AUTOMOTIVE TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

EINDHOVEN UNIVERSITY OF TECHNOLOGY

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This report was finalized on 26 March 2019.

REPORT ON THE MASTER'S PROGRAMME AUTOMOTIVE TECHNOLOGY OF EINDHOVEN UNIVERSITY OF TECHNOLOGY

This report takes the NVAO's Assessment Framework for Limited Programme Assessments as a starting point (September 2016).

ADMINISTRATIVE DATA REGARDING THE PROGRAMME

Master's programme Automotive Technology

Name of the programme:	Automotive Technology
CROHO number:	60428
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specializations or tracks:	Control Systems Technology Dynamics and Control Mechanics of Materials Multiphase and Reactive Flows Signal Processing Systems Electromechanics and Power Electronics Control Systems Electronic and Embedded Systems Model Driven Software Engineering System Architecture and Networking Human Technology Interaction User Centred Engineering
Location(s):	Eindhoven
Mode(s) of study:	full time
Language of instruction:	English
Expiration of accreditation:	30/07/2020

The visit of the assessment panel Mechanical Engineering to the Department of Mechanical Engineering of Eindhoven University of Technology took place on 11 and 12 December 2018.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

Name of the institution:	Eindhoven University of Technology
Status of the institution:	publicly funded institution
Result institutional quality assurance assessment:	positive

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has approved the composition of the panel on 20 August 2018. The panel that assessed the master's programme Automotive Technology consisted of:

- Prof. K.G.S. (Sören) Östlund, professor of Packaging Technology at the Department of Solid Mechanics of the KTH Royal Institute of Technology (Sweden) [chair];
- Prof. H.J. (Henry) Rice, professor in Mechanical Engineering and head of the School of Engineering, Trinity College, Dublin (Ireland);
- Dr. M. (Maddalena) Velonà, coordinator of studies at the Department of Mechanical and Process Engineering (D-MAVT) at Eidgenössische Technische Hochschule (ETH) Zürich (Switzerland);
- Drs. J.J. (Jan) Steen, consultant Quality of Education at Wageningen University & Research;

- Ir. L. (Leo) Kusters, managing director of AutomotiveNL, the cluster organization for the Dutch automotive industry, mobility sector and automotive education sector;
- Ir. M.J.E.H. (Marcel) Muitjens, senior director Environmental Control & Infrastructure at ASML Netherlands, a company that specialises in the development of hardware, software and services for (computer)chip manufacturers;
- C. (Coen) Bakker, BSc, master's student Mechanical Engineering, track High Tech Engineering, at Delft University of Technology [student member].

The panel was supported by dr. B.M. (Barbara) van Balen, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

The site visit to the master's programme Automotive Technology at the Department of Mechanical Engineering of Eindhoven University of Technology was part of the cluster assessment Mechanical Engineering. In December 2018 the panel assessed eleven programmes at three universities. The following universities participated in this cluster assessment: Delft University of Technology, Eindhoven University of Technology and the University of Twente.

On behalf of the participating universities, quality assurance agency QANU was responsible for logistical support, panel guidance and the production of the reports. Dr. Alexandra Paffen was project coordinator for QANU. Dr. Barbara van Balen acted as secretary in the cluster assessment. She is a certified NVAO secretary.

Panel members
The members of the assessment panel were selected based on their expertise, availability and independence.

Preparation
On 9 December 2018, the panel chair was briefed by QANU on his role, the assessment framework, the working method, and the planning of site visits and reports. A preparatory panel meeting was organised on 9 December 2018. During this meeting, the panel members received instruction on the use of the assessment frameworks. The panel also discussed their working method and the planning of the site visits and reports.

The project coordinator composed a schedule for the site visit in consultation with the Department. Prior to the site visit, the Department selected representative partners for the various interviews. See Appendix 4 for the final schedule.

Before the site visit to Eindhoven University of Technology, QANU received the self-evaluation reports of the programmes and sent these to the panel. A thesis selection was made by the panel's chair and the project coordinator. The selection existed of fifteen theses and their assessment forms for the programmes, based on a provided list of graduates 2015-2016-2017. A variety of topics and tracks and a diversity of examiners were included in the selection. The project coordinator and panel chair assured that the distribution of grades in the selection matched the distribution of grades of all available theses.

After studying the self-evaluation report, theses and assessment forms, the panel members formulated their preliminary findings. The secretary collected all initial questions and remarks and distributed these amongst all panel members.

At the start of the site visit, the panel discussed its initial findings on the self-evaluation reports and the theses, as well as the division of tasks during the site visit.

Site visit
The site visit to Eindhoven University of Technology took place on 11 and 12 December 2018. During the site visit, the panel studied the additional documents provided by the programmes. An overview of these materials can be found in Appendix 5. The panel conducted interviews with representatives of the programmes: students and staff members, the programme's management, members of the programme committee, alumni and representatives of the Examination Committee.

