Assessment report
Limited Programme Assessment

Bachelor Electrical Engineering

Delft University of Technology

Contents of the report

1. Executive summary

In this executive summary, the panel presents the main considerations which led to the assessment of the quality of the Bachelor programme Electrical Engineering of the Delft 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. Among others, the programme management improved the relationship with the professional field, identified the learning tracks in the curriculum more clearly, fostered the coherence of the curriculum and took measures to improve the student success rates.

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

The panel approves of the objectives of this programme and welcomes its focus to train the students in this domain at the Bachelor level and to prepare them for a number of relevant Master programmes.

The panel is particularly positive about the Domain-specific Frame of Reference Electrical Engineering that 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 intended learning outcomes of the programme meet the objectives, reflecting the thorough foundation in mathematics, physics, computer science, systems and models, in-depth knowledge of the Electrical Engineering subdomains, research skills, academic skills and social and ethical awareness. Though these last subjects are covered in the learning outcomes, the panel feels the programme being predominantly technically oriented. The panel recommends the programme management to continue their line of thinking on the modern T-shaped engineer and to fit the learning outcomes to these requirements.

The learning outcomes meet the requirements of an academic Bachelor programme and prepare students for relevant Master programmes. The participation of industry in the programme, as exemplified by, among others, the Industrial Advisory Board is satisfactory.

The panel considers the admission requirements to be in line with legal regulations and the admission procedures to be effective in informing the applicants about the challenging nature of the programme.

The intended learning outcomes are met in the curriculum. The curriculum is regarded very positively by the panel, being up-to-date, highly focused and very coherently structured, allowing students to acquire in-depth knowledge of and skills in the Electrical Engineering domain. The projects in the curriculum place knowledge and skills in a broader perspective, introducing practice and training in a number of academic skills. The teaching tracks ensure the coherence of the curriculum.

The educational principle, combining theory and practice, is effective to promote the study pace. The study methods such as lectures, tutorials, lectorials, lab sessions and projects are consistent with this principle. The panel welcomes the new study methods, being introduced in the programme.

The mentoring system and the actions of the academic counsellor are effective in promoting student study progress. The panel welcomes the honours programme, as an opportunity for talented students.

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

The panel thinks very highly of the lecturers in the programme, being renowned experts in their fields and the majority of them having BKO-certificates. The panel supports the plan of the programme management to appoint and recruit dedicated and recognized tutors for the projects. The students indicated to be generally satisfied with the lecturers' educational qualities.

The panel regards the facilities in the programme to be adequate. Having visited some of the laboratories, the panel considers these to be up-to-standard, allowing students to participate in up-to-date education and research.

The panel regards the policies and procedures of the tests and assessments in the programme to be adequate. The policies are meant to ensure valid, reliable and transparent tests and assessments. Tests are drafted by at least two lecturers. Test matrices and rubrics are being implemented. The test methods are varied, being attuned to the learning goals of the courses. The assessment of the projects in the curriculum is elaborate, several tutors being involved in multiple assessments. The panel is satisfied with the procedures for assessing individual performances of students in these group projects.

The panel is positive about the position, responsibilities and duties of the Board of Examiners. This Board monitors the test and assessment procedures, looks into the quality of the tests and inspects the Bachelor graduation projects to verify whether students have achieved the programme intended learning outcomes.

The assessment of the Bachelor graduation projects is regarded by the panel to be appropriate, this being done by more than one examiner, on the basis of a set of relevant criteria. The students' individual contributions in these group projects are being identified appropriately.

Having studied the tests of a number of courses, the panel concludes these to be satisfactory in breadth and depth and to reflect the learning goals. Not one of the Bachelor graduation projects, the panel studied, has been assessed as unsatisfactory. About 25 % of these projects are regarded by the panel to be graded slightly too high, whereas about half of these are assessed by the panel to be clearly of good to very good quality, being elaborate and exhibiting relatively high levels of knowledge and skills. In the panel's opinion, the graduation projects show the students to have achieved the intended learning outcomes of the programme and a substantial proportion of the students to have surpassed the required level. The figures on the graduates' follow-up education show that the graduates meet the demands of Master programmes and are able to continue their studies at Master level.

