

Assessment report
Limited Programme Assessment

Master Electrical Engineering

University of Twente

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1. Executive summary

In this executive summary, the panel presents the main considerations which led to the assessment of the quality of the Master programme Electrical Engineering of the University of Twente, which has been assessed according to the NVAO Assessment Framework.

The panel noted that the programme management followed up on the recommendations, made during the previous assessment in 2010. Among others, the programme management reorganized the internal quality assurance system, clarifying the responsibilities of the Programme Committee and the Examination Committee and introduced scoring or rubrics forms to improve the Master thesis assessments.

The programme's name, Master Electrical Engineering, matches its contents and corresponds to the names of similar programmes.

The panel approves of the objectives of this programme, welcomes the future-oriented character thereof and encourages the programme management to continue educating the engineer of the future. The intended learning outcomes of the programme meet these objectives, addressing specialized in-depth knowledge and skills, research skills, knowledge of adjacent fields, academic skills and awareness of the societal impact of technology. The programme management has succeeded in adequately describing the knowledge and skills of the modern T-shaped engineer. These learning outcomes comply with the Meijers criteria of the Dutch Technical Universities and, therefore, meet the requirements of an academic Master programme. In addition, the learning outcomes prepare students for positions in research and industry alike. The participation of industry in the programme is satisfactory, to be deduced, among others, from the position of the Advisory Board within the programme.

The panel is particularly positive about the Domain-specific Frame of Reference Electrical Engineering which the management of the Electrical Engineering programmes of the three Dutch Technical Universities drafted. This Frame of Reference presents a sound and insightful description of this domain and links Dutch Electrical Engineering programmes to authoritative international concepts, notions and trends. The intended learning outcomes meet the requirements of this Domain-specific Frame of Reference.

The panel considers the admission requirements and the admission procedures of the programme to be very adequate. Students' backgrounds are effectively checked against the entry requirements and the contents of the premaster programme for students with degrees of professional University programmes are solid and elaborate.

The curriculum matches the intended learning outcomes. As the curricula of the students are specialized and to a certain degree personalized, the Examination Committee of the programme checks whether each of the curricula meet the learning outcomes. The panel is convinced of the validity of this procedure.

The curriculum exhibits a fair balance between course work in the first year and practical work in the second year and is very adequate in terms of breadth of the subjects addressed and depth to which these subjects are studied. The panel considers the curriculum to be up-to-date.

The information provided to the students and especially the study guidance are very good. The student-to-staff ratio of 15.8 is favorable, which allows for intensive lecturing and guidance of the students. The

master coordinator and the programme mentors are very effective in assisting the students to choose their specialization and to select the courses, thereby ensuring the coherence of the curriculum. Although the supervision of the internships and the Master thesis projects are adequate, the panel suggests to improve the formal organization of the internships. The student success rates after three years are appropriate.

The panel is very positive about the lecturers in the programme, being experts in their fields. The vast majority of them have PhD's, a very substantial number of them possesses BKO-certificates and they have a good command of the English language. The panel found the lecturers to be very motivated to participate in this programme. They are very easily approachable, as students informed the panel.

The panel is impressed by the facilities of the programme. The laboratories, which the panel visited, are state-of-the-art, allowing students to participate in today's research in electrical engineering.

In the panel's view, the test and assessment policies in the programme are appropriate. The procedures adopted in this respect ensure the quality, validity and reliability of the tests and assessments. The assessment procedures of the internships and Master thesis projects are adequate as well. As the Master thesis projects are conducted in distinct research groups, the grading of these projects may differ between these groups. The panel advises programme management to remain attentive in this respect and to strive for calibration of the results across the research groups. The panel recommends introducing the course files in this programme. The Master thesis projects are graded in integers. In the panel's opinion, this somewhat hampers differentiating between thesis projects.

The Examination Committee monitors the test and assessment procedures, the quality of the tests and the students' achieving the intended learning outcomes of the programme.

Having studied the tests and assignments of a number of courses and the internship, the panel concluded these tests and assignments to be satisfactory in breadth and depth and to meet the learning goals.

The figures the programme management collected on the graduates' careers demonstrate that they both meet the demands of industry and are capable of pursuing careers in research. The representatives of industry have favorable opinions of the students and the graduates, which testifies to them meeting the demands of the professional field.

None of the Master theses, the panel studied, have been assessed as unsatisfactory. Though the performances of students and grades differ, some general observations about the theses' quality may be made. About 30 % of the theses was regarded by the panel to be graded somewhat too high. Some theses, on the other hand, were considered to be graded somewhat too low. A number of theses the panel studied, were elaborately written, analytically sound and were clearly of good to very good quality. In the panel's view, the theses show the students having achieved the intended learning outcomes of the programme.

