

# **AEROSPACE ENGINEERING**

FACULTY OF AEROSPACE ENGINEERING

**DELFT UNIVERSITY OF TECHNOLOGY**

QANU  
Catharijnesingel 56  
PO Box 8035  
3503 RA Utrecht  
The Netherlands

Phone: +31 (0) 30 230 3100  
E-mail: [support@qanu.nl](mailto:support@qanu.nl)  
Internet: [www.qanu.nl](http://www.qanu.nl)

Project number: Q0754

© 2019 QANU

Text and numerical material from this publication may be reproduced in print, by photocopying or by any other means with the permission of QANU if the source is mentioned.



CONTENTS

**REPORT ON THE BACHELOR’S AND THE MASTER’S PROGRAMME AEROSPACE ENGINEERING OF DELFT UNIVERSITY OF TECHNOLOGY .....5**

ADMINISTRATIVE DATA REGARDING THE PROGRAMMES ..... 5

ADMINISTRATIVE DATA REGARDING THE INSTITUTION..... 5

COMPOSITION OF THE ASSESSMENT PANEL ..... 6

WORKING METHOD OF THE ASSESSMENT PANEL ..... 6

SUMMARY JUDGEMENT..... 8

DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED PROGRAMME ASSESSMENTS ..... 12

**APPENDICES ..... 25**

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE ..... 27

APPENDIX 2: INTENDED LEARNING OUTCOMES ..... 29

APPENDIX 3: OVERVIEW OF THE CURRICULUM ..... 38

APPENDIX 4: PROGRAMME OF THE SITE VISIT ..... 40

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL..... 41

This report was finalized on 8 October 2019



# REPORT ON THE BACHELOR'S AND THE MASTER'S PROGRAMME AEROSPACE ENGINEERING OF DELFT UNIVERSITY OF TECHNOLOGY

This report takes the NVAO's Assessment Framework for the Higher Education Accreditation System of the Netherlands for limited programme assessments as a starting point (September 2018).

## ADMINISTRATIVE DATA REGARDING THE PROGRAMMES

### Bachelor's programme Aerospace Engineering

Name of the programme:	Aerospace Engineering
CROHO number:	56956
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Specializations or tracks:	-
Location:	Delft
Mode of study:	full time
Language of instruction:	English
Submission deadline NVAO:	01/11/2019

### Master's programme Aerospace Engineering

Name of the programme:	Aerospace Engineering
CROHO number:	66956
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specializations or tracks:	Control & Operations Spaceflight Aerospace Structures & Materials, Aerodynamics & Wind Energy Flight Performance & Propulsion European Wind Energy Master: Rotor Design (double degree Danmarks Tekniske Universitet)
Location:	Delft
Mode of study:	full time
Language of instruction:	English
Submission deadline NVAO:	01/11/2019

The visit of the assessment panel Aerospace Engineering to the Faculty of Aerospace Engineering of Delft University of Technology took place on 19 and 20 June 2019.

## ADMINISTRATIVE DATA REGARDING THE INSTITUTION

Name of the institution:	Delft 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 6 May 2019. The panel that assessed the bachelor's and the master's programme Aerospace Engineering consisted of:

- Prof. dr. ir. A.M.C. (Lex) Lemmens, professor of Science and Engineering Education, at the Eindhoven School of Education of Eindhoven University of Technology [chair];
- Prof. dr. F. (Franco) Bernelli Zazzera, professor of Aerospace Systems at the technical university Politecnico di Milano (Italy);
- Prof. dr. A.R. (Amy) Pritchett, professor and head Aerospace Engineering at Pennsylvania State University (United States);
- Dr. A. (Annik) van Keer, educational policy advisor and managing director of the School of Undergraduate Studies at the Faculty of Science , Utrecht University;
- Ir. T. (Tjaard) Sijpkas, Chief Technology Officer and member of the board at EBUSCO;
- S. (Sebastiaan) van Kemenade, bachelor's student Mechanical Engineering at Eindhoven University of Technology [student member].

The panel was supported by dr B.M. (Barbara) van Balen, who acted as secretary. The QANU project manager was Peter Hildering MSc.

## WORKING METHOD OF THE ASSESSMENT PANEL

### *Preparation*

The panel chair was briefed by the project manager on 14 May 2019 on the tasks and working method of the assessment panel and more specifically its role, as well as use of the assessment framework. On 18 June 2019, the assessment panel was instructed by the project manager on its tasks and working method, as well as use of the assessment framework. During this meeting, the panel also discussed their working method and its initial findings on the self-evaluation reports and the theses, as well as the division of tasks during the site visit.