The panel assesses the Bachelor programme Electrical Engineering of the Delft University of Technology to be good and recommends NVAO to grant re-accreditation to this programme.

Rotterdam, 17 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 Bachelor programme Electrical Engineering. This request was submitted by the Delft University of Technology.

Certiked requested the approval by NVAO of the proposed panel of experts to conduct this assessment. NVAO have given its 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 sent in (a) 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 assignments 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 5 October 2016, the panel conducted a site visit on the Delft 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 made use of this option.

In a closed session at the end of the site visit, the panel considered each 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: B Electrical Engineering
Orientation, level programme: Academic Bachelor
Grade: BSc
Number of credits: 180 EC
Specializations: N.A.
Location: Delft
Mode of study: Full-time
Registration in CROHO: 56953

Administrative information about the institution:

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

Quantitative data about the programme

Percentage of students who dropped out after one, two or three years (vwo matriculation)

Cohort	2009	2010	2011	2012	2013	2014
Drop-out rate after one year	40 %	32 %	39 %	34 %	36 %	38 %*
Drop-out rate after two years	45 %	34 %	42 %	38 %	40 %*	
Drop-out rate after three years	45 %	37 %	42 %	38 %*		

* preliminary data

Percentage of students who continued their study in the second year and who completed the programme after three, four, five and six or more years (vwo matriculation)

Cohort	2007	2008	2009	2010	2011
Success rate after three years	24 %	18 %	23 %	21 %	25 %
Success rate after four years	43 %	43 %	55 %	56 %	55 %
Success rate after five years	54 %	59 %	77 %		
Success rate after six or more years	68 %	64 %			

Percentage of students who continued their studies in the second year and who completed the programme after three, four, five and six or more years (all students)

Cohort	2007	2008	2009	2010	2011
Success rate after three years	20 %	20 %	23 %	22 %	24 %
Success rate after four years	40 %	43 %	53 %	53 %	51 %
Success rate after five years	49 %	57 %	74 %	70 %	
Success rate after six or more years	62 %	63 %			

Lecturers' qualifications

Qualification	MSc	PhD	BKO*
Percentage of lecturers	100 %	84 %	89 %

*BKO means having obtained Dutch University Teaching Qualification.

The student-to-staff ratio is 24.

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

Year of the programme	Year 1	Year 2	Year 3
Number of contact hours per week	18.2	16.0	12.3*

*This figure refers to one semester (20 weeks) of the year. The minor constitutes the other semester (20 weeks). In the minor, the number of contact hours may differ, but is within a regular range.

3.2 Main facts about the institution

The Bachelor programme Electrical Engineering is a programme of the Faculty of Electrical Engineering, Mathematics and Computer Science of the Delft University of Technology.

According to the Delft University of Technology website, the University's mission statement is to make a significant contribution towards a sustainable society for the twenty-first century by conducting groundbreaking and world-class scientific and technological research, by training scientists and engineers with genuine commitment to society and by helping to translate knowledge into technological innovations and activity with both economic and social value. The Delft University of Technology wants to remain a technology university with a leading global reputation. To do this, the University's aim is to maintain a full range of high-quality disciplines, courses and unique facilities in the engineering sciences.

More than 4,500 students study at the Delft University of Technology, being subdivided in more than 3,000 Bachelor students and about 1,500 Master students.

The Delft University of Technology comprises eight faculties, being the Faculties of Aerospace Engineering, Applied Sciences, Architecture and the Built Environment, Civil Engineering and Geosciences, Electrical Engineering, Mathematics and Computer Science, Industrial Design Engineering, Mechanical, Maritime and Materials Engineering and Technology, Policy and Management. These faculties offer 16 Bachelor programmes and 40 Master programmes.

