MASTER'S PROGRAMME

GEOMATICS

FACULTY OF ARCHITECTURE AND

THE BUILT ENVIRONMENT

DELFT UNIVERSITY OF TECHNOLOGY

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This report was finalised on 3 October 2018.

REPORT ON THE MASTER'S PROGRAMME GEOMATICS OF DELFT UNIVERSITY OF TECHNOLOGY

This report takes the NVAO's Assessment Framework for Limited Programme Assessments as a starting point (September 2016).

ADMINISTRATIVE DATA REGARDING THE PROGRAMME

Master's programme Geomatics

Name of the programme:	Geomatics
CROHO number:	66954
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specialisations or tracks:	none
Location(s):	Delft
Mode(s) of study:	full time
Language of instruction:	English
Expiration of accreditation:	31/12/2019

The visit of the assessment panel Geomatics to the Faculty of Architecture and the Built Environment of the Delft University of Technology took place on the 20th and 21st of June 2018.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

Name of the institution:	Delft University of Technology
Status of the institution:	publicly funded institution
Result institutional quality assurance assessment:	positive

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has approved the composition of the panel on 16 April 2018. The panel that assessed the master's programme Geomatics consisted of:

- Prof. dr. R. (Roland) Billen, professor at the Department of Geography of the Université de Liège (Belgium) [chair];
- Prof. dr. N. (Nico) Van de Weghe, professor Geomatics at the Department of Geography of Ghent University (België);
- Prof. dr. R. (Raúl) Zurita-Milla, adjunct professor in Spatio-temporal analytics at de Faculty of Geo-Information Science and Earth Observation (ITC) of the University of Twente;
- Dhr. Ir. R.M. (Ruud) Kathmann, member of the management team of the Netherlands Council for Real Estate Assessment (Waarderingskamer);
- L.E. (Louise) Prins, master's student of the Geo-Information Science programme at Wageningen University [studentlid].

The panel was supported by Yvet Blom, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

Preparation
In preparation of the assessment, the programme management prepared a self-evaluation report. This report was sent to QANU and was checked by the project manager to ensure that the information provided was complete. In addition, the project manager selected fifteen master's theses randomly, out of a list of all graduates of the last two years and asked the programme management to send the theses. The project manager divided the theses among the panel members. The panel prepared the site visit by studying the self-evaluation and three theses (see Appendix 6 for a list of theses and documents reviewed by the panel). The project manager designed a visiting programme, which was then discussed with the programme coordinator and the chair of the panel.

Site visit
During the initial meeting at the start of the site visit, the panel members discussed their findings regarding the self-evaluation and the theses, and their tasks and working methods. The panel visited the Master of Science of Geomatics on the 20th and 21st of June 2018. The schedule of the site visit was developed by the panel's project manager in consultation with the programme management and the chair of the panel. In addition, the panel studied additional information on the content of several courses, such as reference books and learning materials. The panel also analysed relevant management information and documentation regarding student satisfaction. The panel members did not find it necessary to request any additional theses.

Immediately after the preparatory meeting, interviews were held with the programme management, students, alumni, staff members and the Board of Examiners. The panel used part of the final day of the site visit to discuss the assessment of the programme and to prepare a preliminary presentation of the findings. The site visit was concluded with an oral presentation of the preliminary findings by the chair of the panel, consisting of a general assessment and several specific observations and impressions of the master's programme.

Report
The secretary wrote a draft report based on the findings of the panel. This draft report was reviewed by the panel members. After approval of the draft report by the panel, this was sent to the Geomatics programme of TU Delft to check for factual errors.

Definition of judgements standards
In accordance with the NVAO's Assessment framework for limited programme assessments, the panel used the following definitions for the assessment of both the standards and the programme as a whole.

Generic quality
The quality that, in an international perspective, may reasonably be expected from a higher education Associate Degree, Bachelor's or Master's programme.

Unsatisfactory
The programme does not meet the generic quality standard and shows shortcomings with respect to multiple aspects of the standard.

Satisfactory
The programme meets the generic quality standard across its entire spectrum.

Good
The programme systematically surpasses the generic quality standard.

Excellent
The programme systematically well surpasses the generic quality standard and is regarded as an international example.

SUMMARY JUDGEMENT

Profile
The Faculty of Architecture at Delft University of Technology (TU Delft) offers a two-year master's programme in Geomatics for the Built Environment, which as the name indicates has a strong focus on the technologies for the built environment. Students acquire knowledge in many subject areas, including mathematics, Geo-statistics, 3D Geo-data acquisition, computer science, 3D modelling and data governance in order to better understand and shape the built environment and contribute to solving planning and management issues in urban areas. In the panel's opinion, the focus on the built environment is unique in the Geomatics domain. Moreover, after examining the programme's profile and comparing it to other programmes in Europe and beyond, the panel established that the programme is a valuable contribution to European academic education.

Intended learning outcomes
The intended learning outcomes reflect the academic orientation of the programme and describe what a TU Delft Geomatics graduate is expected to achieve to be awarded the degree. The panel concludes that the programme's intended learning outcomes have been formulated in accordance with the Dublin descriptors for the master's level. In its opinion, the programme could place more emphasis on its strong connection to the built environment including for instance the combination of technologies such as BIM (Building Information Modelling) from the built environment with GIS (Geographic Information Systems) in the Geomatics field. This focus is a unique selling point, and therefore the panel suggests showing the uniqueness of the focus on the built environment by making the learning objectives more specific and more measurable. This will help lecturers assess whether the intended learning outcomes have been achieved, while it also helps students understand how they can realise their study goals.

Curriculum
The master's programme has a study load of 120 EC and takes two full academic years to complete. The first year consists of ten core courses of 5 EC each. In the final quarter of the first year, students apply their accumulated knowledge and skills in a Synthesis Project. In the second year, students can choose electives. The programme rounds off with the individual research project, which integrates the previous building blocks and allows students to specialise in a given topic of their choice.

