NVAO • THE NETHERLANDS

PEER REVIEW NEW PROGRAMME

ACADEMIC MASTER
ROBOTICS
Delft University of Technology

SUMMARY REPORT
7 JULY 2020

1 Peer Review

The quality of a new programme is assessed by means of peer review. A panel of independent peers including a student reviews the plans during a site visit to the institution. A discussion amongst peer experts forms the basis for the panel's final judgement and the advisory report. The focus is on the curriculum, the teaching and learning environment, and student assessment.

The Accreditation Organisation of the Netherlands and Flanders (NVAO) takes a formal decision on the quality of the new programme based on the outcome of the peer review. This decision can be positive, conditionally positive or negative. Following a positive NVAO decision with or without conditions the institution can proceed to offer the new programme. Upon completion of the programme graduates are entitled to receive a legally accredited degree.

This summary report contains the main outcomes of the peer review. A full report with more details including the panel's findings and analysis is also available. NVAO bases an accreditation decision on the full report.

Both the full and summary reports of peer reviews are published on NVAO's website www.nvao.net. There you can also find more information on NVAO and peer reviews of new programmes.

Because of COVID-19 temporary measures apply for this peer review.

2 Panel

Peer experts

1. Dr. Françoise Siepel (*chair*), Assistant professor, research group Robotics and Mechatronics, University of Twente, the Netherlands;
2. Prof. dr. Ming Cao, Full professor with tenure of Networks and Robotics, director of the master program of industrial engineering and management, Institute of Engineering and Technology, University of Groningen, the Netherlands;
3. Dr. Mårten Björkman, Associate professor and former director of undergraduate studies at the Centre for Autonomous Systems, KTH Royal Institute of Technology, Sweden;
4. Vera Broek (*student*), Bachelor in Biomedical Sciences, Leiden University and Bachelor of Music at Codarts University of the Arts, the Netherlands.

Assisting staff

- Aurelie van 't Slot MA, secretary
- Michèle Wera MA, NVAO policy advisor and process coordinator

Site visit: 23 June 2020

3 Outcome

The NVAO approved panel reaches a conditionally positive conclusion regarding the quality of the academic master in Robotics offered by Delft University of Technology. The programme has a study load of 120 EC[1] and is offered in two years.

The master programme in Robotics has established a challenging and inspiring profile that will enable graduates to guide the industry in strengthening and accelerating robotization. Various stakeholders, including students, alumni and representatives of the professional field were involved in the process of developing the programme. The panel advises the programme to define its professional profile in more detail, which is adaptable depending on future changes in the quickly developing field of robotics.

The compulsory part of the curriculum, including the graduation programme, is well-developed. Strong elements include the wide variety of teaching methods and the focus on simulators as a learning environment for students to quickly get access to systems that closely resemble real robotic systems. The programme offers four specialisations intended to deepen the knowledge of students in a sub-field related to the different functions of a robot. However, it was not entirely clear how these specialisations (or tracks) contribute to the learning goals of the programme, or how depth can be assured, since the recommended courses of the specialisations are not obligatory. The programme management and teaching staff are well-equipped to implement and coordinate the programme. The research-intensive education of the programme is embedded in state-of-the-art research facilities that students can make use of during their studies. Whilst admission requirements are appropriate in light of the programme level and discipline, the information on admission provided by the university does not always comply with national legislation.

The master programme has a sound and transparant system of student assesment in place, in which the board of examiners plays an important role in terms of assuring the quality of (final) examinations. The assesment policy of the faculty 3mE describes various measures for enhancing the reliability and validity of examinations, which are to be used in the master programme Robotics.

TU Delft proposes that the programme has a duration of two years (120 EC). The panel advises to grant the programme the right to offer a two-year master's programme, taking into account its breadth and complexity. All in all, the panel assesses the quality of the programme as conditionally positive. The two conditions relate to the admission criteria and the role of the four specialisations.

4 Commendations

The programme is commended for the following features of good practice.