3.3 Intended learning outcomes

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

- (Knowledge of fundamental disciplines) To possess broad and thorough knowledge of and skills in the fundamental engineering sciences, which form the basis for electrical engineering. These include mathematics (linear algebra, Boolean algebra, numerical analysis, complex function theory, integral transformations, differential equations, statistics), physics (electricity and magnetism, electromagnetic waves, mechanics, physics of solids), computer science (programme development, algorithmics, systems architecture), systems and models (measurement and control technology, stochastic processes, signals and systems). The graduates can actively apply this knowledge to electrical systems and have the required level of expertise to be able to gain admission to internationally accredited electrical engineering Master degree programmes.
- (Knowledge of electrical engineering) To possess basic technical and scientific knowledge of and skills in the most important electrical engineering disciplines, namely network theory, telecommunication technology and systems, signal processing, electronic circuits, electrical power engineering, semiconductor components and computer technology. The graduates can actively use their knowledge to analyze and design electrical systems, and to read and understand scientific literature in the above-mentioned fields.
- (Research and design) To possess basic knowledge of and skills in methods and tools for modeling, simulating, designing and conducting experiments with and research into electrical systems. The graduates can actively use this knowledge to analyze and synthesize electrical systems (with a high degree of abstraction).
- (Scientific approach) To be able to contribute to solving technological problems by means of a systematic scientific approach. This concerns conducting an analysis, defining innovative solutions, recognizing the feasibility, recognizing and acquiring knowledge that is lacking, as well as recognizing the relativity and limitations of this knowledge, and the effect of the solution.
- (Collaboration) To be able to work individually and in (multidisciplinary and multinational) teams, and to be able to take the initiative when necessary.
- (Communication) To be able to effectively communicate (including presenting and reporting) with both professional colleagues and a non-specialist audience on their work with regard to information, problems, ideas and solutions.
- (Taking the temporal and social context into account) To be capable of collecting and interpreting relevant information, to be able to evaluate the technological, business-related, social and ethical consequences of their work, and to be able to take responsibility with regard to sustainability, economy and social welfare. The graduates contribute to scientific practice (research system, relationship with clients, publication system, importance of integrity, etc.).
- (Reflection) To show initiative and to be capable of critical reflection (with assistance) on their thinking, decision-making and acting, and to be able to adjust their methods accordingly. The graduates can keep their competences at a high level and expand them by means of permanent self-study, with a high degree of independence.

3.4 Outline of the curriculum

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

Curriculum components	Credits
Linear Circuits A	5 EC
Linear Algebra en Analysis A	5 EC
Classical and Quantum Physics	5 EC
Linear Circuits B	5 EC
Linear Algebra and Analysis B	5 EC
Electrical Engineering Project 1: Booming Bass	5 EC
Amplifiers and Instrumentation	5 EC
Probability and Statistics	5 EC
Digital Systems A	5 EC
Electricity and Magnetism	5 EC
Digital Systems B	5 EC
Electrical Engineering Project 2: Smart Robot Challenge	5 EC
Year 1	60 EC
	5 EC
Integrated Circuits	5 EC
Complex Analysis	5 EC
Electrical Energy Conversion	5 EC
Signals and Systems	5 EC
Linear Algebra and Differential Equations	5 EC
Electrical Engineering Project 3: Design a Chip	5 EC
Systems and Control	5 EC
Telecommunications A	5 EC
Sustainable Energy Supply	5 EC
Signal Processing	5 EC
Telecommunications A	5 EC
Electrical Engineering Project 4: KITT, Autonomous Driving Challenge	
Year 2	60 EC
Minor	30 EC
Electronics	5 EC
Electromagnetics	5 EC
Computer Architecture and Organization	5 EC
Bachelor graduation project	15 EC
Year 3	60 EC
Total of the programme	180 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	Good
Programme	Good

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 Bachelor programme, the main objectives of the Bachelor Electrical Engineering programme are to train students of this programme at the Bachelor of Science level in Electrical Engineering, to educate these students to achieve the intended learning outcomes of this programme and to prepare them for admission to subsequent Master programmes, such as Electrical Engineering, Computer Engineering, Embedded Systems, Biomedical Engineering and Systems & Control. More specifically, the programme management intends to teach the students the academic Bachelor attitude to science and design, to give them a solid foundation in mathematics and physics and to offer them a broad spectrum of topics 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.

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, fundamental knowledge of mathematics, physics, computer science and systems and models, knowledge of the Electrical Engineering subdomains, knowledge of and skills in research and design, scientific approach, collaboration skills, communication skills, awareness of business-related, social and ethical aspects and the ability to reflect critically on thinking, decision-making and acting have been specified.

