

Assessment report
Limited Programme Assessment

Master Electrical Engineering

Eindhoven University of Technology

Contents of the report

1. Executive summary	2
2. Assessment process	5
3. Overview of the programme.....	7
3.1 Basic information about the programme	7
3.2 Main facts about the institution	8
3.3 Intended learning outcomes.....	8
3.4 Outline of the curriculum	9
4. Overview of assessments.....	10
5. Findings, considerations and assessments per standard	11
5.1 Standard 1: Intended learning outcomes	11
5.2 Standard 2: Teaching-learning environment	13
5.3 Standard 3: Assessment.....	16
5.4 Standard 4: Achieved learning outcomes	18
6. Recommendations	19
Annex 1: Site visit schedule	20
Annex 2: Documents reviewed	21
Annex 3: Theses reviewed	22
Annex 4: Composition of the assessment panel	23

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 Eindhoven University of Technology, 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. As the main adjustment, the programme management reorganized the Master curriculum in order to raise student success rates.

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

The objectives of this Master Electrical Engineering programme are sound. For the panel, the programme management has made a distinct and clear choice to educate students to be able to pursue professional and academic careers in this domain.

The panel is particularly positive about the Domain-specific Frame of Reference Electrical Engineering which 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. Dutch Electrical Engineering programmes are linked to authoritative international concepts, notions and trends in this domain.

The panel is very positive about the choices the programme management made, to focus on three societal themes, being *Connected World, Care and Cure* and *Smart and Sustainable Society*. The panel feels these clear choices add substantially to the programme's profile.

The intended learning outcomes of the programme meet the objectives. These learning outcomes specify not only in-depth technical knowledge and skills in the field of Electrical Engineering but also advanced research and design skills, professional skills, such as critical reasoning and reflection, scientific problem-solving skills, communication skills, knowledge and skills to enable students to work in multidisciplinary and interdisciplinary contexts and the awareness of the social impact of science and technology. These learning outcomes specify the competencies 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 to comply with the requirements of an academic Master programme. In addition, the learning outcomes appropriately prepare students for careers in industry and in research in the Electrical Engineering domain.

The admission requirements are valid and the admission procedures of the programme are effective. The panel finds the premaster programme very adequate. In view of the considerable increase in student numbers, the panel recommends to pay attention to the recruitment of students from abroad, to raise the number of staff positions and to maintain the students-to-staff ratio.

The curriculum meets the intended learning outcomes of the programme and is considered by the panel to be adequate in breadth and depth. A substantial number of specializations being offered, students have ample opportunities to select the specialization of their preference. Students are appropriately guided in their choices and, as a consequence, the coherence of the curriculum is ensured. The panel recommends to consider making all core courses compulsory, as these are very relevant for the Electrical Engineering field. The panel has a favorable opinion about the internships and the Master graduation projects but, however, recommends to formalize the criteria for internships and to draft a list of approved internship host organizations. The curriculum is considered by the panel to be up-to-date.

The information provided to the students and the study guidance are appropriate. The student-to-staff ratio of 18 (please refer to section 3.1 of this report) is quite favorable. The lecturers, the Master student counselor and the student mentors ensure the guidance of the students.

The panel considers the student success rates in recent years to be appropriate and regards the efforts of the programme management in this respect to have been effective.

The lecturers are motivated to participate in the programme and are experts in their fields. The vast majority of them have a PhD and many of them participate in research projects in industry. Although measures are being taken to raise the number of lecturers with BKO-certificates, the panel recommends remaining attentive in this respect. The same applies for the number of lecturers, having certificates of proficiency in English.

The panel is impressed by the facilities for the programme. The lecture rooms and laboratories are state-of-the-art, allowing students and lecturers to participate in up-to-date education and research.

The panel regards the test and assessment policies in the programme to be adequate, directed towards ensuring transparent, valid and reliable tests and assessments. The procedures adopted by the programme management with respect to the information provision to students about tests, the drafting of tests and of answering and scoring models and the assessments of tests are appropriate. The procedures for organizing and assessing the Master graduation projects are adequate as well.