1. Stakeholder involvement – Various stakeholders were involved in designing the new programme, both in terms of its goals, ambitions and content.
2. Group effort – The development of the master programme Robotics was a truly collaborative effort by teaching staff and programme management. All staff members seem

[1] European Credits

well-involved and have developed into a close-knit community that is very supportive of this master programme.
3. Expertise of teaching staff – The research profiles of the academic staff members involved complement one another and span the different areas of robotics.
4. Research facilities – The research-intensive education of the programme is embedded in state-of-the-art research facilities that students can utilize during the various (group) projects and graduation work.
5. Green light moment – The board of examiners has recently introduced a so-called 'green light moment', which is a preliminary assessment six weeks before the graduation date to calibrate expectations of the student with those of the supervisor and graduation committee. This is a good example of a procedure that helps to prevent potential conflicts over the final thesis work.

5 Recommendations

For further improvement to the programme, the panel recommends a number of follow-up actions.

1. Professional profile – Define the professional profile in more detail so that it is clear what type of robotics engineers the programme wants to deliver, taking into account market needs. The professional profile is adaptable depending on future changes in robotics.
2. Further alignment – Continue to organise periodic meetings with teaching staff,programme management, representatives of the professional field and students to ensure further alignment of various curriculum components and guarantee the quality of the educational programme (taking into account feedback).
3. COVID-19 – Make sure the programme is fully prepared from the start to deal with the extraordinary circumstances resulting from COVID-19, with special focus on practical work and collaborations in project work.
4. Assessment programme – Reconsider the balance of assessment functions (monitoring student learning vs. evaluating student learning) in the current assessment programme.

6 What comes next?

NVAO grants initial accreditation to a new programme on the basis of a panel's full report. The decision is valid for a maximum of six years. Upon accreditation the new programme will follow the NVAO review procedures for existing programmes. NVAO publishes the accreditation decision together with the full report. A summary report is also available.[2] Each institution has a system of quality assurance in place ensuring continuous follow-up actions and periodic peer-review activities. Peer reviews help the institution to improve the quality of its programmes. The progress made since the last review is therefore taken into consideration when preparing for the next review. The follow-up activities are also part of the following peer-review report. For more information, visit the institution's website.[3]

[2] https://www.nvao.net/nl/besluiten
[3] https://www.tudelft.nl/

7 Summary in Dutch

Het panel oordeelt positief onder voorwaarden over de kwaliteit van de wo-master Robotics van de Technische Universiteit Delft (TU Delft). Dit is de uitkomst van de kwaliteitstoets uitgevoerd door een panel van *peers* op verzoek van de Nederlands-Vlaamse Accreditatieorganisatie (NVAO). Voor deze beoordeling heeft het panel gesprekken gevoerd met de opleiding op 23 juni 2020.

De masteropleiding Robotics heeft een uitdagend en inspirerend programma uitgewerkt dat afgestudeerden in staat stelt de industrie te ondersteunen bij het versterken en versnellen van robotisering. Bij de ontwikkeling van de opleiding waren diverse stakeholders betrokken, waaronder studenten, alumni en vertegenwoordigers uit het werkveld. Het panel adviseert de opleiding het professionele profiel in meer detail te beschrijven.

Het verplichte deel van het curriculum, inclusief het afstudeerprogramma, is goed ontwikkeld. De opleiding biedt vier specialisaties aan die bedoeld zijn om de kennis van een subdiscipline gerelateerd aan de verschillende functies van een robot verder uit te diepen. Het was niet helemaal duidelijk hoe deze specialisaties bijdragen aan de leerdoelen van de opleiding of hoe diepgang kan worden verzekerd, aangezien de aanbevolen cursussen van de specialisaties niet verplicht zijn. Het opleidingsmanagement en het docententeam zijn goed toegerust om uitvoering te geven aan het onderwijsprogramma. Het onderzoeksintensieve onderwijs is ingebed in uitstekende onderzoeksfaciliteiten waar studenten tijdens hun studie gebruik van kunnen maken. Hoewel de toelatingseisen passend zijn voor de opleiding, is de informatie voor toekomstige studenten niet altijd toereikend.

De masteropleiding kent een gedegen en transparant systeem van studentbeoordeling, waarbij de examencommissie een belangrijke rol speelt in het waarborgen van de kwaliteit van de (eind)toetsen. Het toetsbeleid van de faculteit 3mE beschrijft verschillende maatregelen ter versterking van de betrouwbaarheid en validiteit van toetsing die ook gelden voor de nieuwe master Robotics.

