M Geomatics

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Project code P2316

Contents

Summary

Standard 1. Intended learning outcomes

The panel regards the MSc Geomatics programme at TU Delft as unique for its focus on the built environment and comprehensive geo-information chain. The program's well-defined objectives and technical depth effectively align theoretical knowledge with practical urban challenges, such as urban planning and pollution control. The panel commends the programme's interdisciplinary nature and commitment to open science principles, including open data and open-source software. The intended learning outcomes are well-defined, aligned with the Dublin Descriptors, and cover research, design, and operational systems. The programme maintains strong industry connections through internships and alumni feedback. However, the panel suggests establishing a clearer strategy and appointing an advisory board to best manage a healthy balance between the own programme and academic vision and a clear alignment with developments in the industry. Overall, the outcomes effectively integrate professional and academic elements, preparing graduates for multidisciplinary geo-information projects.

Standard 2. Teaching-learning environment

The panel commends the MSc Geomatics programme's curriculum for its progressive, bottom-up structure, blending theoretical learning with practical application. The first year's core courses build a solid foundation, while the second year emphasizes real-world projects and the graduation thesis. The varied didactic methods effectively cater to different learning styles and enhance the overall effectiveness of the teaching-learning environment. The panel finds that new and revised courses better connect to the built environment, and appreciates how the programme is adequately tying in the curriculum with the intended learning outcomes. To follow up on this, the panel believes that the programme would benefit from further exploiting its connection to the built environment: clear communication on this characteristic of the programme could further strengthen the programme's attractiveness and unique selling proposition.

The panel is very positive about the continued development of the programme's curriculum. The panel appreciates the close contact with the industry allowing for agile responses to developments within the field. The panel also appreciates the open feedback culture, with course evaluations leading to timely adjustments. The small class size fosters close student-staff interaction. Though the curriculum is demanding, especially for those without programming backgrounds, support mechanisms like extra lab sessions and MOOCs help. The panel discussed with lecturers and students if the choice for incorporating C++ in the programme was necessary. It understands the considerations and the explicit demands for these skills from future employers, but indicates that the programme still needs to find the optimal form for its incorporation in the programme. A possible solution according to the panel could be to introduce extra elective space in the first semester, and use this to offer levelling courses to students with pre-knowledge gaps. In this way, the programme could get students to a similar starting level for the remainder of the curriculum.

The programme's language of instruction in English is appropriate given the international nature of Geomatics. However, the panel recommends considering a name change to highlight the programme's focus on the built environment, potentially enhancing its appeal to prospective students. The teaching staff, comprising dedicated and diverse members, effectively blend academic expertise and practical experience. Students have expressed high satisfaction with the quality of teaching and support. The strong alignment between faculty research and course content enriches the learning experience. Programme-specific services, including the Geolab, provide adequate study space and resources. The commitment to open science principles, through the use of open educational resources and open-source software, is appreciated. The

panel encourages continuing to promote open access to educational materials and research outputs, enhancing transparency and accessibility.

Standard 3. Student assessment

The panel commends the assessment system of the Geomatics programme, which effectively balances formative and summative assessments, including group projects, programming assignments and written products. The use of rubrics for feedback ensures transparency and consistency. For the thesis assessment, the process involves five evaluation moments (P1-P5), with feedback provided at each stage. This thorough process, involving multiple mentors and an external co-reader, is designed to ensure high-quality research outcomes. The panel finds the thesis assessment procedure to be transparent and insightful, allowing for a thorough evaluation of the students' final research projects. However, recognizing the intensity, the panel supports the programme's plan to streamline this to four evaluation moments from 2025-26. The Board of Examiners (BoE) plays a crucial role in maintaining assessment quality. The panel is positive about the BoE's proactive measures, such as addressing the use of generative AI in assessments and ensuring close monitoring due to the programme's small scale. The panel encourages the programme to keep working on AI policies to keep up with technological developments. Overall, the panel finds the assessment system, thesis evaluation, and the functioning of the BoE to be robust, transparent, and aligned with maintaining high academic standards.

Standard 4. Achieved learning outcomes

The panel was impressed by the high quality of the theses, noting a strong understanding of the subject matter, rigorous methodology, and effective synthesis and analysis. The theses demonstrated high academic standards and practical application, with a number of theses being published in journals. This indicates that the students' exit level is appropriate for a master's programme. Regarding alumni success, the panel found that most graduates secure relevant jobs within three months. Alumni and employer feedback confirms that the programme meets industry needs, with graduates getting praised for their technological expertise, interdisciplinary skills, and ability to create innovative solutions. The high employment rate and positive employer feedback suggest that the programme's learning outcomes are well achieved.

Score table

The panel assesses the programme as follows:

M Geomatics	
Standard 1: Intended learning outcomes	meets the standard
Standard 2: Teaching-learning environment	meets the standard
Standard 3: Student assessment	meets the standard
Standard 4: Achieved learning outcomes	meets the standard
General conclusion	positive

Prof. dr. Pierre Hallot
Chair

Peter Hildering
Secretary

Date: 16 September 2024

Introduction

Procedure

Assessment

On May 14 2024, the masters programme Geomatics of the Delft University of Technology was assessed by an independent peer review panel. The assessment followed the procedure and standards of the NVAO Assessment Framework for the Higher Education Accreditation System of the Netherlands (September 2018).

Quality assurance agency Academion coordinated the assessment upon request of the Faculty of Architecture and the Built Environment at Delft University of Technology. Peter Hildering acted as coordinator and secretary in the assessment. He has been certified and registered by the NVAO.

Preparation

Academion composed the peer review panel in cooperation with the institutions and taking into account the expertise and independence of the members. On 22 February 2024, the NVAO approved the composition of the panel. The coordinator instructed the panel chair on his role in the site visit according to the Panel chair profile (NVAO 2016).

The faculty composed a site visit schedule in consultation with the coordinator (see appendix 3). The faculty selected representative partners for the various interviews. It also determined that the development dialogue would be made part of the site visit. A separate development report was made based on this dialogue.