The curriculum of the Geomatics programme is based on two pillars: the *Geo-information chain* and *the bottom-up approach*. The Geo-information chain includes capturing, storing, analysing and visualising Geo-information, managing the complete chain and controlling the overall quality of the process. The bottom-up approach is designed to address the diversity of the backgrounds of newly enrolled students by offering introductory courses at the beginning of the programme.
The panel is very positive about the highly specialised curriculum, which ensures that the students become real domain specialists in Geomatics. The content is coherent, technically strong, relevant and well structured. The panel is pleased to see that the programme includes an introductory programming course and new topics like point clouds.

Influx
The programme admits a great variety of students. Therefore, it offers a wide range of introductory courses to provide them with the requisite knowledge and skills to cover the complete Geo-information chain. In order to prepare them even better, the panel suggests offering a pre-master programme or a MOOC[1] to eliminate deficiencies before the start of the master's programme. It also suggests offering a more flexible, tailor-made programme for the more advanced students, with the possibility of exemptions and additional electives during the programme.
A relative large part of students come from Universities abroad. This mix of backgrounds has certainly a positive influence on the cooperation in the projects. However the aspect of "built environment"

[1] Massive Open Online Course

can get more emphasize when a larger number of students from the bachelor programs of the Faculty of Architecture and the built environment self will choose for this master, it can help when the Geomatics master would be more visible within the bachelor programmes of the Faculty.

Teaching
The teaching methods mainly consist of classroom lectures, supported by individual and group assignments and additional guest lectures. According to the panel, the courses are well embedded in a research context, and students are encouraged by the programme to conduct research. The panel greatly appreciates the programme's focus on research, although it would like to suggest having more variation in the teaching methods. In its opinion, using a larger variety of teaching methods helps to connect with students in different ways, which could also contribute to bridging the heterogeneity among students.

The panel concludes that the teaching staff is of good quality. Every staff member has obtained a University Teaching Qualification (UTQ = BKO, Basiskwalificatie onderwijs). The panel is also impressed by the fact that each staff member is a specialised researcher in his/her field, which is reflected in the programme's courses. Next to the teaching staff also post docs and other (research) specialists are involved in the courses. These post docs are also stimulated to get a teaching qualification. The role of post docs and other specialists contributes to the link between the courses and high level research. Currently, the programme is experiencing some challenges due to a temporary shortage of lecturers. The panel considers this situation an opportunity to attract a younger and more gender-diverse staff and to form a coherent team to maintain the high quality of the programme.

Student assessment
The panel is positive about the programme's well-defined and clear assessment procedure and graduation manual. The student's level of acquired skills is assessed in nearly every core course with written examinations, which form the basis of the assessment. This is supported by an individual and/or group assignment that covers the principles and concepts of the course content. The supervising lecturers carry out the grading under the guidance of the project coordinator, who acts as an independent adviser. The panel is pleased to see that anyone appointed as an examiner is required to have followed an UTQ course. It is convinced that the programme has integrated an effective assessment policy, but given the limited transparency of the practical application of the test matrices and rubric, it recommends clarifying the way that feedback is given to students by using both rubrics and qualitative comments. This is especially visible in the evaluation forms of the MSc theses, which hardly ever contain specific feedback for the students.
In the second year, the graduation project is split into five stages. The panel studied the stages of the graduation project and expressed its concern about their rigid deadlines. The programme management and lecturers convinced the panel that this system contributes to a clear structure that students are informed of at the beginning of the year and to graduating on schedule.

During the site visit, the panel learned that the Board of Examiners (BoE) has developed suitable general measures and instruments for the quality assurance of examinations and assessments for all curricula within the Faculty. For example, the BoE has taken the initiative to issue proper assessment guidelines including marking guidelines and rubrics. However, it has not been checking whether these guidelines are being properly implemented for the Geomatics master. The panel therefore advises that measures should be taken to determine whether improvements have actually occurred.
The panel would like to see the BoE take a more proactive role and show that it has a vision regarding academic quality control and assurance for the Geomatics programme.

Achieved learning outcomes
The panel is very satisfied with the large number of scientific publications and conference papers that have been developed from the final individual graduation project. The theses show that students are well equipped and able to use the tools they learned in the first year, which is also demonstrated by

the surveys conducted among employers. In the surveys, companies are mainly positive about the know-how and skills of the graduates. The panel is also convinced that graduates are very satisfied with their prospects in various companies and public or private institutions. The theses examined by the panel demonstrate that the master's level has been achieved by graduates of the programme.

The panel assesses the standards from the *Assessment framework for limited programme assessments* in the following way:

Master's programme Geomatics

Standard 1: Intended learning outcomes	Satisfactory
Standard 2: Teaching-learning environment	Good
Standard 3: Student assessment	Satisfactory
Standard 4: Achieved learning outcomes	Good
General conclusion	Good

The chair and the secretary of the panel hereby declare that all panel members have studied this report and that they agree with the judgements laid down in it. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

Date: 3 October 2018

Prof. Roland Billen

Yvet Blom, MSc

DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED FRAMEWORK ASSESSMENTS

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.

Explanation:
The intended learning outcomes demonstrably describe the level of the programme (Associate Degree, Bachelor's, or Master's) as defined in the Dutch qualifications framework, as well as its orientation (professional or academic). In addition, they tie in with the regional, national or international perspective of the requirements currently set by the professional field and the discipline with regard to the contents of the programme. Insofar as is applicable, the intended learning outcomes are in accordance with relevant legislation and regulations.

