wo-master Spatial Engineering

University of Twente

8 March 2018

NVAO limited initial accreditation

Panel report

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1 Executive Summary

The Accreditation Organisation of the Netherlands and Flanders (NVAO) received a request for an initial accreditation procedure regarding a proposed MSc Spatial Engineering at the University of Twente (UT). The master's programme Spatial Engineering is a two-year full-time (120 EC) curriculum. NVAO convened an expert panel, which studied the information available and discussed the proposed programme with representatives of the institution and the programme during a site visit.

Standard 1. Intended learning outcomes
The Faculty of Geo-information Science and Earth Observation ITC adequately describes the aim of the programme: educating professionals who are able to address wicked problems in the fields of climate resilience, sustainability and legitimacy. At face value, such problems seem unsolvable, because of the entanglement of complex societal as well as technological aspects. Spatial engineers should be equipped with strategies to tackle these problems on regional, national and international levels. The panel agrees that this requires academic level thinking and analytical skills, a multidisciplinary approach and international experience. Engineers are expected to be aware that technological and engineering solutions must function within diverse societal, political, economic and cultural contexts. Therefore, spatial engineers should combine technical engineering, spatial information sciences and spatial planning and governance. For each of these disciplinary fields, the programme is based on international reference frameworks. Based on these frameworks and on the criteria for academic curricula the programme has adequately described the final qualifications to be achieved upon graduation. The external stakeholders, represented in the professional advisory board, find the programme to be up to date and appreciate especially its integrative and multidisciplinary approach. The panel agrees that the programme succeeds in striking a good balance between academic orientation and practical approach, and that the final qualifications are geared to the aim to educate reflective practitioners and empathic engineers. They tie in with the disciplinary requirements and national and international qualification frameworks. The panel recommends rephrasing part of the first final qualification, in order to do justice to the nature of the programme: teaching an interdisciplinary approach to solving problems instead of educating a mono- or multidisciplinary expert. The programme meets standard 1.

Standard 2. Teaching-learning environment
The panel considers the curriculum to be well designed. Year 1 consists of three case study projects (15 EC each) and electives, year 2 is spent on a field trip, an MSc proposal and research project (leading to an MSc thesis) and an internship. Matrices clearly show how the final qualifications are addressed in each study unit. Strong elements are the progress in complexity and independence from one case study project to another and from year 1 to year 2 and the project-led education approach with a high degree of guidance and tutoring. The admission criteria and procedure are suitable to attract the right group of students. The Personal Development Portfolio (PDP) is a key asset of the programme, making the individual student's progress visible throughout the programme. The panel believes that the combination of PDP, mentor system and assessment system (see standard 3) guarantees a balanced development of knowledge and skills in all disciplinary areas and competences. For year 2, the panel recommends renaming the field trip in order to reflect more clearly that this study unit is an important component for institutional, cultural and technical experience and learning. Similarly, the panel recommends clarifying in its title that the MSc preparation includes methodological training. The internship at the end of the programme is not only

legitimate in terms of the final qualifications aimed for, but will also be a good quality indicator to find out from the host institutions if the programme is achieving its aims. Host institutions may be (international) companies or organisations, e.g. those that are represented in the professional advisory board or are partners in ITC projects.

The programme staff is well placed to further develop and implement the programme. The three knowledge areas are evenly distributed among them. The staff members have a diverse background in international research experience, nationality and gender. Multidisciplinarity is extended by cooperation with other faculties at UT. The staff development programme shows that it is not taken for granted that staff will be able to execute the programme and its specific didactic approach without additional training. The panel is convinced that the programme offers a strong teaching-learning environment. The programme meets standard 2.

Standard 3. Assessment
The assessment system is guided by the UT assessment guidelines and framework. The Programme Committee assures the alignment of the assessment system with the final qualifications. The assessment plan, to be approved by the Examination Board, makes this explicit for each study unit and provides information on the assessment formats, modality, marking system and weight and the required level of competence. Different types of tests are used, including peer review. Based on the intended learning outcomes, a type of test is chosen and rubrics for assessment are described. Reliability and validity are enhanced in various ways.

The panel finds that the programme has set up a good combination of individual and group assessments in the first year. The combination of tests, PDP and the oral exams guarantees that the intended level of learning outcomes will be achieved. Furthermore, formative and summative assessment activities are well planned and balanced through courses, terms and years. The panel advises to closely monitor that this will work out as planned and to check if the desired level on all three disciplines is achieved. The assessment system in year 2 is equally well organised. The systematic approach and clear rubrics ensure that the student assessments are reliable and valid. The Examination Board plays an important role in the quality assurance of assessment. The panel appreciates its overall philosophy of assessment. The panel is convinced that the programme has an adequate system of student assessment in place. The programme meets standard 3.

Conclusion
The panel concludes that the programme meets all assessment standards. Given these considerations, the panel advises NVAO to take a positive decision regarding the quality of the proposed programme MSc Spatial Engineering at the University of Twente.

Programme extension
UT proposes that the programme has a duration of two years (120 EC). The programme management's arguments regard the range of disciplines, the required level of scientific knowledge to underpin suitable designs and interventions, and the necessary competences and skills to work effectively in multidisciplinary international environments with project teams and stakeholders. The panel agrees that the qualifications the graduates should have in order for them to be competitive in the international academic job market, cannot be achieved in a programme of less than two years. The panel advises to grant the programme the right to offer a two-year master's programme (120 EC).

The Hague, 8 March 2018

On behalf of the assessment panel convened for the initial limited accreditation assessment of the wo-master Spatial Engineering at the University of Twente.

Prof. dr. Martin de Jong
(chair)

dr. Marianne van der Weiden
(secretary)

2 Introduction

NVAO received a request for an initial accreditation procedure including programme documents regarding a proposed MSc Spatial Engineering. The master's programme Spatial Engineering is a two-year full-time (120 EC) curriculum. The request was received on 20 November 2017 from the University of Twente.

