Assessment report
Limited Programme Assessment

Master Computer Engineering

Delft University of Technology

Contents of the report

1. Executive summary

In this executive summary, the panel presents the main considerations that led to the assessment of the quality of the Master programme Computer 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 preparation of the students for the professional field and is keeping track of the alumni.

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

The panel approves of the objectives of the programme and welcomes the focus to train the students thoroughly in the Computer Engineering domain at the Master level and to prepare them for independent professional as well as scientific activities.

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 of the programme meet the objectives and reflect the in-depth knowledge of and skills in the Computer Engineering domain and the constituent disciplines. In addition, research skills and academic skills such as collaboration skills and communication skills and societal and ethical awareness are included. Although it is acknowledged that the broader context of Computer Engineering and societal awareness are covered in the learning outcomes, the panel feels the programme being predominantly technically oriented. The panel advises the programme management to continue their line of thinking on the modern T-shaped engineer and to fit the learning outcomes to these requirements. As the learning outcomes of this programme differ from those of the Master Electrical Engineering programme, the panel suggests aligning these two sets of learning outcomes.

The learning outcomes meet the requirements of this Domain-specific Frame of Reference as well as the requirements of an academic Master programme and prepare students for careers in research and industry. The participation of industry in the programme is satisfactory, as exemplified, among others, by the Industrial Advisory Board.

The influx of students has remained rather stable the past few years. The programme has an international nature, the proportion of foreign students and foreign staff being considerable. The panel regards the admission requirements to be in line with legal regulations and the admission procedures to be elaborate and effective.

The panel observed the intended learning outcomes to be met in the curriculum. The panel has a very favorable opinion about the curriculum, as the students are thoroughly taught the fundamental knowledge of and skills in the specialized Computer Engineering field. Students are acquainted with research, as the courses and the Master thesis projects are closely related to the activities of the research groups. The curriculum is up-to-date. The students have ample opportunities to familiarize themselves with the industry perspective on Computer Engineering, preparing them for careers in the professional field.

The educational principle has been laid down satisfactorily in the study methods. These study methods are consistent with the course contents and foster the students' learning processes.

The panel is positive about the Individual Exam Programme as a means to structure the individual curricula of the students. The information provision and the study guidance in the programme are appropriate. The student-to-staff ratio of 13 is very favorable, allowing for intensive teaching.

The panel considers the students' success rates in recent years to be adequate and is convinced the programme management will act upon possible setbacks.

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 many of them possess BKO-certificates. The students indicated to be generally satisfied with the lecturers' educational qualities.

The panel regards the facilities in the programme to be appropriate, 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 appropriate. Tests and assessments are to be valid, reliable and transparent. Tests are drafted by at least two lecturers, whereas test matrices and rubrics are being implemented. The test methods are aligned with the course learning goals. The assessment of courses, lab assignments and projects is adequate. 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 Master thesis projects to verify whether students have achieved the intended learning outcomes of the programme. The assessment of the Master thesis projects is appropriate, this being done by more than one examiner, on the basis of a set of relevant criteria.

Having studied the tests of a number of courses, the panel concludes these to be good in breadth and depth and to reflect the learning goals of the courses. Not one of the Master thesis projects, the panel studied, has been assessed as unsatisfactory. Not one of these projects are regarded by the panel to be graded too high, whereas about 60 % of these are assessed by the panel to be clearly of good to very good quality. 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 panel suggests to address the societal or ethical dimensions of the Electrical Engineering domain more elaborately in the Master theses. The figures about the graduates' careers show them having the capabilities to pursue relevant careers in industry and in research.

The panel assesses the Master programme Computer 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 Master programme Computer 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. For the Master programmes Electrical Engineering and Computer Engineering of Delft University of Technology a total of 20 theses were selected, for each of the programmes 10 theses. The rationale for this selection is that the two programmes are very similar, having many common courses, sharing the same lecturers and having the same Board of Examiners to monitor the theses' quality.

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 opportunity.

