Erasmus Intensive Program (2011-2013) on Hydrography and Geomatics

Alain DE WULF, Timothy NUTTENS, Cornelis STAL, Bart DE WIT, Belgium
Nicolas SEUBE, France
Volker BODER, Germany

Key words: Erasmus Intensive Program, education, hydrography, geomatics

SUMMARY

A 3-year Erasmus Intensive Program (IP) was granted by the EU and started up in 2011 by the "Ecole Nationale Superieure des Ingenieurs des Etudes et Techniques d'Armement" (ENSTA) of Brest (France), in cooperation with the "Hafencity Universität Hamburg – Universität für Baukunst und Metropolenentwicklung" (HCU) of Hamburg (Germany) and "Ghent University" (UGENT) of Ghent (Belgium).

This IP is the first European-wide hydrography and geomatics course ever set up. All the partner universities already have an Erasmus Mobility agreement, but there is not yet any joint course between the partners of this IP. One of the achievements expected from this IP is to have as much students from hydrography and geomatics as possible discovering their respective expertise during the same project and working together as an international multidisciplinary team. The added value of the European component in this IP is to have several scientists, with various fields of expertise, gathered into one location for several weeks, dedicated to giving their knowledge to students from the partner universities. Thanks to that, this IP gives the students a unique opportunity to practice intensively in conditions close to what their professional life will be, but with the support of highly skilled scientists to guide them.

All the partner universities already have such "measurement camps" in their master curriculum, but none has one covering as many fields as done in this IP. Indeed, in order to set up this IP, it is mandatory to use the knowledge from scientists from all partner universities because this IP implies hydrography, geomatics and the specificities on inland waters. Mixing data from the many sensors that are used in this IP (multibeam sonar, sidescan sonar, laser scanners, inertial motion unit, total station and RTK GNSS), understanding the sources of measurement errors from each of them and how these errors will impact the final results, is regarded as state of the art technics. Professionals with such knowledge are regarded as highly desirable by public and private companies involved in activities related to hydrography and geomatics. Furthermore this IP is thought as a springboard towards an Erasmus Mundus project between the partners. This IP gives an opportunity to the scientists involved to work closely with each other, compare their teaching methods and get a better view of what the upcoming Erasmus Mundus project will be.

Erasmus Intensive Program (2011-2013) on Hydrography and Geomatics

Alain DE WULF, Timothy NUTTENS, Cornelis STAL, Bart DE WIT, Belgium
Nicolas SEUBE, France
Volker BODER, Germany

1. INTRODUCTION

The Erasmus Intensive Program (IP) concerns a hydrographic and topographic survey campaign around Lake Vassivière, located in the Limousin department in France. Students in hydrography and land surveying or geomatics from Ghent University (Belgium), ENSTA Bretagne (France) and HCU (Germany) participate in this program in order to increase their multidisciplinary knowledge and to use different sensors and processing approaches in an international context. The program is funded by the European Commission, through the ERASMUS program. Next to the gouvernmental recognition of the program and its financial support, the Dutch company BOSKALIS is the sole commercial sponsor of this IP.

The main objective of this IP in hydrography and geomatics is to make a survey of Lake Vassivière with a team of about 50 students from France, Belgium and Germany. This team was divided in sub-groups of 5 to 6 students, which are tasked to perform both bathymetric and topographic survey works. EDF (Electricité de France) and the Vassivière Lake planning authority are the requesting parties for a highly detailed bathymetric and topographic map and detailed 3D model of the dammed lake and its direct surroundings. This map and 3D model play a vital role in the management of the energy production based on this water reservoir and the tourism activities on and around the lake. As this is a three year project (2011-2013), different campaigns are planned to cover the whole area in high detail. The first campaign was held from October 29th until November 11th 2011.