An initial accreditation procedure is required when a recognised institution wants to award a recognised bachelor's or master's degree after the successful completion of a study programme. The procedure for initial accreditation is slightly different as compared to the approach for programmes that have already been accredited. Initial accreditation is in fact an ex ante assessment of a programme. The programme becomes subject to the normal accreditation procedures once initial accreditation has been granted. For programmes requesting an extension of the standard programme duration of 60 EC, an explicit panel advice is required.

To assess the programme, the NVAO convened an international panel of experts:
- Prof. dr. Martin de Jong, Professor of Urban and Infrastructure Development, Multi-Actor Systems Department, Delft University of Technology, Netherlands (chair);
- Prof. dr. David E. Goldberg, Professor Em. Entrepreneurial Engineering, Department of Industrial and Enterprise Systems Engineering (IESE), University of Illinois, Urbana-Champaign, Illinois, USA;
- Anna-Karin Högfeldt, Lecturer and Director of Faculty Training, Royal Institute of Technology, Stockholm, Sweden;
- Lennart van Doremalen MSc, PhD candidate in Subatomic Physics, Utrecht University, Netherlands.

On behalf of the NVAO, Michèle Wera MA, policy advisor, was responsible for the process coordination and dr. Marianne van der Weiden acted as the panel's secretary. Aurelie van 't Slot MA, policy advisor NVAO, participated as an observer.

Details of the panel members' expertise are given in Annex 1 (Composition of the panel). All panel members and the secretary signed a statement of independence and confidentiality.

The panel has based its assessment on the standards and criteria described in the NVAO Assessment framework for the higher education accreditation system of the Netherlands (Stcrt. 2016, nr 69458). To assess the two-year duration (120 EC) of the programme, the panel used the NVAO Protocol for programme extension (8 October 2003).

The panel members prepared the assessment by analysing the documents provided by the institution (Annex 3: Documents reviewed) and formulating the issues and questions they wished to raise during the site visit. These questions were shared by e-mail before the preparatory meeting. The panel organised a preparatory meeting on 5 February 2018, i.e. at the beginning of the site visit. During this meeting, the panel members discussed their first impressions and formulated questions for the various groups to be met during the site visit.

The site visit took place on 5 and 6 February 2018 at the University of Twente. During this visit, the panel was able to discuss the formulated questions and to gather additional information during several sessions (Annex 2: Schedule of the site visit). Afterwards, the panel discussed the findings and considerations and pronounced its preliminary

assessments per standard and on the programme extension (120 EC). At the end of the site visit, the initial findings were presented to the institution.

Based on the findings, considerations and conclusions the secretary wrote a draft advisory report that was first presented to the panel members. After the panel members had commented on the draft report, the chair endorsed the report. On 22 February 2018, the advisory report was sent to the institution, which was given the opportunity to respond to any factual inaccuracies in the report. The institution replied on 2 March 2018. The suggested corrections were adopted. Subsequently the final report was endorsed by the panel chair. The panel composed its advice fully independently and offered it to NVAO on 8 March 2018.

3 Programme

3.1 General

Institution	:	University of Twente
Programme	:	Spatial Engineering
Level	:	master
Orientation	:	academic (wo)
Degree	:	Master of Science
Location	:	Enschede
Study Load (EC)	:	120 EC
Mode of study	:	full-time
Field of Study	:	engineering/'techniek' (as confirmed by the panel)

3.2 Profile of the institution

The University of Twente is a young university that is characterised by its entrepreneurial approach and its combination of technological and social sciences ('High Tech, Human Touch'). It was founded in 1961 as the Twente Technological University of Applied Sciences and changed its name to University of Twente in 1986. At the University of Twente 3,300 researchers and professionals work on research, innovation and education for more than 9,000 students. The university campus hosts approximately 100 (student) companies. The University of Twente has already produced more than 800 successful spin-off businesses. Kennispark Twente stimulates and facilitates starting entrepreneurs. In May 2014, the university obtained a positive NVAO judgement following an institutional audit.

3.3 Profile of the programme

The MSc Spatial Engineering is offered by the Faculty of Geo-information Science and Earth Observation ITC. It aims to train engineers to work with large spatial problems, based on technical knowledge related to civil engineering, including hydrology and geo-engineering, spatial data knowledge to get information from a variety of sources (from satellite imagery to crowd sourced information) and spatial planning & governance knowledge, to be able to embed solutions in society and engage stakeholders in the entire process. The integration of these different disciplines will be achieved in project-led education. Three real-life case studies, together with electives, in the first year provide the basis for the second year in which the student learns to do scientific research.

Year 1	Quartile 1	Case Study Project 1 (15 EC)
	Quartile 2	Case Study Project 2 (15 EC)
	Quartile 3	Case Study Project 3 (15 EC)
	Quartile 4	Electives (15 EC)
Year 2	Quartile 1	Field Trip (7.5 EC)
	Quartile 2	MSc Proposal and MSc Research (37,5 EC)
	Quartile 3	
	Quartile 4	Internship (15 EC)

4 Assessment

4.1 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
In the information dossier, the Faculty of Geo-information Science and Earth Observation ITC describes that the aim of the programme is educating professionals who are able to address wicked problems: at face value, such problems seem unsolvable, because of the entanglement of complex societal as well as technological aspects. Spatial engineers are equipped with strategies to tackle these problems on regional, national and international levels, by including more knowledge about processes, creating more understanding within stakeholder groups and defining the feasibility of potential solutions. This requires academic level thinking and analytical skills. The professional in this field must have

- a time-space perspective and the ability to think in terms of different scales (local, regional, global);
- an understanding of the complex relationship between human beings and their environment;
- a systems approach to analysing physical processes, stakeholders and governance;
- expert knowledge of the Spatial Engineering domain;
- international experience.

An interdisciplinary approach is necessary, because engineers should be aware that technological and engineering solutions must function within diverse societal, political, economic and cultural contexts. Therefore, spatial engineers are expected to combine

- technical engineering (analysing and modelling physical and environmental processes to technical designs and interventions),
- spatial information sciences (geo-information and remote sensing as a source of data to communicate about problem perceptions and proposed interventions) and
- spatial planning and governance (understanding the social system where stakeholders negotiate, steer and manage their relations when exploring, structuring and defining problems and designing solutions).

