

Hydrographic education and research at the HafenCity University Hamburg

An article by MONA LÜTJENS and HARALD STERNBERG

With more than 30 years of experience in hydrographic education, the HafenCity University Hamburg (HCU) provides a sophisticated study programme specialised in the field of hydrography which has been certified as a Category A programme by the FIG/IHO/ICA International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers. The programme is completely taught in English and can be completed within two years. Next to profound theoretical courses, the HCU's hydrography programme offers plenty of practical exercises on board of its own shallow-water research vessel *DVocean*. Apart from educational modules, several hydrographic research projects are conducted at HCU to further contribute to the ever rising research interest of the hydrographic sector.

hydrography education | practical training | Category A
 enseignement de l'hydrographie | formation pratique | Catégorie A
 Hydrographieausbildung | praktische Übungen | Kategorie A

Avec plus de 30 ans d'expérience dans la formation hydrographique, l'Université HafenCity de Hambourg (HCU) propose un programme d'études exigeant, spécialisé dans le domaine de l'hydrographie et certifié comme programme de catégorie A par le FIG/IHO/ICA International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers. Le programme est entièrement enseigné en anglais et peut être terminé en deux ans. En plus de cours théoriques approfondis, le programme d'hydrographie de la HCU propose de nombreux exercices pratiques à bord de son propre navire de recherche en eaux peu profondes, le *DVocean*. Outre les modules de formation, différents projets de recherche hydrographique sont menés à la HCU, contribuant ainsi à l'intérêt toujours croissant de la recherche en hydrographie.

Mit mehr als 30 Jahren Erfahrung in der hydrographischen Ausbildung bietet die HafenCity Universität Hamburg (HCU) ein anspruchsvolles, auf den Bereich der Hydrographie spezialisiertes Studienprogramm an, das vom FIG/IHO/ICA International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers als Kategorie-A-Programm zertifiziert wurde. Das Programm wird komplett in Englisch unterrichtet und kann innerhalb von zwei Jahren abgeschlossen werden. Zusätzlich zu fundierten theoretischen Kursen bietet das Hydrographie-Programm der HCU zahlreiche praktische Übungen an Bord des eigenen Flachwasser-Forschungsschiffs *DVocean* an. Neben den Ausbildungsmodulen werden an der HCU verschiedene hydrographische Forschungsprojekte durchgeführt, die zum stetig wachsenden Forschungsinteresse der Hydrographie beitragen.

Authors

Mona Lütjens is research assistant, Harald Sternberg is professor for hydrography and geodesy at the HafenCity University (HCU) in Hamburg, Germany.

mona.luetjens@hcu-hamburg.de

Introduction

The HafenCity University Hamburg (HCU) is the University of Built Environment and Metropolitan Development and combines all aspects of building and design as well as engineering and natural sciences. The overall research agenda prioritises climate, sustainability and digitisation and is implemented in the following degree programmes: Architecture, Civil Engineering, Geodesy and Geoinformatics, Urban Planning, Metropolitan Culture, Urban Design and REAP (Resource Efficiency in Architecture and Planning). For around 2,400 students and approximately 160 research and teaching staff, the HafenCity location, as Europe's largest

inner-city urban development project, provides special attraction to the built environment and metropolitan theme of the university. Especially for hydrographic students, the university's site next to the river Elbe and close to the Port of Hamburg, offers an excellent educational and scientific setting on its own doorstep (Fig. 1).

Hydrographic education is taught in the Master's programme in Geodesy and Geoinformatics which extends over four semesters and is completed with the »Master of Science (MSc)«. Within the scope of the education three specialisations can be chosen: Geodetic Measurement Technology, Geoinformation Technology or Hydrography. All

specialisations are accredited by ASIIN (Akkreditierungsagentur für Studiengänge der Ingenieurwissenschaften, der Informatik, der Naturwissenschaften und der Mathematik e. V.) which is a non-profit association that works nationally and internationally for the recognition, comparability and quality assessment (accreditation) of Bachelor's and Master's degree programmes within the fields of engineering and natural sciences, mathematics and computer science as well as in medicine and economics (ASIIN 2022). To further seal the quality of the English taught specialisation in Hydrography, it has been additionally internationally certified as Category A programme (the highest level) by the FIG/IHO/ICA International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC). The specialisation in Hydrography thus obtains a distinctive feature which is unique in Germany.