De TU Delft stelt voor dat de opleiding een studieduur van twee jaar heeft (120 EC). Het panel adviseert om de opleiding het recht te geven om een tweejarig masterprogramma aan te bieden, rekening houdend met de breedte en complexiteit van het curriculum.

Al met al beoordeelt het panel de kwaliteit van de opleiding als voorwaardelijk positief. De twee voorwaarden hebben betrekking op de toelatingseisen en de vier specialisaties.

Meer informatie over de NVAO-werkwijze en de toetsing van nieuwe opleidingen is te vinden op www.nvao.net. Voor informatie over de Technische Universiteit Delft verwijzen we naar de website van de instelling.[4]

Als gevolg van de beperkende omstandigheden door COVID-19 geldt voor deze kwaliteitstoets een tijdelijke en versnelde procedure.

[4] https://www.tudelft.nl/

The summary report was written at the request of NVAO and is the outcome of the peer review of the new programme academic master Robotics of Delft University of Technology

Application no: 009177

Nederlands-Vlaamse Accreditatieorganisatie
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INITIAL ACCREDITATION

ACADEMIC MASTER
ROBOTICS
Delft University of Technology

FULL REPORT
7 JULY 2020

Content

1 Peer review

The Accreditation Organisation of the Netherlands and Flanders (NVAO) determines the quality of a new programme on the basis of a peer review. This initial accreditation procedure is required when an institution wishes to award a recognised degree after the successful completion of a study programme.

The procedure for new programmes differs slightly from the approach to existing programmes that have already been accredited. Initial accreditation is in fact an ex ante assessment of a programme. Once accredited the new programme becomes subject to the regular review process.

The quality of a new programme is assessed by means of peer review. A panel of independent peers including a student reviews the plans during a site visit to the institution. A discussion amongst peer experts forms the basis for the panel's final judgement and the advisory report. The agenda for the panel visit and the documents reviewed are available from the NVAO office upon request.

The outcome of this peer review is based on the standards described and published in the limited NVAO Assessment framework for the higher education accreditation system of the Netherlands (Stcrt. 2019, nr. 3198). Each standard is judged on a three-point scale: meets, does not meet or partially meets the standard. The panel will reach a conclusion about the quality of the programme, also on a three-point scale: positive, conditionally positive or negative.

This report contains the findings, analysis and judgements of the panel resulting from the peer review. It also details the commendations as well as recommendations for follow-up actions. A summary report with the main outcomes of the peer review is also available.

NVAO takes an accreditation decision on the basis of the full report. The NVAO decision can be positive, conditionally positive or negative. Following a positive NVAO decision with or without conditions the institution can proceed to offer the new programme.

Both the full and summary reports of each peer review are published on NVAO's website www.nvao.net. There you can also find more information on NVAO and peer reviews of new programmes.

Because of COVID-19 temporary measures apply for this peer review.

2 New programme

2.1 General data

Institution	: Delft University of Technology
Programme	: academic master Robotics
Mode of study	: full time
Degree	: Master of Science
Tracks	: Machine Perception, Planning and Control, Vehicle Dynamics and Control, Human Robot Interaction
Location	: Delft
Study load	: 120 EC[1]
Field of study	: Technology (confirmed by panel)

2.2 Profile

Delft University of Technology (hereinafter TU Delft) intends to train students of the Master of Science (MSc) in Robotics in becoming robotics engineers that have knowledge and expertise on the interface between mechanical engineering and artificial intelligence, with a focus on intelligent control. Robotics – if well designed and integrated in society – has the potential to contribute to solutions to complex challenges in the domain of food supply, manufacturing, energy, and healthcare. The programme strives to meet future societal needs by delivering more engineers who are able to build advanced robotic systems. The new programme is offered by the faculty of Mechanical, Maritime and Materials Engineering ('3mE') and has been developed in close cooperation with the scientific department Cognitive Robotics (CoR). It is one of the seven scientific departments of the faculty 3mE and employs all staff in robotics.