A schedule for the site visit was composed. Prior to the site visit, representative partners for the various interviews were selected. See Appendix 4 for the final schedule.

Before the site visit, the programmes wrote self-evaluation reports of the programmes and sent these to the project manager. He checked these on quality and completeness, and sent them to the panel members. The panel members studied the self-evaluation reports and formulated initial questions and remarks, as well as positive aspects of the programmes.

The panel also studied a selection of theses. The selection consisted of 9 bachelor group project reports from a total of 42 students and 15 master's theses, and their assessment forms, based on a provided list of graduates between 2016-2018. A variety of topics and tracks and a diversity of examiners were included in the selection. The project manager and panel chair assured that the distribution of grades in the selection matched the distribution of grades of all available theses.

### *Site visit*

The site visit to Delft University of Technology took place on 19 and 20 June 2019. Because of personal circumstances, panel member ir. Tjaard Sijpkas, could not be present at the site visit. He was present by Skype during the instruction of the panel, the preparation meeting and the final meeting to discuss the findings and to formulate the judgements.

During the site visit, the panel studied additional materials about the programmes and exams, as well as minutes of the Programme Committee and the Board of Examiners. 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, alumni and

representatives of the Board of Examiners. It also offered students and staff members an opportunity for confidential discussion during a consultation hour. No requests for private consultation were received.

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.

#### *Report*

After the site visit, the secretary wrote a draft report based on the panel's findings and submitted it to the project manager for peer assessment. Subsequently, the secretary sent the report to the panel. After processing the panel members' feedback, the project manager sent the draft reports to the faculty in order to have it checked for factual irregularities. The project manager discussed the ensuing comments with the panel's chair and changes were implemented accordingly. The report was then finalised and sent to the Faculty of Aerospace Engineering 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 the standards:

#### **Generic quality**

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

#### **Meets the standard**

The programme meets the generic quality standard.

#### **Partially meets the standard**

The programme meets the generic quality standard to a significant extent, but improvements are required in order to fully meet the standard.

#### **Does not meet the standard**

The programme does not meet the generic quality standard.

The panel used the following definitions for the assessment of the programme as a whole:

#### **Positive**

The programme meets all the standards.

#### **Conditionally positive**

The programme meets standard 1 and partially meets a maximum of two standards, with the imposition of conditions being recommended by the panel.

#### **Negative**

In the following situations:

- The programme fails to meet one or more standards;
- The programme partially meets standard 1;
- The programme partially meets one or two standards, without the imposition of conditions being recommended by the panel;
- The programme partially meets three or more standards.

# SUMMARY JUDGEMENT

## ***Bachelor's programme Aerospace Engineering***

### *Standard 1*

TU Delft is the only university in the Netherlands that offers aerospace engineering programmes at an academic level. For benchmarking, therefore, the Faculty has to look beyond the country's borders. The context of research and education in the Faculty is a society facing great challenges, the aerospace sector in particular, in which the physical space of vehicles and systems fuses with the cyber space of data and algorithms in every phase of the lifecycle of these systems. Engineering professionals need competences that go beyond the traditional engineering skills. In order to meet these societal needs, the Faculty aims to deliver graduates with a broad academic background and a consolidated knowledge of aerospace engineering and technology, as well as intellectual, personal and interpersonal skills. The panel appreciates the strong vision underlying the programmes and recognises the unique position of Aerospace Engineering in the Dutch academic environment.

In the bachelor programme, students acquire a deep working knowledge of the fundamentals of all major disciplines of aerospace engineering and how they contribute to conceiving and designing. The goal of the programme is the acquisition of knowledge, skills, practices and values found in engineering, design and research in the field of aerospace engineering. The intended learning outcomes of the programme are described in line with this goal. The programme is based on a strong profile and is unique for the Netherlands.

The panel concluded that the intended learning outcomes of the bachelor's programme meet the Dutch qualification framework and the international standards, as indicated by the alignment with the Domain-Specific Framework of reference as well as the CDIO and the Pegasus network criteria. The intended learning outcomes sufficiently indicate the academic bachelor's level.

### *Standard 2*

The bachelor curriculum is based on three characteristics: foundational, coherent and compelling. Students learn the fundamentals of mathematics and physics, engineering sciences and the engineering design process, all within the context of aerospace engineering. The programme has a nominal study duration of three years, 60 EC per year, and is delivered in English. All students follow a major of 150 EC of compulsory courses, lab work and projects, and a minor of 30 EC. The minor is scheduled in the first semester of the third year. The curriculum comprises three sets of courses that run concurrently throughout the three-year programme: aerospace design, aerospace engineering & technology, and basic engineering sciences.