The responsibilities and tasks of the Examination Committee are up to standard. The Committee monitors the test and assessment procedures, the quality of tests and the students' achieving the intended learning outcomes of the programme.

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

One of the Master theses has been assessed as unsatisfactory by the panel. The panel considers this to be an outlier, not representative of the quality of the projects in general. The panel considers about 20 % of the theses to be graded somewhat too high, while having assessed a number of theses of good to very good quality. As the projects were written in paper-format, the panel recommends to make it mandatory to include the appendices, to be able to assess the students' performances more reliably, but also to secure sufficient documentation for aggregated learning by next generation students. In the panel's opinion, the Master theses demonstrate the students to have achieved the programme intended learning outcomes.

In view of the high average grade for the Master graduation projects and the relatively high proportion of graduations *with distinction*, the Examination Committee expressed their intention to inspect the grades awarded for the Master graduation projects, especially the higher grades. The panel supports this plan.

As is evident from the recent alumni survey, the graduates of the programme have been well prepared for their careers in industry and in research.

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

Rotterdam, 19 December 2016

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

W. Vercouteren MSc, 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 Eindhoven University of Technology.

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. D. De Zutter PhD, professor Electromagnetics, Ghent University (panel member);
- C.L.M. van der Klauw PhD, 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, W. Vercouteren MSc, 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 sent in their preliminary findings, based on the information file submitted by the programme management, a number of questions to be put to the programme representatives on the day of the site visit and 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 definitive list of questions, which served as a starting point for the discussions with the programme representatives during the site visit.

On 4 October 2016, the panel conducted a site visit on the Eindhoven University of Technology 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. No persons presented themselves.

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: N.A.

Location: Eindhoven

Mode of study: Full-time

Registration in CROHO: 60353

Administrative information about the institution:

Name of institution: Eindhoven University of Technology

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	57 %	75 %	75 %

Lecturers' qualifications

Qualification	MSc	PhD	BKO*
Percentage of lecturers	100 %	97 %	60 %

*BKO means having obtained Dutch University Teaching Qualification (figure for full-time lecturers).

The student-to-staff ratio is 18.

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	12.0	*

*Number of contact hours varies, since year 2 is entirely spent on the internship and Master graduation project.

3.2 Main facts about the institution

The Master programme Electrical Engineering is a programme of the Department of Electrical Engineering of the Eindhoven University of Technology.

According to their website, the mission statement of the Eindhoven University of Technology is to be a leading, international, in engineering science and technology specialized research University. The University wants to offer excellent teaching and research and thereby contribute to the advancement of technical sciences and research in the Eindhoven region and in the world as a whole. The education, research and knowledge valorisation activities of the University are meant to contribute to the solution of major societal issues in the areas of energy, health and smart mobility, to foster the development of technological innovation in cooperation with industry and to strengthen the progress in engineering sciences through excellence in key research areas and through innovation in education.

More than 10,000 students study at the Eindhoven University of Technology, nearly 6,000 of them being Bachelor students and over 4,000 of them being Master students. There are more than 1,000 PhD-students.

The Eindhoven University of Technology comprises nine departments, being the Departments of Biomedical Engineering, Built Environment, Electrical Engineering, Industrial Design, Industrial Engineering & Innovation Sciences, Chemical Engineering & Chemistry, Applied Physics, Mechanical Engineering and Mathematics and Computer Science. These departments offer 11 Bachelor programmes and 22 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 be qualified to degree level within the domain of ‘science engineering and technology’.
- To command the discipline touching on the forefront of the knowledge (latest theories, methods, techniques).
- To be competent in the relevant domain-specific discipline of Electrical Engineering.
- To be able to conduct research and design independently.
- To have the ability and attitude to include other disciplines in their research, where necessary.
- To have a scientific approach to complex problems and ideas.
- To possess intellectual skills that enable them to reflect critically, reason and form opinions.
- To have the ability to communicate the results of their learning, thinking and decision-making processes at an international level.
- To be aware of the temporal and social context of science and technology (comprehension and analysis) and can integrate this context in their scientific work.
- In addition to a recognizable domain-specific profile, to possess a sufficiently broad basis to be able to work in an interdisciplinary and multidisciplinary context. In this context, multidisciplinary means being focused on other relevant disciplines needed to solve the design or research problem in question.
- To have the ability and attitude to seek new potential applications, taking the social context into consideration.