Findings
Profile
The Faculty of Architecture at Delft University of Technology (TU Delft) offers a two-year master's programme in Geomatics for the Built Environment. The programme aims to attract applicants with a university bachelor's degree who show a well-developed capacity for spatial thinking. The field of Geomatics combines knowledge from mathematics, statistics, 3D Geo-data acquisition, computer science, 3D modelling and data governance in a wide range of research fields. The Geomatics programme at TU Delft aspires to train students to exploit these technologies in order to understand and shape the built environment better and to contribute to solving planning and management issues in urban areas. Students acquire knowledge covering the complete Geo-information chain and gain practical skills to process, store and disseminate Geo-information in response to the needs of both industry and society. It also covers relevant legislation aspects of Geo-information.

In the panel's opinion, the focus on the built environment is unique in the Geomatics domain. After examining the programme's profile and the comparison with other programmes in Europe and beyond, the panel established that the programme is a valuable contribution to European academic education.

Intended learning outcomes
The programme's profile is translated into the intended learning outcomes of the Geomatics programme, as described in Appendix 1 of this report. According to the self-evaluation report, the specific study goals aim to realise the objective of educating future engineers to participate in the 'research, design, realisation, operation and maintenance of multidisciplinary projects involving Geo-information'.

The panel noted that the intended learning outcomes reflect the academic orientation and describe what a TU Delft Geomatics graduate is expected to have achieved. It concluded that they have been formulated in accordance with the Dublin descriptors for the master's level. In the panels' opinion, the strong connection between the programme and the built environment could be made more explicit. The focus on the built environment is an unique selling point, and therefore the panel suggests showing this uniqueness by making the learning objectives more specific. In the opinion of the panel, this will provide potential students with a better understanding of the programme and its design.

Furthermore, the panel examined the specific study goals and noticed that some of them are formulated in a manner that cannot easily be measured. For example, students are expected to participate 'at the forefront of data analysis methodology and spatio-temporal database management systems technology'. The programme management explained that in a fast-changing society where artificial intelligence and deep learning have become increasingly important, students need to learn

to adopt an innovative approach. The panel understands the intent, but it advises the programme management to reformulate the learning outcomes so that they are measurable. This will help lecturers assess whether the intended learning outcomes have been achieved, while it also helps students understand how they can realise their study goals. Finally, the self-evaluation describes how the intended learning objectives of the TU Delft and the courses are connected. During the site visit, the panel requested an overview that links the intended learning objectives of the Geomatics programme to the intended learning outcomes of the courses. The panel found the matrix provided by the programme's management too basic. Therefore, the panel recommends to be more transparent and to describe in more detail how the courses link to the programme.

Connection to the professional field
According to the self-evaluation report, there is a great demand for its graduates in the professional field. Taking the advice of the 2012 panel into account, the programme management took several measures to contribute to the professional orientation within the programme and to fine-tune the curriculum. One of these measures was strengthening the cooperation with companies and public organisations, such as RWS [public works directorate-general], Kadaster [land registry], municipalities, provinces and water boards, in graduation projects, synthesis projects and funded research projects.

The programme emphasises cooperating with companies and organisations to keep the study goals up to date regarding the professional field. However, some of the interlocutors have expressed a concern that there is an overall lack of clear direction regarding societal needs as well as uncertainty in technological developments. The fast-changing technological environment might influence which knowledge and skills are required by the professional field. These rapid technological changes could thus lead to uncertainties about the programme's curriculum. Other interlocutors were of the opinion that the programme should focus on the core methodologies in mathematics and computer programming, to provide students with sufficient knowledge and skills to cope with new technologies.

In the panel's opinion, there is a relentless parade of new technologies, all claiming to be the next best thing. Some of them might indeed reshape the Geomatics field, or perhaps the world, while other technologies will not. The panel believes, therefore, that the programme needs to remain aware of the considerable changes in society and the Geomatics field, while retaining a sharp focus on equipping students with the core methodologies so they can deal with rapidly changing realities. Finally, according to the interviewed alumni, the programme actually does provide knowledge and skills on new technologies, even though students may be unaware of this. For example, the alumni mentioned that they found out later, during in their professional careers, that they had been given basic knowledge and skills on Artificial Intelligence and machine learning, though it was never described as such.

Considerations
In the panel's opinion, the focus on the built environment is unique in the Geomatics domain. After examining the programme's profile and the comparison with other programmes in Europe and beyond, the panel established that the programme is a valuable contribution to European academic education.

The panel established that the intended learning outcomes of the Geomatics programme comply with the European standards and guidelines. The programme could place more emphasis on its strong connection with the built environment. This focus is a unique selling point, and therefore the panel suggests including relevant technologies such as BIM and GIS and remote sensing in the intended learning outcomes. Embedding built environment technologies in the intended learning outcomes provides potential students with a better understanding of the programme and its design. Emphasising the strong link with the built environment could also convince students to take part in the Geomatics programme of TUD.

The panel examined the specific study goals and noticed that some of them are formulated in a manner that cannot be measured and advises the programme management to reformulate them to make them measurable. This will help students understand how they can realise their study goals. Finally, the panel recommends to describe in more detail how the intended learning outcomes of the Geomatics programme is linked to the intended learning outcomes of the courses.

Conclusion
Master's programme Geomatics: the panel assesses Standard 1 as 'Satisfactory'.

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.

Explanation:
The intended learning outcomes have been adequately translated into educational objectives of (components of) the curriculum. The diversity of the students admitted is taken into account in this respect. The lecturers have sufficient expertise in terms of both subject matter and teaching methods to teach the curriculum, and provide appropriate guidance. The teaching-learning environment encourages students to play an active role in the design of their own learning process (student-centred approach). Programme-specific services and facilities are assessed, unless they involve institution-wide services and facilities already reported on during the institutional audit.