To demonstrate the correspondence of the intended learning outcomes of the programme to the Domain-specific Frame of Reference requirements, the programme management in the self-assessment report presented a table from which this correspondence can 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 Bachelor level of the learning outcomes. From a table presented in the self-assessment report, it may be concluded that the intended learning outcomes of this programme meet the Meijers criteria for Bachelor programmes.

The programme management installed an Industrial Advisory Board with members representing industry. In the Bachelor graduation projects, students simulate in-company engineering activities and sometimes these projects are proposed by external companies.

Considerations
The panel approves of the objectives of this Bachelor Electrical Engineering programme of the Delft University of Technology. The panel welcomes the focus of the programme management to train the students in this domain at the Bachelor level and to prepare them for a number of relevant Master programmes. Teaching the students thoroughly in mathematics and physics and broadly in Electrical Engineering topics and offering them the academic Bachelor attitude to science and design, is regarded positively by the panel.

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. 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 reflect the thorough foundation in mathematics, physics, computer science, systems and models and knowledge of the Electrical Engineering subdomains. In addition, research skills and academic skills such as collaboration skills, communication skills and critical thinking and social and ethical awareness are included. Although it is acknowledged that the last mentioned subjects are covered in the intended learning outcomes, the panel feels the programme being predominantly technically oriented. As the panel learned, the programme management considers to better adapt the programme to the modern T-shaped engineer requirements. The panel recommends the programme management to continue this line of thinking and to fit the intended learning outcomes to these requirements.

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 Bachelor programme.

The panel considers the intended learning outcomes of the programme to prepare students for Master programmes in this domain. The participation of industry in the programme is satisfactory, to be deduced, among others, from the position of the Industrial Advisory Board.

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 more than doubled over the years from an influx of 66 students in 2008 to an influx of 139 students in 2014. The proportion of female students increased from 4 % in 2013 to 9 % in 2016. The vast majority of the students have as their previous education the Dutch *vwo-diploma*. The rest of the students are from professional Universities (HBO) or come from countries outside of the Netherlands.

The entry requirements for students are to have a Dutch *vwo-diploma*, with the required level of physics and mathematics. Students from professional Universities having completed their first year in the field of electrical engineering or a closely related field, are admitted as well. They may be required to take the HBO-bridging programme. Other applicants, fulfilling certain requirements, may be required to the *colloquium doctum* test.

As the programme is challenging, applicants are informed extensively by the programme management about the contents and the workload. In this way, the programme management wants to decrease the drop-out rates. In addition, applicants may participate in the study-choice check system, which includes making challenging homework, writing a motivation letter, spending a full day on the campus with lectures, taking a concluding test and having an interview with a senior staff member. The grades for mathematics and physics in their previous education are being used as predictors for study success. Taking part in this study-choice check system is not mandatory but is highly recommended and the outcome appears to have a strong correlation with study results.

The programme is Dutch-spoken. The programme management has the intention to change the language of instruction to English, since positions in companies of graduates of Electrical Engineering Master programmes increasingly require proficiency in the English language.

The programme management presented a table in the self-assessment report in which the relations between the intended learning outcomes and the curriculum components were specified. From this table, it can be deduced that all of the intended learning outcomes are addressed in the curriculum.

The curriculum is composed of courses, which typically have a study load of 5 EC. The study years have been divided into four quarters, each of these encompassing three courses. Through the curriculum run a number of teaching tracks to which each of the courses belong. These tracks are Mathematics, Physics, Circuits, Signals and Systems, Computer Engineering, Telecommunications, Electrical Energy, Projects, the Minor and the Bachelor graduation project. In the first-mentioned tracks, students acquire knowledge and skills on these subjects, predominantly by means of lectures and lab sessions. In the projects, students are required to complete open-ended assignments in groups of six to twelve students. In these projects, students not only complete the assignments but also practice academic skills, such as collaborating, communicating orally and in writing, planning the completion of the assignments and scheduling the project activities. Specific tasks are related to roles within the project team. In the first year, the roles in the projects rotate to allow students to fulfill each of the roles. All of the courses as well as the projects are compulsory. Only in the 30 EC minor in the third year, students may select courses of their choice.