The programme provided the coordinator with a list of graduates over the period 2021-2024. In consultation with the coordinator, the panel chair selected 15 theses. He took the diversity of final grades and examiners into account. Prior to the site visit, the programme provided the panel with the theses and the accompanying assessment forms. It also provided the panel with the self evaluation report and additional materials (see appendix 4).

The panel members studied the information and sent their findings to the secretary. The secretary collected the panel's questions and remarks in a document and shared this with the panel members. In a preliminary meeting, the panel discussed the initial findings on the self-evaluation report and the theses, as well as the division of tasks during the site visit. The panel was also informed on the assessment framework, the working method and the planning of the site visits and reports.

Site visit

During the site visit, the panel interviewed various programme representatives (see appendix 3). The panel also offered students and staff members an opportunity for confidential discussion during a consultation hour. No consultation was requested. The panel used the final part of the site visit to discuss its findings in an internal meeting. Afterwards, the panel chair publicly presented the preliminary findings.

Report

The secretary wrote a draft report based on the panel's findings and submitted it to an Academion colleague for peer assessment. Subsequently, the secretary sent the report to the panel for feedback. After processing this feedback, the secretary sent the draft report to the programme in order to have it checked for factual

irregularities. The secretary discussed the ensuing comments with the panel chair and changes were implemented accordingly. The panel then finalised the report, and the coordinator sent it to the TU Delft.

Panel

The panel assessing the M Geomatics at Delft University of Technology consisted of the following members:

- Prof. dr. Pierre Hallot, professor of Heritage Documentation, University of Liège - Chair;
- Prof. dr. Angela Schwering, professor Geoinformatics, University of Münster;
- Prof. dr. ir. habil. Monika Sester, professor Cartography and Geoinformatics, Leibniz University Hannover;
- Prof. dr. Nico Van de Weghe, professor Geomatics , Ghent University;
- Prof. dr. ir. Peter Verburg, professor Environmental Spatial Analysis, Vrije Universiteit Amsterdam;
- Jacotte Monroe BSc., master's student Geo-Information Science, Wageningen University & Research - student member.

Information on the programme

Name of the institution:	Delft University of Technology
Status of the institution:	Publicly funded institution
Result institutional quality assurance assessment:	Positive

Programme name:	
CROHO number:	66954
Level:	Master
Orientation:	Academic
Number of credits:	120 EC
Specializations or tracks:	-
Location:	Delft
Mode(s) of study:	Fulltime
Language of instruction:	English
Submission date NVAO:	01-11-2024

Description of the assessment

Recommendations previous accreditation panel

The self-evaluation report provided by the programme prior to the site visit outlined the recommendations provided by the previous accreditation panel in 2018, specified per standard (learning outcomes, teaching learning environment, and student assessment). The report also detailed the actions taken to address these recommendations. The recommendations and their follow-up actions were discussed in the interviews during the site visit. Many of the follow-up actions were initiated shortly after the previous visit and the panel is satisfied with the programme's approach to the recommendations and the results of those adjustments. The panel concludes that the programme management demonstrates commitment to continuous improvement across all levels, effectively addressing previous external review recommendations. Overall, the panel expresses satisfaction with the improvement strategies implemented, and recognizes their significant contribution to elevating the quality of the programme.

Standard 1. Intended learning outcomes

The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Findings

Profile of the programme

The MSc Geomatics programme of the Faculty of Architecture and the Built Environment (ABE) at Delft University of Technology is a two-year master's programme in the field of Geomatics, focusing on applications in the built environment as well as software development and 3D modelling for Geomatics. Geomatics is described as the science and art of acquiring, modelling, analysing, managing, and visualizing geographic information to better understand the built environment. It's a highly engineering-oriented field that encompasses various disciplines such as mathematics, statistics, computer science, 3D modelling and geo-information governance. The Geomatics programme aims to produce graduates that possess both in-depth knowledge of geo-information and strong software development skills. It aims to address a wide variety of urban issues, such as urban planning, energy applications and pollution. The application in real-world situations is important, as geo-information about built-up areas provides solid foundations for planning and management solutions. The programme at TU Delft is characterized by its interdisciplinary nature, technical depth, focus on 3D modelling, and close ties to applications in the built environment. Unlike other Geomatics programmes that often cover the broad range including Geodesy or Surveying, Delft's programme focuses on the geo-information chain. It also includes governance aspects such as relevant legislation.

The panel considers the profile of TU Delft's programme in Geomatics to be unique, set apart by its specialized focus on the built environment. The panel appreciates that the programme has a very clear vision on its specific niche and a strong focus on technical knowledge for understanding the geoinformation chain. The panel considers this a good choice because it assists students in associating the taught skills with practical applications. The panel also appreciates the programme's emphasis on open science principles, with students using open data, open-source software, and openly publishing research results.

Learning outcomes

The Geomatics programme prepares future engineers to engage in multidisciplinary projects involving geo-information, covering research, design, realization, operation, and maintenance. Students are trained to acquire and apply established knowledge, develop new knowledge through systematic research, and design operational systems to meet industrial and societal needs. To meet the University Education orientation requirements as well as the requirements for the level of the MSc diploma, the programme adheres to the Teaching and Examination Regulations (TER) in the Student Charter of the Geomatics programme: it specifies seven generic course objectives that are aligned with the Dublin Descriptors for all master degree programmes of the universities in the 4TU partnership of the Netherlands' four engineering universities. In addition, the TER specify twelve domain specific final attainment levels for the Geomatics master's programme. The domain specific final attainment levels are detailed across three categories: geo-information chain competences, research competences, and design, implementation, and use of geo-information. These attainment levels are integrated into all Geomatics courses through constructive alignment of learning objectives, activities, and assessments. Following the 2018 assessment panel's recommendations, the programme emphasized its connection to the built environment by refining learning objectives for specificity and measurability. This involved collaboration with an education science expert to review and adjust the final attainment levels and course objectives.