3.4 Outline of the curriculum

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

Curriculum components	Credits
Three core courses (3 x 5 EC)	15 EC
Specialization Path: two specialization courses (2 x 5 EC)	10 EC
Professional Development	10 EC
Six elective courses (6 x 5 EC)	30 EC
Internship	15 EC
Master graduation project	40 EC
Total credits of the programme	120 EC

4. Overview of assessments

Standard	Assessment
Standard 1. Intended learning outcomes	Good
Standard 2: Teaching-learning environment	Satisfactory
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 educating students to be able to embark upon professional careers on an academic level or careers in research, both of these in the Electrical Engineering domain.

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, 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.

Within the domain of Electrical Engineering, as described in the Domain-specific Frame of Reference, the programme management selected a number of focal points, these being in line with the Eindhoven University of Technology policy. These focal points are *Connected World*, aimed at studying communication topics, *Care and Cure*, addressing the challenges arising from an ageing society, and *Smart and Sustainable Society*, dealing with, among others, the transition to clean energy supplies and reducing power and material consumption.

The programme management drafted a series of intended learning outcomes (please refer to the list in section 3.3 of this report). In these learning outcomes, in-depth knowledge and skills in the field of Electrical Engineering, advanced research and design skills, critical reasoning and reflection, scientific problem-solving skills, advanced communication skills, awareness of the social and ethical dimensions of science and technology and knowledge and skills of adjacent areas to be able to work in multidisciplinary or interdisciplinary settings are listed. The programme management's intention has been to describe modern T-shaped engineers and the knowledge and skills they need.

In the self-assessment report, the programme management presented a table, from which may be derived the correspondence of the intended learning outcomes of the programme to the Domain-specific Frame of Reference requirements.

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 the description, presented by the programme management, it may be concluded the intended learning outcomes of this programme meet the Meijers criteria for Master programmes.

The programme management installed an Advisory Board with representatives from industry. As the frequency of their meetings in the last few years remained quite low, the programme management intends to organize at least one meeting per year, from now on.

Considerations

The panel approves of the objectives of this Master Electrical Engineering programme of the Eindhoven University of Technology. In the panel's view, the programme management has made a distinct and clear choice to educate students to be able to pursue professional and academic careers in this domain.

The panel is particularly positive about the Domain-specific Frame of Reference Electrical Engineering which 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. Dutch Electrical Engineering programmes are linked to authoritative international concepts, notions and trends in this domain.

The panel is very positive about the choices the programme management made, to focus on four societal themes, being *Connected World, Care and Cure* and *Smart and Sustainable Society*. The panel feels these clear choices add substantially to the programme's profile.

In the panel's opinion, the intended learning outcomes of the programme meet the programme objectives. These intended learning outcomes specify not only in-depth technical knowledge and skills in the field of Electrical Engineering but also advanced research and design skills, professional skills, such as critical reasoning and reflection, scientific problem-solving skills, communication skills, knowledge and skills to enable students to work in multidisciplinary and interdisciplinary contexts and the awareness of the social impact of science and technology. In the panel's view, these intended learning outcomes specify the competencies of the modern T-shaped engineer, who not only possesses in-depth technical knowledge and skills but has knowledge of adjacent fields, possesses academic and professional skills and is aware of the social and ethical impact of science and technology.

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 careers in industry and in research in the Electrical Engineering domain.

The panel supports the programme management's intentions regarding the position of the Advisory Board.