The panel used the final part of the site visit to discuss its findings in an internal meeting. Afterwards, the panel chair publicly presented the panel's preliminary findings and general observations.

Consistency and calibration
In order to assure the consistency of assessment within the cluster, the following measures were taken:
1. The panel composition ensured regular attendance of (key) panel members, including the chair;
2. The secretary was present at [the start of all site visits as well as the panel discussion leading to the preliminary findings at all site visits of Delft University of Technology, Eindhoven University of Technology and the University of Twente.

Report
After the site visit, the secretary wrote a draft report based on the panel's findings and submitted it to the project coordinator for peer assessment. Subsequently, the secretary sent the report to the panel. After processing the panel members' feedback, the project coordinator sent the draft reports to the Department in order to have these checked for factual irregularities. The project coordinator discussed the ensuing comments with the panel's chair and changes were implemented accordingly. The report was then finalised and sent to the Department and University Board.

Definition of judgements standards
In accordance with the NVAO's Assessment framework for limited programme assessments, the panel used the following definitions for the assessment of both the standards and the programme as a whole.

Generic quality
The quality that, in an international perspective, may reasonably be expected from a higher education Associate Degree, Bachelor's or Master's programme.

Unsatisfactory
The programme does not meet the generic quality standard and shows shortcomings with respect to multiple aspects of the standard.

Satisfactory
The programme meets the generic quality standard across its entire spectrum.

Good
The programme systematically surpasses the generic quality standard.

Excellent
The programme systematically well surpasses the generic quality standard and is regarded as an international example.

SUMMARY JUDGEMENT

Standard 1
The master's programme Automotive Technology (AT) is an interdepartmental programme spanning five departments: Mechanical Engineering, Electrical Engineering, Mathematics and Computer Science, Industrial Engineering and Innovation Sciences, and Industrial Design. The objective of the Automotive Technology master's programme is to educate engineers – in the field of automotive technology – who can act from a systems engineering perspective, and with a specialisation in the sub-themes of smart mobility or sustainable mobility. This objective is translated into ten intended learning outcomes (ILOs). The panel established that the ILOs are formulated in line with the objective and the domain-specific reference framework and that they sufficiently indicate what could be expected from programmes at an academic master's level. They tie in with the international perspective of the requirements set by the professional field and the discipline.

Standard 2
The master's programme AT has a nominal study length of two years. The first year consists of 30 EC of core courses, 15 EC of specialisation electives (to be chosen by the student in consultation with the mentor), and 15 EC of free electives. The second year consists of the internship (15 EC) and the graduation project (45 EC).

The panel appreciates the content and clear structure of this well-integrated, multi-disciplinary programme. The programme has a systems engineering approach and a clear scientific orientation. The panel is particularly positive about the integrative automotive systems engineering project in the core part of the master's programme. This project is also much appreciated by the students, as it forces them to integrate their knowledge and makes them aware of the necessity to collaborate and make use of the input of various experts.

The panel established that the curriculum enables students to achieve the ILOs. It appreciates the close connection to the research groups in the specialisation phase, which allows the students to achieve a high level in research. It also appreciates the extensive and broad collaborations with industry.

The quantity and quality of the teaching staff are good. However, the programme thrives on the enthusiasm of a relatively small group of experts, and this makes it somewhat vulnerable. The panel thinks the recruitment of new teaching staff should be prioritised.

Standard 3
The AT programme uses a variety of assessment methods. Courses are mostly assessed by a written exam, often in combination with assignments. The internship in the master's programme is assessed by a supervisor, who is also an authorised examiner. The assessment of the master graduation project is performed by a Graduation Committee. The panel established that the AT programme has an adequate quality assurance system. There are procedures in place to assure the validity and reliability of the tests. The panel concluded that the examinations, tests and thesis assessment are transparent, valid and reliable.

The panel furthermore established that the Examination Committee responsible for the AT programme is performing its legal duties and responsibilities in a profound way. The Examination Committee and its sub-committee, the Assessment Committee, are doing a good job in assuring the quality of assessments within the AT programme.

Standard 4
The panel studied a selection of 15 master's theses to assess whether the graduates had achieved the ILOs. The conclusion of this assessment was that they have achieved them. The panel found the level of the master's theses to be very good and might have graded them slightly higher than the

graduation committee. The graduates are well prepared for continuing in a PhD programme or a career in industry.

