

# **Higher Education in Satellite Geodesy A Research-Related Intercultural Approach**

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**Key words:** Satellite geodesy, GNSS/GPS, exchange program, research-related intercultural and transnational education

## **SUMMARY**

In order to improve the education of young researchers (master degree, PhD, PostDocs) a cooperation between the Department of Geomatics (DGEOM), Federal University of Paraná (UFPR), Curitiba (Brazil) and the Geodetic Institute (GIK), University Karlsruhe (TH), Karlsruhe (Germany) was established which now exists since more than five years. The joint venture is actually called “PROBRAL: Precise positioning and height determination by means of GPS: Modeling of errors and transformation into physical heights” and focuses on research and education within the field of satellite geodesy. PROBRAL is funded by the Brazilian academic exchange service CAPES and the German academic exchange service DAAD.

The geodetic aim of this research project is to validate and improve the quality of 3d positions derived from observations related to navigation satellite systems like GPS. In order to fulfill this ambitious goal sustainably, research has to be carried out in close cooperation. At the same time, e.g. to guarantee continuous success, a coordinated education has to be ensured. Besides technical education aspects key competencies (e.g. language, capacity for teamwork, project management skills) are trained. Within the paper especially the lessons which were learned from this project are discussed in detail.

# Higher Education in Satellite Geodesy A Research-Related Intercultural Approach

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## 1. INTRODUCTION

In order to improve the education of young researchers (master degree, PhD, PostDocs) a cooperation between the Department of Geomatics (DGEOM), Federal University of Paraná (UFPR), Curitiba (Brazil) and the Geodetic Institute, University Karlsruhe TH (UK), Karlsruhe (Germany) was established which now exists since nearly ten years. The transnational and intercultural joint venture is actually entitled “Precise positioning and height determination by means of GPS: Modeling of errors and transformation into physical heights” and focuses on research and education in the field of Satellite and Physical Geodesy. This project is embedded in the PROBRAL program and has been funded by the Brazilian academic exchange service CAPES and the German academic exchange service DAAD in the period 2006-2009, while in the years 2001-2005 the cooperation was founded by the same organizations within the UNIBRAL program.

The recent geodetic aim of this cooperative research project is to validate and improve the quality of 3d positions derived from observations related to global navigation satellite systems (GNSS) like GPS. In order to fulfill this ambitious goal sustainably, research has to be carried out in close cooperation. At the same time, e.g. to guarantee continuous success, a coordinated education has to be ensured. Besides technical geodetic education aspects, key competencies (e.g. language, capacity for teamwork, project management skills) are trained within this joint venture.

## 2. BACKGROUND: HIGHER EDUCATION

The Geodetic Institute of the University Karlsruhe (Germany) resp. the Karlsruhe Institute of Technology (KIT) is – in close cooperation with the Institute of Photogrammetry and Remote Sensing – responsible for the study courses in “Geodesy and GeoInformatics” (Bachelor, Master, Diplom-Ingenieur).

The Geodetic Institute (GIK) consists of three chairs. Prof. B. Heck is responsible for research and academic education dealing with Physical and Satellite Geodesy.

Besides of teaching fundamental and highly modern learning objectives, the higher education carried out by the GIK aims at the personal growth of the learners in an individual and flexible way with respect to their background, their preferences, and the constraints of the learners. One very successfully used tool to fulfill this ambitious goal is to give the learners the possibility to stay abroad, which has a long tradition at the GIK. This could be done in the framework of studying one or more semesters in a foreign country or the learners could gain experiences as an academic assistance within a project carried out abroad. Both ways broaden

the student's mind and view wider. Within the last decade South America and especially Curitiba (Brazil) became the focus of attention based on established research cooperations. Starting with the year 2001 the possibility of studying abroad (duration: six months) was offered to students of the diploma course "Geodesy and GeoInformatics" of the University Karlsruhe (Germany) as well as to students of the Geodesy-related courses of the Federal University of Paraná (Curitiba, Brazil). This exchange program was carried out in the framework of UNIBRAL and funded by the German academic exchange service DAAD and the Brazilian academic exchange service CAPES.

The exchange cooperation addressed to German students in the 6<sup>th</sup> or higher semester and to Brazilian undergraduate students. The chance of getting insight into another culture and different geodetic knowledge was taken by a major number of students; in the field of Physical and Satellite Geodesy five Brazilian and seven German students studied abroad until funding ended in the year 2005. While the Brazilian students were integrated into regular German lecture courses, the German exchange students did work on their study resp. diploma theses in close cooperation with Brazilian researchers and attended regular Brazilian classes in addition.

Beside the exchange of students, researchers visited each other in order to discuss and coordinate joint and further activities. One other important task of the exchange of researchers (duration: approx. two weeks) was to give lectures.