Findings
Structure and cohesion of the programme
The master's programme has a study load of 120 EC and takes two years. The programme consists of mandatory courses (50 EC), the Synthesis Project (10 EC), free electives (15 EC) and the individual research project (45 EC) (Appendix 2).

The first year consists of ten core courses of 5 EC each. They ensure that each student is equipped with the knowledge and skills necessary to conduct further research in Geomatics. In the final quarter of the first year, students combine their accumulated knowledge and skills in the Synthesis Project. In the second year, they are able to choose electives from the four domains: *Urban Design, Design Informatics; Built Environment; Informatics and Gaming;* and *Geo-data Acquisition.* They can also choose electives outside these four domains offered by TU Delft or other universities (technical colleges) in the Netherlands or other countries. The programme concludes with the individual research project, which integrates the previous building blocks.

According to the self-evaluation report, the curriculum is based on two pillars: *the bottom-up approach and the Geo-information chain*. The former addresses the diversity of backgrounds of potential influx by offering a curriculum in which Geomatics knowledge and skills are introduced in the first semester of the programme, then building upon the achieved knowledge and skills in the second and third semester, and culminating in the Synthesis Project in the final semester. The latter, the Geo-information chain, includes:
1. A systematic and Geodetically sound approach to Geo-data acquisition and information extraction from datasets.
2. An information system's approach to storing, processing, managing, disseminating and visualising data and information while paying attention to the legal and organisational aspects of Geo-information.
3. The role of Geo-information in decision-making within a broad spectrum of Civil Engineering and Geosciences.

The panel is very positive about the highly specialised curriculum, which ensures that the students will become real domain specialists in Geomatics. The content is coherent, technically strong, very relevant, and well structured, based on the collection of data. The panel is pleased to see that the

programme includes an introductory programming course, new topics like point clouds and drones, and the importance of "big" data coming from new types of sensors and how to transfer these data into usable GIS systems.

Teaching methods and facilities
The core courses of the programme are intended to provide students with the requisite skills and knowledge of Geomatics principles and conceptual thinking. According to the self-evaluation report, the teaching methods therefore mainly include classroom lectures, supported by individual and group assignments and guest lectures. Geomatics also offers programme-specific facilities for group work, which includes a specifically assigned room, which enables student to work together and really support each other in the courses and the projects.

To integrate the fast-changing technological environment into the programme and the teaching environment, the lecturers explained that they try to help students develop methodological skills which prepare them for a dynamic professional field. The panel greatly appreciates that courses are well embedded in a research context, and the students are encouraged to conduct research. It describes the programme's teaching methods as adequate, yet mainly classical, and would like to suggest introducing more variation. Using a more extensive variety of teaching methods, such as the flipped classroom, implies addressing students in different ways, which could also contribute to bridging the heterogeneity of the students.

The programme encourages students to participate in extracurricular activities, such as events related to the professional field of Geomatics. Examples include INTERGEO[2], an internship, and additional research. Students and alumni stated that they are very satisfied with the extracurricular activities, which encourage them to develop their knowledge and skills further and to enhance their network. The interviewed alumni explained that working with other companies helped prepare them for the corporate world. They were also very enthusiastic about the possibilities to conduct extracurricular research, which enabled them to publish their work early in their career. In their opinion, the programme should stimulate students even more to engage in these extracurricular activities.

Influx, feasibility and output
In 2012, the review panel emphasised that a much larger intake was vital to the continuation of the programme. The programme has made extensive national and international marketing efforts to recruit a minimum annual intake of 20 students. Since 2013, the intake has steadily increased, though the percentage of students who obtained their bachelor's degree at TU Delft is decreasing. The increased intake is mainly due to a substantial number of international students. Through the intake of international students, the Geomatics programme gains an international character, and it also promotes intercultural communication. This international character may however not keep away the bachelor graduates from the Faculty of Architecture and the Built Environment from choosing for the Geomatics master. In the beginning of May 2018, nearly 40 students applied, including 25 international students.

To be eligible for admission, applicants should hold a university bachelor's degree that indicates a capacity for spatial thinking, or a bachelor's degree from one of the four Dutch technical universities. The international intake and the automatic qualification for admission of applicants from a Dutch technical university result in a wide variety of applicants. The panel questioned how the programme copes with the different levels of newly enrolled students. During the site visit, the programme management acknowledged the diverse student intake, regarding both their nationalities and their prior education. The programme addresses this with the bottom-up approach.

This approach is designed to address the diversity in backgrounds of newly enrolled students by offering introductory courses at the beginning of the programme and continuing to confirm, refine, restructure and develop their knowledge and skills. During the site visit, it became clear that the

[2] The largest Geomatics event worldwide, which is held in Germany.

backgrounds of newly enrolled students may vary substantially. Some students already possess the required knowledge and skills in a specific Geo-information field, while others find the programme quite challenging. After a few weeks, however, these differences have already been significantly reduced. Additionally, the programme assembles students into groups to learn particular types of knowledge. Students who already possess the required knowledge and skills in a certain Geo-information field will still be challenged in the specific introductory courses since each course is designed to address Geomatics- related issues. The interviewed alumni considered the variation in the students' backgrounds to be highly valuable since it allows them to draw on each other's experience, knowledge and skills.

According to the student self-assessment, the mandatory first year is seen as a strong point of the curriculum. During the site visit, it became clear that the interviewed students and alumni are indeed satisfied with the programme's curriculum, although they did feel that the two semesters in the first year could be better balanced. Especially international students experienced some difficulty finding their place in a foreign country and having to cope with the challenging workload. The students and alumni who had a certain basis at the beginning of the programme emphasised that they kept gaining knowledge, insights and skills since the courses are applied to the particular field of Geomatics. The alumni also described how the content and structure of the curriculum and the electives in the second year adequately provided them with the skills for conducting research and writing their thesis. The alumni did stress that some of the courses were challenging.