The panel appreciates the clear lines in the curriculum and the opportunities the minor space offers students to broaden or deepen their knowledge and focus. It finds the bachelor curriculum to be well developed, managed and implemented, and there is a good alignment between the intended learning outcomes and the curriculum. The programme is challenging for the students, reflected by the fact that despite a competitive selection procedure, still a considerable proportion of the first year students do not achieve the BSA requirements. The panel is very positive, in particular, about the Design Synthesis Capstone Project. It recommends explicitly describing ethics in the learning goals and content of courses. Furthermore the panel advises to make sure that students are prepared for working in a group projects before they start in the final Synthesis Capstone Project. The choice to offer the programme in English is sufficiently substantiated according to the panel. The English language proficiency of all tenured staff is considered sufficient to good.

The panel was impressed by the way the programme manages to maintain a stimulating learning environment despite the high student numbers. The didactic approach with the design projects in each semester and the student-activating teaching methods used in the classrooms is truly student-centred in its opinion. It also appreciates the milestone test, which structures the student learning.



The programme is taught by experts in the field with sufficient didactical training. The bachelor students are guided and instructed by many teaching assistants; the panel advises paying attention to the training and selection of these assistants to make sure that their teaching qualities and personal guidance skills when acting as a mentor are equivalent.

The panel noticed a shortage in support staff. It recommends investigating which coaching and counselling tasks can be done by support staff and giving priority to filling vacancies in support staff and even considering increasing the fte dedicated to the support staff in order not to further increase the work load of the faculty.

The high student numbers have put some pressure on the facilities, in particular the instructional labs. The panel was impressed by the fact that the Faculty manages to facilitate practical work and experiments for all students as part of their education. It established that the Faculty has excellent experimental facilities for research and education and also makes excellent use of these facilities for the bachelor's programme.

### *Standard 3*

The Faculty has an Assessment and Examination Policy Plan, which describes in detail how the teaching, assessments and examinations are aligned. Different forms of assessment (written examinations, assignments, reports, computer tests) are used to evaluate and assess. In the construction process of an exam, the examiners have to apply the peer-review principle. The Board of Examiners monitors the assessment quality and the correct application of the Teaching and Examination Regulations. It has started a process of re-assessing the testing of all bachelor courses. Since 2019, the appointment of examiners has been formalised.

The panel is positive about the way the Board of Examiners is performing its tasks. It finds the assessment system and policy adequately developed and implemented. The courses use a variety of assessment methods, which are aligned with the learning outcomes and the curriculum. The procedures are transparent for both teachers and students. The panel was impressed by the detailed rubrics in the forms used for the assessment of the Design Synthesis Capstone Project. It concluded that the examinations, tests and the assessments are transparent, valid and reliable.

### *Standard 4*

In order to establish whether the bachelor's programme demonstrates that the intended learning outcomes are achieved, the panel checked whether all intended learning outcomes are covered in the courses, projects and accompanying assessments that make up the curriculum. It concluded that they are. It also studied a selection of nine Design Synthesis Project reports and agreed with the assessments of all reports. The reports showed that the students are competent in engineering design and have the ability to acquire and validate new knowledge as required for the project. Almost all bachelor graduates (95%) proceed to the master's programme Aerospace Engineering and are well prepared for that. The panel concludes that graduates of the bachelor's programme in Aerospace Engineering have achieved the intended learning outcomes.

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

Standard 1: Intended learning outcomes	meets the standard
Standard 2: Teaching-learning environment	meets the standard
Standard 3: Assessment	meets the standard
Standard 4: Achieved learning outcomes	meets the standard
General conclusion	positive



## **Master's programme Aerospace Engineering**

### *Standard 1*

TU Delft is the only university in the Netherlands that offers aerospace engineering programmes at an academic level. For benchmarking the Faculty has to look beyond the country's borders. The context of research and education in the Faculty is a society facing great challenges, the aerospace sector in particular, in which the physical space of vehicles and systems fuses with the cyber space of data and algorithms in every phase of the lifecycle of these systems. Engineering professionals need competences that go beyond the traditional engineering skills. In order to meet these societal needs, the Faculty aims to deliver graduates with a broad academic background and a consolidated knowledge of aerospace engineering and technology, as well as intellectual, personal and interpersonal skills. The panel appreciates the strong vision underlying the programmes and recognises the unique position of Aerospace Engineering in the Dutch academic environment.