Assessment of this standard

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

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

According to official data, the number of students enrolling in the programme substantially increased over the years from an influx of 62 students in 2010 to an influx of 131 students in 2014. The majority of the students come from the own Eindhoven University of Technology Electrical Engineering Bachelor programme. Other students come from professional Universities (HBO) in the Netherlands or are from abroad. The programme management is working hard to accommodate the growth in student numbers by, among others, raising the number of staff positions.

Students having completed the University Bachelor programme Electrical Engineering or University Bachelor programmes in a related field are admitted unconditionally. Students having graduated from professional Universities (HBO) in Electrical Engineering or related fields, have to take the courses of the pre-masterprogramme before being able to enroll. Foreign students may be admitted, provided they have a relevant, solid Bachelor degree, have a cumulative grade point average of 7.5 (Dutch grading system) and are proficient in the English language. This last prerequisite applies to all students. The Admissions Board of the Electrical Engineering Department decides on admissions. The programme management informs applicants about the programme contents and the prerequisites to enroll.

In the self-assessment report, the programme management presented a scheme in which the relations between the intended learning outcomes and the curriculum components have been specified. From this scheme, it may be deduced that all of the learning outcomes are addressed in one or more courses.

As of September 2015, the Master programme is part of the Eindhoven University of Technology Graduate School. Next to the Master programme, the Technological Designer programme (PDEng) and a number of PhD programmes belong to the Electrical Engineering programmes within the Graduate School. The rationale of incorporating the Master programme into the Graduate School is narrowing the gap with the PDEng and PhD programmes and considering the Master programme as the first step in the students' careers in stead of the last phase of their education.

The curriculum is composed of core courses, specialization path courses, professional development courses, elective courses, the internship and the Master graduation project (for the curriculum overview, please refer to section 3.4 of this report). Students are to select three out of a total of eight core courses, which are courses, such as *Discrete Mathematics*, *Computational Physics*, *Non-linear Optimization* and *Modeling Dynamics*. Students specialize in their curriculum, choosing two specialization path courses. In the programme, a total of thirteen specialization paths are offered. For specializations, some core courses are preferred. In addition, students take two courses on professional development, encompassing subjects such as project leadership, intercultural communication and academic and professional skills, e.g. research skills and writing and presentation skills. From a wide range of courses, students select six elective courses. Some of the electives are highly recommended, given the specialization. In the second year of the curriculum, students take an internship and complete their Master graduation project. Internships may be research internships within the Eindhoven University of Technology or internships in industry, outside of the University. The Master graduation project is an extensive 40 EC, individual project.

In the courses, a number of distinct study methods have been adopted, being lectures, instructions, tutorials and practical training. For a number of courses, digital learning techniques are being developed, such as web lectures, digital exercises and online tests.

For information on the curriculum and courses, students may access the electronic study guide. Student mentors, i.e. elder students, are available for student guidance. Students are to make a number of choices in the programme, selecting core courses and selecting electives. They are assisted in these processes by the Master student counselor and by mentors from the research groups, organizing the specializations. In the selection of their Master graduation project, students will be advised by the chairs of the research groups. In their internships, students have a supervisor from the programme with whom they meet weekly to discuss their progress. Students have an external supervisor from the host organization as well. In the Master graduation project, students are guided by their supervisor.

The student success rates improved significantly over the last few years. The percentage of students completing the programme within three years increased from 57 % (cohort 2010) to 75 % (cohorts, 2011 and 2012). The programme management is satisfied with this increase and will continue to further improve the student success rates.

The number of staff in the Department of Electrical Engineering amounts to 120 lecturers (83 FTE) and a substantial number of temporary staff. About 97 % of the lecturers in the programme obtained a PhD and are active researchers in their fields of expertise. Many staff members are involved in research and engineering projects in industry. About 60 % of the lecturers obtained the Dutch University Teaching Qualification (BKO). Measures have been taken to raise this figure, in particular lecturers not being promoted, if they do not have BKO-certificates. Over 44 % of the staff members have a certificate of proficiency in English. Dutch National Student Survey results show the students in this programme to be satisfied with the lecturers' performances.