The panel assesses the Master programme Electrical Engineering of the University of Twente to be satisfactory and recommends NVAO to grant re-accreditation to this programme.

Rotterdam, 16 November 2016

Prof. ir. A. van Ardenne
(panel chair)

drs. W. Vercouteren RC
(panel secretary)

2. Assessment process

Certiked VBI received a request to conduct a limited programme assessment for the re-accreditation of the Master programme Electrical Engineering. This request was submitted by the University of Twente.

Certiked requested the approval by NVAO of the proposed panel of experts to conduct this assessment. NVAO have given their approval. The panel composition was as follows (for more detailed information please refer to Annex 4: Composition of the assessment panel):

- Prof. ir. A. van Ardenne, strategic advisor-ASTRON, director Ardenne Consultancy (panel chair);
- Prof. dr. D. De Zutter, professor Electromagnetics, Ghent University (panel member);
- Dr. C.L.M. van der Klauw, director of the research activities and programmes, Philips Lighting (panel member);
- E.E.M. Leo BSc, student Master programme Educational Sciences, University of Amsterdam, (student member).

On behalf of Certiked, drs. W. Vercouteren RC was responsible for the process coordination and for drafting the panel's report. All panel members and the secretary signed a statement of independence and confidentiality.

The panel conducted this assessment on the basis of the standards of the NVAO Assessment Framework of 19 December 2014 (Staatscourant nr. 36791).

The following procedure was adopted. The panel members studied the documents presented beforehand by the programme management, including a number of theses (please refer to Annex 2 and 3: Documents reviewed and Theses reviewed). With respect to the selection and study of the theses, the panel proceeded in line with the NVAO Guidelines for the assessment of final projects during external assessments of 18 February 2015.

Before the date of the site visit, the panel chair and the panel secretary met to discuss the assessment procedures. Before the site visit date, all panel members (a) sent in their preliminary findings, based on the information file submitted by the programme management, (b) a number of questions to be put to the programme representatives on the day of the site visit and (c) their findings about the theses, they had studied. The panel secretary summarized this information.

On 28 September 2016, the panel had a meeting to discuss the preliminary findings concerning the quality of the programme. During this preliminary meeting, the findings of the panel members, including those about the theses were discussed, and a number of questions were added to the list drafted beforehand. On the basis of this input, the panel secretary drew up a final list of questions, which served as a starting point for the discussions with the programme representatives during the site visit.

On 3 October 2016, the panel conducted a site visit on the University of Twente campus. The site visit schedule was in accordance with the schedule drafted beforehand (please refer to Annex 1: Site visit schedule). The programme management communicated the open office hours to the students and staff of the programme. Two students took the initiative to inform the panel on a number of items. The panel has taken this information into account, when drafting their considerations and arriving at the conclusions regarding the programme quality.

In a closed session at the end of the site visit, the panel considered every one of the findings, weighed the considerations and drew conclusions regarding the quality of the programme. At the end of the site visit, the panel chair presented a broad outline of the findings to the programme management.

A draft version of this report was finalised by the secretary, having taken into account the information presented as well as the findings and considerations of the panel. The draft report was sent to the panel members, who studied the draft report and made a number of changes. Thereupon, the secretary edited the final report. This report was presented to the programme management to be corrected for factual inaccuracies. After having been corrected for these inaccuracies, the report was sent to the institution's Board to accompany their request for re-accreditation of this programme.

3. Overview of the programme

3.1 Basic information about the programme

Administrative information about the programme:

Name programme in CROHO: M Electrical Engineering
 Orientation, level programme: Academic Master
 Grade: MSc
 Number of credits: 120 EC
 Specializations: Lab-on-a-chip systems for biomedical and environmental applications, Neurotechnology and biomechatronics, Dependable integrated systems, Communication networks, Integrated circuit design, Integrated optical microsystems, Micro sensors & systems, Nanoelectronics, Robotics & mechatronics, Devices for integrated circuits, Computer vision and biometrics, Telecommunication engineering
 Location: Enschede
 Mode of study: Full-time
 Registration in CROHO: 60353

Administrative information about the institution:

Name of institution: University of Twente
 Status of institution: Government-funded University
 Institution's quality assurance: Approved

Quantitative data about the programme

Percentage of students who completed the programme in three years (n+1)

Cohort	2010	2011	2012
Percentage of students	79 %	73 %	81 %

Lecturers' qualifications

Qualification	MSc	PhD	BKO*
Percentage of lecturers	100 %	98 %	57 %

*BKO means having obtained Dutch University Teaching Qualification. This figure underestimates the lecturer's qualifications, because a number of lecturers have been exempt from this obligation on account of their teaching track record.