For each of these disciplinary fields, the programme is based on international reference frameworks, such as ABET (the US engineering accreditation commission) and AESOP (the Association of European Schools of Planning). Based on these frameworks and on the criteria for academic curricula, agreed upon by the technological universities in the Netherlands, the programme has described seven final qualifications. A graduate of Spatial Engineering:

1. is an expert in integrated knowledge development;
2. does research in a purposeful and methodological way;
3. can design interventions for sustainable development;
4. has an academic approach to the development, justified use, and validation of theories and models;
5. is competent in reasoning, reflection and judgment;
6. is competent in cooperation and communication;
7. can work internationally as a global citizen and as an empathic engineer.

In the meetings during the site visit, the panel noted that the rationale for the programme is rooted in the practitioner-based approach of ITC's work in the field worldwide. In these projects, the need for an integrated multidisciplinary approach has become evident. This need was further expressed by representatives from the professional advisory board. They felt that their organisations would benefit from a combination of monodisciplinary specialists and multidisciplinary experts. The professional advisory board expects that the multidisciplinary graduates will be best qualified to oversee a team because they are aware of all knowledge areas and disciplines involved, including intercultural, technical and stakeholder aspects.

The scientific orientation will be guided, as is stated in the information dossier, by the ITC research programme as well as other research groups at the University of Twente (UT). The ITC international research agenda is executed by demand-driven research projects led by ITC professors and supported by expert staff members. During the site visit, programme staff and panel agreed on the term of reflective practitioners, expressing the combination of a practitioner based approach and an academic orientation required by the labour market.

Considerations
Based on the dossier and the constructive discussions during the site visit the panel believes that the master programme Spatial Engineering is a daring new initiative, well attuned to the world of professionals. The programme succeeds in striking a good balance between academic orientation and practical approach. The external stakeholders, represented in the professional advisory board, are excited about the programme and appreciate especially the integrative and multidisciplinary approach.

The master level is demonstrated by the formulation of final qualifications and their relationship to the Bloom's taxonomy of learning levels. The panel agrees that these final qualifications are geared to the aim to educate reflective practitioners and empathic engineers. They tie in with the disciplinary requirements and national and international qualification frameworks.

The panel encourages the programme staff to explicitly manage the polarity of the traditionalist academic on the one hand and the practitioner on the other, by taking the best of both and avoiding their drawbacks. This will lead to a strong intellectual, disciplinary and cultural diversity and the reflective practitioner aimed for. Being aware of such polarities fits with being consistently reflective as a programme and as an institute, knowing that designing an innovative multidisciplinary programme is not a stationary but an iterative process.

The panel notes that the aim is to educate multidisciplinary experts in integrated knowledge development. This implies that their level of knowledge of the three knowledge fields (technical engineering, spatial information science and spatial planning & governance) cannot be as thorough as may be expected from monodisciplinary graduates. One of the final qualifications of the programme is educating students to become experts in integrated knowledge development with the sub goal "The graduate has a thorough knowledge of the theory and principles of ...". This sub goal seems to go beyond the intended level vocalised during the site visit. The panel recommends rephrasing this sub goal to do more justice to the developed programme. A possibility would be to replace "thorough" with "thorough enough" or "sufficient".

Conclusion
The programme meets standard 1.

4.2 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

Structure and contents
The master's programme Spatial Engineering is a two-year full-time (120 EC) curriculum. Year 1 consists of three case study projects (15 EC each) and electives, year 2 is spent on a field trip, an MSc proposal and research and an internship. Matrices show how the final qualifications are addressed in each study unit.

During the site visit, the panel was given a show case presentation on the first case study project, Climate Resilient Cities, focusing on the city of Kampala, Uganda. Students are introduced to core knowledge concepts and theory in the three knowledge fields (technical engineering, spatial information science and spatial planning & governance) which they must integrate and further deepen to work toward solutions for the problem. To ensure that students indeed have the necessary theoretical grounding, they select three choice topics, one in each knowledge field. In addition, keynote lectures are organised to give students a quick overview on the main models, topics and techniques in all three knowledge areas, to allow them to communicate with experts of each. Project groups consist of four or five students. The teaching team allocates the students to the groups and strives for a mix of disciplinary backgrounds, nationalities, gender and team roles. Each group is supported by two tutors who assist with group-work-related issues and potential intercultural issues. At the end of the project, each group presents the intervention they have designed, including an analysis of its effectiveness and feasibility.

This first case study project has been simplified by the teaching staff, in the sense that the problem is relatively clear and the number of stakeholders to be taken into account has been reduced. The second and third case study project are less structured, in content and teaching approach. The theme of the second case study project is Sustainability, in which the students study Food & Water Security in the Mara River Basin, Kenya. This project is more complex: there is less agreement on the nature of the problem and students have to deal with multi-level stakeholders. The third case study project is on Legitimacy and deals with Human Induced Earthquakes in Groningen, the Netherlands. This problem is even more fuzzy and includes a governance crisis. The case study projects will be refreshed by new case studies every three to four years. The panel was informed that the ITC project portfolio offers sufficient possibilities to design appropriate new cases.

In the fourth quartile of year 1, students follow elective courses at ITC or other faculties. Students are given a list of possibilities and are free to choose courses to a total equivalent of at least 15 EC. A course must be of master's level and useful for the student's research project in year 2. The mentor (see below) will help students in making suitable choices.

Year 2 is aimed toward individually achieving master's level academic and professional skills. Firstly, students participate in a field trip to (European) institutes and companies in the knowledge fields of Spatial Engineering (7,5 EC). The field trip is paid for by the institute and is included in the tuition fee. Groups of students each prepare one day of the excursion by relating their experience in the case study projects to the work of the institutes to be visited, and by formulating questions for discussion. The field trip is important for the international skill learning line and the competences of cooperation and communication.