Academic hydrographic training in Hamburg dates back 35 years to 1985 when the first consecutive degree programme in hydrography was introduced at the Hamburg University of Applied Sciences (HAW). After completion of the six-semester degree programme in surveying, students could attend three additional theoretical semesters of hydrography and one practical semester to receive a double diploma in surveying and hydrography (Böder and Egge 2007). The course was first recognised by the FIG/IHO International Advisory Board on Standards of Competence for Hydrographic Surveyors in 1990 with Category A with »Specialization in Nautical Charting« and was followed by a Master of Science degree in 2000. After the Hafencity University Hamburg was founded by the Free and Hanseatic City of Hamburg in 2006, Hydrography has been integrated as a specialisation in the two-year Master of Science »Geodesy and Geoinformatics« (until 2017 »Geomatics«). In 2017, the programme was recertified by the FIG/IHO/ICA IBSC as a Category A course and has been approved under the new Standard S-5A (First Edition, August 2016) and the corresponding Guidelines for the Implementation of the Standards of Competence for Hydrographic Surveyors (First Edition, July 2016) (Sternberg and Dufek 2018).

While the university can look back on many years of experience in hydrographic education, current research should not be neglected. Recent research activities cover autonomous subsea monitoring, deep sea massive sulphide investigations, automatic object detection and habitat mapping. All in all, the university offers comprehensive hydrographic education and attracts many students every year from all over the world.

Programme structure

The discipline of »Geodesy and Geoinformatics« at HCU does not have an ordinary structure com-



Fig. 1: Location of Hafencity University Hamburg on the river Elbe (top) and its interior (bottom)

pared to other universities as there are no specific departments or institutes. Instead, the discipline is integrated into the interdisciplinary Bachelor and Master school for teaching, the research school and some interdisciplinary research groups. The Master programmes are led by a dean of studies who is supported by a programme coordinator and a secretary. Currently, there are four professors teaching in »Geodesy and Geoinformatics« with additional help of about 20 scientific and technical staff.

In the Master's specialisation in Hydrography students are progressively introduced to complex problems in order to solve them using scientific approaches. Special emphasis is given to develop methodological and analytical skills that are needed to independently integrate scientific techniques from various disciplines. The programme is completely taught in English and the programme structure can be seen in Fig. 2.

To successfully finish and graduate with a Mas-

| Module Plan Geodesy and Geoinformatics (M.Sc.) Hydrography | | Semester 1 | | Semester 2 | | Semester 3 | | Semester 4 | |
|---|--|---------------------------|--|---------------------------|--|---------------------------|--|---------------------------|--|
| Domain | | CP | | CP | | CP | | CP | |
| MINT | Geo-M-MOD-101 Engineering Mathematics | 2,5 | | | | | | | |
| | Geo-M-MOD-103 Software and Interface Technology | 5 | | | | | | | |
| Specialization Geodetic Measurement Techniques | Geo-M-MOD-110 GNSS | 2,5 | Geo-M-MOD-202 Terrestrial Laser Scanning 1 | 2,5 | | | | | |
| | | | Geo-M-MOD-204 Integrated Navigation | 5 | | | | | |
| | | | Geo-M-MOD-205 Higher Geodesy | 5 | | | | | |
| Specialization Geoinformation Technology | Geo-M-MOD-105 GI-Science | 2,5 | Geo-M-MOD-209 Spatial data analysis Geostatistics Digital Elevation Models | 5 2,5 2,5 | | | | | |
| Specialization Hydrography | Geo-M-MOD-107 Basics of Hydrography Determin. Of Positions and Water Depths Practical Course 1 | 2,5 1,5 1 | Geo-M-MOD-210 Advanced Hydrography Advanced Hydrography Practical Course 2 | 5 3 2 | Geo-M-MOD-305 Nautical Charting | 2,5 | | | |
| | Geo-M-MOD-108 Hydr. Data Acquisition and Processing Underwater Acoustics Hydrographic Data Processing Practical Course 2 | 7,5 3 2,5 2 | | | Geo-M-MOD-306 Navigation in Hydrography Nautical Science Electronic Chart Display | 2,5 1,5 1 | | | |
| | Geo-M-MOD-109 Marine Environment Marine Meteorology Legal Aspects | 5 3 2 | | | Geo-M-MOD-307 Oceanography Physical Oceanography and Tides Oceanographic Data Processing | 5 3 2 | | | |
| | | | | | Geo-M-MOD-308 Marine Geology / Geophysics Geology/Geomorphology Seismics Magnetics and Gravimetry | 5 1 2 2 | | | |
| | | | | | Geo-M-MOD-310 LIDAR and Remote Sensing | 2,5 | | | |
| | | | | | Geo-M-MOD-309 Hydrographic Practice Supplementary Field Training /Practical Course Quality Management | 7,5 5 2,5 | | | |
| QBS | BS-M-MOD-001 Project Management Project Management Lecture | 5 2,5 | Projekt Management Seminar | 2,5 | BS-M-MOD-002 Interdisciplinary Project | 5 | | | |
| | | | Q-M-MOD-001 Q-Studies I Q-Studies II | 5 2,5 2,5 | | | | | |
| Thesis | | | | | Geo-M-MOD-401 Master-Thesis incl. Final exam | 30 | | | |
| Σ CP 180 | | Σ CP Semester 1 30 | | Σ CP Semester 2 30 | | Σ CP Semester 3 30 | | Σ CP Semester 4 30 | |