The student-to-staff ratio is 15.8.

Number of contact hours per week for each of the years of the programme

Year of the programme	Year 1	Year 2
Number of contact hours per week	8.5	1.3

3.2 Main facts about the institution

The Master programme Electrical Engineering is a programme of the Faculty of Electrical Engineering, Mathematics and Computer Science of the University of Twente.

According to the University of Twente website, the mission statement of the University of Twente is to be the leading entrepreneurial University, to anticipate future developments and to respond rapidly and effectively to the changing world around us. The University's staff are meant to be experts in their field and to assist in setting the agenda for public debate. The University of Twente intends to interact on an ongoing basis with industry, research institutes and government to be able to generate ground-breaking research and world-class innovations. The University wants to produce outstanding graduates who excel by combining expertise from a range of fields, as they design solutions that meet the demands of the future, in the Netherlands and abroad. More than 9,000 students study at the University of Twente, being subdivided in more than 5,000 Bachelor students and about 4,000 Master students.

The University of Twente comprises five faculties, being the Faculties Science and Technology, Electrical Engineering, Mathematics and Computer Science, Engineering Technology, Behavioural, Management and Social Sciences and Geo-Information and Earth Observation. These faculties offer 20 Bachelor programmes and 34 Master programmes.

3.3 Intended learning outcomes

The intended learning outcomes of the programme are as follows. The graduates of the programme are expected:

- To have specialized advanced knowledge in at least one of the specializations of Electrical Engineering.
- To have experience in working in industry-related projects and to have acquired the ability to be effective in a multi-disciplinary environment.
- To be able to work at the frontier of research and design, and to be innovative, contributing to breaking the frontiers of current technology or understanding.
- To define their own research/design goals within the limits of their projects, to judge which parts of the problem need further analysis, to carry out these analyses on an abstract level, to propose experiments and to carry them out in a methodologically correct way.
- To be able to understand, on a general level, areas adjacent to their own area of specialization and use this understanding in the context of their work. They are able to appreciate new knowledge of other disciplines (if necessary, also of non-technical areas) and to integrate this in their work.
- To be able to carry responsibility as leading members of a multidisciplinary design (or research/development) group and to develop broad scopes, e.g. with respect to the economic aspects of their work, or the impact of technological innovation on society. They are serious partners in discussions on aspects regarding the setting and societal environment of their work.

3.4 Outline of the curriculum

In the table below, the programme curriculum has been presented.

Curriculum components	Credits
Compulsory specialization courses	20 EC
Non-technical course(s)	5 to 10 EC
Technical Electives	30 or 35 EC
Year 1 (course work)	60 EC
Internship (outside University of Twente)	20 EC
Master thesis	40 EC
Year 2 (practical work)	60 EC
Total credits of the programme	120 EC

4. Overview of assessments

Standard	Assessment
Standard 1. Intended learning outcomes	Satisfactory
Standard 2: Teaching-learning environment	Good
Standard 3: Assessment	Satisfactory
Standard 4: Achieved learning outcomes	Satisfactory
Programme	Satisfactory

5. Findings, considerations and assessments per standard

5.1 Standard 1: Intended learning outcomes

The intended learning outcomes of the programme have been concretised with regard to contents, level and orientation; they meet international requirements.

Findings

In the words of the management of this Master programme, the main objectives of the Master Electrical Engineering programme are to educate students to achieve high levels of knowledge and skills in this domain, to prepare them for future positions in this field and to meet the present and future demands of industry. More specifically, students of the Master programme are meant to be trained in a spectrum of academic and personal competencies and are meant to expand their knowledge and skills in the Electrical Engineering domain through research and analysis of innovative systems. Students are offered a wide range of specializations within the Electrical Engineering domain from which they may select the specialization of their preference. They will be educated in this subdomain (please refer to section 3.1 of this report for a complete list of these specializations).

In preparation of this external assessment process, the management of the Electrical Engineering programmes of the University of Twente, the Eindhoven University of Technology and the Delft University of Technology drafted the Domain-specific Frame of Reference Electrical Engineering. In this document, the management of these programmes specify the Electrical Engineering domain, especially taking into account the international perspective. For the graduates of the Bachelor and Master programmes in Electrical Engineering consolidated requirements have been compiled. These requirements have been derived from national and international academic and professional sources, such as ABET, the United States-based Accreditation Board for Engineering and Technology and ASIIN, the German Accreditation Organization for degree programmes in Engineering, Informatics, Natural Sciences and Mathematics. In addition, the international IDEA set of qualifications for Electrical and Information Technology were taken into account.

In line with the research foci of the research groups, special attention is being paid in the programme to information-related topics, material science-related subjects and biomedical and health topics with specialized research in Electronics, Communication, Embedded Systems, Robotics, Biomedical Systems, Sensors and Actuators and IC Technology.