2.3 Panel

Peer experts

1. Dr. Françoise Siepel (*chair*), Assistant professor, research group Robotics and Mechatronics, University of Twente, the Netherlands;
2. Prof. dr. Ming Cao, Full professor with tenure of Networks and Robotics, director of the master program of industrial engineering and management, Institute of Engineering and Technology, University of Groningen, the Netherlands;
3. Dr. Mårten Björkman, Associate professor and former director of undergraduate studies at the Centre for Autonomous Systems, KTH Royal Institute of Technology, Sweden;
4. Vera Broek (*student*), Bachelor in Biomedical Sciences, Leiden University and Bachelor of Music at Codarts University of the Arts, the Netherlands.

Assisting staff

– Aurelie van 't Slot MA, secretary
– Michèle Wera MA, NVAO policy advisor and process coordinator

Site visit (online)
23 June 2020

[1] European Credits

3 Outcome

The NVAO approved panel reaches a conditionally positive conclusion regarding the quality of the academic master in Robotics offered by Delft University of Technology. The programme complies with standards 1 and 3 of the limited NVAO framework and partially complies with standard 2.

The master programme in Robotics has established a challenging and inspiring profile that will enable graduates to guide the industry in strengthening and accelerating robotization. Various stakeholders, including students, alumni and representatives of the professional field were involved in the process of developing the programme. The panel advises the programme to define its professional profile in more detail, which is adaptable depending on future changes in the quickly developing field of robotics.

The compulsory part of the curriculum, including the graduation programme, is well-developed. Strong elements include the wide variety of teaching methods and the focus on simulators as a learning environment for students to quickly get access to systems that closely resemble real robotic systems. The programme offers four specialisations intended to deepen the knowledge of students in a sub-field related to the different functions of a robot. However, it was not entirely clear how these specialisations (or tracks) contribute to the learning goals of the programme, or how depth can be assured, since the recommended courses of the specialisations are not obligatory. The programme management and teaching staff are well-equipped to implement and coordinate the programme. The research-intensive education of the programme is embedded in state-of-the-art research facilities that students can make use of during their studies. Whilst admission requirements are appropriate in light of the programme level and discipline, the information on admission provided by the university does not always comply with national legislation.

The master programme has a sound and transparant system of student assesment in place, in which the board of examiners plays an important role in terms of assuring the quality of (final) examinations. The assesment policy of the faculty 3mE describes various measures for enhancing the reliability and validity of examinations, which are to be used in the master programme Robotics.

TU Delft proposes that the programme has a duration of two years (120 EC). The programme's management arguments concern the international requirements of the programme and the breadth and complexity of the programme, reflecting the requirements of the professional field and the multidisciplinary domain of robotics. The panel agrees that the qualifications the graduates should have in order for them to be competitive in the international academic job market, cannot be achieved in a programme of less than two years. The panel advises to grant the programme the right to offer a two-year master's programme (120 EC).

The panel concludes that it is convinced of the quality of the proposed programme MSc Robotics. The programme has a clear focus on cognitive robotics and offers students a robotic fundament (1st year), which has to be expanded in depth later on. The panel's main concerns are twofold, and relate to: (1) the specialisations and the full allignment of intended learning outcomes and curriculum, and (2) the admission criteria. All in all, the panel assesses the quality of the programme as conditionally positive.

The conditions to be met within a period of two years are the following:
1. The programme must ensure that the admission criteria fully comply with the Dutch Higher Education and Research Act (WHW).
2 The programme needs to clearly define the role of the four specialisations, how they provide depth to the curriculum and how they contribute to the achievement of the intended learning outcomes.

Standard	**Judgement**
1 Intended learning outcomes	meets the standard
2 Teaching-learning environment	partially meets the standard
3 Student assessment	meets the standard
Conclusion	**conditionally positive**

4 Commendations

The programme is commended for the following features of good practice:

1. Stakeholder involvement – Various stakeholders (students, alumni, representatives of the professional field, and research institutes) were involved in desiging the new programme, both in terms of its goals, ambitions and content. The panel considers stakeholder involvement a strong suit of the programme.

2. Group effort – The development of the master programme Robotics was a truly collaborative effort by teaching staff and programme management. All staff members seem well-involved and have developed into a close-knit community that is very supportive of this master programme.

3. Expertise of teaching staff – The research profiles of the academic staff members involved complement one another and span the different areas of robotics.