The panel assesses the standards from the *Assessment framework for limited programme assessments* in the following way:

Master's programme Automotive Technology

Standard 1: Intended learning outcomes	good
Standard 2: Teaching-learning environment	good
Standard 3: Student assessment	satisfactory
Standard 4: Achieved learning outcomes	good
General conclusion	good

The chair, prof. Sören Östlund, and the secretary of the panel, dr. Barbara van Balen, hereby declare that all panel members have studied this report and that they agree with the judgements laid down in it. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

Date: 26 March 2019

DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED FRAMEWORK ASSESSMENTS

Governance structure of the Faculty
The master's programme Automotive Technology is an interdepartmental programme spanning five departments: Mechanical Engineering, Electrical Engineering, Mathematics and Computer Science, Industrial Engineering and Innovation Sciences, and Industrial Design. The Department of Mechanical Engineering coordinates the programme and is responsible for all organisational and quality aspects. The programme is offered by Eindhoven University of Technology (TU/e), a research-driven, design-oriented university of technology within the domain of Engineering Science & Technology. TU/e educates engineers who possess a solid scientific basis, in-depth knowledge and the necessary skills to be successful in a variety of societal sectors and functions. All master's degree programmes are embedded in the Graduate School. This report contains the assessment of the master's degree programme Automotive Technology. A separate report is dedicated to the assessment of the bachelor's and master's programmes Mechanical Engineering.

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.

Findings
The master's programme Automotive Technology (AT) was introduced in 2009. The development of the programme is based on the strong conviction that the integration of the disciplines concerned with automotive technology into one programme is an answer to a need in society for smarter and more sustainable automotive mobility. An important aspect of the programme is the shift of the focus to software following current trends in the automotive industry whilst maintaining appropriate elements of "traditional" vehicle technology. The strong drive and vision of the initiators of the programme are central to its success in the panel's opinion. In addition to this master's programme, TU/e also offers an automotive technology track in the bachelor's programme within electrical engineering and the PDEng programme Automotive Systems Design. Thus, the MSc in Automotive Technology integrates well with a range of programmes within TU/e.

The objective of the AT master's programme is to educate engineers – in the field of automotive engineering – who can act from a systems engineering perspective, and with a specialisation in the sub-themes of smart mobility or sustainable mobility. The programme prepares students to function in the current engineering environment and enables them to adapt to new developments. It has a broad interdisciplinary basis and strong links with industry, as mentioned by the teachers and the students during the site visit. It was developed as an answer to demands in the industry (and staff participating in the educational program) to have strong relationships with industry.

The objective is translated into ten intended learning outcomes (Appendix 2). The panel established that the ILOs are formulated in line with the programme's objective and the domain-specific reference framework (Appendix 2) and that they sufficiently indicate what could be expected from programmes at a master's level. It also ascertained that the ILOs meet the internationally accepted description for academic master's programmes, the Dublin descriptors, which are elaborated for engineering programmes in the 4TU (Meijers) criteria[1]. It finds the content, level and orientation of the ILOs to be straightforward, with sufficient demonstration of their fit with the professional field. However, it thinks that the ILOs are formulated a little generically and would benefit from a review with more focus on specific aspects of the automotive technology programme.

[1] https://www.ram.ewi.utwente.nl/embedded2017/doc/Meijers_summarised.pdf

Considerations
The panel finds the programme's profile to be unique and appreciates the strong vision underlying the master's programme Automotive Technology. It encourages the Department Board to create conditions to sustain the programme. It concluded that the intended learning outcomes meet the Dutch qualifications framework. They sufficiently meet the master's level criteria. The intended learning outcomes tie in with the international perspective of the requirements set by the professional field and the discipline.

The panel encourages the programme to tailor the intended learning outcomes to the programme. They are specific enough, however, to fulfil the requirements for standard 1.

Conclusion
Master's programme Automotive Technology: the panel assesses Standard 1 as good.

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.

Findings
The curriculum
The master's programme Automotive Technology has a nominal study length of two years. The first year consists of 30 EC of core courses, 15 EC of specialisation electives (to be chosen by the student in consultation with the mentor) and 15 EC of free electives. The second year consists of the internship (15 EC) and the graduation project (45 EC).

The core programme consists of five courses: Vehicle Dynamics (5 EC), Powertrains (5 EC), Real-time Software Engineering (5 EC), Automotive Human Factors (5 EC) and the Automotive Systems Engineering Project (10 EC). The project concludes the core programme; students work in groups and apply the knowledge that they have acquired in the preceding core courses. This project provides an introduction to the integrative and systemic character of vehicle-system design and research, using selected case studies. The lecturers for the core courses are affiliated with six different research groups throughout all five departments involved. The panel established that the curriculum is aligned to the intended learning outcomes and that the content and level of the courses in the curriculum enable the students to achieve them.

The specialisation electives allow students to compose a trajectory that fits their own interests, capabilities and vision of their professional future. A broad range of electives is offered, from highly technological/application-oriented to strongly fundamental. Free electives give students the opportunity to personalise their trajectory. The panel appreciates this student-centred approach. Students can choose from all TU/e courses offered at the master's level. Homologation courses are offered to students to attain a basic level in a certain discipline if required due to their academic background. Homologation courses concern, for example, Matlab Simulink, C++ and Computer Organisation, and Heat and Flow Thermodynamics.

During their internship, students work individually on a topic within a company, an institute or a university abroad, or occasionally at TU/e. The internship prepares students for their graduation project and allows them to experience a working environment. The graduation project is an individual research assignment conducted either at TU/e, a company, a research institute or another university. It is carried out under the supervision of a professor or associate professor of one of the research groups participating in the AT master's programme.