All minor options of Delft University of Technology, minors offered by other institutions, minors abroad or internships are open to the students. Only very few students take internships. The number of students going abroad, is gradually rising. In the 15 EC Bachelor graduation projects, students work together to complete this assignment (please refer to standard 3, for more detailed information).

The educational principle of the programme may be summarized as the balanced combination of theory and application of concepts and notions. Application plays an important part in the education, as a means to support conceptual understanding, to accommodate different learning styles, to relate theory to real-world experiences and to train academic skills, such as critical thinking and problem-solving. Study methods in the programme include lectures, tutorials, lectorials, laboratory sessions and projects. Lectorials are a combination of instruction by the lecturer, followed in the same session by tutorials with active student participation, guided by several lecturers. The programme management is introducing new study methods, such as *MOOC's* (Massive Open On-line Courses) and *flipping the classroom*.

Lecturers meet and discuss the study load in the various courses, in order to adjust these loads. While the curriculum is designed with a specific order of courses, students are only in certain cases required to take the courses in the prescribed order, but are otherwise made aware of the disadvantages of changing order.

For information on the programme, students may access the digital study guide. To intensify student guidance, the programme management implemented the mentoring system. Groups of ten to twelve students are guided in their first year by a staff mentor and a student mentor. The guidance includes fostering the students' study attitude and monitoring their study progress. Every one of the students has a personal quarterly meeting with their mentor. Every year, information meetings for the students are organized. The number of contact hours is over 18 hours per week in the first year, 16 hours per week in the second year and over 12 hours per week in the second semester of the third year (the first semester being the period in which the students take their minor). Students may consult the academic counsellor for subjects, not directly related to the contents of the programme. In the first year, students are to achieve no less than 45 EC, conforming to the binding advice for continuation of studies (BSA). Otherwise, they will be forced to leave the programme. The mentors and the academic counsellor keep track of the BSA prospects of individual students.

A 20 EC honours programme is offered in the second and third year for talented students. Students who complete the first year curriculum within one year with an average grade of at least 8.0 are admitted. Students having an average grade between 7.0 and 8.0 and having completed the first year curriculum in one year may be admitted, after an interview with the director of studies. Students may also take a dual-degree programme, combining this programme with Bachelor programmes Mechanical Engineering, Computer Science or Mathematics. The study loads of these programmes typically is 240 EC.

To raise the student success rates, the programme management has taken a series of measures, such as improving the information about the challenging nature of the programme to prospective students, introducing teaching tracks in the curriculum and intensifying student guidance by implementing the mentoring system. The student success rate improved over the last few years. Students completing the programme within three years increased from 20 % (cohort 2007) to 24 % (cohort 2011) and to 32 % (cohort 2012). The proportion of students completing the programme within four years grew from 40 % (cohort 2007) to 51 % (cohort 2011). The success rate within four years for students with vwo-matriculation was at 55 %, which meets the Delft University of Technology target figure. The programme management assesses the student success rates of recent years to be satisfactory. The drop-out rates did not recede, however, and have remained relatively high, especially in the first year.

More than 84 % of the lecturers in the programme obtained a PhD and are active researchers in their fields of expertise. No less than 20 % of the lecturers are IEEE-fellows, which is a highly respected honorary degree in the Electrical Engineering field. About 89 % of the lecturers obtained the Dutch University Teaching Qualification (BKO), testifying to their teaching capabilities. Obtaining this qualification is strongly promoted in the Faculty of Electrical Engineering, Mathematics and Computer Science of the University. The programme management has had some difficulty in recruiting tutors for the projects in the curriculum, as the workload of these projects is quite substantial and has less scientific exposure. The programme management intends to recruit and appoint dedicated lecturers for tutoring the projects. The students' opinion on the lecturers' qualities are at the Dutch average, being 3.7 (scale of 5).

Lecture and project rooms are available. Students have access to laboratories at the Delft University of Technology campus for laboratory work. The panel was offered the opportunity to visit a number of these facilities. Students are satisfied with the facilities, so they told the panel.