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: M Computer Engineering
Orientation, level programme: Academic Master
Grade: MSc
Number of credits: 120 EC
Specializations: N.A.
Location: Delft
Mode of study: Full-time
Registration in CROHO: 60351

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 completed the programme in three years (n+1)

Cohort	2010	2011	2012
Percentage of students	71 %	83 %	64 %

Lecturers' qualifications

Qualification	MSc	PhD	BKO*
Percentage of lecturers	100 %	89 %	87 %

*BKO means having obtained Dutch University Teaching Qualification.

The student-to-staff ratio is 13.

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	4.5*

*Number of contact hours calculated on the basis of the proportion of 15 EC courses (12.0 hours per week) and the 45 EC Master thesis project (about 2.0 hours per week).

3.2 Main facts about the institution

The Master programme Computer 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:

- Computer Engineering is the discipline that embodies the science and technology of design, construction, implementation, and maintenance of software and hardware components of modern computing systems and computer-controlled equipment. Computer Engineering is solidly grounded in the theories and principles of computing, mathematics, science, and engineering and it applies these theories and principles to solve technical problems through the design of computing hardware, software, networks, and processes. The graduates of the programme are expected:
  - (Knowledge) To have general knowledge of mathematics, electrical engineering, and computer science and to have profound and broad understanding of computer engineering disciplines, including but not limited to programming, hardware description languages, state-of-the-art computer architectures, methods and algorithms for computer system design, computer arithmetic, compiler construction and code generation, and parallel computers and algorithms.
  - (Design) To possess the ability to design computers and computer-based systems that include both hardware and software to solve novel engineering problems, subject to trade-offs involving a set of competing goals and constraints. They are capable of utilizing a variety of computer-based and laboratory tools for the design and analysis of computer systems.

- (Research) To be able to develop new knowledge and understanding through systematic research. They have a creative mind-set, which enables them to achieve an objective by taking other than conventional paths. They can study recent advances in Computer Engineering, classify recent research articles, and report on this, both verbally and in writing. They can define a Computer Engineering research problem, choose a specific approach, and complete a Computer Engineering related research project.
- (Collaboration) To be able to work and cooperate in an international and multidisciplinary team. They can take on all roles in a project team and handle social dynamics.
- (Communication) To be able to communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously. They can do this both verbally and in writing, in the language (English) and terminology of the field.
- (Learning) To be able to reflect and to have the learning skills to allow them to continue to study in a manner that is largely self-directed or autonomous.
- (Context) To understand the professional, societal and ethical context in which engineering is practiced, as well as the effects of engineering projects on society. They can take part in debates related to these contexts.

3.4 Outline of the curriculum

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

Curriculum components	Credits
Compulsory courses:	(6 EC)
Profile Orientation and Academic Skills	3 EC
Systems Engineering	3 EC
Common core (one course to be selected):	(5 EC)
Statistical DSP and Modelling	5 EC
Electromagnetics	5 EC
Control Theory	5 EC
Networking	5 EC
Advanced Computing Systems	5 EC
Measurement & Instrumentation	5 EC
Structured Electronic Design	5 EC
Track core (four courses to be selected):	(20 EC)
Methods and Algorithms for System Design	5 EC
Modern Computer Architecture	5 EC
Computer Arithmetic	5 EC
Processor Design Project	5 EC
High Performance Computing	5 EC
Compiler Construction	5 EC
Specialization (selection of Electrical and Computer Engineering courses)	(29 EC)
Free electives	15 EC
Master thesis project	45 EC
Total of the programme	120 EC

4. Overview of assessments

Standard	**Assessment**
Standard 1. Intended learning outcomes	Satisfactory
Standard 2: Teaching-learning environment	Good
Standard 3: Assessment	Satisfactory
Standard 4: Achieved learning outcomes	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 Master programme, the main objectives of the Master Computer Engineering programme are to impart sufficient knowledge, skills and a clear understanding of the Computer Engineering domain, as laid down in the intended learning outcomes, in order for the graduates to be able to perform independent professional and scientific activities at an academic level in this field. Computer Engineering is a separate programme, but may be regarded as a specialization of Electrical Engineering. The management of these programmes, which is the same for both programmes, holds this view.