The panel appreciates the content and clear structure of this well-integrated, multi-disciplinary programme. The programme has a systems engineering approach and a clear scientific orientation. During the site visit the panel learned that there is a strong mentoring system in place; students are

coached in making their choices for specialisation electives. Students report that the workload is high but feasible; they expect that they have to work hard in a master's programme. They very much appreciate the integration project, as it really forces them to integrate their knowledge and learn things from other students with different backgrounds that they did not know. The integration project helps the students to become aware of the necessity to collaborate with and make use of the input of various experts to find solutions for complex projects.

The relation with research is obvious from the beginning of the programme. The specialisation courses are clearly related to the current research of the teaching staff.

The panel appreciates the extensive and broad collaborations of the programme with industry. Integration of disciplines is an important aspect of the programme in general and the integration project in particular. However, there are still many specialisations possible and different research groups involved. The panel can imagine that integration could become a specialisation in itself. The integration makes this programme unique, in the panel's opinion.

Students and study yield
The master's programme accepts students with a bachelor's degree from several engineering programmes offered by the three technical universities in the Netherlands: Advanced Technology, Aerospace Technology, Applied Physics, Electrical Engineering, Marine Technology and Mechanical Engineering. Candidates from a university of applied sciences must complete the pre-master programme before they can enrol. The programme also aims to attract international students; in 2016-2017, 50% of the student intake was international. The competences and level of the international students can differ from those of the Dutch students, and most homologation courses are very relevant for them. Some of the international students do very well, and many of them manage to finish their studies in the nominal time. More international than Dutch students proceed to a PhD programme upon graduation. The programme aims its marketing at a solid international intake but also wants to avoid attracting too many students.
The overall study yield of the AT programme is comparable to that of other engineering master's programmes, 20% graduates in the nominal time, and 70% graduates within three years. Several measures have been taken to improve the study yield. Homologation courses are offered to reduce the study load for students who lack knowledge in a certain field. To support a large group of students to finish their thesis within the agreed period, the thesis work has been split into two phases, motivating the students to keep up with their planning.

Teaching staff
An overview of the teaching load in the programme is provided in an appendix to the critical reflection. The teaching staff is based in five different departments; the number of involved teachers varies per year and is 70 on average. Almost all (98%) of the involved teaching staff has a PhD, 70% holds a University Teaching Qualification (UTQ). When calculated on basis of fte, the latter percentage is 75%. The other teaching staff members are currently working on their certification, so a further increase of this percentage is expected. The student-staff ratio is difficult to calculate because of all the departments involved and the different teaching tasks delivered. An estimation of the student-staff ratio based on the ratios of the involved departments is presented in an appendix to the self-evaluation report. It has increased significantly in recent years and is now around 25 students per teaching fte. The programme has sufficient budget to recruit new staff members, but the recruitment landscape is challenging, and it takes time to find good candidates. Overall, the panel thinks that the quality of the teaching staff is good. It got the impression that the involved staff members are very enthusiastic and put a lot of effort into making this programme a success. The programme thrives on the enthusiasm of a core group, which makes it somewhat vulnerable. The panel recommends prioritising the recruitment of new teaching staff.

Considerations
The panel established that the curriculum of the master's programme Automotive Technology enables the students to achieve the intended learning outcomes. It appreciates the content and clear

structure of this well-integrated, multi-disciplinary programme. It is particularly positive about the integrative automotive systems engineering project in the core part of the master's programme. It appreciates the close connection to the research groups in the specialisation phase, which enables the students to achieve a high level in research. It also appreciates the extensive and broad collaborations with industry.

The quantity and the quality of the teaching staff are good. However, the programme thrives on the enthusiasm of a small group of experts, which makes it somewhat vulnerable. The panel thinks it is urgent to attract new teaching staff.

Conclusion
Master's programme Automotive Technology: the panel assesses Standard 2 as good.

Standard 3: Student assessment
The programme has an adequate system of student assessment in place.

Findings
Automotive Technology is an interdepartmental programme, and the assessment policies of several departments have to be taken into account. The assessment policy of the Department of Mechanical Engineering is described in 'Toetsbeleid Faculteit Werktuigbouwkunde' and is based on the TU/e framework. This policy applies to all programmes and describes the instruments, procedures and criteria for examinations, group work and individual projects. It also sets out the composition and tasks of the Examination Committee and Assessment Committee, as well as the fraud and plagiarism policies. There are Programme and Examination Regulations concerning assessors, marking and quality assurance for examinations published for each programme. The Assessment Committee is a sub-committee of the Examination Committee. It is tasked with monitoring the quality of the course assessments, internships and thesis work. The findings of the Assessment Committee are first shared with the Examination Committee, which discusses the findings and recommendations with the programme director.

The AT programme uses a variety of assessment methods. Courses are mostly assessed by a written exam, often in combination with assignments. Some courses require an oral examination upon the completion of an individual or group assignment.