The programme management drafted a series of intended learning outcomes (please refer to the complete list in section 3.3 of this report). In these learning outcomes, technical knowledge and skills of the specialization chosen by the students and research skills as well as knowledge of adjacent areas within the domain have been listed. In addition, academic skills such as communication and project management skills as well as awareness of the societal impact of technological innovations have been addressed. The intended learning outcomes specify the competencies of the modern T-shaped engineer, who not only possesses in-depth technical knowledge and skills but also has academic skills and is aware of societal and ethical effects of technological innovations.

To demonstrate the correspondence of the intended learning outcomes of the programme to the Domain-specific Frame of Reference requirements, the programme management drafted a table from which this correspondence may be derived.

In addition, the programme management has shown the intended learning outcomes to comply with the Meijers criteria, being the Dutch Technical Universities standard for the Master level of the learning outcomes. From a table, presented by the programme management, it may be concluded the intended learning outcomes of this programme meet the Meijers criteria for Master programmes.

Quite recently, the programme management installed an Advisory Board with members representing industry. The representatives of industry with whom the panel met, indicated this Advisory Board to be effective in voicing the industry's views on the programme, leading to adequate response on the part of the programme management.

Considerations

The panel approves of the objectives of this Master Electrical Engineering programme of the University of Twente. The panel welcomes the future-oriented character of these objectives and encourages the programme management to continue educating the engineer of the future.

The panel is particularly positive about the Domain-specific Frame of Reference Electrical Engineering which the management of the Electrical Engineering programmes of the three Dutch Technical Universities drafted. To the knowledge of the panel, this Frame of Reference is the first substantial effort in the Netherlands to define and describe the Electrical Engineering domain. In the panel's opinion, this Frame of Reference presents a sound and insightful description of this domain. In addition, the document links Dutch Electrical Engineering programmes to authoritative international concepts, notions and trends in this domain.

In the panel's opinion, the intended learning outcomes of the programme meet the programme objectives. These intended learning outcomes not only address the in-depth knowledge and skills the students are to acquire in their specialization and research skills but also describe the knowledge of adjacent fields which students are to gain. In addition, the academic skills, knowledge of economic aspects and awareness of societal impact of technology have been listed. For the panel, the programme management has succeeded in adequately describing the knowledge and skills of the modern T-shaped engineer.

The panel observed the intended learning outcomes to meet the requirements of the Domain-specific Frame of Reference Electrical Engineering and, therefore, to correspond to international concepts and trends in this domain.

The panel ascertained the intended learning outcomes of the programme to comply with the Meijers criteria of the Dutch Technical Universities and, therefore, to meet the requirements of an academic Master programme.

The panel considers the intended learning outcomes of the programme to prepare students for positions in research and industry alike. The participation of industry in the programme is satisfactory, to be deduced, among others, from the position of the Advisory Board within the programme.

Assessment of this standard

These considerations have led the assessment panel to assess standard 1, *Intended learning outcomes*, to be satisfactory.

5.2 Standard 2: Teaching-learning environment

The curriculum, staff and programme-specific services and facilities enable the incoming students to achieve the intended learning outcomes.

Findings

The number of students enrolling in the programme increased over the years from an influx of 32 students in 2010 to 45 students in 2014. In the years between 2010 and 2013, the number of incoming students remained fairly constant, however. The vast majority of the students come from the own the University of Twente Bachelor programme Electrical Engineering, accounting for about 2/3 of the influx. The intention of the programme management is to raise the number of students in the programme, especially students coming from abroad. This last goal is in line with the University of Twente internationalization policy, aimed at increasing the influx of international students.

Students who have completed the Electrical Engineering Bachelor programme of one of the Technical Universities in the Netherlands are admitted without further conditions. The admission of students with other backgrounds is decided upon by the programme Admission Committee. Students from Dutch professional Universities (HBO) have to take a predefined premaster programme, which includes courses in, among others, mathematics, electromagnetic fields and academic research skills.

The programme management drafted a scheme in which the relations between the intended learning outcomes and the curriculum components have been specified. In addition, the programme management provided an explanation of this scheme.