The preparation and planning of this first campaign of the project was a challenging task for all three partner universities. After the recognition of the project by the European Counsil, the campaign was carefully prepared by the organizing staff, implementing the expertise and equipment of the different partners. Firstly, the area was explored in order to plan the survey activities and to preselect the areas of prioritary interest and the possible methods for a fast and accurate 3D data acquisition. After the arrival of the participating students, everybody was informed about the requirements of the campaign and initial exercises were organized to get familiar with the available equipment. The students were all assigned to a group, combining different nationalities into one group, and each group was assigned to specific areas that had to be measured. After an exploration of the areas per group, the measurements and quality assessments of the acquired data could start. Each group had the responsability to deliver high quality data of the assigned areas, using the most suited acquisition equipment and software for the quality analysis.

2. STUDY AREA

Lake Vassivière is an artificial lake, located in the Limousin department in France (Figure 1). The lake was created in 1950, in order to increase the potential of French hydraulic power production. The lake is exploited by EDF (Electricité de France), Unité de Production Centre, as a dammed water reservoir for a nearby hydraulic plant of 63,7MW. The lake is managed by the “Syndicat Mixte du Lac de Vassivière”, the Lake Vassivière authority, and also comes under the authority of the Conservatoire du Littoral, the French agency for coastal management and protection.

It is one of the largest lakes in France, covering around 1 000 hectares, with a depth until 35 meter, and a nominal volume of around 100 million cubic meters. By creating the dam which forms the lake, EDF contributed to the creation of a very active tourism area, covering 45 kilometer of lakeside and beaches. It also includes a coastal footpath and many nautical activities. With 70 000 visitors per year, the lake is an important source of income for this rural and peripheral area in France. Around the lake, there are six fully equipped sandy beaches and four fully equipped harbors (www.vallonvert.com, 2011).

During the first campaign of this project in October - November 2011, the water level (average level of 643 m) was very low compared with the normal level of 650 m (coordinate system Lambert 93 – height reference system IGN69). It is clear that for further development of the lake and the surrounding area, these water level fluctuations must be managed, in order to avoid problems for tourism and electricity production.

