realized at variable places in the vicinity of Stuttgart (see section 3.3).

The Master Program will be concluded with the Master-of-Science-Examination. This exam consists of separate exams for the different courses according to the individual study plan. The master thesis counts for one quarter of the final grade (see section 3.4).

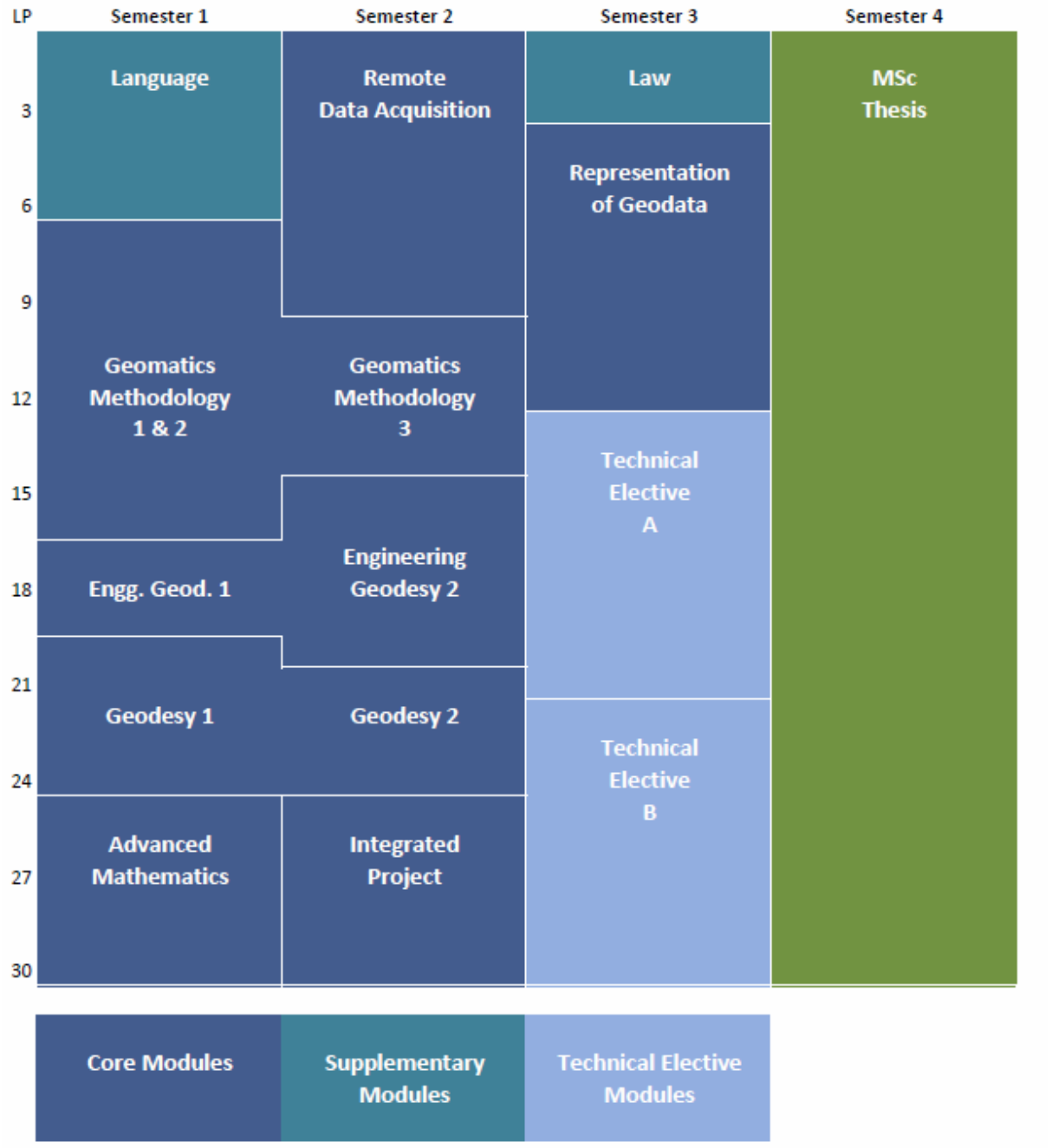


Figure 5: Structure of GEOENGINE program

3.3 Integrated Fieldwork

As already mentioned, one highlight of the course is the 10 days' Integrated Field Training. The students work in groups of three to four persons and solve different tasks every day, e.g. trigonometric leveling, kinematic survey, three-dimensional reference frame and terrestrial

laserscanning. In the following a typical structure of project that is realized with the help of the scientific and technical staff of the four mentioned institutes is given. For 2012 the student project deals with the plan to build a new water conduit for the pump storage station in the Swabian Alb. The following text is the introduction of the task description for the GEOENGINE students to give a real idea of the project.