As has been mentioned under standard 1, students select the courses in the curriculum on the basis of the specialization they have chosen (for the curriculum overview, please refer to section 3.4 of this report). These specializations are organized by the research groups in the Faculty of Electrical Engineering, Mathematics and Computer Science. For each of the specializations, students select a number of specialization courses from a compulsory set, which introduce them to the specialization they have chosen. In addition, they select technical electives, being advanced courses in the specialization area, in adjacent fields or courses dependent upon the student's personal interests. On top of this, students may choose one non-technical course, in addition to the non-technical compulsory course *Philosophy of Engineering*. The package of technical electives is assembled by the student under the guidance of the programme mentor from the research group. The curriculum has to be approved by the Examination Committee of the programme. Whereas the first year of the curriculum is course work, the second year is predominantly practical work and meant to teach the students to apply the knowledge acquired and to gain the skills of the future engineer. The second year is composed of an internship and the Master thesis project. Students will typically take their internships in an industrial setting outside of the University of Twente, working as freshmen engineers under technical, commercial and financial constraints. About 50 % of the students take their internships abroad. In the Master thesis project, the students work on a research subject within the research group of their specialization, this is within the University of Twente. Only occasionally, Master thesis projects are conducted outside of the University, which are also closely supervised. In line with Dutch law, students are allowed to design their own (free) curriculum. These curricula are subject to approval by the Examination Committee. Only very few students opt for such a free curriculum, since the range of choices in the programme is already quite substantial.

The educational principles of the programme are derived from the objective to approach the future work setting of the students as closely as possible. In the courses, students are required to study literature, acquiring knowledge in an independent way and engage in discussions about the course subjects. Study methods in the first year of the programme include lectures, tutorials and supervised practical work. In the second year, students are to learn to work as engineers in the internships and conduct research activities in the Master thesis project. The number of contact hours is 8.5 hours per week in the first year and 1.3 hours per week in the second year.

At the beginning of the curriculum, students are informed by the Master coordinator about the options in the programme. Having decided on their specialization, they assemble their curriculum in consultation with the programme mentor of this specialization. The mentor will guide the student during the curriculum, up to the beginning of the thesis project, where the thesis supervisor will take over. The Faculty of Electrical Engineering, Mathematics and Computer Science Mobility Office will assist students in selecting and organizing a suitable internship. Internships have to be approved by the programme management. During their internships, students are guided by the supervisor of the host organization and a staff member of the programme. Students may consult the programme study advisor for subjects, not directly related to the contents of the programme. The study advisor may give advice on study planning and requests for curricula, to be presented to the Examination Committee for approval. The student-to-staff ratio is 15.8.

The first year of the curriculum has been divided into four quarters, the study load being evenly spread over these periods. The internship in the second year takes 14 weeks, whereas the Master thesis project consumes the rest of the year. Rules have been enforced to prevent the thesis project to take more than the planned time.

The success rate of students having completed the programme within three years increased from 46 % for the cohort of 2009 to 73 % to 81 % for the cohorts of 2010, 2011 and 2012. The programme management assesses these success rates to be satisfactory.

More than 98 % of the lecturers in the programme obtained PhD's and are active researchers in their fields of expertise. About 57 % of the lecturers obtained the Dutch University Teaching Qualification (BKO), testifying to their teaching capabilities. Most of the other lecturers are exempt of this obligation, since they have long and substantial track records in teaching. All lecturers are to be proficient in the English language (C1 or C2 on the Cambridge English Scale), to be demonstrated by means of an assessment. About 85 % of the lecturers have these English language skills. The other lecturers are in the process of acquiring these skills. Guest speakers from industry highlight new developments. Dutch National Student Survey results show the students in this programme to be satisfied with the lecturers' performances. The students with whom the panel met, confirmed this.

For the students, the programme website is accessible, offering information on the programme, the specializations and the courses. All of the research groups, which organize the specializations in the programme, have laboratories at the University of Twente campus, tuned to their research. In addition, clean rooms have been constructed to accommodate research in micro systems and nano systems. The panel was offered the opportunity to visit a number of these facilities. Students are happy with the facilities, so they told the panel.

Considerations

The panel considers the admission requirements and the admission procedures of the programme to be very adequate. The panel welcomes the work of the Admission Committee checking the students' backgrounds against the entry requirements and is very positive about the contents of the premaster programme for students with degrees of professional University programmes.

On the basis of the diagram presented to the panel and the verbal explanation by the programme management, the panel considers the intended learning outcomes to be met in the curriculum. As the curricula of the students are specialized and to a certain degree personalized, it remains a challenge to ascertain whether the intended learning outcomes are met in all of these curricula. The Examination Committee of the programme checks whether this is the case. The panel is convinced this procedure ensures the correspondence between the intended learning outcomes and the curricula.

The panel considers the curriculum of the programme to be quite appropriate, exhibiting a fair balance between course work in the first year and practical work in the second year. The curriculum is regarded by the panel to be very adequate in terms of breadth of the subjects addressed and depth to which these subjects are studied. The panel considers the curriculum to be up-to-date. The programme management, the research groups and the Advisory Board, representing industry keep abreast of new trends and developments.