4. Research facilities – The research-intensive education of the programme is embedded in state-of-the-art research facilities that students can utilise during the various (group) projects and graduation work.

5. Green light moment – The board of examiners has recently introduced a so-called 'green light moment', which is a preliminary assessment six weeks before the graduation date to calibrate expectations of the student with those of the supervisor and graduation committee. The panel sees this as a good example of a procedure that helps to prevent potential conflicts over the final thesis work.

5 Recommendations

For further improvement to the programme, the panel recommends a number of follow-up actions:

1. Professional profile – Define the professional profile in more detail so that it is clear what type of robotics engineers the programme wants to deliver, taking into account market needs. The professional profile is adaptable depending on future changes in robotics.

2. Further alignment – Continue to organise periodic meetings with teaching staff,programme management, representatives of the professional field and students to ensure further alignment of various curriculum components and guarantee the quality of the educational programme (taking into account feedback).

3. COVID-19 – Make sure the programme is fully prepared from the start to deal with the extraordinary circumstances resulting from COVID-19, with special focus on practical work and collaborations in project work.

4. Assessment programme – Reconsider the balance of assessment functions (monitoring student learning vs. evaluating student learning) in the current assessment programme.

6 Assessment

6.1 Standard 1: Intended learning outcomes

The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Judgement
Meets the standard.

Findings, analysis and considerations
The programme's main objective is to train students in acquiring state-of-the-art knowledge in a broad technical domain, focusing on hardware and software integration, as well as the development of transferrable skills to become well-educated robotics engineers. Industry professionals indicated robotics engineers are essential in order to make advancements in robotization and for the further technological development of society and the Dutch economy. According to the programme, society needs robotics engineers who understand the application of algorithms that enable mechanical engineering systems to learn and interact in complex environments, and who can use their knowledge for the development of robotics for the future of society. The panel recognizes this societal need and the high demand for robotics engineers who have knowledge of the interface between mechanical engineering and artificial intelligence.

The profile of the programme has been translated into 31 intended learning outcomes based on seven broad competence areas agreed upon by the technological universities in the Netherlands. These learning outcomes are constructed in a matrix and match compulsory courses. The panel has established that the learning outcomes comply with the 4TU Criteria for Academic Bachelor and Master Curricula and therefore, meet master level requirements. Although the panel initially questioned the broadness of the learning outcomes, it became convinced that these were very carefully constructed to reflect the ambition of delivering broadly educated robotics engineers.

The panel was pleased to read that students, alumni and representatives of the professional field were involved in the process of developing the programme, including the intended learning outcomes. For example, during the online discussion with the programme management, the panel learned that the programme included communication and leadership skills in the learning outcomes upon recommendation by industry professionals, who need graduates that can lead the process of robotization. It is clear to the panel that the intended learning outcomes and content of the programme are up-to-date and well-aligned with (international) professional needs and demands. The programme will continue to consult with representatives of the professional field for its further development through the use of a dedicated professional advisory board. The panel considers stakeholder involvement a strong suit of the programme.

Companies, research institutes, alumni and scientific staff were also consulted in formulating the professional profile of the programme. The application file describes the vision on the profession, but also notes that the professional profile is not yet clear because there are currently no well-defined positions in the industry as robotics is developing rapidly. Whilst the panel recognizes this, it is of the opinion that a more detailed profile based on the current situation is possible and needed for the programme to establish a sharper profiling, which can

be adapted in the future. It therefore advises the programme to consider what type of robotics engineers it wants to deliver, taking into account industry needs and the alignment with the specialisations.

The programme intends to offer students four specialisations corresponding to the functions of the robot: Machine Perception, Planning and Control, Vehicle Dynamics and Control, and Human Robot Interaction. For the panel, the relation between the specialisations and the intended learning outcomes was not entirely clear. During the online discussion with the programme management, it was explained that the specialisations are meant to offer structure to the programme and give guidance on how the research field is divided. According to programme management, a more accurate term for the specialisations is 'profiles'. These profiles are not meant as independent master specialisations with their own learning objectives.