The programme also aims to maintain a strong professional focus in their intended learning outcomes through close contact with the industry. The connection with the national and international Geomatics community is established in an informal way. In their interview with the panel, the programme management explained that the programme's connection with the professional field is maintained in several ways, such as: through the part-time employment of staff members by other organizations, the use of feedback from student's internship supervisors to find out what the professional field misses in the programme's graduates, and through lunch lectures organized with alumni to learn about their current work and how the Geomatics programme links to this. The panel appreciates a lot is done to keep up-to-date with the field, but thinks the programme would benefit from a clearer strategy to do so. The panel thinks that the programme would benefit from a more systematic way of collecting input from the field, as this will help the programme in keeping the objectives of the programme and the content of the curriculum connected to developments in the field. In this light, the advisory board that the programme is considering to appoint could be a useful tool, as it can be a good way to regularly and methodically engage with the field.

The panel studied the final attainment levels of the Geomatics programme and concludes that the intended learning outcomes for the Geomatics programme are clear and well-defined and encompass a good mix of knowledge and skills. The intended learning outcomes are clearly tied to the Dublin descriptors, making the master's level and academic orientation clearly visible. The professional focus of the intended learning outcomes is also clear and maintained through close contact with the industry.

Considerations

The panel regards the MSc Geomatics programme at TU Delft as unique for its focus on the built environment and comprehensive geo-information chain. The program's well-defined objectives and technical depth effectively align theoretical knowledge with practical urban challenges, such as urban planning and pollution control. The panel commends the programme's interdisciplinary nature and commitment to open science principles, including open data and open-source software. The intended learning outcomes are well-defined, aligned with the Dublin Descriptors, and cover research, design, and operational systems. The programme maintains strong industry connections through internships and alumni feedback among other ways. However, the panel suggests establishing a clearer, more systematic strategy to best manage a healthy balance between the own programme and academic vision and a clear alignment with developments in the

industry, for example through the appointment of an advisory board. Overall, the outcomes effectively integrate professional and academic elements, preparing graduates for multidisciplinary geo-information projects.

Conclusion

The panel concludes that the master's programme Geomatics meets standard 1.

Standard 2. Teaching-learning environment

The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.

Findings

Curriculum and didactics

The curriculum is structured to offer knowledge and skills progressively in a bottom-up approached. The first year features ten common core courses (5 EC each) and two elective courses (5 EC each). In the first quarter (Q1), students are introduced to geo-data acquisition technologies, GIS, Cartography, and Geomatics-related computer programming. Subsequent courses in Q2, 3, and 4 build upon this foundation of achieved knowledge and skills, providing a foundation to all students by teaching the fundamentals of the geo-information chain: data collection, processing, analysing and visualisation, as well as geo-information governance. These core courses emphasize foundational principles and conceptual thinking through lectures and assignments. The elective courses can be done in Q3 and Q4. The seven electives that the Geomatics programme offers, cover new technologies like machine learning and societal challenges such as data ethics and energy transition, with the potential to become core programme topics in the future. Additionally, students may choose electives from TU Delft or other universities, subject to the approval of the Board of Examiners. The second year starts with the Synthesis Project (10EC) in Q5, which is carried out in groups. In this project students combine the knowledge from the core programme and apply it to a real-world project while gaining hands-on experience in project management. Students also do two more elective courses (5 EC each) in the first half of the second year. The remainder of the second year is largely covered by the graduation project, which constitutes a third part of the entire programme's workload (40 EC divided in a 10 EC preparation course and the 30 EC thesis itself).

The panel appreciates the well-structured curriculum that gives students a solid basis in geomatics, with adequate attention to professional skills like software skills and academic skills in the graduation project. The panel views the engineering-focused first year followed by its application in the second year as a strong point of the curriculum. The panel also appreciates that there is quite a bit of flexibility in the programme for students to choose their own direction with electives, adding to the student-centredness of the programme. The panel does feel that 10 EC for the thesis preparation course could be narrowed down, for example to 5 EC, to further increase flexibility of the programme, for another elective course or other curriculum innovation.

The teaching-learning environment of the master's programme Geomatics is designed around balancing theoretical learning with practical application to real-world challenges. This is particularly evident in the Synthesis Project in the third semester, where students apply the acquired knowledge of the first year to a real-world challenge assigned by an external client. Active teaching and learning methods are fundamental to the Geomatics programme, with courses using various strategies such as instruction clips, flipped

classrooms, quizzes, discussions, and small group research to engage students and enhance their understanding. These methods often serve as formative assessments, or to help students to visualize and apply theoretical concepts. The panel has studied the teaching methods in the programme and found them to be fitting with the curriculum and learning outcomes. According to the panel, the use of varied didactics and teaching methods helps cater to different learning styles and enhances the overall effectiveness of the teaching-learning environment.

To keep the curriculum and the course objectives of the Geomatics programme up-to-date and aligned with intended learning outcomes, lecturers regularly adjust their courses based on scientific and societal developments in their fields while maintaining the connection to the final attainment levels. There is extensive collaboration with companies and organizations through various means, including research projects, geomatics committees, the organization of international geomatics events, internships, synthesis projects, guest lectures, and graduation projects. Geomatics Day is a significant event where students, staff, alumni, and professionals discuss innovative geomatics solutions and present synthesis project results, attracting about 100 participants. Regular meetings, both quarterly among staff and annually or biannually involving all lecturers, facilitate alignment and implementation of course adjustments. Additionally, the Director of Studies meets with individual lecturers to discuss these adjustments. The panel is very positive about the continued development of the programme's curriculum. The panel appreciates the close contact with the industry allowing for agile responses to developments within the field.