Fig. 2: Structure of the study programme »Geodesy and Geoinformatics – Specialisation in Hydrography«

ter of Science, students are required to complete a workload of 30 credit points (CP) per semester, resulting in a total of 120 CP for the entire study. After completing three regular semesters of lectures and practicals, students write their final thesis in the fourth semester over a period of five months. As the Master's programme in »Geodesy and Geoinformatics« is divided into three specialisations, modules can be both compulsory and elective and are taught in conjunction with each other. Consequently, all students will attend an introductory hydrography lecture in their first semester to gain basic understanding in this field. Having this close linkage within the »Geodesy and Geoinformatics« programme, students learn and work together which emphasises on scientific exchange. Moreover, all professors are equally involved in the hydrography specialisation.

The HCU's interdisciplinary and transdisciplinary approach is also reflected beyond the individual study fields as modules such as [Q]-Studies and BASICS are offered across all degree programmes. Within these modules, the university educates

students not only to be confident in their own discipline but to have an understanding and appreciation of neighbouring disciplines, thereby promoting creative collaboration and receptiveness to different ways of seeing and thinking. While the [Q]-Studies are a set of elective courses where students choose from a variety of changing topics, BASICS courses teach competencies and soft skills that enable students to use and examine classic project management tools.

Beyond the interdisciplinary approach of the HCU, the professional identity of geodesy and geoinformatics is maintained on the one hand by a common, regular meeting »Plenum Geodesy and Geoinformatics«, on the other hand by four disciplinary laboratories: »Geodesy«, »Geoinformation and Geovisualization«, »Hydrography« and »Photogrammetry and Laserscanning«.

Research vessel *DVocean*

The *DVocean* (Fig. 3) is the new survey vessel of the HCU which can be used for both teaching and research projects. It was designed for the use



Fig. 3: Research vessel *DVocean*

in shallow waters to explore and monitor primary inland waterways and their built-up banks. Moreover, areas of application include the investigation of new approaches for position determination and bottom structure analyses to determine the stability of buildings and underwater structures. Initial measurements to create test fields for hydrographic sensors will be further acquired and analysed.

The survey equipment for the *DVocean* comprises of state-of-the-art sonars such as multibeam echo sounder and sub-bottom profiler in addition to a positioning and inertial measurement system. These instruments will be used in conjunction with low-cost equipment such as a two-frequency single-beam echo sounder, fish finder and an open-source ROV. Special or further borrowed sensors may be mounted on the vessel for detailed surveys or specific tasks. With three poles of which one is located at the bow and one on each side of the vessel, sensors are able to record data simultaneously. Additionally, the vessel can be equipped with a laser scanner on its roof to map the surrounding environment both below and above the water line. As the assembly of sensors is modular, they can be easily installed and replaced depending on the application question.

With a length of about 8 metres, the aluminium vessel can be towed with a trailer making it accessible to more distant and secluded survey areas. In addition to the skipper, the cabin can accommodate six people with sufficient free working space. Further details can be seen in [Table 1](#).

| <i>DVocean</i> |
|---|
| Total length: 8.8 m |
| Total width: 2.6 m |
| Maximum draft: 0.9 m |
| Height of the boat above the waterline: 2.8 m |
| Propulsion: 2 outboards and bow thruster |
| Maximum number of persons on board: 10 |
| Shipyard: Lübeck Yacht Trave Schiff GmbH |
| Launched: 2019 |

Table 1: Key specifications of the *DVocean*

The name *DVocean* was chosen in memory of the professors Delf Egge and Volker Böder, who were very committed to the HCU's Hydrography specialisation and contributed significantly to its development. The letter D is the initial letter of Prof. Delf Egge and the letter V is the initial letter of Prof. Volker Böder. The pronunciation shall further remind of the English word »devotion«.