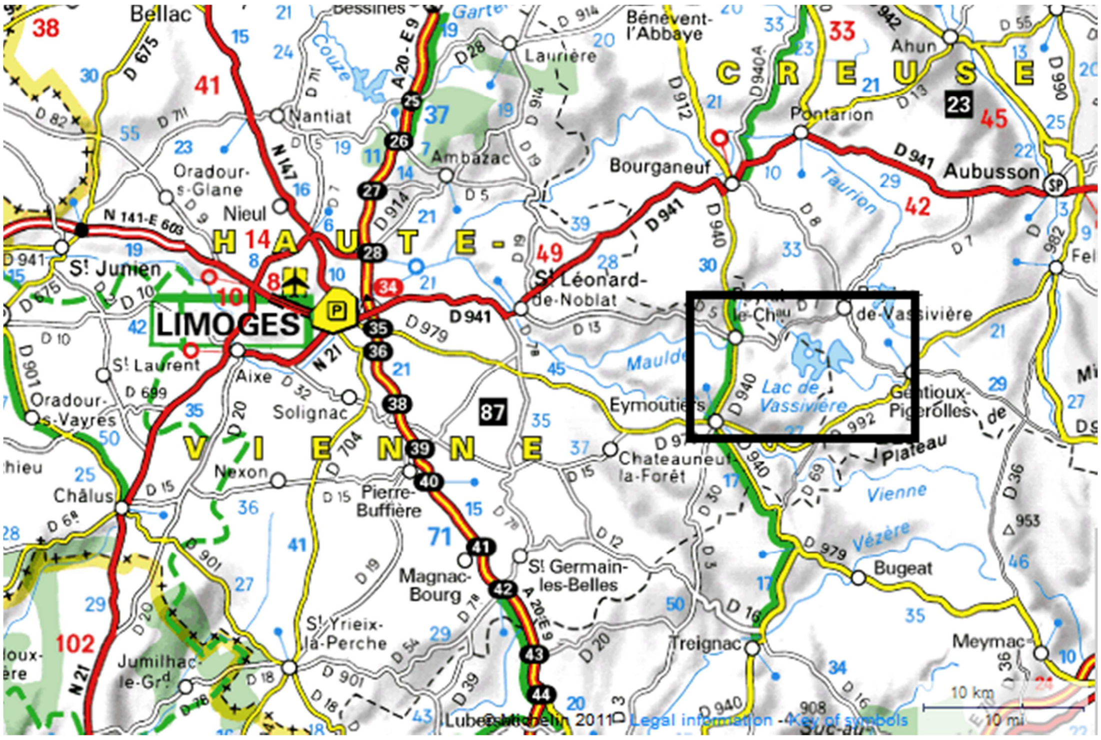

Figure 1: Lake Vassivière is located in the Limousin Department in France (Source: Michelin, 2012)

3. DATA ACQUISITION

The participating universities and the sponsor supplied a lot of hydrographic and topographic equipment. The students are divided into different groups, containing students skilled in both topography and bathymetry. During the campaign, the groups have to perform topographic measurements on-shore, resulting in an equidistant grid of 5 by 5 meter. There was also a special focus on the measurement of specific objects, directly related to the lake, like the dam, key walls and anchor places. Moreover, the hydrographic survey contains a series of bathymetric measurements of the bottom of the lake with different sensors.

3.1 Hydrography

During the hydrographic data acquisition, a Kongsberg EM3002 multibeam echo sounder (MBES) is deployed. Besides, the land surveying measurements are supplemented with continuous laser scanning data from a Leica HDS6200 laser scanner, which is installed on the stern of the bathymetric measurement boat. This data set contains millions of points of the shore and interesting engineering constructions (e.g. bridges, dam) on the banks of the lake, which were impossible to measure by on-shore topography. The acquisition with the on-board laser scanner is impeded by sunlight reflection on the water's surface, causing some noise in the data.

In order to start each bathymetric survey, the velocity parameter of the measuring instruments has to be calibrated. However, in a small area around the water outflow of the electricity generator, where the floor of the lake is the deepest, the velocity calculations need to be corrected. This is caused by underwater flows in the old river bed, when the generator is operational, resulting in sudden temperature decreases. The former valley of the lake was inhabited before the construction of the lake. Many artificial constructions are therefore detectable from the MBES data, such as an old flour mill, a house and a Roman bridge (Figure 2). For the actual feature detection, recognition and characterization, a TRITECH seaking tow fish side scan sounder was deployed.

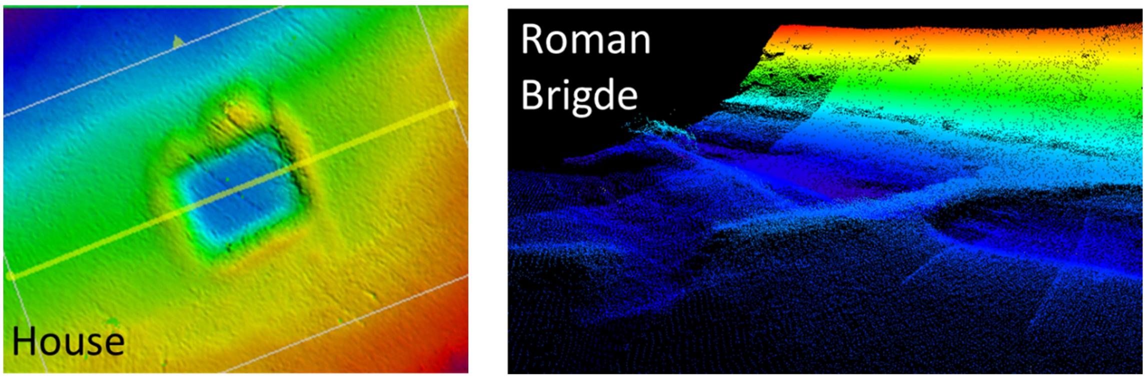

Figure 2: Remnants of artificial constructions in the MBES data

3.2 On-shore topography

The topographic equipment consists of a series of total stations (Pentax, Trimble and Leica), multiple GNSS sets (Trimble and AdNav) and terrestrial laser scanners (Leica). The general workflow consisted of the measurement of a series of reference points by GNSS in RTK mode using the French TERIA RTK network or a Boskalis UHF local reference antenna. Thereafter, the total stations were oriented by resection and positioned in the Lambert93 coordinate system. A 5 by 5 meter grid of detail points was then measured using a prism (Figure 3). Inaccessible areas like wetlands and engineering constructions were measured reflectorless or by terrestrial laser scanning.