"The whole project is divided into several work packages (WP). Two students should be responsible for the project management (WP 0). An orthophoto and a digital terrain model (DTM) are necessary for planning and visualisation (WP 1). Furthermore, we need a three-dimensional reference frame, thus enabling survey of details. To provide control points with local Gauss-Krueger-coordinates for measurements in detail, the Global Positioning System (GPS) has to be used, and transformation parameters have to be calculated (WP 2). In addition to the plane coordinate reference frame, a height network has to be generated by levelling and measuring of gravity (WP 3). The results have to be made available to the other WPs conveniently. Due to the huge height differences between the dam and the lake, trigonometric levelling should be used for the steepest part. To reach highest accuracies, the trigonometric levelling has to be done in both directions at the same time (WP 4). At the same time information about existing roads and points of interest (POI) is needed to plan the construction site facilities and access roads for transportation. To accomplish these tasks rapidly, efficiently and area-wide, a kinematical route survey has to be done (WP 5 and WP 6). All measurements of interest (from all WPs) should be made available to WP 10 in an appropriate format. For visualisation and further planning of the constructions, as well as for analysis and checking of all measurements a GIS (WP 10) is used. Definition and measurement of two reference networks near the water conduit portals are necessary for planning the water conduit and executing the construction work (WP 7). Therefore, points representing the connection to the existing road network are to be marked and measured (WP 8). By using a network adjustment software, the coordinates of the network-points have to be calculated. After the software-based planning and calculation of the water conduit route, position and bearing of the path as well as the portals are to be staked out (WP 9). Due to subsidences expected in the dam area, a monitoring of the buildings above the water conduit is required. Therefore, the location and geometry of the endangered buildings has to be recorded. This will be done by terrestrial laserscanning (WP 14) and with close-range photogrammetry (WP 13). For geo-referencing of the scans and the pictures it is necessary to densify the reference network (WP 11) and to provide additional coordinated points near the buildings (WP 12). Some of these points are also used for later quality assessment of digital orthophoto and the DTM obtained from laserscanning."

The following Figures 6 and 7 illustrate some results of the project: the reference points determined minimally three times by GNSS and the point cloud that was acquired by terrestrial laser scanning within the project.

Figure 6: GNSS reference points (blue) at Swabian Alb, visualized in ArcGIS

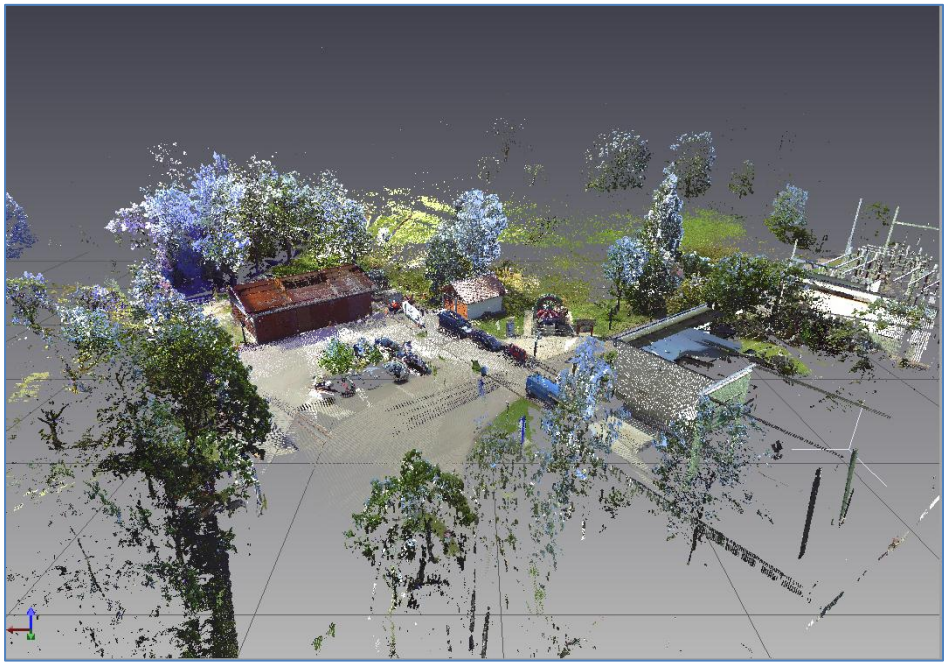


Figure 7: Point cloud of terrestrial laser scanning, visualized by Faro Scene

3.4 Master Thesis

An important part of the education is the master thesis that fosters scientific work and autonomous as well as creative working on a focused target. Figure 8 presents the number of theses finalized up to 2012. The increasing number of theses through the years reflects the increasing student numbers. Additionally the figure shows that external theses can be realized in cooperation with companies like Bosch or research organizations like DLR (German Aerospace