By means of the UNIBRAL project geodetic knowledge was transferred sustainably to Brazil, which enabled geodetic development and strengthened capacity. Simultaneously, the social and cultural as well as linguistical competence of all participants was improved. Based on the great success of the UNIBRAL-related cooperation, it was decided to intensify the close cooperation focusing on the working field of Physical and Satellite Geodesy.

### **3. BACKGROUND: SATELLITE-GEODETIC RESEARCH**

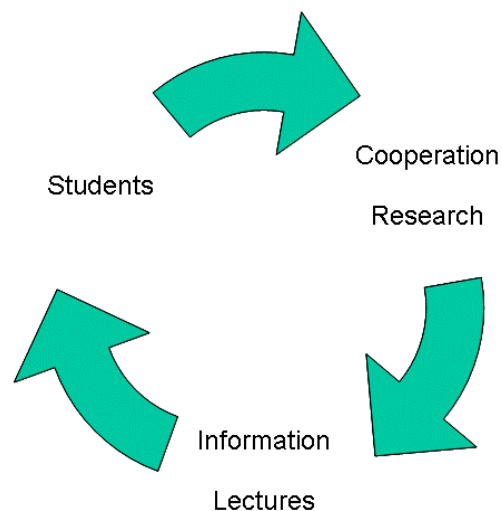
During the last two decades a large number of GPS reference station services with different performances and architectures have appeared world-wide. They could be classified in global, regional, and national services. The implementation of these services started in Brazil at the end of 1996. The services are based on networks of stations, which are receiving data from GNSS like GPS. The stations are equipped with geodetic GNSS antennas. The receiving behavior of these antennas has to be known very exactly in order to be able to determine highly precise and highly accurate 3d point positions reliably. Therefore, in Europe those antennas are nowadays routinely calibrated. The Brazilian stations are yet not calibrated due to lack of geodetic knowledge as well as unavailable hardware.

These crucial deficiencies were resolved within the framework of the transnational project "PROBRAL: Precise positioning and height determination by means of GPS: Modeling of errors and transformation into physical heights". The main goal of this joint venture was to validate and improve the quality of GNSS-based point positioning. Therefore, a relative receiver antenna calibration field for GNSS instrumentation was established on the roof top of the Astronomical Laboratory Camil Gemael UFPR (<http://www.lage.ufpr.br/>), which is situated on the Polytechnic Campus of the Federal University of Paraná, Curitiba (Brazil). This calibration field will enable Brazilian geodesists to provide GNSS antenna calibration

values and will create the possibility for verification of GNSS instrumentation for all countries of the Latin America, too.

#### 4. SUSTAINABILITY

Within this cooperation between the DGEOM and the GIK it was found in great accordance, that sustainability is one of the most important aspect of CAPES- resp. DAAD-funded cooperations, like UNIBRAL and PROBRAL. In order to guarantee sustainability within the geodesy-related cooperation, a cycle of sustainable knowledge transfer (see Fig.1) was established in order to guarantee advance in research as well as personal growth of all participants.



**Figure 1: Cycle of knowledge transfer.**

The focus was set on detailed and widely spread information for all members of the participating institutions. Therefore, not only the cooperating researchers but also their colleagues as well as the students were informed, presentations and classes were realized as appropriate tools as well as integration of research results into the regular curriculum. By means of these tools, follow-on generations of researchers are educated, who will be able to keep this fruitful cooperation alive.

Within the next sections carefully selected representative methods for generation of sustainability are presented:

- In order to determine GNSS antenna calibration values of good quality it is very important to choose an appropriate location, where the GNSS antennas are going to be calibrated. In Karlsruhe the GNSS antenna calibration field has been installed on the roof top of a multi-story building. Therefore, no obstacles and low multipath effects are affecting the signal propagation. In Curitiba – especially due to logistic and security aspects – a flat building had to be chosen. This location suffers from obstacles (e.g. trees) which are disturbing the electro-magnetic GNSS signals. The effect of the obstacles on the GNSS observations was investigated within two study works by German exchange students. Therefore, e.g. these students learned in a research-related way. After returning to Germany they accepted the

task of teaching other students within a 90 minutes lesson. Hence, the requirements as well as the fundamentals of research-related learning resp. teaching are fulfilled.

- Another good and representative example of knowledge transfer in close cooperation is dealing with the building of calibration pillars. In the beginning of the joint project, there were no pillars on the roof top existing in Curitiba. Pillars are essential for high quality calibration results. Therefore, three pillars were established based on experiences existing at the GIK and using results from comparable investigations carried out at the GIK by a Brazilian exchange PHD student.
- Besides carrying out research autonomously (e.g. in the framework of study works), various experiments were carried out in close cooperation by Brazilian and German researchers. Within these investigations the geodetic infrastructure at UFPR was improved, too. Software was developed and introduced in order to simplify and automate the data processing. This will contribute to the sustainability of the results of the project.
- The basis for the great success of this cooperation was established sustainably within presentations and lessons, which German researchers gave to whole courses (20-40 persons; e.g. master students, PhD students) as well as within intensive discussions with students resp. researchers. Within a time span of three years five German researchers visited Curitiba for approx. 8 months in total.