The information provided to the students and the study guidance are very much up to standard. The panel considers the student-to-staff ratio of 15.8 to be quite favorable, allowing for intensive lecturing and guidance of the students. The panel regards the involvement of the master coordinator and the programme mentors to be very effective in assisting the students to choose their specialization and to select the courses. The efforts of the coordinator and the mentors contribute substantially to the coherence of the curriculum. The supervision of the internships and the Master thesis projects are adequate. The panel suggests, however, to improve the formal organization of the internships, as at the moment they may depend too much on the personal contacts of the lecturers. The panel considers the student success rates after three years to be appropriate.

The panel is very positive about the lecturers in the programme. They are experts in their fields, while the vast majority of them have a PhD and a very substantial number of them possesses BKO-certificates. In addition, the lecturers have a good command of the English language. The panel regards the team of lecturers to be very motivated to participate in this programme. They are very easily approachable, as the students informed the panel.

The panel is impressed by the facilities for the students and lecturers in the programme. Having visited some of the laboratories, the panel considers these to be state-of-the-art, allowing students to participate in today's research in the specializations of electrical engineering.

Assessment of this standard

These considerations have led the assessment panel to assess standard 2, *Teaching-learning environment*, to be good.

5.3 Standard 3: Assessment

The programme has an adequate assessment system in place.

Findings

The management of this Master programme adheres to the University of Twente assessment policy. For the programme, an assessment plan has been drafted, listing the procedures to ensure the quality of the tests and assessments. For each of the courses, test schemes are designed, specifying the learning goals of the course, the tests and the weighing factors of these tests. The tests themselves including the answering models are drafted by one of the lecturers in the programme who presents the test to another lecturer for review. Course files are being introduced in the Bachelor programme Electrical Engineering and will be used in the Master programme. These course files document for each of the courses, among others, the test scheme, test assignments, answering models, marking rules and evaluation results. Students are informed about the tests and the grading of the items in the test. Assessing the tests is done by examiners, who use answering models in case of written tests and scoring models or rubrics in case of assignments. These models are derived from the learning goals of the courses. In case of group assignments, students' individual performances are identified either by the group project supervisor or by an oral examination.

For the Faculty of Electrical Engineering, Mathematics and Computer Science, an Examination Committee is in place and rules and regulations governing examinations and assessment have been drafted. For the programme, a sub-committee of this Committee monitors the examination rules and regulations, ensures the quality of the tests and verifies the graduates having achieved the intended learning outcomes. The Examination Committee appoints the examiners who will only be appointed if they have fulfilled the University Teaching Qualification (BKO) obligations. Handling cases of fraud or plagiarism is part of the Examination Committee's tasks. All written tests are checked for plagiarism.

Test methods adopted in the courses depend on the nature of the learning goals to be assessed and include oral tests, written tests, or the results of projects. Projects may include assessing the use of software tools by the students.

As has been indicated above, the internships are supervised by the supervisor of the organization, hosting the internship and by the internal supervisor of the programme. At the completion of the internships, students are required to present their internship report and are to discuss the report with the internal supervisor. The internal supervisor assesses this report, having read the advice of the supervisor of the host organization. The latter is not involved in the examination of the internship.

The Master thesis projects at the end of the curriculum are assessed by the Graduation Committee, composed of three to five examiners, one of whom being the thesis supervisor. One of the examiners comes from another research group than the group in which the thesis project was conducted. The examiners grade the Master thesis project by means of a scoring model on scientific quality (50 % of the grade), organizational skills (20 %) and oral and written communication skills (30 %). The final grade is the result of discussions among the examiners.

Considerations

The panel regards the test and assessment policies in the programme to be appropriate, as these comply with the University of Twente assessment policy and specify the procedures with respect to the drafting, giving and assessing the tests in the programme. The panel considers these procedures appropriate for ensuring the quality, validity and reliability of the tests and the assessments.

The panel is positive about the position, responsibilities and tasks of the Examination Committee, monitoring the test and assessment procedures, the quality of the tests and the students' achieving the intended learning outcomes of the programme. The panel recommends introducing the course files in this programme.

The assessment of the internships and Master thesis projects is regarded by the panel to be adequate. As the Master thesis projects are conducted in distinct research groups, the grading of these projects may differ between these groups. The panel acknowledges the examiners from outside the research groups may reduce this risk but recommends the programme management to remain attentive in this respect, striving for calibration of the results across the research groups. The Master thesis projects are graded in integers. In the panel's opinion, this somewhat hampers differentiating between thesis projects.

Assessment of this standard

The considerations have led the assessment panel to assess standard 3, *Assessment*, to be satisfactory.

5.4 Standard 4: Achieved learning outcomes

The programme demonstrates that the intended learning outcomes are achieved.