Following up on the recommendations of the 2018 assessment panel, the curriculum has placed more emphasis on its connection to the built environment. For example, the new core course '3D Modelling of the Built Environment' includes Building Information Modelling (BIM) in the learning outcomes, and 'GIS and Cartography' and 'Digital Terrain Modelling' highlight the focus on the built environment in the course description. The programme also introduced a new elective 'Machine Learning for the Built Environment'. The panel finds that new and revised courses better connect to the built environment, and appreciates how the programme is adequately tying in the curriculum with the intended learning outcomes as discussed under standard 1. To follow up on this, the panel believes that the programme would benefit from further exploiting its connection to the built environment. Clear communication on this characteristic of the programme could further strengthen the programme's attractiveness and unique selling proposition. Furthermore, this could also help in better explaining curriculum design choices to students. For instance, in the student chapter of the self-evaluation report, students noted that they felt that attention to the topic of remote sensing was falling short in the curriculum. The panel addressed this issue during the site visit and learned from the programme management that this is a deliberate choice, as the topic of remote sensing is less aligned with the built environment. The panel understands this decision, and feels that clearer communication about what the programme is about would have helped students in understanding the design of the curriculum.

To enrol in the Geomatics programme, students need to have a university Bachelor's degree that indicates a capacity for spatial thinking, but no prior knowledge of Geomatics is required. Any student with a Bachelor's degree from TU Delft, the University of Twente and Eindhoven University of Technology will be admitted. Students with other backgrounds need to motivate their choice for the programme after which their eligibility will be decided upon by the Admission Board. This allows for a diverse intake from various BSc backgrounds. This diversity in backgrounds leads to an equally diverse set of knowledge and skills of new students. Knowledge and experience of incoming students range from beginner to advanced in topics like architecture, geo-information, and programming. A 'Python Programming for Geomatics' course is given in the first quarter, but in the student chapter of the self-evaluation report, students mention that students without prior programming experience feel that 5 EC worth of programming experience is not sufficient

preparation for the highly intensive nature of coding in the rest of the curriculum. Furthermore, following the recommendations from the Geomatics industry, the programme recently also incorporated the arguably more difficult programming language C++ into the programming course. Students and alumni confirmed the importance of learning C++ for their work in the programme. However, it means that now two programming languages need to be taught in the same amount of ECs. According to the student chapter in the self-evaluation report and interviews with students during the site visit, this results in this course being significantly more difficult and time consuming for students with little prior programming experience. The programme offers students the possibility to follow extracurricular Massive Open Online Courses (MOOCs) prior to the start of the programme to fill in the gaps in knowledge and skill. Furthermore, the programme offers extra lab sessions during the programming course where a student assistant is available to answer all software development questions. The programme management has chosen this course of action over stricter admission requirements or an obligatory pre-master's programme to keep the admission requirements as open as possible. The programme is also considering to focus the programming course mainly on C++ and add Python later, as this is easier to learn if students have already mastered programming principles through C++. This was also suggested by some of the students during the interview with the panel. The panel concludes that the programme has made a valid choice to incorporate C++ into the curriculum, but it still needs to find the optimal form for its incorporation in the programme. A possible solution according to the panel could be to introduce extra (conditional) elective space in the first semester, and use this to offer (obligatory) levelling courses to students with pre-knowledge gaps. Students with a computer science background could for instance follow a course related to the built environment, whereas students without prior programming knowledge could follow an extra course on programming. In this way, the programme could get students to a similar starting level for the remainder of the curriculum without enforcing them to spend extra time outside the programme.

Feasibility

The Geomatics programme is a small-scale programme. Over the past six years, an average of 27 students have registered for the programme each year. The small scale of the programme allows for close interaction between students and programme staff. An academic counsellor is available to students of the programme for personal and study-related advice. In addition to this, students and alumni told the panel that they often go to the teaching staff for support, because they are very approachable and helpful. The panel appreciates the close interaction with and guidance from the programme's staff. They have shown to be a big support for students, both in terms of student well-being but also for instance in helping them make curriculum-related choices. Students generally consider the curriculum to be feasible, even though students mention in the student chapter that it can be overwhelming at times. This is mainly related to differences in pre-knowledge (predominantly programming), which is discussed above. Even so, around two-thirds of students complete the programme within three years, with drop-out rates around 10%. According to the panel, the success rates and the low drop-out numbers show that the curriculum is feasible.

The panel also commends the openness to student feedback in the programme. Students told the panel that they feel that their experience and wellbeing is really being taken into account. Core courses are evaluated with student feedback and adjusted for future years. An example given to the panel by one of the lecturers was about students that indicated that the workload for an individual assignment was too high. This was then addressed by making the assignment a group assignment in the next year. A positive development in this light is also the official installing of a programme-specific Board of Studies, consisting of four members of staff and four Geomatics students. Before 2023, the Geomatics programme was advised by the Board of Studies of ABE where only one member of staff and one student represented the Geomatics programme. Since 2020, the programme had an informal programme-specific Board of Studies, which was formalized and made into the legal Board of Studies for the programme per 2023. This Board meet every six weeks to

evaluate the education of the previous quarter, and discuss the education of the coming quarter, as well as other issues such as issues evolving during running courses and improvements of the programme. Students and members of staff can anonymously inform the Board of Studies of any issues through an online form.

Language and programme name
During the site visit, the panel discussed the use of English as the language of instruction and for the programme name. Since the field of Geomatics is very international, the panel considers English an appropriate choice in order to prepare students for their future career in this field.

During the site visit, the panel discussed with programme representatives the possibility to change the programme name to include a reference to the built environment, such as 'Geomatics for the built environment'. The programme's primary focus is on the built environment, a distinctive focus that distinguishes it from other geomatics programmes. However, this aspect is not currently prominently highlighted in the programme's external communications. A new name could help to better advertise this to prospective students, most prominently with a background in the built environment. The panel recommends investigating whether such a name change would be a good idea.

Teaching staff
The Geomatics programme is run by thirteen core teaching staff members, including assistant, associate and full professors, amounting to a total of 11.9 FTE, of which approximately 40% is dedicated to education. All are in the possession of a University Teaching Qualification (UTQ). Following up on the advice of the 2018 assessment panel, the programme has attracted additional younger as well as female staff members to the programme. The newly added diversity in the teaching staff is appreciated by the panel. The core courses are coordinated by core teaching staff members, in collaboration with other lecturers, postdocs or PhD students who supervise labs, give lectures and are involved in assignments.