The internship in the master's programme is assessed by a supervisor, who is also an authorised examiner. The role of the supervisor is to assure the quality of the work performed during the internship and to grade it. The final assessment by the supervisor is based on an external assessment by a company supervisor and a report written by the student.

The assessment of the master graduation project is performed by a Graduation Committee. The student delivers a thesis report, gives a presentation and defends the thesis in front of the Graduation Committee. The committee consists of at least three faculty members from TU/e or another university, is chaired by a full or an associate professor of the research group in which the student carried out the graduation project, and includes at least one member from a different research group (or another department / university). A standard assessment form is used to grade the thesis.

During the site visit the panel had a meeting with the Examination Committee about its responsibilities and the way the quality of assessment is assured. The Examination Committee responsible for the AT programme is an interdepartmental committee responsible for three interdepartmental master's programmes. Along with AT, it is also responsible for the master's programmes Sustainable Energy Technology and Systems and Control. The panel had a look at the assessment plans.

The panel finds the assessment system and policy very well developed and implemented. To ensure the assessment quality, an Assessment Committee has been installed as a sub-committee of the

Examination Committee. Each semester the Assessment Committee evaluates one of the core courses, two master's theses and two internship reports. The theses are assessed by external reviewers (from for example TU Delft) to check whether the procedure has been carried out correctly. The Examination Committee reported to the panel that they are now quite sure that the marking of theses is adequate. The panel got a very good impression of the proactive way the Examination Committee is performing its legal tasks and monitoring the quality of the assessments. Students and teachers found the assessment system, the assessment methods and the instruments to be transparent.

Considerations
The panel established that the Examination Committee is performing its legal duties and responsibilities in a profound way. The master's programme Automotive Technology has an adequate quality assurance system. There are procedures in place to assure the validity and reliability of the tests. The panel concluded that the examinations, tests and thesis assessment are transparent, valid and reliable. It also established that there are adequate assessment forms in place.

The panel is of the opinion that the Examination Committee and its sub-committee, the Assessment Committee, are proactively involved in monitoring and assuring the quality of assessments within the AT programme.

Conclusion
Master's programme Automotive Technology: the panel assesses Standard 3 as satisfactory.

Standard 4: Achieved learning outcomes
The programme demonstrates that the intended learning outcomes are achieved.

Findings
The panel studied a selection of 15 master theses with a mix of high grades and low grades to assess whether the graduates had achieved the intended learning outcomes. It concluded that the graduates did indeed achieve the expected level and found the theses to be of a high level overall. The theses cover all aspects required; the analysis and results in the theses are very thoroughly and clearly described. The panel approved the linking of the thesis topics to industry. The assessment of the theses demonstrated a careful check of the results. The theses showed that the graduates are able to conduct research and design independently, take a scientific approach to complex problems and ideas, and are able to seek new potential applications, taking the social context into consideration. The theses showed an advanced level of knowledge in a specialised field, systematic understanding of the key aspects and concepts in automotive technology, and the ability to integrate theory and practice. Written feedback on the theses was provided on the marking sheets.

The AT programme conducted a survey among employers of their graduates. The feedback showed that employers are positive about the programme, and AT graduates largely meet their expectations. Most employers would recommend AT graduates to colleagues. The results of this survey underline the conclusion that the graduates of the master's programme are well prepared for the professional field. In 2018 an alumni survey was conducted by the programme. The results indicated that AT alumni are very positive about the programme and achieve the intended learning outcomes. AT alumni have good prospects on the labour market. The panel supported the outcomes of the survey, which were also confirmed by the interviewed students and alumni during the site visit. Several graduates continued in PhD programmes. The panel had an interview with two of them, who confirmed that they felt well prepared for a research career.

Considerations
The panel concludes that graduates of the master's programme Automotive Technology have achieved the intended learning outcomes. It found the level of the master's theses to be very good

and would have graded most theses higher than the graduation committee. The graduates are well prepared to continue in a PhD programme or a career in industry.

Conclusion
Master's programme Automotive Technology: the panel assesses Standard 4 as good.

GENERAL CONCLUSION

The panel assesses standard 3 as satisfactory and standard 1, 2 and 4 as good. It was very positive about the profile of the programme, the curriculum and the level achieved by the graduates. Following the NVAO decision rules, the panel's general conclusion is that the programme is assessed as good.

Conclusion
The panel assesses the *master's programme Automotive Technology* as good.