Lecture and project rooms are available. Students have access to laboratories at the Eindhoven University of Technology campus for laboratory work and work on the Master graduation project. The panel was offered the opportunity to visit a number of these brand new facilities.

Considerations

The panel considers the admission requirements valid and the admission procedures of the programme to be effective. The premaster programme is regarded by the panel to be very strong. In the panel's view, applicants are well-informed by the programme management. In view of the considerable increase in student numbers, the panel recommends to pay attention to the recruitment of students from abroad, to increase the number of staff positions and to maintain the students-to-staff ratio.

The panel considers the intended learning outcomes to be met in the curriculum of the programme. The curriculum is considered by the panel to be adequate in breadth and depth, the course contents testifying to this observation. A substantial number of specializations being offered, students have ample opportunities to adapt the curriculum to their preferences and to select their specialization. As students are appropriately guided in their choices by the lecturers and the student counselor, the programme management ensures the coherence of the curriculum. The panel is of the opinion students ought to take not just three out of eight core courses but all eight courses, as these are considered to be fundamental for the Electrical Engineering field. Therefore, the panel recommends to consider making all core courses compulsory. The panel regards the curriculum to be up-to-date.

The information provided to the students and the study guidance are appropriate. The student-to-staff ratio of 18 (please refer to section 3.1 of this report) is quite favorable. The lecturers the Master student counselor and the student mentors ensure the guidance of the students.

Overall, the panel has a favorable opinion about the internships and the Master graduation projects in the curriculum. The panel, however, recommends the programme management to formalize the criteria for internships and to draft a list of approved host organizations, to further improve the internship's quality, certainly in view of the increasing number of students.

The panel considers the student success rates in recent years to be appropriate and regards the efforts of the programme management in this respect to have been effective.

The panel regards the lecturers to be motivated to participate in this programme and to be experts in their fields, while the vast majority of them have a PhD and many of them participate in research projects in industry. Although measures are being taken to raise the number of lecturers with BKO-certificates, the panel recommends remaining attentive in this respect. The same applies for the number of lecturers, in possession of certificates of proficiency in English.

The panel is impressed by the facilities for the programme. Having visited lecture rooms and laboratories, the panel considers these to be state-of-the-art, allowing students and lecturers to participate in up-to-date education and research.

Assessment of this standard

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

5.3 Standard 3: Assessment

The programme has an adequate assessment system in place.

Findings

The Department of Electrical Engineering designed an assessment policy. This policy is in line with the assessment policy of the Eindhoven University of Technology. The main goals of the Department policy is to ensure transparent, valid and reliable tests and assessments and to provide guidelines for the Examination Committee.

For each of the tests, students are informed timely about the nature and conditions of the test. The programme management is in the process of drafting test matrices to align the courses' learning goals and tests' contents. Answering models for written examinations or scoring models or rubrics to assess assignments are drafted prior to the tests. The assessment of tests is done by at least two lecturers, using the answering or scoring models. In case of group projects, student feedback within the group of students or the assessment of the individual contribution of every one of the students in the group is adopted to counter free-riding.

An Examination Committee has been installed for the programmes of the Department of Electrical Engineering. The Examination Committee acts in conformity with Dutch law, monitoring the examination rules and regulations, ensuring the quality of the tests and verifying the graduates of the programme having achieved the intended learning outcomes. Since the number of students increased substantially, sub-committees have been given a mandate to perform some of the Examination Committee's duties, such as approving study programmes and granting exemptions.

For each of the courses, the programme management specified the test methods. For practically all courses in the programme, a set of distinct tests methods have been specified. Test methods adopted are dependent upon the learning goals of the courses and include written examinations, oral presentations, project assignments, quizzes or homework.