The aim of the master's programme is to deliver graduates with a solid background in aerospace engineering and technology combined with competence in critical thinking, problem-solving and independent judgement. The general aim is translated into intended learning outcomes and competences.

The panel concluded that the intended learning outcomes (ILOs) meet the Dutch qualification framework and the international standards, as indicated by the alignment with the Domain-Specific Framework of reference as well as the CDIO and the Pegasus network criteria. The ILOs sufficiently indicate the academic master's level. The panel appreciates the level of detail of the ILOs.

### *Standard 2*

The master's programme in Aerospace Engineering offers six tracks, five of which are connected to the four research departments of the Faculty and one to the European Wind Energy Master (EWEM). The programme starts with 10-14 EC of core courses, 8-20 EC of profile courses and around 15 EC of electives. It furthermore consists of a literature study of 12 EC and research methods course of 2 EC, an internship of 18 EC and a master's thesis project. The EWEM students do not carry out an internship, but follow courses at other universities. The very diverse tracks and profiles in the programme accommodate the diverse interests of students. All tracks have the same structure, foundation and level, but differ in their specific substantive focus. They all prepare the students for achieving the intended learning outcomes. The panel is of the opinion that the programme is responsible for making it possible to finish the master in two years and therefore recommends the Faculty to pay special attention to the position of foreign students in regard to the planning of internships. It recommends reconsidering the scheduling of the internship in order to make this more flexible. The choice to offer the programme in English is sufficiently substantiated according to the panel. The English language proficiency of all tenured staff is considered sufficient to good.

The panel was impressed by the way the programme manages to maintain a stimulating learning environment despite the growing student numbers. However, it should be noted that the student success rates after two years remain very low. The panel advises to have sufficient attention for this fact and take measures to improve these success rates. The panel established that the programme is taught by experts in the field with sufficient didactical training. The workload of the teaching staff is very high, however. The panel noticed a shortage of support staff. It recommends investigating which coaching and counselling tasks can be done by support staff and giving priority to filling vacancies in the support staff.

The high student numbers have put some pressure on the facilities. The panel was impressed by the fact that the Faculty manages to facilitate practical work and experiments for all students as part of their education. It established that the Faculty has excellent experimental facilities for research and education and also makes excellent use of these facilities for the master's programme.

### Standard 3

The Faculty has an Assessment and Examination Policy Plan, which describes in detail how the teaching, assessments and examinations are aligned. Different forms of assessment (written examinations, assignments, reports, computer tests) are used to evaluate and assess. When constructing an exam, the examiners have to apply the peer-review principle. The Board of Examiners monitors the assessment quality and the correct application of the Teaching and Examination Regulations.

The panel is positive about the way the Board of Examiners is performing its tasks. It finds the assessment system and policy adequately developed and implemented. The assessment of the internship in the master's programme is adequate in its opinion, but it recommends checking its quality from the start of the project and at the midterm review through personal contact between the academic supervisor, the external supervisor and the student for each internship. The assessment procedure for the master's thesis project is very well developed in the panel's opinion. It noted, however, that improvement is possible in the use of the rubrics on the assessment forms.

### Standard 4

The panel checked whether all intended learning outcomes are covered in the courses, projects and accompanying assessments and concluded that the curriculum ensures that the graduates have achieved the intended learning outcomes. It studied a selection of 15 master's theses. In general, it agreed with the assessment and the grading given, although it would have graded some theses lower than the graduation committee; this difference could have resulted from the lack of feedback on the forms. It would welcome more argumentation for the rubric scores and more written feedback to students.

The graduates of the master's programme find a job on a master's level very easily within a short time. About 25% of the graduates proceed to a PhD programme and feel very well prepared for it. Graduates are also sought after by various branches in industry and are much appreciated for their competences. The alumni are very proud to have studied at the Faculty Aerospace Engineering in TU Delft. The panel concludes that the graduates are well prepared for continuing in a PhD programme or a job in industry and have achieved the intended learning outcomes.

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

Standard 1: Intended learning outcomes	meets the standard
Standard 2: Teaching-learning environment	meets the standard
Standard 3: Assessment	meets the standard
Standard 4: Achieved learning outcomes	meets the standard
General conclusion	positive

The chair, Prof. Lex Lemmens, and the secretary, Dr. Barbara van Balen, of the panel 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: 8 October 2019



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

The Faculty of Aerospace Engineering is one of eight faculties at Delft University of Technology (TU Delft). It offers one bachelor's and one master's degree programme and one doctoral education programme. The faculty is headed by the dean. He is supported by a Management Team which consists of the four Heads of Department, the director of education and the Faculty secretary.