Findings

External supervisors from organizations hosting internships, rated the students' performances during the internships on average 5 on a 6-point-scale. The representatives of industry with whom the panel met during the site visit, declared to be very satisfied with the graduates' capabilities.

The programme management listed the grades for the Master thesis projects for the last five years in order to illustrate the level achieved by the students, at completion of the programme. The average grade for these projects was 8.0 in these five years. Quite a number of these result in scientific publications.

The panel members, also reviewed a total of 15 Master theses and discussed these theses within the panel.

The programme management collected figures on the graduates' careers in recent years. These figures show the majority (about 61 %) of the graduates find a position in industry. Another major part of the graduates (about 29 %) continue their studies, pursuing a PhD trajectory.

Considerations

Having studied the tests of a number of courses of the programme which the programme management presented, the panel concluded these tests to be satisfactory in breadth and depth and to reflect the learning goals of the courses. The assignments and the internship reports, which the panel inspected, meet the learning goals of the courses and the internship.

The panel acknowledges that the favorable opinions of the representatives of industry testify to the students' and the graduates' capabilities and performances and demonstrate that they meet the demands of the professional field.

None of the Master theses, the panel studied, have been assessed to be unsatisfactory by the panel. Although the performances of the students and the grades given differ, some general observations about the theses' quality may be made. About 30 % of the theses were regarded by the panel to be graded somewhat too high. Some theses, on the other hand, were considered to be graded somewhat too low. In some theses, reference to literature would have been more suitable than copying this literature into the thesis itself. A number of theses the panel studied, were elaborately written, analytically sound and were clearly of good to very good quality. In the panel's view, the theses show the students having achieved the intended learning outcomes of the programme.

In the panel's view, the figures the programme management collected on the graduates' careers demonstrate that the graduates meet the demands of industry as well as being capable of pursuing careers in research.

Assessment of this standard

The considerations have led the assessment panel to assess standard 4, *Achieved learning outcomes*, to be satisfactory.

6. Recommendations

In this report, a number of recommendations have been listed. For the sake of clarity, these have been brought together below. The recommendations are the following.

- To improve the formal organization of the internships, as at this moment they may depend too much on personal contacts of the lecturers.
- To introducing the course files in this programme.
- To remain attentive regarding the grading of the Master thesis projects in the distinct research groups and to try and accomplish calibration of the grades across these groups.

Annex 1: Site visit schedule

The site visit took place at the University of Twente on 3 October 2016. The site visit schedule was as follows.

08.30 h. – 09.00 h.	Arrival and deliberations panel (closed session)
09.00 h. – 09.30 h.	Dean and programme management Prof. dr. P. Apers (Dean of Faculty Electrical Engineering, Mathematics and Computer Science), dr. ir. M. Bentum (programme director)
09.30 h. – 10.30 h.	Programme management and core lecturers Dr. M. Korsten (Master coordinator, lecturer), dr. ir. C. Salm (Bachelor coordinator, lecturer), D. Boere MSc (study advisor), dr. ir. M. Bentum (programme director), dr. ir. R. van der Zee (chair Programme Committee, lecturer), prof. dr. ir. B. Nauta (chair Electrical Engineering department, module coordinator, core lecturer), prof. dr. ir. G. Krijnen (core lecturer), prof. dr. ir. R. Veldhuis (core lecturer)
10.45 h. – 11.30 h.	Examination Committee Prof. dr. J. Eijkel, dr. ir. J. Broenink, dr. M. Korsten
11.30 h. – 12.30 h.	Lecturers of a various courses and theses' examiners Ir. B. Molenkamp, dr. ir. A. Kokkeler, dr. ir. L. Spreeuwens, dr. ir. M de Jong, prof. dr. J. Schmitz, dr. ir. P.T. de Boer, prof. dr. ir. W. van der Wiel, dr. ir. L. Segerink
12.30 h. – 13.30 h.	Lunch panel (closed session), open office hours 12.30 h. – 13.00 h.
13.30 h. – 14.15 h.	Tour around facilities (various laboratories)
14.15 h. – 15.00 h.	Students and alumni, including Programme Committee members N. Leijen (Bachelor student, Programme Committee), M. Alesandrovic (Bachelor student), J. van 't Hof BSc (Master student), P. van der Ven (Bachelor student), M. Kriele BSc (Master student), M. Refai Mohamed Irfan BSc (Master student), S. Naveen Kumar BSc (Master student), R. Kers BSc (Master student, Programme Committee), M. Ufkes MSc (alumnus, Thales), M. Brehouwer MSc (alumnus, ASTRON)
15.00 h. – 15.45 h.	Representatives from industry Ir. M. Boer (AEMICS, Advisory Board member), ir. P. Eikendal (Use System Engineering), ir. R. Oude Velthuis (Thales Nederland, Advisory Board member), ir. L. Hogendoorn (TMSi), dr. ir. C. Mensink (Teledyne DALSA), dr. ir. R. Roovers (NXP), dr. ir. C. Roeloeffzen (SARTRAX)
15.45 h. – 16.00 h.	Programme management Dr. ir. M. Bentum (programme director)
16.00 h. – 17.30 h.	Deliberations panel (closed session)
17.30 h. – 17.45 h.	Main findings presented by panel chair to the programme management