In some cases, the lack of a background in mathematics or computer sciences was considered to be the difficulty leading to failing courses like Python or Geodatasets. The level of English is considered to be another reason why (international) students experience difficulties at some points. The panel has taken note of the points for improvement mentioned by the students and alumni regarding the feasibility of the programme. Overall, it was pleased to see that students and alumni were very enthusiastic about the programme. They emphasised the communal group feeling of the lecturers and fellow students and how they support each other. The variety of backgrounds is generally considered to be a very positive aspect; as everyone has different strengths, students can learn from each other, especially in group assignments.

Considering the significant contrast between the level at which lectures are given in the first year and the high level of individual research projects conducted at the end of the second year, the panel is convinced of the curriculum's design. However, the various backgrounds and nationalities of the students imply that they have very different levels of prior knowledge at the beginning of the programme. Taking the diversity of the student population into account, the panel suggests preparing students better by offering a pre-master programme or a MOOC to alleviate deficiencies.

During the site visit, the panel and the programme's interlocutors explored the possibilities of making students who are advanced in certain fields of Geomatics aware that they can apply for exemptions in the first year of the master's programme. Subsequently, if an exemption is granted, they can follow additional electives. The panel suggests further exploring the possibilities to challenge the more advanced students and keep them engaged throughout the programme. In its opinion, a more flexible, tailor-made programme could be a solution for students who are more advanced.

The interlocutors explained that the programme imposes fixed deadlines throughout the year. Students and alumni experience these deadlines as a means that provides structure, although it might also result in an additional delay, which has only happened when following an internship or when taking extra courses. Alumni stated that they have extensive career opportunities, mentioning positions in government agencies, companies and universities.

Finally, students and alumni with an architecture background at TU Delft noted that it would be helpful to introduce a compulsory Geomatics course in the bachelor's programme of Architecture, Urbanism and Building Sciences. During the interviews with the lecturers, the panel learned that Geomatics is the only master's programme that is not represented in the bachelor programme.

According to the panel, Geomatics is becoming increasingly important in the fields of Architecture, Urbanism and Building Sciences. Therefore, the panel believes that including Geomatics in the bachelor's programme would provide bachelor students with essential knowledge and skills for their future profession. In particular *Building Information Modelling* (BIM) is seen as an increasingly important concept in architecture and construction. The panel proposes to use BIM to connect Geomatics and the faculty of Architecture and the Built Environment (ABE).

An additional benefit of introducing Geomatics during the bachelor programme is that it would probably attract potential new students to the Geomatics master's programme. Furthermore, the panel suggests creating a minor in Geomatics for bachelor students who would like to broaden their knowledge after following the introductory course during their bachelor's studies. During the site visit, the panel also discussed the possibility of collaborating with the related master's programme Geoscience and Remote Sensing, of the faculty of Civil Engineering and Geosciences at TU Delft. Both students and lecturers of the two master's programmes could benefit from this ability to scrutinize, debate and share experience, which again might attract more students to both master's programmes.

Teaching staff
The programme's teaching staff includes lecturers from three departments of the Faculty of ABE. In 2016-2017, the teaching staff consisted of 10 assistant professors, associate professors and full professors, who are often assisted by researchers (some tenured) (6), post-docs (4) and PhD students (6). All of the lecturers have obtained a University Teaching Qualification (UTQ; BKO, Basiskwalificatie onderwijs). The programme actively stimulates post-docs to obtain an UTQ. The general policy is that one must be obtained within three years after employment.

Each course falls under the responsibility of an assistant, associate, or full professor, who almost always has a PhD degree in a field related to Geomatics. The researchers, lecturers, post-docs and PhD students may supervise labs, give lectures, or assist with assignments. Lecturers carry out research within the field of their course, enabling them to incorporate recent developments in their courses.

The panel is impressed with the teaching staff, all of whom are specialised researchers in their field, which is reflected in the programme's courses. However, the self-evaluation report indicates that the programme is currently experiencing some challenges, due to a temporary shortage of lecturers. In 2017-2018, four members of the teaching staff retired or continued their career elsewhere. Three of the programme's researchers have taken a new position within the programme, for example as a lecturer or an assistant professor. These changes have left the programme with an older and male-dominated teaching staff. The panel has taken note of the situation and sees this as an opportunity to attract a younger and more gender-diverse staff and to form a coherent team to retain the high quality of the programme.

Considerations
The panel concludes that the curriculum of the Geomatics programme is designed according to its intended learning outcomes. The programme offers a very specialised and coherent curriculum for its diverse student population and enables students to become real domain specialists in Geomatics. The panel is greatly impressed by the contrast between the basic level at which lectures are given in the first year and the high level of theses produced in the final year.

The panel is pleased to see that the programme anticipates the needs of the varied student intake. The various backgrounds and nationalities of the students imply that they have very different levels of prior knowledge at the beginning of the programme. A wide range of introductory and additional mandatory courses exists to provide them with the required knowledge and skills to cover the complete Geo-information chain.

Taking the diversity of the student population into account, the panel suggests alleviating deficiencies before the start of the master's programme by offering a pre-master programme or a MOOC. In its opinion, the Geomatics programme would additionally benefit if advanced students could follow a more flexible, tailor-made curriculum, in which they can apply for exemptions and follow additional electives during the programme.

The panel recommends introducing a compulsory Geomatics course in the bachelor's programme of Architecture, Urbanism and Building Sciences and using BIM as a connection between Geomatics and the faculty of ABE. This would probably increase the number of potential new students in the Geomatics master's programme. The panel also suggests creating a minor in Geomatics, designed for bachelor's students who would like to broaden their knowledge after following the introductory course during their bachelor's studies. Finally, the panel proposes collaborating with the related master's programme Geoscience and Remote Sensing, of the faculty of Civil Engineering and Geosciences at TU Delft.