Center). The theses completed within the last years are accessible on the GEOENGINE-Homepage (http://www.geoengine.uni-stuttgart.de/forum/masterprojects.html). Some example titles are "Time Series Analysis for Construction Monitoring: Detailed analysis of high frequencies", "Comparison and Evaluation of Civil GPS Signals", "Analysis of Earthquake Signals by Spaceborne Gravimetry" and "Extraction and Improvement of Digital Surface Models from Dense Point Clouds".

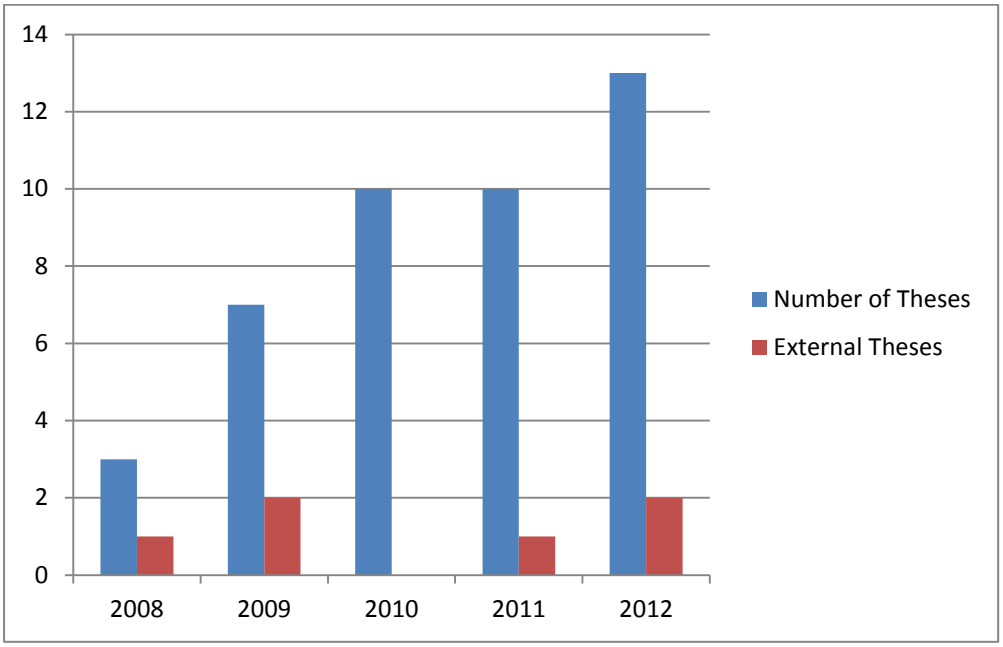


Figure 8: Completed Master theses per year

4. FURTHER INFORMATION

4.1 Scholarships

As already mentioned before, no tuition fees apply at the University of Stuttgart, as public university in Baden-Wuerttemberg. As this is the case in almost all the federal states of Germany, there are not many organizations supporting students by scholarships. The German Academic Exchange Service (DAAD – Deutscher Akademischer Auslandsdienst) well known, is offering scholarships for students. But these scholarships are designated to doctoral programs mostly. Master of Science programs are not supported, unless they belong to a group of programs with "relevance for developing countries" or unless special country related scholarships are offered through DAAD. The classification into programs with relevance to developing countries is made by DAAD. GEOENGINE is not part of this group of programs even though the objectives of our program may fully fit into it.