The director of education is responsible for the educational mission, vision and policy of the faculty and the bachelor's and master's programmes. He is supported by the Education Management Team, which consists of the year coordinators, the bachelor's and master's programme director, the Aerospace Engineering Online Education Coordinator, the Head of Education & Student Affairs, and two student assessors.

### **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**

TU Delft is the only university in the Netherlands that offers aerospace engineering programmes at an academic level. For benchmarking, therefore, the Faculty has to look beyond the country's borders. An important network in this regard is the PEGASUS network, which is the most important international network in aerospace engineering education. Among its members are ISAE Toulouse, KTH Stockholm, Cranfield University, RWTH Aachen and Politecnico di Milano. In an appendix to the self-evaluation report, the fields of major subjects in the domain of aerospace engineering sciences are listed (see also Appendix 1 Domain-Specific Framework of Reference). The Faculty of Aerospace Engineering describes a growing demand for affordable, fast, sustainable, safe and secure aerospace technology and operation in its self-evaluation report. The context of research and education in the Faculty is a society facing great challenges, the aerospace sector in particular, in which the physical space of vehicles and systems fuses with the cyberspace of data and algorithms in every phase of the lifecycle of these systems. Engineering professionals have to be more agile and resilient than ever, according to the self-evaluation report. They need competences that go beyond the traditional engineering skills. In order to meet these societal needs, the Faculty aims to deliver graduates with a broad academic background and a consolidated knowledge of aerospace engineering and technology, as well as intellectual, personal and interpersonal skills. The panel appreciates the strong vision underlying the programmes and recognises the unique position of Aerospace Engineering in the Dutch academic environment, which is reflected in the huge numbers of applicants (more than 1500 for the bachelor's and 400 for the master's programme). It also studied the domain-specific framework of reference the Faculty provided and is of the opinion that this framework is in line with the international requirements.

### *Bachelor's programme*

In the bachelor's programme, the students acquire a deep working knowledge of the fundamentals of all major disciplines of aerospace engineering. The goal of the programme is the acquisition of knowledge, skills, practices and values found in engineering, design and research in the field of aerospace engineering.

In line with this general goal of the bachelor's programme, intended learning outcomes (ILOs) and competence areas have been described by the Faculty. These ILOs describe what the students have to demonstrate to prove that they are competent in the domain of aerospace engineering, in terms of research, design, and cooperating and communicating, that they are able to follow a scientific approach and apply basic intellectual skills, and that they are considering the temporal and societal context. The ILOs describe that the bachelor graduates have a consolidated body of knowledge in

the field of basic and engineering sciences, and aerospace engineering sciences in particular, and have the skills to increase and develop this further through study.

The panel appreciates the elaboration of this body of knowledge in the ILOs. It was impressed by the concrete and measurable elaboration of the competence areas. It established that these ILOs and competence areas are formulated in line with the internationally accepted description for academic bachelor's programmes, the Dublin descriptors, which are elaborated for the engineering programmes in the 4TU Criteria for Academic Bachelor's Curricula and fit with the Domain-Specific Reference Framework. The ILOs clearly match the CDIO Syllabus. This syllabus codifies what engineers should know and be able to do at the conclusion of their programme in engineering education and at what level of proficiency. The panel established that the ILOs sufficiently indicate the content, level and orientation of the bachelor's programme and match the expectations of the professional field. It appreciates the level of detail of the ILOs and established that they are at a bachelor level and clearly distinctive from the master's qualifications.

#### *Master's programme*

The aim of the master's programme is to deliver graduates with a solid background in aerospace engineering and technology combined with competence in critical thinking, problem-solving and independent judgement. Graduates are trained to apply engineering skills in relevant research and industrial areas. The general aim is translated into ILOs and competences. These ILOs describe what the students have to demonstrate to prove that they are competent in the domain of aerospace engineering, in terms of research, design, and cooperating and communicating, that they are able to follow a scientific approach and apply basic intellectual skills, and that they are considering the temporal and societal context. The Faculty offers six tracks in the master's programme, which all have the same ILOs. The panel established that these ILOs and competence areas are formulated in line with the internationally accepted description for academic master's programmes, the Dublin descriptors, which are elaborated for the engineering programmes in the 4TU Criteria for Academic Master's Curricula, and fit with the Domain-Specific Reference Framework. The panel finds the ILOs to be clear and ambitious and appreciates the attention paid to open-ended research and critical thinking. The ILOs are clearly distinctive from the bachelor's qualifications.