The Master graduation project is an extensive 40 EC, individual project. At the beginning, the student and his or her supervisor agree on the graduation plan. Deviations of the plan have to be approved by the Examination Committee. Halfway the project, students are to present their results to the graduation panel, being composed of four to five lecturers, one of whom comes from outside of the research group in which the project is being done. The project supervisor is not a member of this panel, but may give advice. The graduation panel assesses the project on the basis of the written report and the oral defense, using standardized criteria. These criteria are in-depth understanding of the specialization of the project, research skills, professional attitude, referring to, among others, communication skills and planning skills and written reporting and oral defense. Each of these criteria accounts for 25 % of the final grade.

Considerations

In the panel's opinion, the test and assessment policies in the programme are adequate, as these comply with the Eindhoven University of Technology assessment policy and are directed towards ensuring transparent, valid and reliable tests and assessments.

The panel regards the procedures adopted by the programme management with respect to the tests and assessments to be satisfactory with regard to the information provision to students about the tests, the drafting of the tests, answering models and scoring models and the test assessments. The panel is satisfied with the procedures for identifying and assessing individual performances of students in group projects.

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 organization and the assessment of the Master graduation projects are regarded by the panel to be adequate. The graduation project is adequately planned and appropriately supervised. The assessment of the project is conducted by a broad panel of examiners and well-organized, being based upon a set of relevant assessment criteria.

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

The programme management listed the grades for the Master graduation 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 over 8.0 in these five years. A relatively large proportion of the projects has been graded with 9.0 or over. In addition, the programme management indicated the number of students having graduated *with distinction*. For the last seven years, this proportion was about 15 % of the graduates.

The panel members studied a total of 15 Master theses and discussed these projects within the panel.

The programme management conducted a survey among alumni of the programme and collected figures on a number of topics. Of these alumni, 60 % were employed and working in industry, 16 % pursued a PhD-trajectory and 6 % were self-employed. More than 80 % of the alumni indicated to be very satisfied with their current position. About 90 % of them said the programme had provided a good basis for them to find suitable positions in the labor market and to continue their careers.

Considerations

Having studied the tests of a number of courses 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.

One of the Master theses has been assessed as unsatisfactory by the panel. The panel considers this to be an outlier, not representative of the general quality of the projects. Although the performances of the students and the grades given differ, some general observations about the projects' quality may be made. About 20 % of the projects were regarded by the panel to be graded somewhat too high. A number of the projects were clearly of good to very good quality. As the projects were written in paper-format, the panel recommends to make it mandatory to include appendices, to be able to assess the students' performances in a more reliable way and to secure accumulated learning references for future generations of students. In the panel's view, the Master theses demonstrate the students having achieved the intended learning outcomes of the programme.

The panel observed the grades for the Master graduation projects to have been relatively high in recent years and the proportion of students having graduated with distinction to have been relatively sizeable as well. In their meeting with the panel, the Examination Committee expressed its intention to inspect the grades awarded for the Master graduation projects, especially the higher grades and the graduations *with distinction*. The panel supports the plan of the Examination Committee to look into the grading of the Master graduation projects across the research groups, in particular the higher grades.

The panel considers the graduates of the programme to have been well prepared for their careers in industry and in research in the domain of Electrical Engineering.

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.

- In view of the considerable increase in student numbers, to pay attention to the recruitment of foreign students, to increase the number of staff positions and to maintain the students-to-staff ratio.
- To consider making all eight core courses compulsory, as all of these are regarded fundamental for the Electrical Engineering field.
- To formalize the criteria for internships and to draft a list of approved internship host organizations, in order to further improve internships' quality further, particular in view of the increasing student numbers.
- To remain attentive with regard to the number of lecturers, being in possession of BKO-certificates or certificates of proficiency in English.
- To make it mandatory to include the appendices of the Master graduation projects, in order to be able to assess the students' performances in a more reliable way.