Finally, the panel concludes that the staff is of good quality: the staff members are all specialised researchers in their field. The programme's recent shortage of lecturers is seen by the panel as an opportunity to attract a younger and more gender-diverse staff and to form a coherent team to retain the high quality of the programme.

Conclusion
Master's programme Geomatics: the panel assesses Standard 2 as 'Good'.

Standard 3: Student assessment
The programme has an adequate system of student assessment in place.

Explanation:
The student assessments are valid, reliable and sufficiently independent. The requirements are transparent to the students. The quality of interim and final examinations is sufficiently safeguarded and meets the statutory quality standards. The tests support the students' own learning processes.

Findings
The assessment procedures follow the regulations of the Faculty of Architecture and the Built Environment (ABE). The regulations on examinations are provided in the *Student Charter for the Geomatics for the Built Environment* (Appendix 4), and the most important regulations for lecturers are summarised in *The Golden Rules* (Appendix 4). The student's level of acquired skills is assessed for nearly every core course with written examinations, which form the basis of the assessment. Additionally, there are individual and/or group assignments, with the aim to help the students understand the principles and concepts of the course content better.

In the second semester of the first year, the programme focuses more on assignments, which is reflected in the weights of assignments in the grading. In the final phase of the first year, students take part in the Synthesis Project. This is a group assignment in which students are primarily graded based on their individual performances, following a set procedure (Appendix 4). According to the self-evaluation report, the supervising lecturers carry out the grading under the guidance of the coordinator of the project, who acts as an independent advisor.

System of assessment
The panel is positive about the well-defined and clear assessment procedure of the programme, which is based on the Faculty Assessment Policy. It is pleased to see that examiners are required to have followed an UTQ course. The assessment seems valid and transparent to students, as reflected in the interviews with students and alumni and the student evaluations. According to the students and alumni, the assessment procedure and the feedback provided are clearly formulated. Alumni explained that they had received an additional written report with a clear and detailed description of

the grading. Nevertheless, the panel suggests being more transparent on the assessment forms, as they now consist merely of minuses and pluses. This makes it difficult for the panel to verify the qualitative feedback on the students' theses.
The programme management, lecturers and examination board have elaborated the assessment policy, which involves the use of rubrics and test matrixes. The panel is convinced that the programme has integrated an effective assessment policy, based on the interviews with the programme's representatives and the correct grading of the theses examined by the panel. However, given the limited transparency of the practical application of the test matrixes and rubric, the panel recommends clarifying the way that feedback is given to students by using both rubrics and qualitative comments.

Assessment of the thesis
The final individual research project consists of two components: the *Thesis Preparation* and the *Thesis*. The project has been split into five stages: P1 through P5. P1 and P2 aim to create a research proposal, consisting of a progress review (P1) and a progress report, oral presentation and discussion which are judged by a panel of supervisors, leading to a go/no-go moment (P2). The assessment is guided by a delegate of the Board of Examiners who operates as a chairperson. In the case of a no-go decision, the student can either retake it within 4 weeks or start the thesis preparation from the beginning.

P3, P4 and P5 belong to the thesis component. P3 consists of a mid-term progress review. P4 is a formal assessment based on the P2 assessment, which is assessed by the supervisors' panel and an additional, independent co-reader. The co-reader is a TU Delft staff member who is knowledgeable in Geomatics. Students pass the P4 stage after the supervisors' panel has established that the research has sufficient quality for graduation. The panel studied the stages of the graduation project and expressed its concern about the rigid deadlines. The programme management explained that this system contributes to a clear structure that students are informed about at the beginning of the year. With the right time management skills, students can graduate on schedule. Some flexibility does exist, according to the programme management, especially in P1, when presentations can be given via Skype.

The P2, P4 and P5 stages are chaired by a delegate from the BoE. Students are offered a time span of a month between P4 and P5 to allow them to improve their research and/or report. The actual grading takes place at P5, and consists of *Research* (50%), *Presentation* (20%), *Project* (15%) and *Process* (15%).

The programme uses a rubric to weight the assessment components in P2, P4 and P5, and to harmonise the grading process. The rubric must be approved by the Board of Examiners.
Important information about the structure and regulations of the graduation process is provided in the graduation manual, which is based on the official regulations of the graduation process of the Faculty of ABE. The manual addresses students, supervisors, delegates from the Board of Examiners and others who are involved in the graduation process. The panel examined the graduation manual and established that it is very clear and transparent.
Board of Examiners

The Board of Examiners (BoE) for Geomatics is responsible for supervising the quality of examinations and assessments and for looking into students' questions, problems and applications regarding, for example, exemptions, minors and accreditation of academic achievements gained abroad. Other tasks include appointing examiners and determining whether students meet the final attainment levels. The BoE consists of seven faculty staff members and one external examiner, and it therefore meets the formal compositional requirements.

The panel was pleased to see that the BoE has standardised the assessments for the complete faculty of ABE, using assessment criteria that are listed in rubrics in the form of test matrices. It also appreciated that the BoE elaborated the improvement and implementation of a new assessment

system in the faculty of ABE. This system will ensure that students know in advance what the programme expects of them and how their work is assessed. The BoE shared its idea about developing an app for lecturers in which they can include their feedback. The panel is positive about this idea and encourages the BoE to move forward with it.

In general, the panel concludes that the BoE has developed suitable measures and instruments for the quality assurance of examinations and assessments. However, the BoE has not been checking whether these guidelines are being properly implemented. The panel advises taking measures to determine whether the improvements have actually occurred. During the site visit, the panel found the discussion with the BoE slightly disappointing. The panel would like to see the BoE take a more proactive role and show that it has a vision regarding academic quality control and assurance for the Geomatics programme.