#### **Considerations**

The bachelor's and the master's programmes Aerospace Engineering are based on a strong profile and are unique for the Netherlands. The panel established that the Faculty of Aerospace Engineering cooperates and can compare itself with other leading aerospace engineering programmes worldwide.

The panel concluded that the ILOs of the bachelor's as well as the master's degree programmes Aerospace Engineering meet the Dutch qualification framework and the international standards, as indicated by the alignment with the Domain-Specific Framework of reference as well as the CDIO network criteria. The ILOs sufficiently indicate the academic bachelor's or master's level, respectively. The panel appreciates the level of detail of the ILOs.

#### **Conclusion**

*Bachelor's programme Aerospace Engineering:* the panel assesses Standard 1 as 'meets the standard'.

*Master's programme Aerospace Engineering:* the panel assesses Standard 1 as 'meets the standard'.



**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***Bachelor's programme*

The bachelor curriculum is based on three characteristics according to the self-evaluation report: foundational, coherent and compelling. The students learn the fundamentals of mathematics and physics, engineering sciences and the engineering design process, all within the context of aerospace engineering. They are broadly prepared with respect to both disciplinary content and the development of academic and engineering skills. They learn and apply disciplinary knowledge and the engineering design process within the concrete, multidisciplinary context of authentic aircraft and spaceflight projects. The programme has a nominal study duration of three years (60 EC per year) and is delivered in English. All students follow a major of 150 EC compulsory courses, lab work and projects, and a minor of 30 EC. The minor is scheduled in the first semester of the third year.

The curriculum comprises three sets of courses that run concurrently throughout the three-year programme: aerospace design, aerospace engineering & technology, and basic engineering sciences. Aerospace design consists of one module with two elements per semester: a design project and a complementary engineering design course. Aerospace engineering & technology contains theoretical courses on aerodynamics, aerospace materials and structures, production engineering, flight and orbital mechanics, systems and control, and aircraft and rocket propulsion. The courses in this set build upon each other and feed into the design projects. The third set is formed by generic courses on mathematics, programming and physics. In the first year of study, about half of the study load is allocated to basic engineering sciences as a solid foundation for the subsequent years. The other half addresses aerospace engineering and design, complemented by intellectual, personal and interpersonal skills. In the second year, about 30% of the study load is allocated to developing the students' knowledge of the basic engineering sciences and 65% to the sub-disciplines of aerospace engineering. The first semester of the third year is for the minor. In the minor, students have the choice to focus on a certain area of engineering, technology or science, or the development of personal, professional or engineering business skills. In the second semester the students follow courses on flight dynamics and aerospace engineering.

The programme concludes with the Design Synthesis Capstone Project (15 EC). This project is a ten-week, full-time design project in which students conceive and design an authentic aerospace-related object or mission. They work in self-governing ten-member teams. The professional role of the students in the project is that of a systems engineer. They go through the complete design process in a structured and iterative manner, from drawing up a set of design requirements to the final presentation of the design.

Ethics and scientific integrity are one of the ILOs which should necessarily be covered in the bachelor's programme, according to the panel, before students start to do research. It noticed that there is no dedicated course on ethics scheduled. The students and teachers assured the panel that scientific integrity is covered in several courses and design projects in the bachelor curriculum, but they admit that it is not always visible. The panel recommends explicitly describing ethics in the learning goals and in the content of the respective courses.

The panel appreciates the clear lines in the curriculum and the opportunities the minor space offers students to broaden or deepen their knowledge and focus. It finds the bachelor curriculum to be well developed, managed and implemented, and there is a good alignment between the ILOs and the curriculum. It is very positive, in particular, about the Design Synthesis Capstone Project. This project tests more ILOs than those listed in the course description; this concerns, in particular, teamwork skills. The panel recommends including learning goals about these skills in the course description.

The panel also recommends the training of students in peer-feedback at an earlier stage of their study programme. If students are confident in giving each other feedback, they will maximally benefit from this activity lead by their peers.

TU Delft chose to offer the bachelor programme in English with the aim to create an international environment to prepare the students for their future careers in a fully international sector of aerospace and aviation. The choice for English as the language of instruction is sufficiently substantiated according to the panel due to this international field.

#### *Master's programme*

The master's programme in aerospace engineering offers six tracks, five of which are connected to the four research departments of the Faculty: Control & Operations, Spaceflight, Aerospace Structures & Materials, Aerodynamics & Wind Energy, and Flight Performance & Propulsion. Within the tracks the students can choose several profiles.