Secondly, students work on their MSc research project. During the proposal writing phase (7.5 EC) students receive additional training in scientific skills and qualitative and quantitative research methods. Approval of the research proposal is necessary for the student to continue into the research phase. The research (30 EC) must be multidisciplinary, using at least two out of the three core knowledge areas, with a strong reflection on the implications for the third area. The topic will be co-created by students and supervisors and integrated into the main research themes at ITC. The thesis must be defended orally before a Thesis Assessment Board.

The last study unit is the internship (15 EC), which has been asked for by the students who have been involved in the development of the programme. Students will be able to provide evidence that they can apply the knowledge and skills acquired during the programme in real world professional practice. Especially project management and personal skills will be the focus of the internship. The internship may be carried out in an organisation in the Netherlands or abroad, with which ITC has a working relation and has made an agreement on the possible placement of interns. This may also be a research institute if a student wants to pursue an academic career. At the end of the internship, the student submits a project report, to be discussed with an assessment committee.

Admission

Incoming students must have a bachelor's degree from a research university and knowledge at bachelor level in at least three relevant knowledge fields, listed in the (draft) education and examination rules. Proficiency in the English language is also a requirement. The teaching staff informed the panel that based on their experience in the existing ITC international master's programme Geo-information Science and Earth Observation, they know the value of degrees from universities in different countries. When in doubt, they can call upon the expertise of Nuffic, the Dutch organisation for internationalisation in education.

Students with a bachelor's degree from a Dutch research university in relevant fields are directly admissible. All other applicants are judged based on an individual CV and motivation letter. Applicants may be admitted conditionally. Graduates from a Dutch university of applied sciences can be admitted on the condition of having completed a premaster programme.

Interested candidates are informed about the multidisciplinary character of the programme and the educational approach, involving a large amount of group work. This information will help to attract and select the target group, referring others, who are e.g. more interested in a monodisciplinary programme, to more suitable possibilities.

Didactic approach

In order to accommodate the different backgrounds of students and to stimulate that students learn from each other, ITC has adopted an integrated, student-centred approach aimed at lifelong learning in an international context. In year 1, project-led education is the core educational concept. This approach coaches students through increasingly complicated projects to independently devise solutions. The programme offers an integrated approach, linking the knowledge of different disciplines (multidisciplinary) to the skills needed to operate between disciplines (interdisciplinary) and further to skills needed to connect to particular stakeholders and user groups in co-learning and co-management in projects (transdisciplinary). The integrated curriculum helps students to link their knowledge to important social skills and work ethics.

Within the master's framework and guidelines, students develop their own learning plans and build their own personal development portfolio (PDP), with the help of a mentor who provides academic guidance. The mentor supports the students in selecting their choice topics and electives, making sure that sufficient attention is devoted to all three knowledge fields. In year 2, the academic guiding role is taken over by the supervisor. The PDP provides students and teachers an overview of learning and serves as a showcase for job applications and a lifelong learning tool.

Students learn not only from their teachers, but also from each other. An important part of the learning process takes place in small groups of four to five students. New groups are set up for each case study project. As mentioned above, the teaching staff takes care that the composition of these groups is sufficiently diverse, in order to enhance the learning opportunities. The group work supports the acquisition of important qualifications, such as cooperation and communication, e.g. presenting project results orally and in writing.

Staff

A teaching staff of 51 members is available. The information provided shows that a large majority of them has obtained a PhD (86%) and a University Teaching Qualification (UTQ, 73%). The three knowledge areas are evenly distributed among them. The staff members have a diverse background in international research experience (100%) and in nationality (37% non-Dutch) and gender (31% female).

Staff members are involved as lecturer, case study coordinator, mentor, tutor, coordinator for field trip and internship and/or supervisor. The programme manager is available to discuss content-related issues of the curriculum and is also appointed as the study advisor.

Not all staff members are familiar with the didactic approach of project-led education and working with a PDP. The panel learnt during the site visit that a staff development programme will provide additional preparation, using role-play and video training.

Facilities

During the site visit, the panel was shown a number of specific facilities, such as the library, decision room and labs. The library provides (physical and digital) access to books, journals and databases and is involved in the academic skills curriculum. Teaching students to evaluate the quality of data and scientific information is an important learning goal. The decision room provides geo-tools for stakeholder involvement in planning and regulated decision-making. It allows researchers to observe the group dynamics and interaction between stakeholders when they talk about the rationale of choices. The geo-science lab of

ITC consists of four different facilities (chemistry, geophysical, spectroscopy and drones). When they want to book one of these, MSc students have priority over project staff and PhD students because their stay at ITC is more limited. For each piece of equipment, all data are stored, so they are available for further research.

Considerations
The panel considers the curriculum to be well designed. Strong elements are the progress in complexity and independence from one case study project to another and from year 1 to year 2, the project-led education approach with a high degree of guidance and tutoring and the range of available facilities. The admission criteria and procedure are suitable to attract the right group of students. The PDP is a key asset of the programme, making the individual student's progress visible throughout the programme. The panel believes that the combination of PDP, mentor system and assessment system (see paragraph 4.3) guarantees a balanced development of knowledge and skills in all disciplinary areas and competences.

The case study projects in year 1 are well prepared and structured, as was apparent in the show case presentation during the site visit. The case studies are based on real data, gained from ITC project work in the regions, but are not authentic in a full sense. The panel recommends adding real stakeholder interaction to create an even stronger learning experience and more engagement. An incremental approach to make actors come more alive, e.g. using media reports to illustrate controversies and differences between stakeholder's views, could be a useful suggestion.

The panel brings forward that it is important that the students get a clear overview of the knowledge in the three main disciplines. From the discussions with staff, it became apparent that lectures will be organised to achieve this, but this was not evident from the written documentation. The panel advises to make it more visible how students obtain this overview in the programme. Similarly, it became clear during the site visit that communication skills are viewed as a two-way process, and both at macro and at micro level. The panel recommends to explicitly include training of students and faculty in noticing, listening and questioning skills, speech acts, storytelling and wholeheartedness.