Therefore, GEOENGINE from its very beginning tried to find external sponsors to financially support the incoming international students. Due to our long term contacts with two well-known companies in the field of photogrammetry and navigation, GEOENGINE has access to

9000 EUR per year, which are distributed to the students. The companies IGI Ingenieurgesellschaft für Interfaces mbH located in Siegen/Germany (see http://www.igi.eu) and the Microsoft Photogrammetry Vexcel Imaging in Graz/Austria (see http://www.microsoft.com/ultracam/) both providing digital airborne cameras and additional hardware / software for photogrammetric data generation are supporting the GEOENGINE students. Since winter term 2007/08 is was altogether 51000 EUR spend by IGI and Vexcel. Since summer 2010 two scholarships (i.e. 375 EUR per month, for one semester, 6 months period) are awarded to the top two students in the second and third semester. The student's performance is based on the results of their examinations from the previous semester(s). This is to guarantee fully objective criteria for scholarship decisions, and this is the reason, why these scholarships are only available from the second semester.

In addition to the IGI and Vexcel Imaging scholarships, which are acquired by GEOENGINE itself, additional financial support is given through the so-called Matching Funds scholarships. This money, which originates from the DAAD STIBET scholarship program, is spent on those programs that have been able to acquire their own scholarship sponsors. The matching funds are given to the university and then distributed to the individual programs. In the optimal case it will double the own scholarship money, i.e. it will give another 9000 EUR per year to support GEOENGINE students. This again is divided into 3–5 months lasting scholarships, covering at least 250 EUR per month. Typically 3–5 students per semester are selected for these awards.

Figure 9 shows the cumulative amount of scholarships per semester. The matching funds became available from summer 2009. Consequently around 9000 EUR per semester are available for the student's support. In each year between 5 and 8 students are supported for their studies in second and third semester (compare figure 10).