Based on discussions with programme representatives and the materials presented, the panel finds that the new MSc programme in Robotics presents an interesting, well-balanced and challenging set of intended learning outcomes. The programme management conducted an extensive benchmark study, which was well received by the panel. Whilst it agrees that the field of robotics is developing quickly, the panel advises the programme to define its professional profile in more detail over the coming months. Furthermore, it recommends to clarify the specialisations and their relation to the intended learning outcomes so that students understand their function (see also standard 2). The panel concludes that the programme has established a challenging and inspiring profile that will enable graduates to guide the industry in strengthening and accelerating robotization.

6.2 Standard 2: Teaching-learning environment

The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.

Judgement
Partially meets the standard.

Findings, analysis and considerations
The compulsory part of the curriculum, including the graduation programme, is well-developed. Strong elements include the wide variety of teaching methods and the focus on simulators as a learning environment for students to quickly get access to systems that closely resemble real robotic systems. According to the panel, this is very much in line with current research in robotics that, to a far greater extent than before, exploits simulators for development and prototyping. The panel found the compulsory courses of the first year (40 EC) to have a strong focus on dynamics, system identification, modelling, control, machine learning, machine perception, and human-robot interaction. This provides students with a solid common background in robotics. In this sense, the first semester is essential and most critical.

In addition to compulsory courses, students may choose electives (20 EC) of which 5 EC must concern a societal course. During the online discussions, the panel grasped that these electives are grouped according to the specialisations (also called 'tracks' or 'profiles') of the master programme. These specialisations come with recommended courses, but they appear not to be fixed because students are free to choose their electives beyond the specialisations, the faculty 3mE and even the university, and students can switch between specialisations at

any moment. The electives offered as part of a specialisation were said to deepen the students' knowledge in a sub-field to prepare them for their thesis work. The panel had trouble understanding the exact role of the specialisations for two reasons. First, it was not made clear how they contribute to the achievement of the intended learning outcomes. The panel would prefer to see alignment between the specialisations and the learning outcomes of the programme. Second, since the recommended courses are not obligatory, the panel does not see how the specialisations can ensure students gain in-depth knowledge of a specific sub-field.

The faculty 3mE intends for the programme to start as early as September 2020. During the online assessment of the programme, the panel has verified that appropriate measures are in place to deal with COVID-19 restrictions. Remote teaching currently is the norm. The achievement of the intended learning outcomes functions as a guiding principle in determining the needs of every programme when it comes to on-campus teaching. The programme management stressed that teaching staff have prepared one-and-a-half years for the Robotics programme. They are fully aware they might have to teach their courses partly on-campus or fully online. This was later confirmed by the teaching staff. The panel wants to stress that it is important the programme is fully prepared from the start to deal with the extraordinary circumstances resulting from COVID-19, with special focus on practical work and collaborations in project work.

The didactical approach of the programme that is derived from the Vision on Education of the faculty 3mE fits the curriculum. Students are challenged through group assignments and (interfaculty) projects on which they work together with students from different backgrounds and industry to learn from each other, using their (creative) skills in teams with variable roles on which they have to reflect. Technical and transferrable skills come together in project work. The multidisciplinary approach is expressed in the translation of societal issues from different perspectives (human, sustainability, ethics, etc.) to intelligent robotic solutions. The panel established that the programme management has adequately described how the Vision of Education informed the design of the programme.

The language of instruction is English. The programme management substantiates its choice by arguing that the nature of the scientific field, international background of teaching staff and the diverse influx of students who will be working as robotics engineers in a global labour market necessitate an English-taught programme. The panel supports this choice.

The panel considers the admission requirements appropriate in light of the programme level and discipline. However, the panel understood from the information provided on the university website and from documentation provided to the panel that only students with a BSc degree Mechanical Engineering or Aerospace Engineering from TU Delft can be admitted for the September 2020 intake. The programme management later rectified this in its discussion with the panel, so students with an appropriate bachelor degree from other Dutch universities can apply but this is not encouraged. However, this information is not provided on the university website and in the documentation provided to the panel. Given the fact that the stricter admission criteria for the first intake will lead to a rather uniform cohort, the panel questions how the somewhat narrow educational backgrounds of the students is conducive to the multidisciplinary approach of the programme.