The contents and learning objectives of year 2 were discussed during the site visit. Initially, the panel felt that the number of EC allocated for field trip and MSc preparation were rather high. The additional information made it clear that they are justified, but, to avoid misunderstandings, the panel recommends to rename these study units and clarify that the field trip is more than a trip and the MSc preparation includes more as well. The field trip is an important component for institutional, cultural and technical experience and learning. It provides an opportunity to boost specific skills not focused on in year 1, such as learning to see how stakeholders are embedded in local culture and organisations, and the role of local institutions in planning and governance. The title should reflect this more clearly. For the MSc preparation, the panel recommends explicitly adding to the title that this includes methodological training.

The internship at the end of the programme is not only legitimate in terms of the final qualifications aimed for, but will also be a good quality indicator to find out from the host institutions if the programme is doing the right thing and achieving its aims. The learning outcomes, stated for the internship, are ambitious and refer to all final qualifications. The panel wonders if all placements will be able to provide an environment in which all of these

can be achieved. The panel advises formulating the learning outcomes in a more targeted way, distinguishing the internship from the other study units in year 2.

The programme staff is well placed to implement the programme. Multidisciplinarity is part of the diversity in the team and is extended by cooperation with other faculties at UT. The staff development programme shows that it is not taken for granted that staff will be able to execute the programme and its specific didactic approach without additional training. The panel was given a good example of how staff will be prepared for the oral exam assessment. The panel is convinced that the programme offers a strong teaching-learning environment. The curriculum, the teaching-learning environment and the quality of the teaching staff will enable the incoming students to achieve the intended learning outcomes.

Conclusion
The programme meets standard 2.

4.3 Standard 3: Assessment

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

Findings
The assessment system is guided by the UT assessment guidelines and framework. The Programme Committee assures the alignment of the assessment system with the final qualifications. The assessment plan makes this explicit for each study unit and provides information on the assessment formats, modality, marking system and weight and the required level of competence. The Examination Board must approve and assess the validity of the assessment plan.

Different types of tests are used, such as oral, written and peer review. Based on the intended learning outcomes, a type of test is chosen and rubrics for assessment are described. Reliability and validity are enhanced in various ways: tests are prepared by the examiner in collaboration with teaching staff involved in the study unit, questions and outcomes are discussed in teaching staff meetings, oral tests will be videotaped and rubrics are used to describe the level of competence for each student. Students are informed about the assessment in the study guide and, in more detail, in the electronic learning environment.

The case study projects are assessed by a combination of four tests: two group-based (40%) and two individual tests (60%). The four tests are a group based inception report as a midterm assessment of the group's take on the wicked problem in the case study project (15%), an individual written test as a midterm assessment on the theory learned during the choice topics (20%), a group based final report and presentation (25%) and an individual final oral test (40%). The panel noted that a number of questions on the choice topics were at the lower levels of the Bloom taxonomy, focusing on reproduction rather than comprehension or analysis. The staff explained that this is indeed true for some of the questions and that this is intentional: they are meant to check that the minimum knowledge is there, and to stimulate the knowledge levels of students at the beginning of the test. Higher levels are assessed in other parts of the assessment system, such as learning how to apply that knowledge. In addition to the formal assessment (summative assessment), continuous feedback (formative assessment) is provided during the projects, both by fellow-students and by the tutors in a well-structured and well-organised way.

The final oral test takes 45 minutes and is conducted by two examiners. The student presents a 7-minute pitch about what the student sees as the important elements of the project, followed by a set of questions on the core knowledge areas and the application of theory from these topics, the overall project work, the student's own component in the project, and the skills-learning lines. The panel wondered if a student could theoretically pass the case study project while failing the individual test on the choice topics or otherwise failing to show sufficient knowledge on each of the three core knowledge areas. The staff explained that this is not possible: a student who fails one of the choice topics, will have to re-sit the test until it is passed. A second chance is offered in the same quartile. If the student fails again, another chance will be given in the following year. A student cannot start on the MSc research project until all case study projects have been passed, including the tests on the choice topics. In addition, students must be able to answer questions on all parts of the project and all knowledge areas during the final oral exams.

The PDP contains the student's plan and choices, specific knowledge gained in courses and projects, development of skills in the learning lines, and reflection on project participation and process. The mentor will guide the student in developing the PDP and keeps track of progress and completeness. Some parts are mandatory to enable the assessment of the final qualifications of the programme. Students may add other items and take parts from the PDP as a showcase portfolio for their future career.

The study units of year 2 are assessed by at least two staff members. The assessments are based on an assessment form, an example of which is available for the students in the electronic learning environment. The student must pass the MSc research proposal qualification before being allowed to start with the MSc research project. The assessment of the field trip focuses on international and multicultural skills, the MSc research on academic and research skills, the internship on project management skills. In all cases, students must show an academic approach and address the core knowledge areas.

The Examination Board is organised at the level of the faculty ITC. As mentioned above, the Examination Board must approve the assessment plan. The Board checks the procedures and system of assessment and if the assessment criteria are in place. Two members of the Examination Board are involved to evaluate tests afterwards, both on content and didactic quality. The Board explained its assessment philosophy for the programme: given the fact that the case study projects have no fixed outcomes, the assessment procedure is of the process engineering type. It does not assess if a solution is good or wrong, but if the way of thinking was adequate.

Considerations

The programme has set up a good combination of individual and group assessments in the first year. The PDP is a valuable instrument. The combination of tests, PDP and the oral exams guarantees that the intended level of learning outcomes will be achieved. The panel feels reassured about the level of the written midterm tests and the assessment of all three knowledge areas in the case study projects. The panel advises the Examination Board to closely monitor if this will work out as planned and that the students have achieved the required level. Similarly, the personal development plan plays an important role as input for the oral exams of the case study projects and in guaranteeing that the students achieve the required level on all three disciplines. The panel advises to closely monitor that this is done correctly and to check if the desired level on all three disciplines is achieved. The panel believes that, in addition to the formal assessment, formative assessment is important, and

sees that this is well included in the teaching and assessment process, offering a valuable system of continuous assessment in the three case studies.