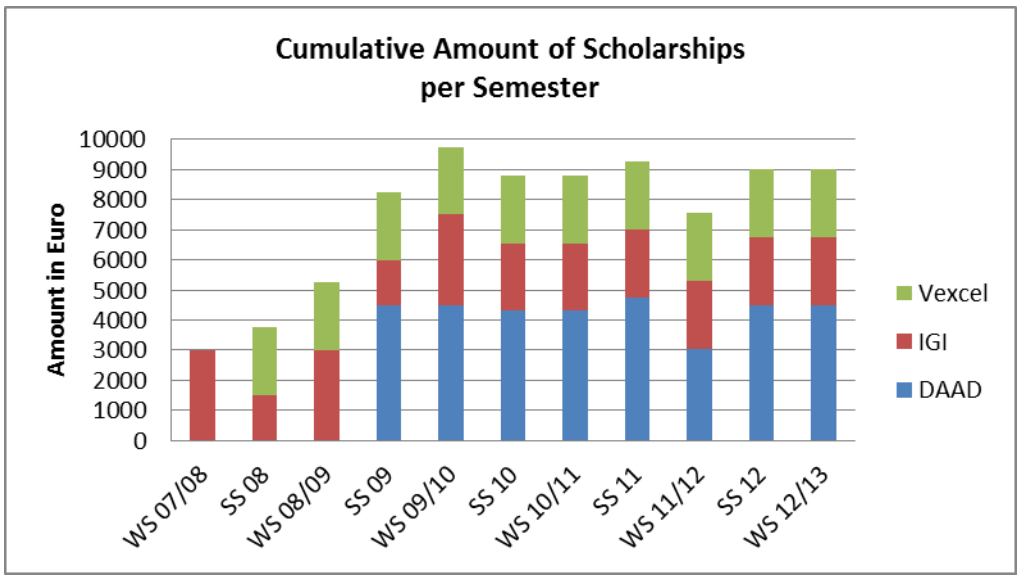


Figure 9: Scholarships [Euro] per semester

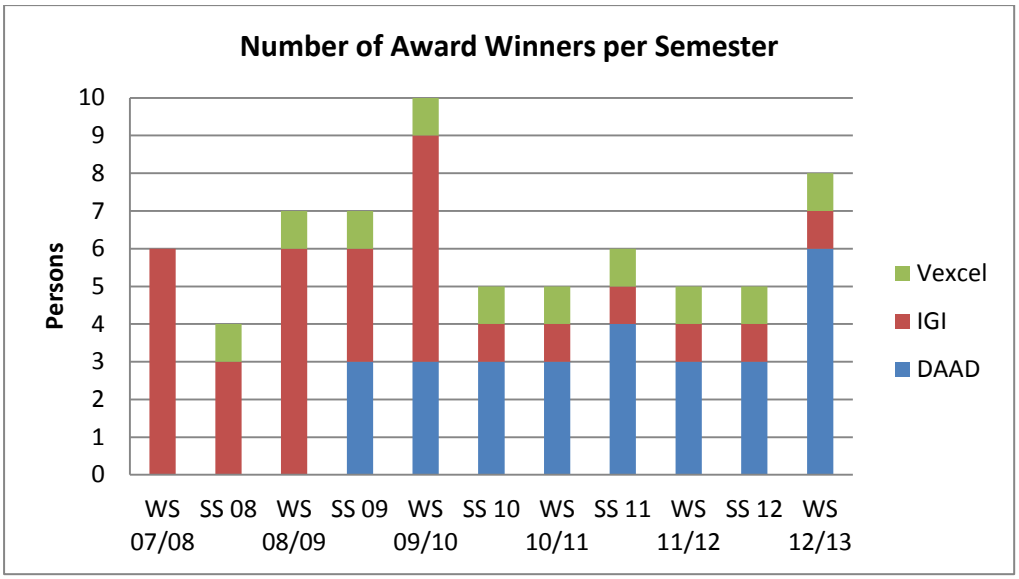


Figure 10: Number of Scholarships / award winners per semester

4.2 Social Activities and other aspects

4.2.1 GEOENGINE seminar

One main objective of the GEOENGINE program is to prepare the senior students for their start in their professional careers. Lectures and labs is just one part of this; in addition it is also very important to talk to geomatics professionals and to get a first glimpse on how the profession looks like. This is why the responsible lecturers organize the GEOENGINE seminar every year, where external speakers are invited, mostly from business but also from research, to illustrate their work, their business. As such they help students to get first ideas for potential directions after graduation. Since 2008 seven well-known speakers have been giving their presentation on the following topics:

- Georeferencing with AEROcontrol GPS/IMU data (Dr. Jens Kremer, IGI Systems, Germany)
- Ultracam-X – state-of-the-art digital airborne imaging (Dr. Michael Gruber, Microsoft Photogrammetry Vexcel Imaging, Austria)
- Real-time and Predictive Traffic Information: Data Sources and Traffic Models (Dr. Ulrich Fastenrath, DDG Gesellschaft für Verkehrsdaten mbH, Germany)
- Cooperative Systems in Road Transport - Issues Relating to Geo-Referencing and Digital Maps (Michael Landwehr, PTV AG, Germany)
- SOFIA and Infrared Remote Sensing (Prof. Hans-Peter Röser, Institute of Space Systems, University of Stuttgart)
- Geodetic Works for the Gotthard Base Tunnel (Dr. Urs Marti, swisstopo, Switzerland)
- From Bohnenberger's Machine to Integrated Navigation Systems: Two centuries of Gyro Technology (Prof. Jörg Wagner, German SOFIA Institute, University of Stuttgart)

As one can see, the list of topics nicely illustrates the potential fields of work, where students

can start their business or research career.

4.2.2 Excursions

In addition to these professional presentations the GEOENGINE program is regularly organizing excursions. Typically three excursions per year are realized, where the students visit the DLR in Oberpfaffenhofen, which is the national aeronautics and space research centre of Germany. The main focus there is on satellite remote sensing which is performed at the EOC (Earth Observation Centre) in the Remote Sensing Institute. In addition we typically have the chance to also visit the Institute of Robotics, which is a completely different field of applications for geodetic technologies like computer vision and machine control. A second excursion to Leica Geosystems in Heerbrugg has a different focus, covering the more "earth-related" side of geo-data acquisition and processing. It is always very impressive to see, how the well-known Leica total stations are screwed together on the assembly lines. Nevertheless during the Leica visit we are also introduced into the airborne data acquisition using novel digital cameras and laser scanners. This is then completed by a tour to the Intergraph/ZI company in Aalen, only 80km east of Stuttgart, which is also well known for their digital airborne imaging sensor but based on using very large format monolithic CCD sensors of up to 250 Mpix each. Students are much impressed when they can "take-hands-on" the world's largest CCD frame which is made available for commercial civil applications!

To add a social component to these excursions also, these tours always are shared by the GEOENGINE students and those from the German-speaking Geodesy & Geoinformatics program. This is also one aspect of internationality.

Figure 11: DLR Excursion: The students on the top of the Earth Observation Centre

Figure 12: Leica Geosystems Excursion: Enjoying the lunch invitation in the Leica cantine

4.2.3 Social Events

As previously mentioned, the contacts between students of different countries and cultures are one of the key issues of international programs like GEOENGINE. Currently, seven international Master programs in the University of Stuttgart exist, all of them exclusively taught in English. As there is a good network between the different program coordinators, several social events are organized to "stimulate" exchange between the students in their different study programs. One example is a football tournament in summer (this is why part of the integrated field work is unofficially used as football training camp for the GEOENGINE students also). Other events focus on cultural activities, like visits of the medieval cities of Tübingen and Esslingen nearby Stuttgart. Students have also visited the Planetarium, where a special English-spoken show is organized for them.