## **5. LESSONS LEARNED AND EXPERIENCES GAINED**

Within this section, the most important lessons, which were learned during the cooperation between the satellite geodetic sections of the DGEOM and the GIK are going to be presented:

- The fundamental basis of scientific as well as individual process is the ability of communication. Therefore, it is recommended that all participants of such an intensive research and social exchange initiative should be able to communicate with each other. To be able to speak and read the English language fluently is a must. This should be checked – if necessary – in detail in the forefront of a stay abroad. In addition, it is recommended to be able to communicate in the foreign language, especially due to the fact that one important goal of the here described exchange programs is to improve the social and intercultural skills. This could only be guaranteed based on communications with persons which are not part of the scientific community.
- Another important contribution to a fruitful cooperation is a careful selection of the exchange candidates. This has to be done in a close cooperation of the participating institutes resp. project directors. Both cooperating institutions resp. project directors should have various experiences in studying resp. researching abroad. In addition, there should also be deep insight into the conditions which are existing abroad. The selection of appropriate exchange candidates should be carried out respectfully, faithfully, and truthfully in order to guarantee sustainability of the knowledge transfer.
- Especially, when learners are exchanged appropriate guidance from the participating institutes resp. project directors is needed. This statement is also correct when young scientists are exchanged for long time spans (e.g. one year). At the beginning, when there are no social contacts outside the universities existing, some faithful persons should be

available to be contacted. In order to guarantee best options for high quality learning resp. research results the exchange person should be fully integrated into a research group.

- Working together (team work) in order to fulfill one big (research) goal seems to be a good way to keep the motivation of each participant as well as the motivation to participate at a high level. It is very important to collaborate in an equal, active, and cooperative way.
- The results of joint ventures should be as concrete as possible (e.g. publications, further joint projects, symposia). In the cooperation described here, one concrete result is the establishment of the GNSS antenna calibration field. The results should also be integrated into (other) academic courses in order to guarantee sustainability.
- After returning to their home country, all participants should try to stay in contact (networking). It was realized that even within a short cooperation period many additional research possibilities were opened up.
- Especially, if something went wrong or unexpected problems occurred, the circumstances should be reflected within a quality management process.

## 6. CONCLUSIONS

Physical and satellite geodetic engineering knowledge was used as a bridge between science and society. The cooperation within UNIBRAL and PROBRAL between the Geodetic Institute, University Karlsruhe (TH) resp. Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany and the Department of Geomatics, Federal University of Paraná, Curitiba, Brazil ended in December 2009. A lot could be learned and a lot of experiences could be gained – geodesy-specific experiences as well as experiences related to so-called key competencies. As a measure of the geodesy-specific outcome, PhD dissertations (>5), joint publications (>20), oral resp. poster presentations on the occasion of symposia and workshops (>20) may be used. To measure the improvement of key competencies of the participants is more difficult. Therefore, some keywords are listed below: friendship, personal engagement, helpfulness, hospitableness, social competence, intercultural competence, social involvement, sharpness of details, lingual competence, negotiation competence, improvisation skills, handling of time, team competence, open-minded, cosmopolitanism, and interdisciplinarity.

On the background of the great success of the collaborative teaching and research projects both partners wish a contribution of the cooperation in the future.

## BIOGRAPHICAL NOTES

**Dr.-Ing. Michael Mayer** received his doctoral degree in 2005 from the Karlsruhe University (TH), when he was investigating the appropriate modeling within the deformation network Antarctic Peninsula. He is actually head of the GNSS working group of the chair of Prof. B. Heck (KIT). He is interested in studying the mitigation of atmospheric and site-specific GNSS effects with a special focus on continuously operated reference sites. Furthermore, Michael Mayer received a diploma in higher education pedagogy in 2008.

**Prof. Dr.-Ing. Dr.h.c. Bernhard Heck** holds the chair of Physical and Satellite Geodesy at the Karlsruhe Institute of Technology (KIT) in Karlsruhe/Germany. He received the PhD degree in 1979 from the Karlsruhe University (TH) and worked in the fields of geometrical geodesy, deformation analysis, gravity field determination, and GNSS positioning. In addition, he is director of the Black Forest Observatory (BFO) and has experiences in higher education in various sub-fields of Geodesy.

**Prof. Dr.-Ing. Claudia Pereira Krueger** received her doctoral degree in 1996 from the Federal University of Paraná (UFPR), when she was investigating applications of high precision GPS in marine environments. She is actually responsible for the coordination of satellite-geodetic research carried out at the Space Geodesy Laboratory (LAGE) at UFPR. She and her working group are dealing with GNSS antenna calibration, hydrographical, and marine geodesy.

## ACKNOWLEDGEMENT

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