Figure 3: Topographic measurements on the lake shore

Due to the remoteness of the lake, with the nearest TERIA RTK antenna at a distance of 50 km, and the morphology of the terrain, the measurement of reference points was not always possible around the lake and a careful selection of suitable areas for these points was required. Near the end of the 2011 campaign, this issue was overcome by the configuration and construction of a local geodetic network. High accuracy GNSS measurements are combined with long range topographic angular and distance measurements. This network will be used and extended in the future campaigns to insure a fixed and reliable reference frame.

4. DATA PROCESSING

The final topographic data sets were presented in regular ASCII readable xyz-files, complemented with a metadata file for each data set. The students were free to choose their own suitable software for the both the processing of the data and the quality analysis of individual and overlapping data sets. The bathymetric data should be delivered in the .qpd-file format. This is a native output format from Quinsy bathymetric software. Besides, hydrographic data processing is performed by using Caris HIPS/SIPS and the bathymetric data management is done by using Caris Base Editor, resulting in ASCII-readable xyz-files as well.

4.1 Hydrography

The raw data from both the bathymetric and topographic acquisition had to be processed by performing data adjustment in order to improve the quality of the data by removing erroneous data and. The bathymetric data suffered from reciprocal outliers, located at the nadir of the sonar near the surface. Outliers were also caused by physical deviations in the water column, like air bubbles around the sensor, fluvial vegetation at the bottom of the lake or floating sediment. The system itself also created unwanted outliers by resonance and self-echoing. After the removal of these outliers, the density and standard deviation of the bathymetric data sets have been evaluated.

A DEM (digital elevation model) with a resolution of 0.30 meter by 0.30 meter was calculated by interpolating a TIN (Triangular Irregular Network). The redundancy of the bathymetric data makes that the density of this meshed surface is higher than 80 soundings per cell of 30 by 30 cm.

The standard deviation of the bathymetric data is around 0.15 meter in the middle areas but slightly increases near abrupt elevation deviations, caused by walls or steep slopes at the bottom of the lake. The data of the scan sonar needed to be processed as well. This has been done by digitizing the altitude of the tow fish and performing a slant range correction. In order to improve the quality of the side scan images, a beam pattern was first processed on a relatively flat area, in order to calculate correction parameters for other areas.

4.2 On-shore topography

As mentioned above, the students were free to select from a range of software packages for processing topographic data and analyzing the quality of these data. For the laser scanning data (both the terrestrial 3D scanning and the bathymetric 2D scanning) Leica's Cyclone software is used for the removal of non-ground points and points not belonging to civil constructions.

The post processing of the topographic measurements is simplified by the direct measurement of Cartesian coordinates instead of polar coordinates. However, this processing simplification makes it more difficult to perform data adjustment and quality analysis. In general, the students are making use of the following software for topographic data processing and quality analysis:

- ESRI Arcgis: 3D Spatial Analyst;
- Autodesk Civil 3D: Survey and surface manager;
- Ghent University's own Wintopo software: TIN and Grid based data processing;
- Specific software tools, individually programmed by students in order to deal with their specific needs.

5. DATA ANALYSIS AND RESULTS

After the processing step, the density of the data is evaluated using open source GIS (Geographic Information System) software. By establishing a data collecting database for all the data, all participants had a permanent overview on the progress of the measurements.

Based on the measurement data of this first year of the campaign, some quality analyses are performed and some comparisons between overlapping data sets are made. The quality analysis of the data is still ongoing, so only partial results are summarized hereunder.