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

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, the requirements for the graduates of the programme have been specified. In particular, the graduates ought to have acquired profound and broad understanding of computer engineering disciplines, supplemented with general knowledge of mathematics, electrical engineering and computer science, should be able to design computers and computer-based systems, ought to have acquired research, communication and collaboration skills and should be able to understand the professional, societal and ethical dimensions of computer engineering activities.

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

The programme management installed an Industrial Advisory Board with members representing industry, advising on the profile of the programme. This meeting frequency of this Board will be increased in future.

Considerations
The panel approves of the objectives of this Master Computer Engineering programme of the Delft University of Technology. The panel welcomes the focus of the programme management to train the students thoroughly in the Computer Engineering domain at the Master level and to prepare them for independent professional as well as scientific activities. The panel considers these objectives to be robust.

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 in-depth knowledge of and skills in the Computer Engineering domain and the constituent disciplines. In addition, research skills and academic skills such as collaboration skills and communication skills and societal and ethical awareness are included.

Although it is acknowledged that the broader context of Computer Engineering and the societal awareness 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. As the learning outcomes of this programme differ from those of the Master Electrical Engineering programme, the panel suggests aligning these two sets of learning outcomes.

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 participation of industry in discussing the programme profile is satisfactory, to be deduced 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 remained more or less stable in the last few years, showing an influx of 35 students in 2008 and an influx of 27 students in 2014. The intake of female students varies widely, being between 0 % and 25 % of all students per year. The incoming students are in large part coming from the own Delft University of Technology Bachelor programmes (about 60 % to 70 % of the total intake) or are coming from abroad (about 30 % to 40 %). Only a limited number of students come from other Universities in the Netherlands or from professional Universities (HBO), although the latter may be more than suggested by official figures, since these students are included in the Delft University of Technology Bachelor students' numbers.

Students who have completed the Electrical Engineering or Computer Science Bachelor programmes of one of the Technical Universities in the Netherlands are admitted without further conditions. Graduates of University Bachelor programmes in related fields and students having completed their Bachelor programme of professional Universities (HBO) are also allowed in, but only after having taken the premaster or bridging programme. For the former students, this programme may be tailor-made. The latter students are required to take the full 40 EC bridging programme, including 15 EC in mathematics and 5 EC in academic skills. Foreign students are admitted, provided they come from Universities, being up-to-standard and have an grade point average of 75 % of the maximum score. In addition, these students are required to submit an essay, motivation letter, two letters of recommendation and the summary of their Bachelor programme. International applications are screened by the Delft University of Technology International Office. All applications by students, not fulfilling the prerequisites to be directly admitted, are studied by the programme Admission Committee. In addition, proficiency in English is checked.

To inform prospective students about the programme, the programme management organizes a series of information meetings. The director of studies informs these students about the programme and the Master coordinator for Computer Sciences provides specific information. For students coming from professional Universities and other Bachelor programmes than Electrical Engineering or Computer Science, two separate meetings are being organized.

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

The curriculum is composed of a number of different layers of courses, the Master thesis project and 15 EC space for free electives (for the curriculum overview, please refer to section 3.4 of this report). The students take two compulsory courses, focusing on academic skills and system engineering. Also, they select one out of seven common core courses, addressing fundamental knowledge components, such as Electromagnetics, Control Theory and Measurement & Instrumentation. In addition, students are to select four track core courses, specifically designed for the Computer Engineering specialization. To deepen the specialist knowledge and skills in Computer Engineering, students are offered a number of specialization courses. Compulsory courses, common core courses, track core courses and specialization courses add up to 60 EC. All students are to complete their 45 EC Master thesis project, meant to conduct a substantial research project within the domain of Computer Engineering. The remaining 15 EC may be spent on free electives. Students may also choose to take an internship or use these credits to prepare for their Master thesis project, this taking the form of literature study or initial conceptual design. In 2015, the curriculum was drastically redesigned, following intensive rounds of discussions and consultations. The curriculum as presented here, is the result of this renewal process.

In a number of ways, students are acquainted with the industry perspective on Computer Engineering, the programme management's intention being to familiarize students with the professional field and to prepare them for careers in industry. Representatives from industry give guest lectures. Between 30 % and 50 % of all students take internships. Students may take their internships in the 15 EC free electives space. A substantial number of Master thesis projects are proposed by companies and are conducted with an industrial end purpose in mind, even if many of these students tend to do their projects at the Delft University of Technology campus.