The assessment system in year 2 is equally well organised. The systematic approach and clear rubrics ensure that the student assessments are reliable and valid. The Examination Board plays an important role in the quality assurance of assessment. The panel appreciates its overall philosophy of assessment. The panel is convinced that the programme has an adequate system of student assessment in place.

Conclusion
The programme meets standard 3.

4.4 Conclusion

The initial accreditation information dossier for a wo-master Spatial Engineering, put forward by the ITC Faculty of the University of Twente, proposes a daring master's programme that promises to deliver the ITC-style reflective engineering practitioner of the future who can integrate technical engineering, spatial information systems, and planning and governance knowledge and know-how in the real-world of wickedly complex problems we increasingly face.

The panel has found that the programme meets all standards. 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. The programme offers a strong teaching-learning environment. Strong elements are the progress in complexity and independence from one case study project to another and from year 1 to year 2, the project-led education approach with a high degree of guidance and tutoring and the range of available facilities. The curriculum, the teaching-learning environment and the quality of the teaching staff will enable the incoming students to achieve the intended learning outcomes. The programme has an adequate system of student assessment in place. The programme has set up a good combination of individual and group assessments in the first year. All in all, the panel assesses the quality of the programme as positive.

4.5 Recommendations

Standard 1:
- Rephrase the first sub goal in final qualification #1 to do more justice to the developed programme. A possibility would be to replace "thorough" with "thorough enough" or "sufficient".

Standard 2:
- Add real stakeholder interaction in the case study projects to create an even stronger learning experience and more engagement.
- Implement more visibly in the programme that students achieve the theoretical overview of the core knowledge areas.
- Explicitly include training of students and faculty in noticing, listening and questioning skills, speech acts, storytelling and wholeheartedness, to emphasise that communication is a two-way process.
- Rename the field trip and the MSc preparation in order to clarify that the field trip is more than a trip and the MSc preparation includes methodological training.

- Formulate the learning outcomes of the internship in a more targeted way, distinguishing the internship from the other study units in year 2.

Standard 3:
- Closely monitor if the assessment of core knowledge during the case study projects works out as planned and that the students have achieved the required level on all three disciplines.

4.6 Programme extension

The panel has assessed the arguments, using the criteria put forward in the Protocol for programme extension of NVAO, published on 8 October 2003.

The University of Twente proposes that the master's programme Spatial Engineering has a duration of two years (120 EC). The programme management's arguments regard the international requirements of the programme and the level of complexity of the programme, reflecting the requirements of the multidisciplinary domain of spatial engineering.

Findings
The learning outcomes to be attained by the students must be consistent with the international requirements for the domain. The programme's knowledge base used the international reference frames of three disciplines: spatial planning, geographical information and civil engineering (ABET/OCIB, GI-BOK, AESOP), but goes further. The integrated, multidisciplinary and technical nature of the domain distinguishes the master Spatial Engineering from the separate monodisciplinary domains. Since the programme is a research-oriented programme, the thesis should be the result of a substantive research project.

To check the domain-specific standards in the field of spatial engineering, the programme management has investigated similar master programmes internationally. This search showed there are only two programmes that use a similar name:
- Master of Engineering (Spatial); Melbourne School of Engineering, Australia;
- Master of Engineering Science (Geospatial Engineering); University of New South Wales, Australia.

The content of these two, and other programmes with related names (Environmental Engineering, Copenhagen; Earth Systems Science and Policy, Grand Forks, North Dakota, USA; Earth Sciences, Gothenburg; Earth Science, Uppsala; Earth Resources Engineering, Fukuoka, Japan; Earth and Space Physics and Engineering, Copenhagen) overlap with the UT master's programme Spatial Engineering, but none of them covers more than two of the three knowledge areas. From the comparison of these programmes, it is clear that all of them require a relevant bachelor's degree from an accredited college or university, including sufficient knowledge of mathematics, natural sciences and/or engineering. All programmes have at least a 2-year curriculum.

The learning outcomes to be attained by the students should enable them to compete on an equal basis with their peers on the global labour market. The graduates will need to acquire both academic and professional skills at a master level. The academic and research skills will be grounded on and build up from the technical science base. The spatial engineer is expected to provide scientific knowledge for informed decision making, especially in cases where goals and values are not agreed upon and the knowledge is uncertain. In addition,

the labour market will be global and graduates must be able to evaluate the impact that differences in culture, governance, economics and gender have on the design and suitability of interventions. The acquisition of professional skills and knowledge as well as ethical values needed for working in international and multicultural teams and environments is necessary. The programme management refers to the minutes of the professional advisory board (January 2016), which recommends a strong basis in technical engineering and assures that 'an engineer with only a one year master (60 EC) will not find employment, either in their organisations or internationally'. The outcomes of a labour market research organisation (Panteia) shows that to be able to reach the intended learning outcomes of Spatial Engineering a 120 EC curriculum is required.

Considerations
The first criterion refers to the international requirements for a master programme in the relevant domain. Generally speaking, master programmes in natural sciences and engineering have a duration of two years since the introduction of the bachelors and masters in the Netherlands. Academic programmes in natural sciences and engineering in the Netherlands were set at a duration of five years (300 EC; three years bachelor; two years master), in order to allow the students to attain an international comparable level. The international standard for the programmes was five years and offering an education of four years, implying a one-year master's programme, would have put graduates of Dutch programmes in an unfavourable position compared to their peers abroad, regarding the knowledge and skills they would have acquired. More specifically for the MSc Spatial Engineering, the panel regards the comparison made by the programme management to be relevant and thorough, and concludes that all similar programmes abroad take two years (120 EC). In the opinion of the panel, graduates of the proposed programme should take a two-year master's programme to achieve the learning outcomes, set at an international level.

According to the second criterion, it should be convincingly shown that the learning outcomes that enable the students to compete on an equal basis with their peers from other countries, cannot be attained in a one-year programme. The panel is convinced that the range of disciplines, the scientific knowledge to be achieved to underpin suitable designs and interventions, and the competences and skills to work effectively in multidisciplinary international environments with project teams and stakeholders are essential to the programme. The panel strongly feels that the qualifications the graduates should have in order for them to be competitive in the international academic job market, cannot be achieved in a programme of less than two years.