The sixth track is the European Wind Energy Master (EWEM), which is a master's track offered by an international consortium of four top wind energy universities in Europe: TU Delft, DTU (Denmark), NTNU (Norway) and the University of Oldenburg (Germany). All associated programmes are accredited through the European Standards and Guidelines. In preparing engineers for a global wind energy sector, one of the EWEM programme's goals is to train the students to become resourceful professional solvers of engineering problems and capable of collaborating with colleagues from a wide array of cultural and professional backgrounds. TU Delft offers a pre-defined profile in Rotor Design with DTU, which leads to a double degree with TU Delft and DTU. In addition, electives from NTNU and the University of Oldenburg can be followed after approval from the TU Delft track coordinator. The thesis project can be conducted at either TU Delft or DTU, and always has at least one supervisor from TU Delft. TU Delft coordinates the educational activities within the track through the EWEM Consortium.

The master's programme Aerospace Engineering offers 10-14 EC of core courses, 8-20 EC of profile courses and around 15 EC of electives, providing the students with knowledge in specific areas of interest. All of the tracks include two common courses: Research Methodology and Ethics for Aerospace Engineering, which covers personal integrity and awareness of the technical and societal implications of aerospace engineering. The programme furthermore consists of a literature study of 12 EC, an internship of 18 EC and a master's thesis project. The EWEM students do not do an internship, but instead follow courses at other universities.

The core courses are a fixed package and obligatory for everyone enrolled in that particular track. The profile courses are essential for a particular sub-discipline and obligatory for students enrolled in the particular profile. The core and profile courses have a total study load of about 32 EC. The electives provide flexibility for the students to specialize. Students select these courses in consultation with the track coordinator, the profile coordinator or a staff member. The literature study is a preparatory research assignment directly linked to the subsequent thesis subject. The master's thesis should be based on an in-depth research or expert design assignment in the specific field of expertise chosen by the student. The students can do a thesis within the faculty or externally, at a company or some other institute/faculty. The thesis work is organized as a project, including milestones and deadlines. The panel noticed differences in study load and feasibility of the master's programme between the tracks. In particular, the time to graduate varies significantly, supposedly because of the different expectation for how long the thesis project should take.

The students are very satisfied with the courses, which they consider to be of high quality. The electives are a very good preparation for their master's thesis project. The panel established that the master tracks have the same basic structure, foundation and level, but differ in their specific substantive focus. All of the tracks prepare the students to achieve the ILOs. The obligatory ethics module for all tracks is a very positive element in the panel's opinion.



The internship is considered a valuable experience by the students. Students have to find an internship by themselves which also can be a valuable experience but often causes study delay and, in particular, disadvantages the foreign students. International students meet several obstacles in finding an internship place. They lack a network in the Netherlands and, partly for financial reasons, have fewer opportunities to take more time to finish their master's programme. Companies often prefer longer internship periods than three months and prefer Dutch students who have no objections and no financial constraints to extending this period. Furthermore, the scheduling of the internships offers little flexibility and leaves very limited room for even short delays. The panel is of the opinion that the programme is responsible for making it possible to finish the master in two years and therefore recommends the Faculty to pay special attention to the position of foreign students in regard to the planning of internships. It recommends to increase the number of internships facilitated, to make sure that foreign students can do an internship to avoid study delay, reconsider the scheduling and make the position of the internship more flexible.

In general, the panel finds the curriculum to be well developed. It enables the students to achieve the ILOs. The thesis project has a clear structure for all students, with a timeline and go/no-go meetings scheduled. The Faculty offers very diverse tracks and profiles, accommodating the diverse interests of many students.

The programme is offered fully in English. The panel agrees with the Faculty that considering the international character of the scientific domain, the international industry, and the desired balance of the national and international student and staff population, offering the programme in English ensures the best fit.

#### *Honours programme*

Both the bachelor's and the master's programmes offer an honour's programme. The Honours Programme Bachelor (HPB) is meant for a selection of 20 students who have completed their first year with an average mark of 8.0 or higher. They get the opportunity to follow a unique and challenging programme on top of their regular study. They perform an individual research project with one of the research groups of the Faculty (13 EC) and follow interdisciplinary courses or set up an interdisciplinary project to broaden their academic and professional skills (7 EC). Some 75-80% of the HPB students complete the honours programme successfully.