Considerations
The panel considers the admission requirements to be in line with legal regulations. In the panel's view, the admission procedures of the programme are very elaborate and effective in informing the applicants about the challenging nature of the programme. Using the grades for mathematics and physics in their previous education as predictors for study success is considered by the panel to be very relevant.

The panel observed the intended learning outcomes to be met in the curriculum. The panel is very positive about the curriculum. The curriculum is strongly directed towards the core of the Electrical Engineering domain, exhibiting very focused training in knowledge of and skills in this field. In addition, the panel welcomes the projects in the curriculum as the preferred way to put knowledge and skills in a broader perspective, introducing practice and training in a number of academic skills. The teaching tracks ensure the coherence of the curriculum. In the panel's view, the programme is up-to-date. Summarizing, the panel regards the curriculum to be highly focused and to be very coherently and strictly structured, allowing students to acquire in-depth knowledge of and skills in the Electrical Engineering domain.

In the panel's view, the educational principle, being especially exemplified by the combination of theory and practice, is effective to promote the study pace of the students. The combination of theory and practice and the interaction between these two is fruitful. The study methods such as lectures, tutorials, lectorials, laboratory sessions and projects are consistent with the goals of the educational principle. The panel also welcomes the new study methods, being introduced in the programme.

The student-to-staff ratio of 24 is within the normal range. The panel regards the mentoring system implemented by the programme management and the actions of the academic counsellor effective in promoting student study progress. The panel welcomes the honours programme, as an opportunity for talented students.

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

The panel thinks very highly of the lecturers in the programme. They are renowned experts in their fields, while the vast majority of them have a PhD and most of them possess BKO-certificates. The panel supports the plan of the programme management to appoint and recruit tutors for the projects. This has been a concern, also for the students with whom the panel met. These students indicated, on the other hand, to be generally satisfied with the lecturers' educational qualities.

The panel regards the facilities in the programme to be adequate. Having visited some of the laboratories, the panel considers these to be up-to-standard, allowing students 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 good.

5.3 Standard 3: Assessment

The programme has an adequate assessment system in place.

Findings
The management of this Bachelor programme adheres to the Faculty of Electrical Engineering, Mathematics and Computer Science assessment policy. This policy rests on the principle of constructive alignment, being the alignment of the learning goals of the courses, the course contents and the tests in the courses. The main goals of the assessment policy are to ensure the validity, reliability and transparency of the tests and assessments. The tests are drafted either by a team of lecturers or by one lecturer, who presents the test to a colleague for review. In order to further improve the tests' quality, the programme management is in the process of implementing test matrices, identifying the relations between learning goals and the test items. For lab assignments and projects, rubrics are being designed to improve the assessment of these tests. This is also an ongoing process, being promoted by the programme management. Prior to the tests, students are informed about the tests and the grading of the items in the test.

For each of the courses and projects, test methods have been specified. In most of the courses, more than one test method applies. Test methods are written examinations, progress tests, homework, lab assignments and multiple tests for projects. The test methods selected depend on the learning goals to be tested. Prior to the summative testing, weekly formative tests are organized to provide feedback to the students on their study progress. In a number of courses, the written examinations are split into two parts, one part midterm and the other one at the end of the course, in order to spread the study load. The written examinations tend to be a mix of closed questions and open questions, including calculations. Lab work is typically tested by means of assignments, to be assessed by lab tutors. The students' performances in the projects are assessed on the basis of a number of deliverables, such as a team report, a presentation of the results and an oral defense. Every one of the students in the group is to present individual, mandatory contributions. The assessment of the group and individual products is being done by more than one tutor, including the tutor of the group. Students' individual results within the group may slightly differ, depending on their individual performances. Students are entitled to resits for each of the tests and assignments.

For the Faculty of Electrical Engineering, Mathematics and Computer Science, a Board of Examiners is in place and rules and regulations governing examinations and assessments have been drafted. The Board of Examiners has three subcommittees, one of these being responsible for the Bachelor programme. The Board has a number of duties. These are monitoring whether the course learning goals meet the intended learning outcomes of the programme, assessing the Bachelor graduation projects' quality by being present at a number of thesis defense meetings, inspecting deviating assessment outcomes, ensuring reliable test and assessment procedures and taking care of cases of fraud or plagiarism.