Conclusion
Given strong arguments in favour of a duration of two years, the panel advises to grant the programme the right to offer a two-year master's programme (120 EC).

4.7 Sector classification

The panel agrees with the proposed sector classification: Technical.

5 Overview

Standard	Assessment
Intended Learning outcomes *Standard 1 : 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*	Meets the standard
Teaching-learning environment *Standard 2 : The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.*	Meets the standard
Student assessment *Standard 3: The programme has an adequate system of student assessment in place.*	Meets the standard
Conclusion	Positive

Annex 1 – Panel

Prof. dr. Martin de Jong (chair) is full professor Urban and Infrastructure Development in China at the Faculty of Technology, Policy & Management of Delft University of Technology (the Netherlands), distinguished professor of International Relations and Public Affairs at Fudan University (China) and guest professor Public Law and Administration at the Erasmus School of Law of Erasmus University Rotterdam (the Netherlands). Martin de Jong (born 1970 in Vlaardingen, married, three children) has obtained his master's degree in public administration from Erasmus University Rotterdam and Leiden University in 1993, a then existing double degree master programme. He obtained his PhD degree in system engineering and policy analysis from Delft University of Technology in 1999. Since then, he has worked or been a visiting scholar (apart from his permanent position at TU-Delft) at the School for Planning and Geography (University of Amsterdam, the Netherlands), the School of Public Policy (George Mason University, USA), the Systems Laboratory (Helsinki University of Technology, Finland), the School of Management (Harbin Institute of Technology, China) and the School of Law and Humanities (Dalian University of Technology, China). He has specialised in urban and infrastructure planning and development, decision-making theory, cross-national institutional comparison and urbanisation in China, especially in transport and eco/low carbon city development.

Prof. dr. David E. Goldberg is an American computer scientist, civil engineer, and former professor at the department of Industrial and Enterprise Systems Engineering (IESE) at the University of Illinois at Urbana-Champaign (UIUC) and is most noted for his work in the field of genetic algorithms. He was the director of the Illinois Genetic Algorithms Laboratory and the chief scientist of Nextumi Inc. He is the author of *Genetic Algorithms in Search, Optimization and Machine Learning*, one of the most cited books in computer science. In 2003, David Goldberg was appointed as the first holder of Jerry S. Dobrovolny Professorship in Entrepreneurial Engineering at the University of Illinois at Urbana-Champaign. Goldberg left UIUC with the aim of transforming higher education through hands-on engagement with campuses in Asia, Europe, North & South America. He continued to support transformative experiences at the University of Illinois for 3 years on a part-time basis. In 2010, Dave Goldberg resigned his tenure and distinguished professorship at the University of Illinois after a 27-year career in academia (Illinois and Alabama) to found ThreeJoy Associates, a coaching, training, and consulting firm to help transform engineering. A civil engineer (Michigan) and leadership coach (Georgetown), he helps better balance the need for technical and professional skills.

Anna-Karin Högfeldt is a Lecturer and Director of Faculty Training at the Royal Institute of Technology. Anna-Karin is actively involved in Nordic and International/cross-continental education evaluation, development and research projects. She is one of the main authors of the book *Guide to Challenge Driven Education*, which originates from a collaboration project with partners in East Africa. At KTH, she has worked ten years strategically to support management, schools, education program directors and individual teachers to strengthen education and system level approaches. She holds a Master's degree in Education, in the specializations of Mathematics and Swedish language and literature. She has been working as a teacher on all school levels including university, mainly in the field of Mathematics. At KTH, Anna-Karin has developed Teacher training courses for PhD-students and faculty,

both in the general field of Teaching and Learning, and in specific fields/topics, such as Grading criteria and assessment, Supervision and Sustainable development. At the moment she is carrying out development and research projects together with partners from Tanzania.

Lennart van Doremalen MSc (student-member) is a PhD candidate at the institute of Subatomic Physics at Utrecht University. He studied the research master 'Experimental Physics' and the bachelor 'Physics and Astronomy' at the same university. During his studies, he was co-founder of the student party Lijst Helder and student representative for this party in UU's University Council. From 2009 until 2010 he was the student board member of the Department of Physics. In 2012, he organised the International Conference of Physics Students (ICPS) in collaboration with fellow students. In addition, Lennart was an active member of the national
student union LSVb, the local student union VIDIUS, and fulfilled several functions as board member or advisor next to his studies. He is also co-founder of the Utrecht municipality council party Student & Starter.

Assisting staff:

- Dr. Marianne van der Weiden, secretary to the panel;
- Michèle Wera MA, policy advisor NVAO and process coordinator;
- Aurelie van 't Slot MA, policy advisor NVAO, participated as an observer.

All panel members and the secretary signed a declaration of independence and confidentiality prior to the assessment process.

Annex 2 – Site visit

Date: 5 and 6 February 2018
Venue: Faculty of Geo-Information Science and Earth Observation (ITC)
Hengelosestraat 99, Enschede

Monday 5 February 2018

13.00-13.15 Welcome
- Prof.dr. T.T.M. Palstra (Thom) Rector, University of Twente
- prof.dr.ir. A. Veldkamp (Tom) Dean of Faculty ITC
- prof.dr. V.G. Jetten (Victor) Programme director for the masters programme
- drs. T. R. Luiten MBA (Tiny) Programme manager for the masters programme
- drs. L.A. Woud-van der Graaf (Lisette), Policy adviser Education, University of Twente

13.15-15.00 Preparatory meeting panel during lunch (closed meeting)

15.00-15.45 Professional Advisory Board
- drs. W. Bekkering (Wil), member of directorate Aeres
- drs. A. de Groof (Arthur), senior consultant at Sweco
- prof.dr. G. van der Steenhoven (Gerard), Director KNMI