Moreover, social events between the German and international Geodesy program students take place. Beside the excursions and the integrated field work, organized between German and International students in our Geodesy department, one of the highlights in student's social events is the international evening organized by GEOENGINE students for all the German students, teachers and staff members of the Institutes. This is a unique platform not only to meet-and-greet but also to introduce different countries and cultures, to sample international culinary treats and even to perform traditional folkloric dances. For sure, there are also the fixed events within the students "festival season", like Christmas party, first semester students' party, barbecue and so on. Social activities are very important, as this is the easiest way

to really become familiar with the culture and life in a foreign country. This is why GEOENGINE officers always support any kind of social activities for students, by students.

Figure 13: Football tournament: The GEOENGINEs supported by German Geodesy student won the second place in the University of Stuttgart

4.3 The city of Stuttgart and its surrounding

The University of Stuttgart is located in Baden-Württemberg, the south-western region of Germany. Its history dates back to 1829. The University of Stuttgart hosts about 22000 students, of which more than 20% are from abroad. It is one of the oldest technical universities and ranks among the top universities in Germany. The university hosts 10 faculties, several centres of excellence, various technology transfer centres, graduate research programs and a federal supercomputing centre. Many large research centres have strong connections to the University of Stuttgart. Therefore, it is a truly innovative place of research and advanced education and a beneficial network for the execution of internships and theses.

Stuttgart is the state capital of Baden-Württemberg. It has a population of about 600 000 inhabitants. Situated in the valley of the Neckar river, between the hills of the Swabian Alb and the Black Forest, it is often called "the city between forests and vineyards". A large number of cultural highlights are to be found in the city including opera, ballet, theatres, concert and music halls, art galleries and various famous museums. There is also a rich variety of sports events as well as many possibilities for individual activities such as mountain biking and hik-

ing. Due to Stuttgart's central location, it is easy to visit neighbouring countries like France, Switzerland, Italy, Austria, Czech Republic, Belgium and the Netherlands.

The Stuttgart region is one of the most attractive regions in Germany. It is well known for its high-tech industries such as car manufacturing, environmental technologies, machining tools, electronics and information and communication technology. Many internationally renowned companies such as Daimler, Porsche, Bosch, HP and IBM Germany are located in the Stuttgart region. In addition, numerous smaller and medium sized technology-oriented companies are making their mark on the industrial and business environment.

BIOGRAPHICAL NOTES

Dr.-Ing. **Michael Cramer**

1987 – 1993	Studies of Geodesy in Stuttgart
1993	Dipl.-Ing. Geodesy (University of Stuttgart)
2000	Dr.-Ing. Geodesy (University of Stuttgart)
1999	Senior lecturer at Institute for Photogrammetry (ifp), University of Stuttgart
2006	Course Director GEOENGINE international MSc program

Prof. Dr.-Ing. habil. **Volker Schwieger**

1983 – 1989	Studies of Geodesy in Hannover
1989	Dipl.-Ing. Geodesy (University of Hannover)
1998	Dr.-Ing. Geodesy (University of Hannover)
2004	Habilitation (University of Stuttgart)
2010	Professor and Head of Institute of Engineering Geodesy (IIGS), University of Stuttgart
2012	Chair Elect of FIG Commission V „Positioning and Measurement“

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1974 – 1977	Studies of Surveying at Bonn University
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1982	Dr.-Ing. "Signal Processing" (Bonn University)
1990	Habilitation "Geographical Information Systems" (Technical University of Munich)
1992	Full Professor and Head of Institute for Photogrammetry (ifp), University of Stuttgart
2000 – 2006	President University of Stuttgart
2009 – 2013	Vice President Research EuroSDR

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1972-1976	Studies of Mathematics in Dresden, Germany
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1985	Habilitation (Technical University Dresden)
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1971 – 1974	Studies of Surveying, University of Applied Science Bochom
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1984	Dr.-Ing. (University Stuttgart)
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1997	Professor and Head of Institute for Navigation (INS), University of Stuttgart

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1984–1989	Studies of Geodesy in Delft, Netherlands
1989	ir.-Diploma Geodetic Engineering (Delft University of Technology)
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