APPENDICES

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

The domain-specific reference framework is first described within its global context, after which the field of automotive technology is defined and further explained. Also, the specific positioning of this interdisciplinary master programme at the TU/e is discussed. Vehicles, both for human transport as well as commercial vehicles, have undergone tremendous changes over the past decades and will undoubtedly continue to do so. Environmental and social issues have a large impact on the current challenges facing the automotive industry. Some of the main elements are the growing concerns regarding emissions and air pollution, the use of and alternatives to fossil fuels, and the fast development of driver support automotive systems with more and more steps towards cooperative and autonomous vehicles. Also, both in the Netherlands and across the world, mobility and safety have become key drivers in the development of smarter vehicles. We are seeing significant growth in vehicle to vehicle (V2V) and vehicle to infra (V2I) communication technology. Many of the challenges facing the automotive field are now being approached through the development of novel sensor technologies (camera, radar, lidar) and integration software. This has, of course, profound effects on all automotive OEMs2, first tier automotive companies, and all their relevant suppliers. This demand forms the basis of the AT curriculum. As suppliers become more and more relevant in the "smartification" of vehicles, the toolbox of the automotive engineer is changing accordingly. In the creation of a car, a screwdriver now seems of less use than the "control-alt-delete" command. The total amount of software in a car has been growing towards 100 Million lines of code in the last decade. The Automotive Technology master curriculum was set up in 2009 as an outgrowth of a pre-existing mastertrack within the Department of Mechanical Engineering. The motivation to create a multidisciplinary master programme – utilising the technical specialties of the departments of Mechanical Engineering, Electrical Engineering, Mathematics and Computer Science, Industrial Engineering and Innovation Sciences, and Industrial Design – was born out of contemporary industrial demands and the automotive trends described above. In the past decade, the Dutch automotive industry (from all levels, OEM, tier1, tier 2) has developed a strong focus on the following areas:

1. Driving guidance of the connected and automated car, human-machine interaction, and vehicle dynamics and control.
2. Vehicle efficiency, focusing on powertrain efficiency, lightweight construction/materials and clean combustion.

The above areas were described and identified in the self-assessment of 2013. In the current curriculum, these have become the cornerstones of the AT education. Driving guidance, or so-called Advanced Driver Assistance Systems (ADAS) is a concept of rapidly expanding utility and importance in modern cars and commercial vehicles. A primary focus area of the AT education is on these advanced driver assistance systems (ADAS), reflecting the wider TU/e emphasis on systems thinking.

The modern car can increasingly be seen as a system consisting of a wheeled platform housing numerous (smart) components. All of these components need to interact within the vehicle in a safe, predictable and reliable manner. Besides basic components such as engine, steering wheel, tires, and vehicle body, active components like ABS and cruise control must be integrated and, therefore, require knowledge in the disciplines of system engineering and software development (particularly software architecture). With the increase of ADAS, the role of the driver changes and it is therefore important to acknowledge the human-machine interaction, another concept firmly embedded in the AT curriculum. Vehicle efficiency, on the other hand, focuses on the powertrain system of a vehicle exploring various technological options such as fully electric, range-extended or hybrid vehicles. This concept addresses issues of efficiency and emissions of the internal combustion engine as well as the development of newer types of electric drivelines. In particular, lightweight materials are of utmost importance for the modern vehicle. The multidisciplinary and multi-objective character of this element of design requires knowledge in the disciplines of engineering system

[2] Original Equipment Manufacturer

design, optimization techniques and control methods. The expertise within TU/e in these fields has been widely acknowledged.

APPENDIX 2: INTENDED LEARNING OUTCOMES

A TU/e Master of Science graduate of Automotive Technology:

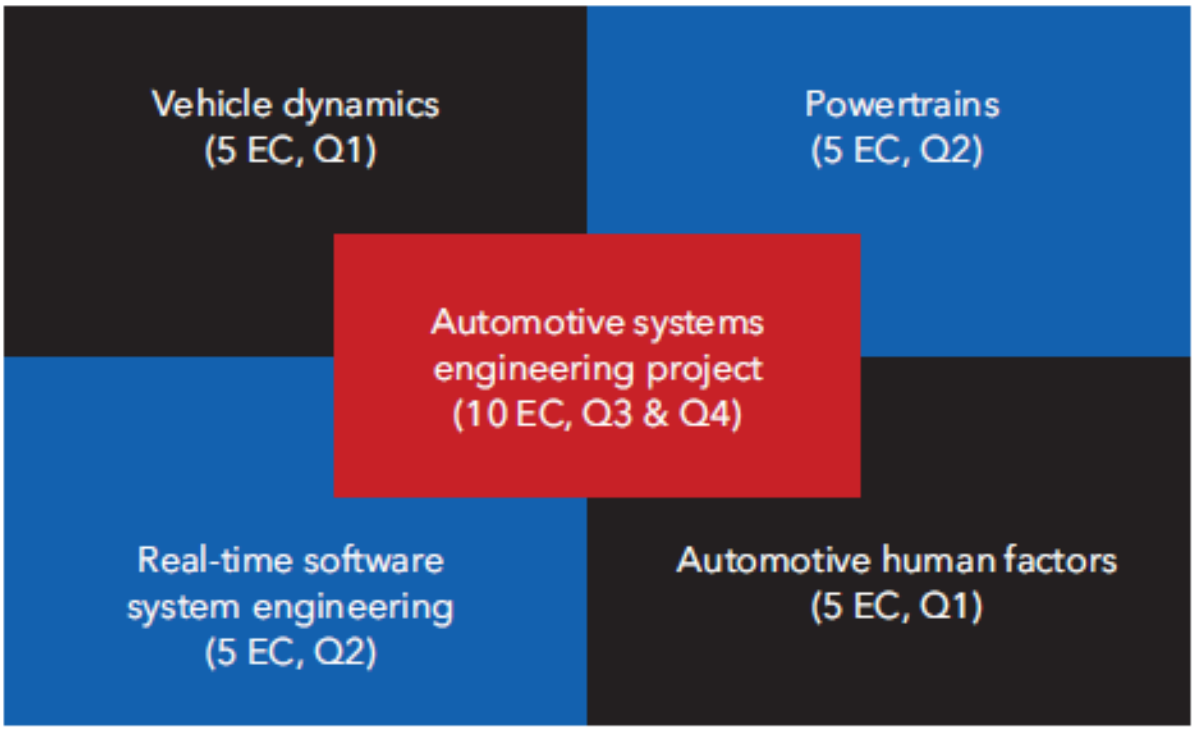
1. is qualified to degree level within the domain of "science engineering & technology";
2. is competent in the relevant domain-specific discipline(s), namely Automotive Technology, i.e.
    a. has a system overview and is able to work from a systems engineering perspective;
    b. has a profound knowledge in one of the automotive-related engineering sciences (electrical engineering, mechanical engineering, computer science, human factors) and is able to apply this knowledge in the automotive field;
3. is able to conduct research and design independently;
4. has the ability and attitude to include other disciplines in his/her research, where necessary;
5. has a scientific approach to complex problems and ideas;
6. possesses intellectual skills that enables him/her to reflect critically, reason and form opinions;
7. has the ability to communicate the results of his/her learning, thinking and decision-making processes at a professional level;
8. is aware of the temporal and social context of science and technology (comprehension and analysis) and can integrate this context in his/her scientific work;
9. in addition to a recognizable domain-specific profile, possesses a sufficiently broad basis to be able to work in an interdisciplinary and multidisciplinary context. In this context, multidisciplinary means being able to take into consideration other relevant disciplines needed to solve the design or research problem in question;
10. has the ability and attitude to seek new potential applications, taking the social context into consideration.

APPENDIX 3: OVERVIEW OF THE CURRICULUM

Year 1	30 EC core courses		15 EC specialization electives	15 EC homologation/ free electives*
Year 2	15 EC internship*	45 EC graduation project		

* The internship can be extended with 5 EC of free electives.

Core program (30 EC)



Specialization electives (15 EC)
Specialization electives enable students to compose an examination program that fits their own interests, capabilities and vision of their professional future. Students are offered a broad range of specialization electives, ranging from those that are highly technological/application-oriented to those that are strongly fundamental, to build up a profile. The participating research groups within the five departments offer these courses. The specialization electives are selected to improve the students' theoretical and/or fundamental basis and deepen specific knowledge in an automotive technology-related research field prior to the graduation project.

Code	Course title	EC
5SMA0	Model-based control	5
5SMB0	System identification	5
5LMB0	Model predictive control	5
5XWC0	Energy management	5
5LEJ0	Secondary batteries and hydrogen storage	2,5
5SWA0	Rotary permanent magnet machines	5
5LWE0	Control of rotating field machines	5
5XWB0	Electric drive systems	5
5SWB0	Advanced power electronics	5
5LWF0	FEM for electromagnetic devices	5
5LWC0	Advanced actuator design	5
5LWH0	Modeling and control of power converters	5
5LIC0	Networked embedded systems	5
5LIG0	Applied combinatorial algorithms	5
5LIJ0	Embedded control systems	5
5LIB0	Embedded systems laboratory	5
5LIA0	Embedded visual control	5
5LSH0	Advanced video content analysis & video compression	5
5XSB0	Signal analysis and estimation	5
5SSB0	Adaptive information processing	5
5AUA0	Advanced sensing using deep learning	5
0HM110	UX Design	5
0HM150	Advanced cognitive engineering	5
4CM00	Control engineering	5
4CM10	System theory for Control	5
4CM20	Hybrid systems and control	5
4CM30	Supervisory control	5
4CM40	Physical modelling	5

Code	Course title	EC
4AT070	Advanced control for future HD powertrains	5
4AT030	Advanced full-electric hybrid powertrain design	5
4DM20	Engineering optimization	5
4SC000	Optimal control and dynamic programming	5
4BM30	Modelling combustion	5
4BM20	Experimentation for MW	5
4BM40	Optical diagnostics for combustion and fluid flow	5
4AT020	Clean engines and future fuels	5
4DM10	Multibody and non-linear dynamics	5
4DM30	Nonlinear control	5
4AT050	Vehicle control	2,5
4EM70	Sustainable energy sources	5
4EM30	Scientific computing for MW	5
4MM00	Composite & light-weight materials: design and analysis	5
4MM10	Advanced computational continuum mechanics	5
4MM20	Computational and Experimental Micromechanics	5
4MM50	Fracture mechanics: theory and application	5
2IMF30	System validation	5
2IMF25	Automated reasoning	5
2IMF35	Algorithms for model checking	5
2IMF20	Hardware verification	5
2IMF05	Capita selecta FSA	5
2IMN10	Architecture of distributed systems	5
2IMN15	Internet of things	5
2IMN20	Real-time systems	5
2IMN05	Capita selecta system architecture and networking	5
2IMP20	Generic language technology	5
2IMP00	Seminar software engineering and technology	5
2IX20	Software specification	5
2IMP05	Capita selecta software engineering and technology	5
2IBP90	Programming	5