16.00-16.45 Tour of the facilities including the decision room, the lab and the library
- dr. J. Flacke (Johannes) Decision Room, Assistant Professor, Department of Urban and Regional Planning and Geo-information Management (ITC-PGM)
- drs. M. T. Koelen (Marga) Library, Coordinator Research Support
- dr. C. Lievens (Caroline) Head Geo-Science Laboratory
- T.K.A. Brefeld (Teresa) tour guide

17.00-18.30 Preparatory meeting panel (closed meeting, continued)

Tuesday 6 February 2018

8.30-9.30 Showcase (Case Study Project 1, Climate Resilient Cities)
- dr.ir. R. van der Velde (Rogier), Assistant Professor, Department of Water Resources, Case study project coordinator, examiner.
- ir. M.J.G. Brussel (Mark), Senior Lecturer, Department of Urban and Regional Planning and Geo-information Management, tutor and expert teacher (tutorial)
- dr. C.L. de Boer (Cheryl), Assistant Professor, Department of Urban and Regional Planning and Geo-information Management , tutor
- dr. ir. S. Oude Elberink (Sander), Assistant Professor, Department of Earth Observation Science, tutor and expert teacher (choice topic).
- prof.dr. P.Y. Georgiadou (Yola), Professor, Department of Urban and Regional Planning and Geo-information Management, coordinator International and intercultural skills learning line

- dr. R.V. Sliuzas (Richard), Associate Professor, Department of Urban and Regional Planning and Geo-information Management, coordinator Academic & Research Skills learning line, Keynote on Kampala
- dr. D. Alkema (Dinand), Project manager, Department of Earth Systems Analysis, coordinator Project management learning line
- dr.ir. S. Salama (Suhyb), Associate Professor, Department of Water Resources, expert teacher (choice topic), mentor
- E. Perez Molina MSc (Eduardo), PhD candidate, Department of Urban and Regional Planning and Geo-information Management, expert teacher (tutorial)
- Dr. M. Brugnach (Marcela), Assistant Professor, Department of Water Engineering and Management, Faculty of Engineering Technology University of Twente, expert teacher (choice topic)

9.45-10.45 Standard 1: Why (a master's programme Spatial Engineering)?
- prof.dr. P.Y. Georgiadou (Yola), Full Professor, Department of Urban and Regional Planning and Geo-information Management
- prof.dr. V.G. Jetten (Victor), Full Professor, Department of Earth Systems Analysis
- prof. dr.ir. A. Stein (Alfred), Full Professor, Department of Earth Observation Science
- prof.dr.ir. A. Veldkamp (Tom), representing portfolio holder education
- drs. T. R. Luiten MBA (Tiny) Programme manager Masters programme Spatial Engineering

11.00-12.00 Standard 2: How (are we teaching the masters programme Spatial Engineering)?
- dr.ir. R. van der Velde MSc (Rogier), Assistant Professor, Department of Water Resources, Case study project 1 coordinator, examiner and expert teacher
- dr. O.C. Mavrouli (Olga), Assistant Professor, Department of Earth Systems Analysis, Case study project 3, expert teacher and tutor
- dr.ir. W. Bijker (Wietske), Assistant Professor, Department of Earth Observation Science, Expert teacher case study project 2, examiner Fieldtrip, mentor
- dr. R.V. Sliuzas (Richard), Associate Professor, Department of Urban and Regional Planning and Geo-information Management, coordinator Academic & Research Skills learning line and study unit MSc Research phase
- dr. M.J. Verkroost (Marie José), Education Development Officer, staff didactical quality

12.00-13.00 Lunch and panel meeting (closed meeting)

13.00-14.00 Assessment
- prof.dr.ir. A. Veldkamp (Tom), Dean of Faculty ITC
- prof.dr.ir. M.G. Vosselman (George), Full Professor, Department of Earth Observation Science, chairman of the Examination Board
- dr.ir. T.A. Groen (Thomas), Assistant Professor, ,Department of Natural Resources, member of the Examination Board

- prof.dr. M. van der Meijde (Mark), Associate Professor, Department of Earth Systems Analysis, chair of the board of studies
- Imam Purwadi, student member of the board of studies

14.00-15.45 Final panel meeting (closed meeting)

14.30-14.45 Extra session

- dr.ir. W. Bijker (Wietske), Assistant Professor, Department of Earth Observation Science, Expert teacher case study project 2, examiner Fieldtrip, mentor
- prof.dr. P.Y. Georgiadou (Yola), Full Professor, Department of Urban and Regional Planning and Geo-information Management
- prof.dr. V.G. Jetten (Victor), Full Professor, Department of Earth Systems Analysis
- drs. T. R. Luiten MBA (Tiny) Programme manager Masters programme Spatial Engineering

15.45-16.00 Feedback outcomes peer review

Annex 3 – Documents

Programme documents presented by the institution

– Application dossier including appendices

Documents made available during the site visit

- Handbooks
- Examples of teaching materials (presentations, assignments)
- List of research topics 2017
- Information on field trip
- Possible internships
- Educational quality assurance documents
- Information on staff support and capacity building
- Pre-programme information for students

- Posters to illustrate various aspects of the programme:
    - Framing of the problem in case studies 1, 2 and 3
    - Content case study projects
    - Most frequently assessed Bloom levels in the study units
    - Building a personal development profile – student workflow
    - How student spends time
    - Staff facts

Annex 4 – Abbreviations

ABET	Engineering accreditation commission USA (originally: Accreditation Board for Engineering and Technology)
AESOP	Association of European Schools of Planning
ba	bachelor
EC	European Credit
GI-BOK	Geographic Information Science & Technology Body of Knowledge
hbo	hoger beroepsonderwijs
ITC	Faculty of Geo-information Science and Earth Observation ITC
ma	master
NVAO	Nederlands-Vlaamse Accreditatieorganisatie
OCIB	Stichting Opleiding Civiel-Ingenieurs
PDP	personal development portfolio
SE	Spatial Engineering
UT	University of Twente
wo	wetenschappelijk onderwijs

The advisory report was written at the request of NVAO and is the outcome of the peer review of the new MSc programme Spatial Engineering of the University of Twente.

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