Considerations
According to the panel, the Geomatics programme has a well-defined and clear assessment procedure. The panel is pleased to see that a requirement for being appointed as an examiner is to have followed an UTQ course. It is convinced that the programme has integrated an effective assessment policy; however, given the limited transparency of the practical application of the test matrices and rubric, it recommends clarifying the way that feedback is given to students by using both rubrics and qualitative feedback.

During the site visit, the panel learned that the BoE has developed suitable measures and instruments for the quality assurance of examinations and assessments. It has also taken the initiative to issue proper assessment guidelines. However, it has not been checking whether these guidelines are being properly implemented. The panel therefore advises that measures should be taken to determine whether improvements have actually occurred. It would also like to see more collaboration between the BoE and the Geomatics programme.

Conclusion
Master's programme Geomatics: the panel assesses Standard 3 as 'Satisfactory'.

Standard 4: Achieved learning outcomes
The programme demonstrates that the intended learning outcomes are achieved.

Explanation:
The achievement of the intended learning outcomes is demonstrated by the results of tests, the final projects, and the performance of graduates in actual practice or in post-graduate programmes.

Findings
Students demonstrate the achievement of their competences on a Master of Science level by conducting an individual graduation project. To judge whether students achieve the intended learning outcomes by the end of the programme, the panel studied the graduation manual, spoke to alumni and reviewed a random selection of recent graduation theses (15).

According to the self-evaluation report, the individual graduation project consists of conducting two types of research:
- research that supports the scientific staff, including post-docs and PhD students, through carrying out a project which fits within the research programme at TU Delft, or organisational agencies or companies who are involved in TU Delft's research programmes;
- research that addresses the application of Geomatics technologies to solve real-world problems, which is usually carried out in close cooperation with organisations and companies.

Students may choose topics concerning Geodata Acquisition; DBMS; 3D modelling; Spatial analysis; Web GIS; Visualisation; Urban Dynamics; Indoor Positioning; Standards; Land Administration; and DTM.

Prior to the site visit, the panel reviewed 15 theses. It was impressed by the excellent research conducted in the programme, which is reflected in the high quality of the theses. The high quality of the research projects is also demonstrated by the large number of scientific publications and conference papers that have resulted from these final research projects. According to the panel, theses showed that students are well equipped to use the tools they learned about in the first year of the programme and to combine these tools within a framework of a given Geo-problem on a subject they are really able to understand.

According to the self-evaluation report and interlocutors, graduates find jobs easily in various companies and public or private institutions. The survey amongst employers shows that companies are mainly positive about the know-how and skills of the graduates.

Considerations
The panel concludes that the learning outcomes of the master's programme are of an extremely high level, as reflected in the graduation projects. A large number of scientific publications and conference papers show that the theses are of very high quality. The theses prove that students are well equipped and able to use the tools they learned about in the first year, which is also confirmed by the surveys of employers. In the surveys, companies are mainly positive about the know-how and skills of the graduates. The panel has also taken note of the fact that alumni are satisfied and feel well prepared for the professional field. In conclusion, it is impressed by the well-considered way in which research is interwoven into the programme and how the structure of the Geomatics programme guarantees the realisation of a broad spectrum of learning outcomes at a master's level.

Conclusion
Master's programme Geomatics: the panel assesses Standard 4 as 'Good'.

GENERAL CONCLUSION

The panel has assessed Standards 2 and 4 as 'good', and Standards 1 and 3 as 'satisfactory'. According to the assessment rules of the QANU, the assessment of the Master's programme Geomatics of Delft University of Technology is awarded a 'good' score.

Conclusion
The panel assesses the *Master's programme Geomatics* as 'good'.

APPENDICES

APPENDIX 1: INTENDED LEARNING OUTCOMES

1. Study Goals Geomatics for the Built Environment
The Generic and Specific study goals are defined in the Student Charter (click here). Below the study goals are listed.

1.1. Generic Study Goals
The Geomatics programme educates future engineers for participation in research, design, realization, operation and maintenance of multidisciplinary projects involving Geoinformation. They are trained in acquiring established knowledge and know-how, in developing new knowledge through systematic research, and in applying this knowledge for the design of operational systems in response to the needs of industry and society.

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.
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.
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).
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.
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.
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.
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.

1.2. Specific Study Goals
A graduate of the Masters 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; (b) applying a formal, theoretical and methodologically sound approach to store, process, manage, disseminate and visualise geo-data and Geo-information; (c) acting at the forefront of data analysis methodology and spatio-temporal database management systems technology; (d) having appropriate knowledge of legal and organisational aspects of Geoinformation; and (e) utilising a technology and application driven approach to geo-data acquisition and Geo-information extraction.
2. Has the research competences to (a) investigate and analyse spatio-temporal models and systems of complex real-world situations; (b) formulate hypotheses or research questions and develop new concepts; (c) validate developed concepts by appropriate prototypes; and (d) analyse and evaluate thoroughly obtained results.
3. Has the competences to design, implement and use (a) models and systems for management, storage, processing, integration, exchange and dissemination of Geoinformation; (b) systems and