The 15 EC Bachelor graduation projects at the end of the curriculum are projects of groups of six students, subdivided in three groups of two students. The projects are being assessed by a committee, composed of at least two senior lecturers, who have not been involved in the graduation project process, and the project supervisor. The examiners make use of an assessment form with criteria and rubrics. The individual performances of the students are taken into account, by grading the activity and motivation in the project and the individual oral defense. In the context of the Bachelor graduation projects, the technical knowledge and skills of the students are assessed in the thesis (10 EC), but also the business plan component (3 EC) and the *Ethics and Technology* part of the project (2 EC).

Considerations
The panel regards the policies and procedures of the tests and assessments in the programme to be appropriate, as these comply with the Faculty of Electrical Engineering, Mathematics and Computer Science assessment policy. In this policy, tests and assessments in the courses are, as a matter of principle, aligned with the learning goals of the courses. In addition, the tests and assessments are to be valid, reliable and transparent. In the procedures, tests are drafted by at least two lecturers. Test matrices are not all in place at this moment but are seriously being promoted by the programme management.

The panel is positive about the variety of test methods, adopted in the courses. In the panel's opinion, these methods are certainly aligned with the course learning goals to be assessed. The distinct test methods allow for assessing the various knowledge and skills categories the students are to have mastered. The assessment of the projects in the curriculum is regarded by the panel to be elaborate and strict, several tutors being involved in the assessment and a number of different deliverables being taken into account. The panel supports the intention of the programme management to implement rubrics to improve the assessment of assignments. The panel is also satisfied with the procedures for identifying and assessing individual performances of students in these group projects.

The panel is positive about the position, responsibilities and duties of the Board of Examiners, as this Board monitors the test and assessment procedures, looks into the quality of the tests and inspects the Bachelor graduation projects to verify if the students have achieved the intended learning outcomes of the programme.

The assessment of the Bachelor graduation projects is regarded by the panel to be appropriate. This is being done by more than one examiner. The assessments are directed towards the constituent components of the projects and specify relevant criteria. The students' individual contributions in these group projects are being identified and assessed appropriately.

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
In the Bachelor graduation projects, all the intended learning outcomes of the programme are addressed and the students are to demonstrate in these projects to master these learning outcomes. In 2010, 2015 and 2016, Bachelor graduation projects of this programme were awarded the prestigious UfD-Damen Bachelor Award of Delft University of Technology. The programme management considers these prizes to give evidence of the quality and level achieved by the graduates of this programme.

The panel members studied a total of 15 Bachelor graduation projects and discussed these projects within the panel.

The programme management collected figures on the graduates' follow-up education in recent years. By far most of the graduates (82 %) continued their studies at Delft University of Technology in Master programmes Electrical Engineering, Computer Engineering or Embedded Systems. Other students went to other programmes of this University or enrolled in Master programmes of other institutions, some of which being quite prestigious. Only 3 % of the graduates entered the labor market and found a job.

Considerations
Having studied the tests of a number of courses, which the programme management presented, the panel concludes these tests to be satisfactory in breadth and depth and to reflect the learning goals of the courses.

Not one of the Bachelor graduation projects, the panel studied, has been assessed as unsatisfactory by the panel. Although the performances of the students and the grades given differ, some general observations about the graduation projects' quality may be made. About 25 % of these projects were regarded by the panel to be graded slightly too high. About half of the projects are assessed by the panel to be distinctly of good to very good quality, being elaborate and exhibiting relatively high levels of knowledge and skills. In the panel's opinion, the Bachelor graduation projects demonstrate the students to have achieved the intended learning outcomes of the programme and a substantial proportion of the students to have surpassed the required level.

In the panel's view, the figures the programme management collected on the graduates' follow-up education show the graduates meeting the demands of the Master programmes and being able to continue their studies at Master level.

Assessment of this standard
The considerations have led the assessment panel to assess standard 4, *Achieved learning outcomes*, to be good.