The educational principle of the programme mainly consists of a variety in the study methods offered to the students. The study methods include lectures, involving presentations and additional homework assignments, practical work and projects, being meant to apply the knowledge acquired in assignments, often derived from real-life problems, self-study activities and the Master thesis project.

The design of the curriculum, including the coherence, is monitored by the Curriculum Committee in consultation with the Board of Studies. As students have considerable leeway in the curriculum, they draft their Individual Exam Programme. Students are to consult their Master coordinator about their programme as well as, preferably, their Master thesis supervisor. This individual programme has to be signed off by the responsible professor and is to be approved by the Board of Examiners. Students are only allowed to start their Master thesis project, if they at least have acquired 63 EC of course work.

For information on the programme, students may access the digital study guide. In the first weeks of the programme, a number of events are organized to familiarize the students with the programme and with the diversity of students in the programme, many students coming from abroad. Students meet with their Master coordinator, who will inform them about the programme. To guide the students to the programme, quarterly so-called Master Information Meetings are being organized at the faculty level, mainly in the first year. At the end of these meetings, students may consult their Master coordinator. He or she is the primary source for information and for guidance for the students. The Master coordinator may direct students to the academic counsellor, in case personal circumstances are in play.

With regard to the students' success rates, the trend is somewhat unclear. The proportion of students completing the programme within three years increased from 71 % (cohort 2010) to 83 % (cohort 2011), declining, however, to 64 % (cohort 2012). The programme management has no plausible explanation for the last figure but will continue to monitor the students' success rates and take measures, if required.

About 89 % 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, this being a very distinguished honorary degree in the Electrical and Computer Engineering field. About 87 % 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 students' opinion on the lecturers' educational qualities are slightly above the Dutch average, being 3.9 (scale of 5). Nearly 50 % of the lecturers is of non-Dutch origin.

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

Considerations
The panel noted the influx of students to have remained rather stable over the past few years. The programme has an international profile, given the proportion of students coming from abroad and given the proportion of non-Dutch lecturers.

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 specifically meant to admit only students with a fair chance to complete the programme. In the panel's view, the applicants are being well-informed about the programme.

The panel observed the intended learning outcomes to be met in the curriculum. The panel has a very favorable opinion about the curriculum, as the students are thoroughly taught the fundamental knowledge of and skills in the specialized Computer Engineering field and are intensively acquainted with research, as the courses and the Master thesis projects are closely related to the activities of the research groups. In the panel's view, the programme management ensures the curriculum to be up-to-date, as has been demonstrated in the renewal of the curriculum in 2015.

The panel considers the students to have ample opportunities to familiarize themselves with the industry perspective on Computer Engineering. Representatives from companies giving quest lectures, industry internships and industry-related Master thesis projects offer students the preparation for careers in the professional field.

The educational principle has been laid down satisfactorily in the study methods. In the panel's opinion, these study methods are consistent with the course goals and contents and promote the students' learning processes.

The panel is positive about the Individual Exam Programme as a means to structure the individual curricula of the students and welcomes the involvement of the Master coordinator, responsible professor and Board of Examiners in this respect. The information provision and study guidance in the programme are appropriate. The student-to-staff ratio of 13 is very favorable, allowing for intensive teaching and guidance.

The panel considers the students' success rates in recent years to be appropriate. The success rate in 2012 disappointed somewhat, but the panel is convinced the programme management will continue to monitor these figures and seek improvement, if required.

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 many of them possess BKO-certificates. The students indicated to be generally satisfied with the lecturers' educational qualities.

The panel considers the facilities in the programme up to standard, allowing students to participate in up-to-date education and research. It is noted that the main building will soon require upgrading to be able to continue to meet general housing standards

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

5.3 Standard 3: Assessment

The programme has an adequate assessment system in place.

Findings
The management of this Master programme adheres to the 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 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, essays, oral examinations, poster presentations, lab assignments and homework assignments. The test methods selected depend on the learning goals to be tested.