Once students are admitted, they can receive support and study guidance from the Master

Coordinator. From online discussions, the panel learned that the programme cares about the learning process of individual students. Therefore, students are required to draw up an Individual Student Programme (ISP). This is discussed with the Master Coordinator, who then links student preferences and ideas with staff expertise and advises on the course selection appropriate to specific thesis topics and supervisors. In addition, during the introduction week of the programme, students are asked to write down their goals and ambitions, interests, networks, and the kind of role they envisage for themselves as robotics engineers. This vision document is later used in the development of the Student Portfolio, where students reflect on their acquired skills and personal goals. To the panel, the distinction between the tasks of the Master Coordinator and the mentor in the development of the portfolio was not entirely clear. The panel encourages the programme to make a clear distinction of tasks so students and teachers know where to go when issues arise. The panel also noted that there are no EC coupled to the portfolio. The programme management might want to reconsider this and attach EC to this task.

The panel considers the programme management and teaching staff well-equipped to implement and coordinate the programme. All staff members are well-established researchers who actively contribute to the development of robotics. The proposed lecturers hold positions as assistant professors, associate professors or full professors. Teaching quality and motivation are important aspects in the selection process for new academic staff. The faculty has a dedicated scheme to appoint more women in scientific staff functions. The panel heard that the scientific department of Cognitive Robotics has recently attracted two new female colleagues (tenure track) who will contribute to the programme. The faculty 3mE offers staff members various opportunities to further develop their didactic skills, for example by following training in teaching and coaching transferrable skills or partaking in the annual Education Day. The panel was particularly impressed by the enthusiasm of the teaching staff, who seem very invested in making this new programme work and have a shared vision on the teaching-learning environment. The panel knows periodic meetings were held in the development of the programme and would encourage the teaching staff and programme management to continue these meetings to ensure further alignment of the various curriculum components.

Since the assessment was conducted online, the panel was unable to have a tour of the facilities. Instead, the programme provided the panel with a pre-recorded digital lab tour and a photo album of various robotics software and hardware. The panel was impressed by the range of excellent facilities and learned that the three robotics labs managed by the scientific department of Cognitive Robotics will soon be brought together in a new Robotics Hall with a surface area of 1000 m^2. The panel particularly values that the research-intensive education of the programme is embedded in top research facilities that students can make use of during the various (group) projects and their graduation work. Besides the facilities available on campus, students may also make use of RoboHouse, the Smart Industry Fieldlab of RoboValley which offers a large facility for robot construction.

The panel is convinced that the programme offers a strong teaching-learning environment. The curriculum, state-of-the-art facilities and the quality of the teaching staff will enable incoming students to achieve the intended learning outcomes. The panel nevertheless had serious difficulties understanding the role of the specialisations. The expectations of what specialisations are meant for seemed to differ depending on who the panel was speaking with. At present, it seems that the curriculum is larger than the intended learning outcomes

capture. The programme needs to clearly define the role of the four specialisations, how they provide depth to the curriculum and how they contribute to the achievement of the intended learning outcomes. In addition, the panel noted that the admission criteria for the first intake as mentioned on the university website and in documentation provided to the panel do not comply with Dutch Higher Education and Research Act. Taking into account these considerations, the panel judges this standard as partially met.

6.3 Standard 3: Student assessment

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

Judgement
Meets the standard.

Findings, analysis and considerations
The system of assessment of the master programme in Robotics is guided by the assessment policy of the faculty 3mE. In line with faculty policy, the master in Robotics has an assessment programme prescribing the form of assessment per course. The assessment programme concerns the totality of tests and forms of assessment that together guarantee the final qualifications of the programme. The faculty has laid out several principles in its assessment policy that guide the design of the assessment programme.

One of these principles is the use of different assessment forms ('method mix'). The master programme in Robotics makes use of written exams, oral exams, individual project work, simulations, group project work and homework assignments. Every form of assessment is tailored to the learning objectives and teaching methods applied. Reliability and validity are enhanced in various ways: examiners have to apply the 'four-eyes' principle in the process of making tests, a test matrix is needed in advance as a blueprint for the exams and an educational advisor periodically assesses the exams of compulsory courses and gives feedback on issues such as reliability, validity, construction and the safeguarding of learning goals. The panel is positive that these procedures help to maintain high quality in assessment.