The panel appreciates the mix of dedicated core teaching staff and supporting lecturers, and considers the quantity appropriate for the number of students and the amount of courses. Students have expressed themselves very positively about the quality of the lecturers during the site visit, further substantiated by the high scores awarded by students in the student exit evaluation on topics like professional expertise, guidance from the thesis mentor, and the academic level of the programme.

Almost all lecturers gained a PhD degree in a field related to Geomatics. The course coordinators are all active research in the topics of covered by their courses, enabling them to incorporate recent research developments in their courses. The panel finds that it is an important asset that the research of the lecturers is strongly aligned to the content of the teaching.

Programme-specific services
During the site visit the panel was given a tour of the faculty building for the Faculty of Architecture and the Built Environment. In addition to the generic facilities available to all students of the faculty, the Geomatics students have access to a designated working space called 'Geolab'. This is designated Geomatics working space for students intended for self-study and occasionally for lectures. The lab is open during the opening hours of the building. During the site visit, students stated that the lab offers sufficient space for them and the opening hours are suitable. The programme management arranged for more computer screens when the students asked for it. According to the students, IT-support is helpful and quick and they have access to computers with more processing power for heavy-duty tasks, which is crucial in the field because it works with a lot of data. The panel concludes that the facilities are sufficient and fitting the ambitions of the programme.

The programme has made its ambition clear to fully embrace open science principles in its education by utilizing open educational resources such as open research data, open access course materials, and open-source software. Additionally, they plan to openly disseminate output of the education in the TU Delft repository. Several of the programme's courses already provide all learning materials, including lecture slides, clips, handbooks, and assignments, openly available. The panel appreciates the efforts already made and advices to continue to push open platform and open access of the teaching.

Considerations

The panel commends the MSc Geomatics programme's curriculum for its progressive, bottom-up structure, blending theoretical learning with practical application. The first year's core courses build a solid foundation, while the second year emphasizes real-world projects and the graduation thesis. The varied didactic methods effectively cater to different learning styles and enhance the overall effectiveness of the teaching-learning environment. The panel finds that new and revised courses better connect to the built environment, and appreciates how the programme is adequately tying in the curriculum with the intended learning outcomes. To follow up on this, the panel believes that the programme would benefit from further exploiting its connection to the built environment: clear communication on this characteristic of the programme could further strengthen the programme's attractiveness and unique selling proposition.

The panel is very positive about the continued development of the programme's curriculum. The panel appreciates the close contact with the industry allowing for agile responses to developments within the field. The panel also appreciates the open feedback culture, with course evaluations leading to timely adjustments. The small class size fosters close student-staff interaction. Though the curriculum is demanding, especially for those without programming backgrounds, support mechanisms like extra lab sessions and MOOCs help. The panel discussed with lecturers and students if the choice for incorporating C++ in the programme was necessary. It understands the considerations and the explicit demands for these skills from future employers, but indicates that the programme still needs to find the optimal form for its incorporation in the programme. A possible solution according to the panel could be to introduce extra elective space in the first semester, and use this to offer levelling courses to students with pre-knowledge gaps. In this way, the programme could get students to a similar starting level for the remainder of the curriculum.

The programme's language of instruction in English is appropriate given the international nature of Geomatics. However, the panel recommends considering a name change to highlight the programme's focus on the built environment, potentially enhancing its appeal to prospective students. The teaching staff, comprising dedicated and diverse members, effectively blend academic expertise and practical experience. Students have expressed high satisfaction with the quality of teaching and support. The strong alignment between faculty research and course content enriches the learning experience. Programme-specific services, including the Geolab, provide adequate study space and resources. The commitment to open science principles, through the use of open educational resources and open-source software, is appreciated. The panel encourages continuing to promote open access to educational materials and research outputs, enhancing transparency and accessibility.

Conclusion

The panel concludes that the master's programme Geomatics meets standard 2.

Standard 3. Student assessment

The programme has an adequate system of student assessment in place.

Findings

Assessment system

In line with the TU Delft Assessment Framework, the assessment system of the Geomatics programme encompasses three main purposes of assessment: checking whether students have met the learning objectives ('assessment of learning'), providing feedback for ongoing learning ('assessment for learning'), and helping students adjust their learning processes ('assessment as learning'). The programme employs a mix of formative and summative assessments, including written and oral exams, programming assignments, individual and group assignments, quizzes, papers, and a thesis. Formative feedback, which has no impact on grades, is given to support learning, whereas summative assessments are used to evaluate the acquired knowledge and skills. Typically, grades are based mainly on individual exams and partially on assignments, either individual or group-based.

To mitigate issues related to grading group work and to prevent free-riding, for example in the "Synthesis Project" which is entirely a group assignment, various strategies are employed. These include alternating group compositions, basing assessments on individual contributions within group work, conducting oral exams about group papers, and requiring self and group performance reflections in some courses. Talks with the teaching staff and the Board of Examiners during the site visit, made it clear to the panel that the scale of the Geomatics programme and the close interaction between students and lecturers help in detecting free-rider behaviour as well as raising and resolving the issue with the student that is concerned. Assignments begin early in the term, with weekly or bi-weekly deadlines, and lecturers coordinate workloads and deadlines to manage students' overall workload effectively.

Following up on the advice of the 2018 assessment panel, the programme has implemented the use of rubrics to give feedback to students. Most courses now make use of rubrics to explain the assessment score and in the grading of theses, mentors are required to complete an evaluation using the rubric and qualitative comments. The panel appreciates the effective addressing of the issues put forward by the previous accreditation committee and is very positive about the use of rubrics, as it provides for a more transparent and consistent assessment process and also helps students understand what is expected of them.

The panel concludes that the programme has a very solid assessment policy in place that is designed to ensure that students achieve the intended learning outcomes. The assessment methods are varied, including group work, programming assignments and written products, and in line with the goals and educational methods of the programme. The assessment of students not only checks whether they have met the learning objectives, but also aims to help students in their learning process.