Annex 2: Documents reviewed

The panel studied the following documents, presented prior to the site visit:

- Critical Reflection Master Electrical Engineering
- Required appendices, as specified by NVAO
- Domain-specific Frame of Reference
- University of Twente institutional quality assurance audit report
- Study Association Scintilla information
- Criticism in former external assessment report, including programme response
- Assessment form Master thesis
- Meijers criteria for academic Master and Bachelor programmes
- Dublin-descriptors
- Faculty of Electrical Engineering, Mathematics and Computer Science rules and regulations
- Rules of examinations and assessment
- Assessment policy
- Cambridge English scale
- Master programme website
- Course catalogue
- Timetable for the programme and example of schedule
- Internal quality assurance for programme
- University of Twente assessment framework
- Quantitative data on programme, provided by VSNU
- Overview of curriculum
- Description of curriculum components

On the day of the site visit, the programme management presented the following documents:

- Literature
- Course material (representative selection)
- Internship reports
- Tests and examinations (representative selection)
- Examination Committee annual reports
- Programme Committee minutes

In addition, panel members were given access to the programme's electronic learning environment

Annex 3: Theses reviewed

The theses of the following 15 students have been selected for review by the panel

- 1063693
- 0087750
- 0174718
- 1003968
- 0012432
- 1298720
- 0001082
- 1283642
- 1006207
- 0210552
- 1108131
- 1077112
- 0142530
- 1008048
- 1098616

Annex 4: Composition of the assessment panel

The assessment panel had the following composition:

- Prof. ir. A. van Ardenne, strategic advisor-ASTRON, director Ardenne Consultancy (panel chair);
- Prof. dr. D. De Zutter, professor Electromagnetics, Ghent University (panel member);
- Dr. C.L.M. van der Klauw, director of the research activities and programmes, Philips Lighting (panel member);
- E.E.M. Leo BSc, student Master programme Educational Sciences, University of Amsterdam, (student member).

Prof. ir. A. van Ardenne, panel chair

Mr. Van Ardenne graduated from Twente University of Technology as a Master of Science in Electronics and Applied Physics. Having completed his studies, he held, among others, positions as a research engineer, scientific project manager, research & development director and technical director at organizations like ASTRON/NWO, Ericsson Radio Systems and NOFIQ Firesystems. From 2006 to 2015, he was adjunct professor Radio Astronomy at Chalmers University of Technology, Gothenburg, Sweden. Mr. Van Ardenne, currently, is working as a strategic advisor to, among others, the Dutch province of Drenthe, in particular advising on research programmes and space-related activities.

Prof. dr. D. De Zutter, panel member

Mr. De Zutter received his Master of Science degree in Electrical Engineering from Ghent University. He was a research assistant at this University, subsequently obtained a PhD and completing a thesis, leading to the degree equivalent of the French Aggrégation. He, currently, is a full professor of Electromagnetics at Ghent University. His main research interests are circuit and electromagnetic modeling of high-frequency interconnections and packaging, electromagnetic compatibility (EMC) and numerical solutions of Maxwell's equations. Mr. De Zutter is a Fellow of the IEEE. Previously, he held the position of Dean of the Faculty of Engineering of Ghent University.

Dr. C.L.M. van der Klauw, panel member

Mr. Van der Klauw graduated as a Master of Science in Electronics Engineering from Delft University of Technology and received a PhD in the area of semiconductor devices (CCD's). Having completed his studies, he joined Philips Research, working on the design and characterization of CMOS devices and processes. Subsequently, he was employed at Philips Flat Panel Displays, being involved in establishing Philips' joint ventures in Korea and Japan. Subsequently he worked as Chief Technology Officer in Philips Television. Mr. Van der Klauw is, currently, in charge of the research programme of Philips Lighting.

E.E.M. Leo, student member

Ms. Leo is a student in the Master programme Educational Sciences of University of Amsterdam. Previously, she completed the Bachelor programme in Educational Sciences at this University. She was, among others, a member of the Educational Committee of her programme and vice-chair of the Student Council of the Faculty of Social and Behavioral Sciences of University of Amsterdam. Ms. Leo participates as a student member on a regular basis in NVAO-accreditation panels.