Measurement exercises

The hydrography lectures are accompanied by a variety of exercises and tutorials and these training phases provide necessary practical experience. In the third semester, a final field project will be executed which is a multidisciplinary exercise that builds on the knowledge acquired in previously attended courses. In this final project, a complex hydrographic scenario has to be planned, prepared, conducted, documented and evaluated by all students from scratch. The project also enables the formulation of research questions leading to individual elaborations of the practical by each student. Apart from the timeline, available instrumentation and facilities, students have to plan and prepare everything by themselves. [Fig. 4](#) gives impressions of the measurement exercises. To gain insights into the professional world, HCU is in close cooperation with various institutes and authorities. The students have the possibility to apply for

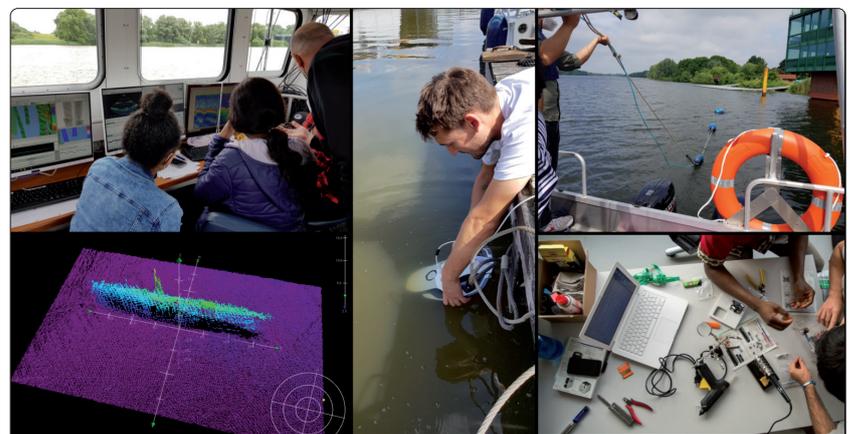


Fig. 4: Students during the exercises and the final project

internships or write their final thesis in collaboration with these partners.

Research projects

As a leading academic institution in hydrography, HCU's research projects cover multiple topics. Within the INDEX project (INDian ocean EXploration), the Federal Institute for Geosciences and Natural Resources (BGR) is supported by the HCU in the acquisition and analysis of multibeam echo sounder data from ship-based and deep-towed platforms (BGR 2022). In the face of ever rising prices for raw materials, potential deposits of polymetallic seafloor massive sulphides are being explored. With licences issued from the International Seabed Authority, annual exploration campaigns have been undertaken using different available research vessels. The aim is to identify massive sulphide deposits that have been formed at the outflow points of formerly active hydrothermal vents on the seabed. With the use of a deep-towed sled, bathymetry, backscatter and water column data are acquired. HCU is involved in the analysis and evaluation of such data sets to identify and characterise hydrothermal vent sites, corresponding sulphide deposits and their extent. The results will be implemented into a general exploration concept.

Another current research project is investing in

the development of a novel autonomous underwater vehicle (AUV) that is able to autonomously monitor underwater installations and infrastructure such as pipelines or cables in the deep sea. The CIAM project (Comprehensive Integrated and fully Autonomous subsea Monitoring) was funded by the German Federal Ministry for Economic Affairs and Energy as a joint project (ROSEN Group 2022). HCU's contribution lies in the development of adaptive navigation filters and automated object detection from hydrographic data for autonomous underwater docking of the AUV to a mother ship or harbour. Additionally, HCU is developing methods for the detection and automated tracking of pipelines and overseas cables.

Research regarding object detection and instance segmentation is further addressed in the field of benthic habitat mapping in the Southern Ocean. Underwater images were collected during the expedition PS118 conducted by the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI). The focus rests on the development of an automatic object detection and segmentation algorithm (Lütjens and Sternberg 2021). Findings of this work will contribute to the estimation of distribution and abundances of encountered species revealing relationships with the environment for predictive habitat mapping. //

References

- ASIIN (2022): ASIIN – Global Leader in Quality Assurance in Higher Education. www.asiin.de/en/
- BGR (2022): Marine polymetallic sulphides (INDEX) – Germany's exploration license in the Indian Ocean. www.bgr.bund.de/EN/Themen/Min_rohstoffe/Projekte/Meeresforschung-Projekte-laufend_en/Index2011-2013_en.html?nn=1548238
- Böder, Volker; Delf Egge (2007): Hydrographische Ausbildung (Cat-A) an der neugegründeten HafenCity Universität Hamburg (HCU). 6. FIG Regionalkonferenz 2007, 12.-15. November, San José, Costa Rica
- Lütjens, Mona; Harald Sternberg (2021): Deep Learning based Detection, Segmentation and Counting of Benthic Megafauna in Unconstrained Underwater Environments. 13th IFAC Conference on Control Applications in Marine Systems, Robotics and Vehicles. DOI: 10.1016/j.ifacol.2021.10.076
- Sternberg, Harald; Tanja Dufek (2018): Hydrographische Ausbildung an der HafenCity Universität Hamburg. Hydrographische Nachrichten. DOI: 10.23784/HN109-04
- ROSEN Group (2022): Go-ahead for marine technology cooperation. www.rosen-group.com/global/company/insight/news/2021/Go-Ahead-for-Marine-Technology-Cooperation.html