Thesis assessment

The thesis assessment procedure comprises five evaluation moments (P1-P5). P1 and P2 are part of the thesis preparation component (GEO2011), aimed at setting up a research proposal. P1 is a progress review and P2 a go/no-go moment judged by two mentors from the programme based on a progress report, oral presentation, and discussion. A delegate of the Board of Examiners acts as chairperson, guiding the assessment. P3 is a mid-term progress review. P4 involves a formal assessment with an extended committee to judge the research quality for graduation, and a pass of P4 means that the research has sufficient quality for graduation. Finally, P5, the final stage, determines the grade based on evaluations by the mentors and a

co-reader, with feedback provided both orally at the graduation ceremony and in writing. The co-reader is a scientific staff member of the TU Delft or an employee of another university, who is an expert in the field of the graduation project. The first task of the co-reader is to assess the quality of the student's work in an unbiased way. To guarantee independence, the chair of the co-reader is different from the chair of the mentors. The delegate of the Board of Examiners also acts as chairperson for P4 and P5.

The panel finds the thesis assessment procedure to be transparent and insightful, allowing for a thorough evaluation of the students' final research projects, facilitated by the feedback provided in the different stages of the graduation project and through the use of rubrics. The grades of the theses studied by the panel were in line with panel's own judgements. The panel found that the assessment forms are structured to cover a wide range of criteria, which not only ensures a comprehensive assessment of each thesis, but the use of rubrics also helps to maintain a consistent standard of feedback. At the same time, it also considers the procedure to be very intensive with five evaluation moments and three graders, something which is only feasible with low student numbers. From the documentation provided by the programme and discussion with the programme management, it became clear to the panel that from 2025-26 the programme intends to simplify the thesis assessment procedure by narrowing down the evaluation moments to four instead of five. The panel understands and supports this decision.

Board of examiners
The Board of Examiners (BoE) is an independent committee appointed to safeguard assessment quality within the programme. To safeguard assessment quality within the programmes, the BoE has a broad set of tasks and responsibilities. Responsibilities include advice on policy, establishing the Rules and Guidelines of the Board of Examiners, creating guidelines for assessors and examiners, appointing examiners, judging on requests for exemptions based on the Teaching and Examinations Regulations (TER), investigating suspicions of fraud and other irregularities like big differences in grades in exams, and the degree audit in which the BoE determines whether the student has successfully completed all examinations in the courses of the degree programme in order to receive their diploma. At the end of each semester, the BoE reviews all assessment results achieved for all courses taught. If anything comes to the BoE's attention, such as a high average grade for a particular course several years in a row, the BoE will investigate this. The grades for the Geomatics core courses have not given any reason to do this for a Geomatics course. The BoE carries out annual sampling of theses, with around ten Geomatics theses checked every year. The BoE also selects several courses every year to check exams for these courses in a similar sample-wise fashion.

The panel appreciates that the BoE has clear procedures outlined and that these procedures are followed up. The panel feels the Board is clearly in control, with good procedures for exams and master's theses, and all the necessary checks and balances in place.. The work is done efficiently and the faculty-wide BOE provides the possibility to exchange best practices with other programmes on topics like grading and assessments. The small scale of the Geomatics programme ensures a close monitoring of assessment quality of the programme.

During the site visit, the panel also discussed the issue of generative AI by students with the BoE, as it is a very relevant topic that all programmes are dealing with. The Board demonstrated that they are aware of this topic, and are working on policies to prevent improper use of AI by students in assessment. One of the measures that the programme is considering is to compare assessment results performed under supervision with assessment results without supervision in case of suspicion of fraud in order to detect any differences that can point to the use of AI. When there is a suspicion of fraud, the BoE will investigate this and hold a hearing with the student. This works well for the Geomatics programme, because of the small scale of the

programme and the close student-teacher interaction. The panel encourages the programme to keep working on AI policies to keep up with technological developments.

Considerations

The panel commends the assessment system of the Geomatics programme, which effectively balances formative and summative assessments, including group projects, programming assignments and written products. The use of rubrics for feedback ensures transparency and consistency. For the thesis assessment, the process involves five evaluation moments (P1-P5), with feedback provided at each stage. This thorough process, involving multiple mentors and an external co-reader, is designed to ensure high-quality research outcomes. The panel finds the thesis assessment procedure to be transparent and insightful, allowing for a thorough evaluation of the students' final research projects. However, recognizing the intensity, the panel supports the programme's plan to streamline this to four evaluation moments from 2025-26. The Board of Examiners (BoE) plays a crucial role in maintaining assessment quality. The panel is positive about the BoE's proactive measures, such as addressing the use of generative AI in assessments and ensuring close monitoring due to the programme's small scale. The panel encourages the programme to keep working on AI policies to keep up with technological developments. Overall, the panel finds the assessment system, thesis evaluation, and the functioning of the BoE to be robust, transparent, and aligned with maintaining high academic standards.

Conclusion

The panel concludes that the master's programme Geomatics meets standard 3.

Standard 4. Achieved learning outcomes

The programme demonstrates that the intended learning outcomes are achieved.

Findings

Quality of theses

To assess the achieved learning outcomes of the programme, the panel studied a sample of 15 theses. The panel was impressed by the overall high quality of the theses. According to the panel, the theses generally show a good understanding of the subject matter and display rigorous methodology. They are well-structured and demonstrate the students' ability to synthesize and analyse information effectively. Theses demonstrated a high standard of academic achievement and practical application of the students' knowledge. The panel also appreciates the very topical nature of the theses for both research and industry. The high thesis quality is further demonstrated by the number of theses that have been transformed into published journal articles in recent years. The panel concludes that the exit level of students, as evidenced by their theses, is up to standard for a master's programme.

Alumni success

To determine alumni success, the panel reviewed the documentation presented by the programme and interviewed several alumni of the programme. In the documentation provided by the programme, it is shown that the majority of graduates find a job at the appropriate level within three months after graduation. This was confirmed by the alumni interviewed during the site visit, with one of the alumni even stating he had found a job before graduating. The panel concludes that the Geomatics programme offers a very good job perspective. The analysis shows that Geomatics graduates mostly find jobs in companies, but also universities and governmental institutes locally and abroad.