One of the didactic goals of the programme is for students to develop transferrable skills. During its discussion with the members of the Board of Examiners (hereafter: BoE), the panel learned that the intended learning outcomes related to competences in cooperation and communication, as well as the consideration of temporal and societal contexts, are covered particularly well in project-based education, such as the multi-disciplinary project in the first year and the joint interdisciplinary project in the second year. In addition, the Student Portfolio was mentioned as a reflective tool to monitor student development and provide constructive feedback for acquiring the competences and skills needed to meet the learning outcomes. The panel noted that this is one of the few compulsory courses that consists of formative assessment and recommends reconsidering the balance in assessment functions (formative vs. summative), which is also listed as a basic principle for the design of the assessment programme.

In addition to the assessment programme, there is a graduation programme which consists of a combination of tests and final products through which students show their learning achievements. The graduation programme of Robotics is made up of three elements: (1) a project with a focus on interdisciplinarity (15 EC), (2) a literature assignment or problem statement (10 EC), and (3) thesis work (35 EC). The panel values that the literature study is assessed as a separate component before the actual thesis work begins. This helps students

to go in-depth without yet having to worry about the practical aspects of the thesis. The assessment of thesis work is clearly designed and its quality is guaranteed by an extensive Master Thesis Grading Rubric. The panel was pleased to hear about the introduction of the so-called 'green light moment', which is a preliminary assessment six weeks before the graduation date to calibrate expectations of the student with those of the graduation committee. This helps to prevent potential conflicts over the final thesis work.

The master programme in Robotics will fall under the responsibility of one of the two Boards of Examiners of the faculty 3mE. The panel established that the BoE has the necessary level of independence and fulfills its tasks in line with its statutory duties. The BoE is supported by the faculty in the development and professionalization of assessment practices through close contact with the faculty management team and the assistance of an educational advisor.

The panel concludes that the master programme has a sound and transparent system of assessment in place. It is characterized by a wide variety of assessment forms and provides sufficient insight into the relationship between the intended learning outcomes and learning objectives for a given course. The BoE plays an important role in ensuring assessment quality and has spent considerable efforts to create standard policy and reliable procedures, resulting in consistent and efficient decision-making processes.

6.4 Degree and field of study

The panel advises awarding the following degree to the new programme: Master of Science.
The panel supports the programme's preference for the following field of study: Technology.

6.5 Programme extension

TU Delft proposes that the master programme in Robotics has a duration of two years (120 EC). The faculty management's arguments concern the international requirements of the programme and the breadth and complexity of the programme, reflecting the requirements of the professional field and the multidisciplinary domain of robotics.

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

Findings, analysis and considerations
The panel is convinced that for students to be truly competitive on an international market, they must master the knowledge in both mechanical engineering and artificial intelligence, with a focus on intelligent control. The professional field demands a combination of strong technological education with knowledge of artificial intelligence. The panel is of the opinion that the range of disciplines, state-of-the-art technical knowledge, and transferrable skills to work effectively in multidisciplinary environments, are essential to the programme. The panel strongly feels that the qualifications graduates should have in order for them to be competitive in the international academic job market cannot be achieved in a programme in less than two years.

The panel notes that master programmes in engineering generally have a duration of two years since the introduction of the bachelor and master programmes in the Netherlands. Academic engineering programmes in the Netherlands were set to a duration of five years (300 EC; three years bachelor studies; two years master studies), for students to attain an internationally comparable level. More specifically for the master programme in Robotics, the

panel finds the benchmark study conducted by the programme management relevant and thorough, and concludes that nearly all similar programmes abroad take two years (120 EC). In the opinion of the panel, graduates of the proposed programme should take a two-year master programme to achieve the learning outcomes, set at an international level.

Conclusion
Given these strong arguments in favour of two-year curriculum, the panel advises to grant TU Delft the right to offer a two-year master programme (120 EC).

Abbreviations

BoE	Board of Examiners
BSc	Bachelor of Science
CoR	Cognitive Robotics
Faculty 3mE	Faculty of Mechanical, Maritime and Materials Engineering
ISP	International Student Programme
MSc	Master of Science
TU Delft	Delft University of Technology
WHW	Dutch Higher Education and Research Act

The full report was written at the request of NVAO and is the outcome of the peer review of the new programme academic master Robotics of Delft University of Technology
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