6. Recommendations

In this report, one recommendation has been listed. For the sake of clarity, these have been brought together below. The recommendation is the following.

- To pursue systematically the line of thinking, already begun, to fit the programme's profile to the modern T-shaped engineer requirements.

Annex 1: Site visit schedule

The site visit took place at the Delft University of Technology campus on 5 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. ir. R.H.J. Fastenau (Dean of Faculty Electrical Engineering, Mathematics and Computer Science), dr. ir. N.P. van der Meijs (director of studies), dr. A. Coetzee (head of Education and Student Affairs of Faculty), dr. ir. J.F.M. Tonino (director of Education of Faculty), prof. dr. M. Zeman (Department chair)
09.30 h. – 10.30 h.	Programme management and core lecturers Dr. ir. N.P. van der Meijs (director of studies), prof. dr. ir. A.H.M. Smets (member Board of Studies, lecturer), dr. ir. G.J.M. Janssen (Master track coordinator, lecturer), dr. ir. L.M. Ramirez Elizondo (Master track coordinator, lecturer), dr. ir. R Heusdens (Master track coordinator, lecturer), dr. ir. A. Bossche (Master track coordinator, lecturer), dr. ir. A.J. van Genderen (Master track coordinator, lecturer), ir. J.M.A. Kooijman (Bachelor coordinator, academic counselor)
10.45 h. – 11.30 h.	Board of Examiners Dr. ir. F.A. Kuipers (Board chair), dr. ir. Z. Al-Ars (Board member), dr. ir. R.F. Remis (Board member), dr. ir. M. Popov (Board member), S.C.M. Nijemanting MSc (educational advisor), T. Termorshuizen MA (Board official secretary)
11.30 h. – 12.30 h.	Lecturers and theses' examiners Dr. A. Rodrigo Mor (lecturer), prof. dr. ir. P. Bauer (lecturer), dr. ir. M.A.P. Pertijs (lecturer), dr. ir. T.G.R.M. van Leuken (lecturer, member Board of Studies), prof. dr. ir. A.J. van der Veen (lecturer), dr. R.A.C.M.M. van Swaaij (lecturer), prof. dr. ing. L.C.N. de Vreede (lecturer)
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 Board of Studies members W.F.M. Brevet MSc (alumnus), J. van der Meulen MSc (alumnus, former Board of Studies member), L. Enthoven (Bachelor student, Board of Studies member), L. van den Buijs BSc (Bachelor alumnus, former Board of Studies member), M. Fieback BSc (Master Electrical Engineering student, former Faculty Student Council member), D.S.M. Verhaert BSc (Master Computer Engineering student, Board of Studies member), T. Wieffering (Bachelor student), G.R. Chandra Mouli MSc (alumnus)
15.00 h. – 15.45 h.	Representatives from industry K.W.J. Tijskens MSc (ASML), dr. ir. R. Hekmat (KPN), dr. ir. F. Witte (Catena), dr. H.M. van Veldhoven (NXP), ir. E.J. Wiggelinkhuizen (ECN), dr. ir. G.L.E. Monna (Hyperion Technologies)

15.45 h. – 16.00 h.	Dean Prof. dr. ir. R.H.J. Fastenau (Dean of Faculty Electrical Engineering, Mathematics and Computer Science)
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 Bachelor Electrical Engineering
- Domain-specific Frame of Reference
- Exit qualifications
- Schematic overview of curriculum
- Description of contents of curriculum
- Teaching and examinations regulations
- Overview of lecturing staff and qualifications
- Overview of theses
- Student-to-staff ratio
- Summary of contact hours
- Student drop-out rates and student success rates
- Programme management's response to recommendations previous external assessment
- Education vision

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

- Study guide, including rules and regulations
- Course material (representative selection)
- Tests and examinations (representative selection)
- Thesis assessment form
- Board of Examiners annual reports
- Regulations on fraud and plagiarism
- Board of Studies annual reports

Annex 3: Theses reviewed

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

- 1354728
- 1376306
- 4061195
- 4107624
- 4137396
- 4091515
- 4145348
- 4161645
- 4211189
- 4215672
- 4227018
- 4103505
- 4174283
- 4173767
- 4044533

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.