A recent alumni survey shows that graduates feel well-prepared for a career in the field, which was verified by the alumni that the panel spoke with during the site visit. Feedback from the professional geo-field, gathered by the programme through on-site surveys in December 2023, also indicates that the Geomatics programme effectively meets industry needs. The quality of graduates was praised by the interviewees, noting the broad curriculum's emphasis on IT/programming, traditional geo courses, and transferable skills, which enhance employability. Geomatics graduates are recognized by employers for their technological expertise, interdisciplinary communication skills, and the ability to develop innovative, user-friendly, and aesthetically pleasing solutions. The panel concludes that the high employment rate with relevant companies and high employer happiness with the graduates indicates that learning outcomes are well achieved.

Considerations

The panel was impressed by the high quality of the theses, noting a strong understanding of the subject matter, rigorous methodology, and effective synthesis and analysis. The theses demonstrated high academic standards and practical application, with a number of theses being published in journals. This indicates that the students' exit level is appropriate for a master's programme. Regarding alumni success, the panel found that most graduates secure relevant jobs within three months. Alumni and employer feedback confirms that the programme meets industry needs, with graduates getting praised for their technological expertise, interdisciplinary skills, and ability to create innovative solutions. The high employment rate and positive employer feedback suggest that the programme's learning outcomes are well achieved.

Conclusion

The panel concludes that the master's programme Geomatics meets standard 4.

General conclusion

The panel's assessment of the master's programme Geomatics is positive.

Development points

1. Structuralize the connection to the professional field, for instance through the introduction of an external advisory board;
2. Exploit the connection to the built environment more by communicating this characteristic of the programme more clearly to further strengthen the programme's attractiveness and unique selling proposition;
3. Address the pre-knowledge gaps of incoming students in a way that does not increase the workload outside the standard hours of the curriculum for some students, particularly those without previous programming skills;
4. Keep working on AI policies to keep up with technological developments and to prevent improper use of AI by students.

Appendix 1. Intended learning outcomes

Dublin Descriptors Master's programmes

1. Knowledge and understanding
Students have demonstrated knowledge and understanding that is founded upon and extends and/or enhances that typically associated with the Bachelor's level, and that provides a basis or opportunity for originality in developing and/or applying ideas, often within a research context.
2. Applying knowledge and understanding
Students can apply their knowledge and understanding, and problem solving abilities in new or unfamiliar environments within broader or multidisciplinary contexts related to their field of study.
3. Making judgements
Students have the ability to integrate knowledge and handle complexity, and to formulate judgements with incomplete or limited information, but that include reflecting on social and ethical responsibilities related to the application of their knowledge and judgements.
4. Communication skills
Students can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously.
5. Learning skills
Students have the learning skills that allow them to continue to study in a manner that may be largely self-directed or autonomous.

Generic final attainment levels MSc Geomatics

The generic final attainment levels for the Master's programme in Geomatics are as follows. A student graduating with a TU Delft Masters:
1. Is skilled in one or more academic disciplines. A university graduate is familiar with existing academic knowledge and is capable of expanding this through study. (TUD.1)
2. Is able to perform research. A university graduate is capable of acquiring new academic knowledge through research. In this connection, 'research' means developing and discovering new knowledge and insights in a purposeful and methodical manner. (TUD.2)
3. Is able to design. Many university graduates will formulate designs in addition to performing research. Designing is a synthetic activity geared towards bringing about new or modified artefacts or systems, for the purpose of creating values in accordance with the requirements and wishes stated beforehand (for example, mobility or health). (TUD.3)
4. Has an academic approach. A university graduate follows a systematic approach, characterised by developing and using theories, models and coherent interpretations, has a critical attitude and has an understanding of the unique nature of science and technology. (TUD.4)
5. Possesses basic intellectual skills. A university graduate is able to reason, reflect and form judgments. These are skills which are learned or sharpened in the courses of a discipline, and are generically applicable afterwards. (TUD.5)
6. Is able to cooperate and communicate. A university graduate has the capacity to work with and for others. This requires not only sufficient interaction, a sense of responsibility, and leadership, but also good communication with individuals both in and outside the profession. In addition, the university graduate is able to participate in academic or public debates. (TUD.6)
7. Takes into account the temporal and social context. Science and technology are not isolated, but rather, always have a temporal and social context. Opinions and methods have a background; decisions have social consequences over time. A university graduate realises this and is able to integrate these insights into their academic work. (TUD.7)

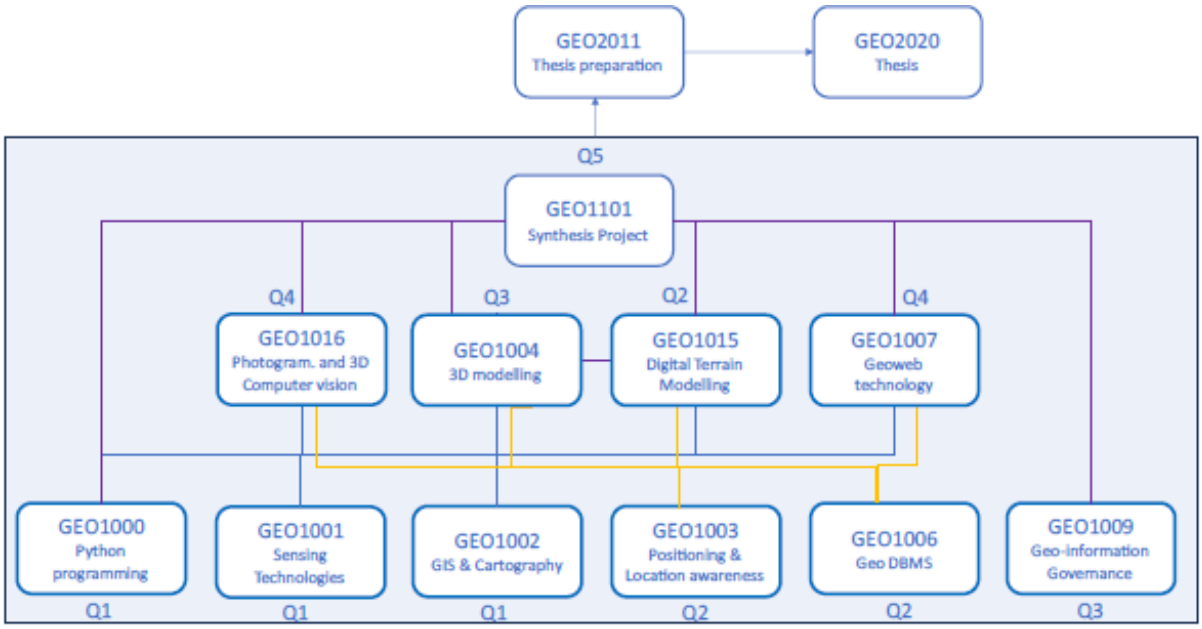
Domain specific final attainment levels MSc Geomatics