First, a comparison between the topographical measurements based on GNSS and total station and the data from the laser scanner on the vessel is made. The mean algebraic difference between both data sets in overlapping areas is around 1 cm. The mean of the absolute differences is 8.5 cm and the comparison of both data sets shows a root mean square error of approximately 11 cm. Based on the Pearson coefficient (very close to 1), the data from the total station measurements and the laser scanner on the vessel can be assumed to be equivalent. Differences between both data sets are mainly due to uncertainties in the positioning with GNSS and the set-up of the total station.

The performance of the different GNSS sets is also compared in overlapping areas. Some areas are covered by a Trimble GNSS receiver based on the TERIA RTK network and also by an AdNav GNSS receiver, based on a ground-based local reference station with UHF connection. The comparison between both measurement instruments shows a horizontal and vertical difference within a 5 cm range.

A pair wise comparison is performed between the data sets acquired by total station, GNSS and laser scanning in overlapping areas. In general, we can conclude that there are no significant incoherence noticed when merging the data sets from all different measuring instruments and all different student groups.

In the quality analysis of the bathymetric data, a depth accuracy estimation for each area is performed, based on the processed EM3002 data. For this estimation, a reference base surface in a flat area is computed from an orthogonally navigated control line with the vessel. The resulting reference surface is then compared with the digital terrain model from regular navigated lines. This allows verifying if the processed data meet the requirements of the bathymetric standard IHO S-44. The results from the 2011 campaign meet this IHO S-44 standard, more precise the first order requirements (IHO, 1998). Besides, the results meet with the requirement of EDF, imposing s total propagated uncertainty of 15 cm for a 95% confidence level.

6. CONCLUSIONS

The main objective of this three year European Erasmus Intensive Program is the production of a highly detailed topographic map and 3D model of the Lake Vassivière (France) and its surroundings. These detailed 3D data sets are important for the electricity production in the nearby hydraulic plant and the touristic development of the shore around the lake.

For this purpose, students from the three partner universities perform bathymetric and topographic measurements, including a thorough quality analysis and quality control of these data. This quality assessment is mainly based on the constructed local geodetic reference network, a calibration of the used equipment, cross validation in overlapping areas between different sensors…

Based on the measurement data from this first campaign, it can be concluded that the resulting maps and 3D models form a high definition accurate survey of the lake and parts of its surrounding area. Specifically for the bathymetric depth model of the lake, the measurements meet the requirements of the IHO S-44 standard, first order class.

In the following years of the Intensive Program, the measurements of the lake and the surrounding area will be completed following the same accuracy standards.

7. ACKNOWLEDGEMENT

The program is funded by the European Commission, through the ERASMUS program. Next to the gouvernmental recognition of the program and its financial support, the Dutch company BOSKALIS is the sole commercial sponsor of this IP.

The partner universities of the Erasmus Intensive Program thank also EDF and the Vassivière Lake authority for their cooperation.

REFERENCES

IHO (1998), Standard for Hydrographic Surveys, Special Publication, 44 (4).

Lake Vassivière, www.vallonvert.com, March 2011.

BIOGRAPHICAL NOTES

Prof. Dr. Alain De Wulf is MSc. in civil construction, MSc in informatics and MSc. in Industrial Management. He is full professor at Ghent Univeristy, working on quality aspects of geodesy and land surveying in general. Within his research field, he plays a key role in topographic campaigns for archaeological projects (Malta, Altai (Russia), Thorikos and Titani (Greece), etc.). He has special interest in hydrography and is as vice-chairman of the Hydrographic Society Benelux. Moreover, with his expertise in hydrographic surveying, he is developing specialized software for the processing and quality assessment of hydrographic 3D acquisition sensors.

CONTACTS

Prof. dr. ir. Alain De Wulf
Ghent University – Department of Geography
3D Data Acquisition Cluster
Krijgslaan 281 (Building S8)
B-9000 Ghent
BELGIUM
Tel. +32 9 264 46 56
Fax +32 9 264 49 85
Email: Alain.DeWulf@UGent.be
Web site: http://geoweb.ugent.be/data-acquisition-3d