Oral examinations may be taken in front of two examiners, if so requested by the student. In the labs, the typical test methods are assignments, to be assessed by lab tutors. The students' performances in projects are assessed on the basis of a set of deliverables, such as reports, presentations and design documents. The assessment of these projects is being done by more than one tutor. 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 this Master 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 Master thesis projects' quality by being present at a number of thesis defense meetings, inspecting deviating assessment outcomes, ensuring reliable test and assessment procedures and handling cases of fraud or plagiarism.

The 45 EC Master thesis project at the end of the curriculum is an individual research project. Students have their own thesis supervisor with whom they very regularly meet. In case of external projects, students also have their external supervisor at the company or research institute site. The projects are assessed by a thesis committee, consisting of at least three experts, one of them being from another field than the domain of the project. The external supervisor may, also, be a member. The thesis committee assesses the project on the basis of the written report, the thesis oral defense and the public presentation, using a scoring model or rubrics, using as the assessment criteria the quality of the work, the performance during the project, the quality of the written report and the performance during the oral defense and the public presentation.

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.

In the panel's opinion, the test methods display a satisfactory variety, the test methods being aligned with the course learning goals to be assessed and allowing for the assessment of various knowledge and skills categories. The programme management ensures the appropriate, distinct assessment of course work, lab work and projects. The assessment of the projects is regarded by the panel to be adequate, 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 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 Master thesis projects to verify whether the students have achieved the intended learning outcomes of the programme.

The organization and assessment of the Master thesis projects are regarded by the panel to be appropriate. Supervision of these projects is intensive, as students with whom the panel met, confirmed. The projects' assessment is elaborate and adequate, being performed by a thesis committee, composed of at least three experts with one of the members coming from another domain, being based on several deliverables and being done by using rubrics to substantiate the grade.

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 Master thesis projects, all the intended learning outcomes of the programme are addressed and the students are to demonstrate in these projects to master those learning outcomes. The programme management considers these to give evidence of the quality and level achieved by the graduates of this programme. As has been indicated, thesis projects may be research-oriented or industry-oriented. About 24 % of the graduates, completing their studies in 2013 and 2014, had research resulting from their thesis published in journals or at conferences.

The panel members studied a total of 10 Master thesis projects (please refer to chapter 2 of this report for the number) and discussed these projects within the panel.

The programme management collected figures on the graduates' careers. Of the graduates, who finished their studies in 2013 and 2014, about 18 % proceeded to pursue a PhD-trajectory, most of them at the Delft University of Technology but also at other Universities in the Netherlands or abroad. From the graduates of the year 2016, all found positions, not a single one being unemployed. Of the graduates having completed their studies in the period 2011 to 2015, about 25 % went on to do a PhD and 75 % found a job in industry. In alumni evaluations, the vast majority of the alumni rated the programme to have prepared them good to very good for the labor market.

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

Not one of the Master thesis 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 thesis projects' quality may be made. Not one of the thesis projects were regarded to be graded too high. About 60 % of the projects are assessed by the panel to be clearly of good to very good quality, being elaborate and exhibiting high levels of knowledge and skills. In the panel's opinion, the Master thesis projects demonstrate the students to have achieved the intended learning outcomes of the programme and a substantial proportion of them to have surpassed the required level. As a single remark, the panel suggests to address in the Master thesis projects the societal or ethical dimensions of the Computer Engineering domain more elaborately.

In the panel's opinion, the figures the programme management collected on the graduates' careers show them having the capabilities to pursue relevant careers in industry as well as in research.

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

- To pursue systematically the line of thinking, already initiated, to fit the programme's profile to the modern T-shaped engineer requirements.
- To try and align the intended learning outcomes of this programme and the Master Electrical Engineering programme of the Delft University of Technology.
- To more elaborately address the societal or ethical dimensions of the Computer Engineering domain in the Master thesis projects.

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 Master Computer 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 lecturers qualifications
- Summary of contact hours
- Throughput figures
- Programme management's response to recommendations previous external assessment

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 Master thesis projects (theses) of the following 10 students have been selected for review by the panel

- 1213563
- 4172922
- 4240189
- 1517295
- 1314130
- 4319699
- 1296647
- 1546244
- 4119037
- 4184424

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.