The domain specific final attainment levels for the Master's programme in Geomatics are as follows. A graduate of the Master's programme in Geomatics:

1. Is familiar with existing scientific knowledge, and has the competence to increase and develop this through study, and is competent in one or more scientific disciplines covering the complete geo-information chain, by
    (a) having appropriate knowledge of the role of geo-information in decision making applied to the built environment (GM1a);
    (b) applying a formal, theoretical and methodologically sound approach to store, process, manage, disseminate and visualise geo-data and geo-information (GM1b);
    (c) acting at the forefront of data analysis methodology and spatial-temporal database management systems technology (GM1c);
    (d) having appropriate knowledge of legal and organisational aspects of geo-information (GM1d); and
    (e) utilising a technology and application driven approach to geo-data acquisition and geo-information extraction (GM1e).
2. Has the research competences to:
    (a) investigate and analyse spatial-temporal models and systems of complex real-world situations (GM2a);
    (b) formulate hypotheses or research questions and develop new concepts (GM2b);
    (c) validate developed concepts by appropriate prototypes (GM2c); and
    (d) analyse and evaluate thoroughly obtained results (GM2d).
3. Has the competences to design, implement and use:
    (a) models and systems for management, storage, processing, integration, exchange and dissemination of geo-information (GM3a);
    (b) systems and methodologies to analyse measurements and other evidence material for the purpose of geo-information extraction (GM3b); and
    (c) select, combine and extend above-mentioned systems and methodologies to meet geo-information requirements, notably in the built environment, in the present and in the future (GM3c).

Appendix 2. Programme curriculum

<table>
<tr><th colspan="4">FIRST YEAR</th></tr>
<tr><th colspan="2">1ST SEMESTER</th><th colspan="2">2ND SEMESTER</th></tr>
<tr><td>PYTHON PROGRAMMING FOR GEOMATICS (5EC)</td><td>GEO DATABASE MANAGEMENT SYSTEMS (5EC)</td><td>3D MODELLING OF THE BUILT ENVIRONMENT (5EC)</td><td>GEOWEB TECHNOLOGY (5EC)</td></tr>
<tr><td>SENSING TECHNOLOGIES (5EC)</td><td>DIGITAL TERRAIN MODELLING (5EC)</td><td>GEO-INFORMATION GOVERNANCE (5EC)</td><td>PHOTOGRAMMETRY AND 3D COMPUTER VISION (5EC)</td></tr>
<tr><td>GIS AND CARTOGRAPHY (5EC)</td><td>POSITIONING AND LOCATION AWARENESS (5EC)</td><td>FREE ELECTIVE (5EC)</td><td>FREE ELECTIVE (5EC)</td></tr>
<tr><th colspan="4">SECOND YEAR</th></tr>
<tr><th colspan="3">3RD SEMESTER</th><th>4TH SEMESTER</th></tr>
<tr><td>FREE ELECTIVE (5EC)</td><td rowspan="2">Or: JOINT INTER-DISCIPLINARY PROJECT (15EC)</td><td>THESIS PREPARATION (10EC)</td><td rowspan="2">GRADUATION PROJECT (30EC)</td></tr>
<tr><td>SYNTHESIS PROJECT (10EC)</td><td>ELECTIVE (5EC)</td></tr>
</table>



Appendix 3. Programme of the site visit

13 May 2024

17.00	19.00	Preliminary panel meeting (incl. consultation hour)

14 May 2024

08.45	09.00	Arrival and welcome
09.00	09.45	**Interview programme management**
09.45	10.15	Internal panel meeting
10.15	11.00	**Interview students & alumni**
11.00	11.15	Break
11.15	11.45	**Interview Board of Examiners**
11.45	12.30	Lunch
12.30	12.45	Break
12.45	13.30	**Interview teaching staff members**
13.30	14.15	Internal panel meeting
14.15	14.45	**Final interview programme management**
14.45	15.30	**Development dialogue**
15.30	16.30	Concluding panel meeting
16.30	17.00	**Oral report**

Appendix 4. Materials

Prior to the site visit, the panel studied 15 theses. Information on the theses is available from Academion upon request. The panel also studied other materials, which included:

- Company Survey Outcome
- Alumni Survey Responses
- Organigram of Geomatics Programme
- Admission Criteria International Students
- Student Performance
- Evaluations at Programme Level
- Dublin Descriptors for Master's Programmes
- Generic Final Attainment Levels TU Delft Masters
- Specific Final Attainment Levels Geomatics
- Generic/Specific Final Attainments Levels Implemented Through Core Courses
- 2018 Assessment Panel Recommendations on Intended Learning Outcomes
- Overview of BSc Programmes Geomatics Students
- Developments in the Geomatics Curriculum 2018-2023
- Overview of Approved Electives
- Overview Staff Involved in the Geomatics Programme
- Overview of Course Coordinators
- 2018 Assessment Panel Recommendations on Teaching Learning Environment
- 2018 Assessment Panel Recommendations on Student Assessment
- Distribution of Assessment of Exams/Assignments over the Common Core Courses
- Graduation Theses 2018-2023
- Rubric Graduation Project
- Publications Geomatics Students
- Career Path Graduates
- Geomatics Bridging Programme