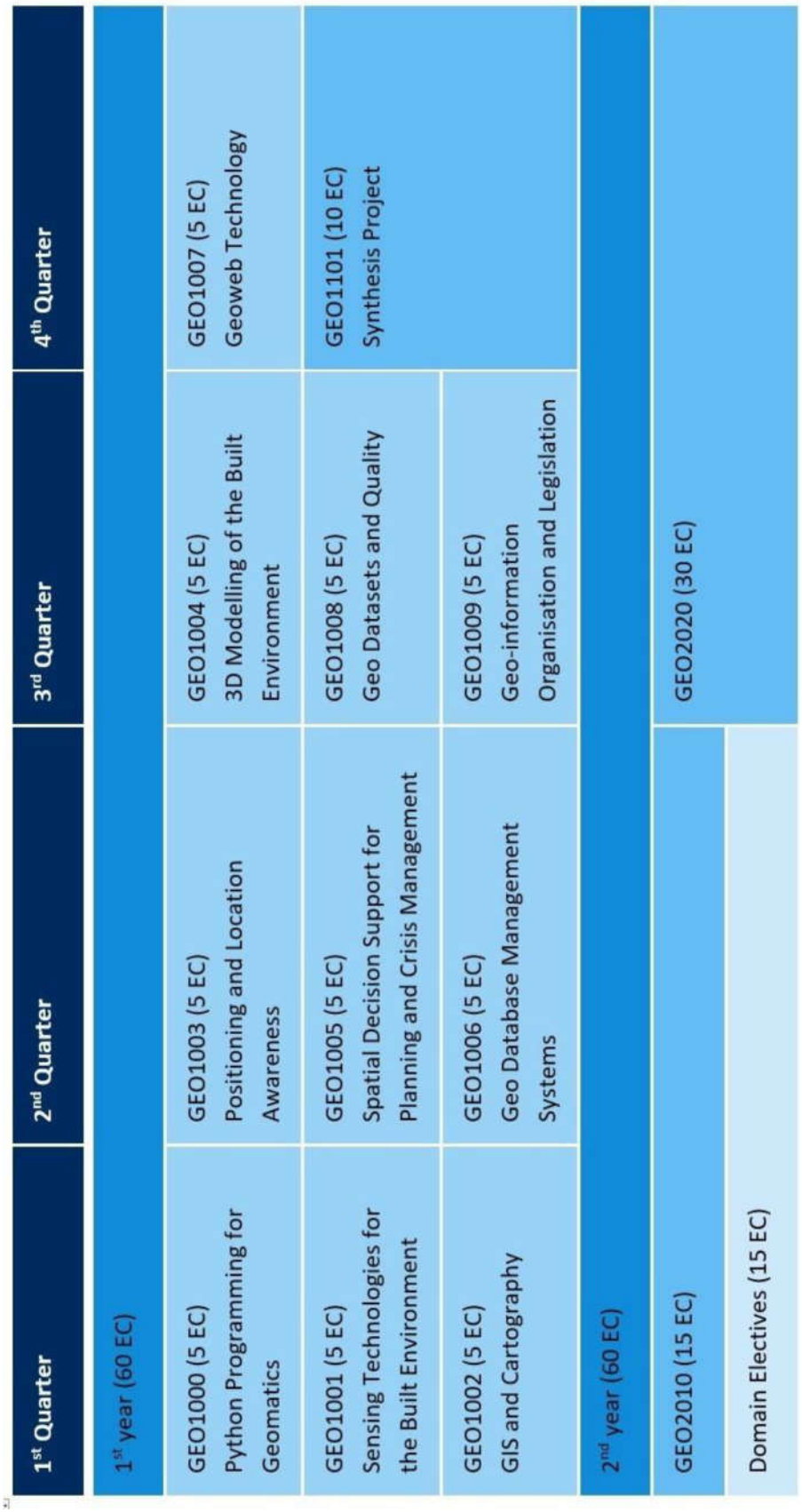
methodologies to analyse measurements and other evidence material for the purpose of Geo-information extraction; and (c) select, combine and extend above-mentioned systems and methodologies to meet Geo-information requirements, notably in the built environment, in the present and in the future.

The implementation of the study goals in the diverse courses and projects is shown in Table 1.

Study Goal	Geo 1000	Geo 1001	Geo 1002	Geo 1003	Geo 1004	Geo 1005	Geo 1006	Geo 1007	Geo 1008	Geo 1009	Geo 1101	Geo 2010	Geo 2020
1		x	X	x	X	X	x	x	x	X	X	X	X
2										X	X	X	X
3					x	x			x	x	X	X	X
4	x	x	X	x	x	x	x	x	x	x	X	X	X
5	x	X	X	X	X	X	X	X	X	X	X	X	X
6										x	X	X	X
7		x	X	x		X		x		x	X	X	X

Table 1 – Genetic study goals realized by core courses; x: contribution; X: major contribution

APPENDIX 2: OVERVIEW OF THE CURRICULUM



APPENDIX 3: PROGRAMME OF THE SITE VISIT

Wednesday 20 June 2018		
8.45	9.00	Arrival panel
9.00	12.00	Preparations panel + reviewing documentation
12.00	12.30	Lunch panel
12.30	13.15	Meeting with management
13.15	13.30	Break panel
13.30	14.15	Meeting with students + student members Program Committee
14.15	14.30	Break panel
14.30	15.15	Meeting with teaching staff + staff members Program Committee
15.15	15.30	Break panel
15.30	16.00	Meeting with alumni
16.00	16.30	Break panel
16.30	17.15	Interview Board of Examiners
18.00	20.30	Diner panel

Thursday 21 June 2018		
8.45	9.00	Arrival panel
9.00	10.00	Panel meeting: reviewing documentation + preparing final meeting with management
10.00	10.30	Final meeting with management
10.30	11.30	Panel meeting: discussing scores
11.30	11.45	Oral feedback by chairman
11.45	12.30	Lunch
12.30	13.30	Development dialogue
13.30		Departure panel

APPENDIX 4: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 15 theses of the master's programme Geomatics. Information on the selected theses is available from QANU upon request.

During the site visit, the panel studied, among other things, the following documents (partly as hard copies, partly via the institute's electronic learning environment):
- General material about assessment;
- the Annual Report and minutes of the Programme Committee and the Board of Examiners;
- Course evaluations 2016-17;
- Teaching and Examination Regulations.
- Course manuals, assessment material, supervisors guide and student guide.