Annex 1: Site visit schedule

The site visit was at the Eindhoven University of Technology campus on 4 October 2016, the schedule being:

08.30 h. – 09.00 h.	Arrival and deliberations panel (closed session)
09.00 h. – 09.30 h.	Dean and programme management Prof. ir. B. Smolders PhD (Dean Department of Electrical Engineering), ir. H. de Waardt PhD (director Master programme Electrical Engineering), ir. S. Hulshof (director Bachelor programme Electrical Engineering), J. van Wevelingen MSc (business managing director), D. Daverveld (student advisor Department Board)
09.30 h. – 11.00 h.	Programme management and core lecturers Prof. ir. B. Smolders PhD (Dean Department of Electrical Engineering), ir. H. de Waardt PhD (director Master programme Electrical Engineering), ir. S. Hulshof (director Bachelor programme Electrical Engineering), ir. M. van Beurden PhD (lecturer), ir. H. Jansen PhD (lecturer), prof. S. Weiland PhD (chair Educational Committee), S. Gomez Puente PhD (education advisor)
11.15 h. – 12.00 h.	Examination Committee Prof. ir. T. Basten PhD (chair), E. Bente PhD (member), ir. J. Vleeshouwers PhD (advisor), prof. ir. L. Feijls PhD (external member), prof. S. Weiland PhD (Educational Committee chair), ir. T. Tjalkens PhD (member), S. Gomez Puente PhD (education advisor)
12.00 h. – 13.00 h.	Lunch panel (closed session), open office hours 12.00 h. – 12.30 h.
13.00 h. – 13.45 h.	Meeting with Eindhoven University of Technology Rector Magnificus prof. ir. F. Baaijens PhD and Dean and tour around facilities (various laboratories)
13.45 h. – 14.45 h.	Lecturers of a various courses and theses' examiners S. Zinger PhD, ir. S. Stuijk PhD, M. Matters PhD, M. Lazar PhD, ir. A Tijsseling PhD, ir. R. Mestrom PhD, prof. ir. P. Baltus PhD, S. Gomez Puente PhD (education advisor)
14.45 h. – 15.30 h.	Students and alumni, including Educational Committee members L. Zhang (Bachelor student), T. van Teeffelen (Bachelor student), J. Borsboom (Bachelor student Automotive), S. Beumer BSc (Master student), R. Sanders BSc (Master student), J. Scholten MSc (alumnus), L. Chan MSc (alumna), E. Raaijmakers MSc (alumna)
15.30 h. – 16.00 h.	Representatives from industry C. van Dinther (NXP), P. van Zeijl (Omniradar), G. van den Hoven (Genexis)
16.00 h. – 16.15 h.	Programme management Prof. ir. B. Smolders PhD (Dean), S. Gomez Puente PhD (education advisor)
16.15 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:

- Self-assessment report Master Electrical Engineering
- Relation between intended learning outcomes and courses
- General Eindhoven University of Technology framework: Engineers for the Future
- Curriculum overview
- Core courses Master: Specialization group preferences
- Specialization paths Master
- Overview of composition of teaching staff
- Overview of teaching staff
- Student-to-staff ratio
- Forms of education and assessment
- List of recent graduates
- Course details Master Electrical Engineering
- Key quantitative data
- Domain-specific Frame of Reference
- Assessment policy of Department of Electrical Engineering
- Meijers criteria
- Programme and examination regulations
- Analysis and investment plan growth student numbers Electrical Engineering (in Dutch)
- Regulations Examination Committee
- Research report Department of Electrical Engineering

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

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

Annex 3: Theses reviewed

The Master graduation projects (theses) of the following 15 students have been selected for review by the panel

- 0633552
- 0758240
- 0637088
- 0787916
- 0643182
- 0715979
- 0720074
- 0655840
- 0650183
- 0738540
- 0806248
- 0630365
- 0631025
- 0630291
- 0718164

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. D. De Zutter PhD, professor Electromagnetics, Ghent University (panel member);
- C.L.M. van der Klauw PhD, 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. D. De Zutter PhD, 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.

C.L.M. van der Klauw PhD, 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.