Code	Course title	EC
2IMP30	System design engineering	5
2IMS20	Cyberattack crime and defenses	5
DDB150	Contextual research for design	5
DDM120	Design for focused and peripheral interaction	5
DDM150	User experience theory and practice	5
DDM110	Design for behavioural change	5
DDM140	Research methods	5

Free electives and homologation (15 EC)
Free electives give students the opportunity to personalize their degree program further. Students can choose from all TU/e courses offered at a master's level, including an extension of their internship. This enables students to focus on their field of specialization, focus on entrepreneurship, or integrate a broader perspective on automotive technology in their program. Homologation courses are offered to students so that they can attain a basic level in a certain discipline if required due to their academic background.

Course code	Course name	EC	Strongly advised for
4WM20	Homologation Matlab Simulink	2.5	Students without experience with Matlab or Simulink
2DMW00	Homologation C++ and Computer Organization	2.5	All AT students except students with BSc Automotive Technology
4SE010	Homologation Heat and Flow Thermodynamics	2.5	Students with BSc EE and students with BSc Automotive Technology without 4GB10

Students take an average of 5 EC worth of homologation courses in their examination program.

Internship (15 EC)
During their internship (15 EC), students work individually on a topic that fits their personal profile, often in the field of their specialization. The internship prepares students for their graduation project and allows them to experience a working environment for the first time. The internship takes place within a company, an institute or university abroad, or (occasionally) at TU/e, depending on the student's individual learning objectives, interests and background. For students with a background in higher vocational education, a research internship at a university is mandatory.

Graduation project (45 EC)
The graduation project, which concludes the degree program, is an individual research assignment carried out by the students over a period of three quarters. The graduation project is conducted either at TU/e, a company, research institute or occasionally at another university. The final project is carried out under the supervision of a professor or associate professor from one of the research groups participating in the MSc program. Its primary purpose is to allow the student to gain in-depth experience in research and design, using the competences acquired in the program.
Graduation projects offered within the AT program may be related to research activities carried out in collaboration with industrial partners or research institutes. The graduation project consists of two phases: the preparation phase and the project phase. The preparation phase has to be concluded at least with a research plan as well as a project plan, and a time plan for the remainder of the graduation project. During the project phase, the actual project has to be carried out in accordance with the research plan.

APPENDIX 4: PROGRAMME OF THE SITE VISIT

Tuesday 11 December 2018

Time	Delegations	
10.30-11.15	Programme Management Mechanical Engineering	Graduate Program Director, Programme Coordinator, Chair programme committee, Member curriculum committee
11.20-12.00	Bachelor students Mechanical Engineering	Two 1st year students, two second year students, two third year students
12.00 - 13.00	Labtour	
13.00-13.45	Master students and alumni Mechanical Engineering	Three master students, four alumni
13.50-14.35	Lecturers Bachelor Mechanical Engineering	
14.45-15.30	Lecturers Master Mechanical Engineering	
15.30-16.00	Examination committee Mechanical Engineering	
16.00-18.00	Drafting preliminary conclusions Mechanical Engineering	

Wednesday 12 December 2018

Time	Delegations	
9.30-10.15	Programme Management Automotive Technology	Graduate Program Director, Adjunct Program Director, Chair program committee
10.15-11.00	Master students Automotive Technology and alumni	Four master students and three alumni
11.00-11.30	Lecturers Automotive Technology	
12.30-13.00	Examination committee Automotive Technology	
13.30-14.15	Formal management Mechanical Engineering + Automotive Technology	Dean, Graduate Programme Director ME, Graduate Program Director AT
14.15 -16.00	Drafting preliminary conclusions	
16.00	Feedback to management, staff and students concerning the bachelor and master programme Mechanical Engineering and the master programme Automotive Technology	

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 15 theses of the master's programme Automotive Technology. Information on the selected theses is available from QANU upon request.

During the site visit, the panel studied, among other things, the following documents (partly as hard copies, partly via the institute's electronic learning environment):

- Annual Report Education 2015-2016, 2016-2017
- Minutes of the Programme Committee (OCAT) 2017-2018
- Programme and Examination Regulations Automotive Technology 2018-2019
- Quality Assurance Plan 2018-2019
- Result Form Internship 2018
- Minutes Examination Committee 2017-2018
- Automotive System Engineering Project