Excellent students who have completed their bachelor's programme with an average of 7.5 or higher within four years have the possibility to do an Honours Programme Master by obtaining 20 EC in addition to the regular programme. This Honours Programme is an individual, unique programme shaped by the student in consultation with the honours coordinator. Completion results in a certificate. The panel very much appreciates the opportunities offered by these honours programmes to students who want to excel.

#### *Didactics*

The self-evaluation report describes how the bachelor's curriculum employs pedagogical approaches that engage students as active participants in the learning process. They are challenged to develop personal and interpersonal skills and the skills to conceive, design and implement the aerospace design projects which are scheduled each semester. The design projects contain aeronautical and spaceflight assignments. They increase in complexity from the first year to the third year. As described, the bachelor's programme culminates in a 10-week, full-time Design Synthesis project in which the students work through each stage of the design cycle as explored in the preceding design projects. The staff uses active teaching and learning methods, wherever possible. The students agreed that there is a good mix of teaching methods. The teachers use interactive, engaging lecturing techniques, more active studio classroom sessions in which students get brief instructions and do computer-based work in real time, as well as flipped-classroom sessions with a blend of online and face-to-face learning.



In the fourth week of the first year, the bachelor's programme has a milestone test, which is a formative test indicating if the students are up to speed with studying, a kind of wake-up call for the first examination at the end of the period. This milestone is appreciated by the vast majority of the students and helps to structure their learning process.

The panel was impressed by the way the programme manages to maintain a stimulating learning environment despite the high student numbers. The didactic approach in the bachelor's programme with the design projects in each semester and the student-activating teaching methods used in the classrooms is truly student-centred according to the panel. It also appreciates the milestone test, which structures the student learning.

The teaching forms in the master's programme are in line with those used in the bachelor's programme, although a higher level of autonomy is expected of the students. The students appreciate the high level of the courses. They described how small communities of students are created and that they motivate each other. Both the students and staff are very proud and passionate about the subjects they are working on, which creates a great environment to work in.

#### *Feasibility*

The Faculty is facing an exponential increase in applicants for the bachelor's programme from 500 applicants in 2013 to 1547 in 2018. The programme attracts students from all over the world. The Faculty has imposed a set limit of 440 students. The students are selected on the basis of motivation and academic performance. The first step for applicants is to successfully complete the mini-MOOC 'Introduction to the Bachelor's Aerospace Engineering at TU Delft'. About 50% of the admitted students is Dutch, 35% EER, and 15% non-EER. The proportion of female students is rising but still low (16% in 2018). Various measures are in place to attract more female students. The panel appreciates these efforts and encourages the Faculty to keep on in this line.

Despite the careful selection procedure, a considerable proportion of the students (37%) did not get a positive Binding Study Advice at the end of their first year in 2017-2018. However, the figures show improvement compared to 2012 (47%). Some 74% of the students who enrol in the second year complete their bachelor's study within four years. The panel established that the study duration is decreasing, and the study yield is increasing comparably, which is positive. It also discussed the feasibility of the programme with the students and teachers during the site visit. The students mentioned that the programme is challenging, in particular the first year. Neither group, however, mentioned obstacles in the programme hindering the students from finishing in time. The students are of the opinion that it is possible to finish the bachelor's programme within three years. The panel encourages the programme to proceed with implementing measures aimed at stimulating study progress and to stay attentive to the feasibility of the programme.

As discussed above, the feasibility of the master's programme is not optimal according to the panel due to the scheduling of the internship. The students reported that the master's programme can be finished in two years, but in fact only 7% of all students does so, and 47% takes more than three years to finish. The panel thinks that for the foreign students, in particular, all obstacles in the master's programme should be removed in order to make it possible to finish in time.

#### *Teaching staff*

The courses and projects in aerospace design, engineering and technology are designed, developed and delivered by full, associate or assistant professors and lecturers of the Faculty of Aerospace Engineering. Staff from different departments and sections collaborate on courses and projects to achieve a broad and consolidated knowledge of engineering sciences. The mathematics courses in the first and second years of the bachelor's programme are taught by experts from the Delft Institute of Applied Mathematics.



About 95% of the tenured teaching staff has a PhD degree, and 48% is of international origin. Only 1/7 of the academic staff is female, which the faculty considers lower than desired. The Faculty is paying special attention to the recruitment of female staff to fill vacancies.

A University Teaching Qualification is required for new staff. A faculty-wide committee has reviewed the didactic competence levels of all tenured teachers who have more than five years of experience. Staff members who obtained a low score were obliged to follow one or more modules of the UTQ programme to readdress specific deficiencies. The panel established that there are sufficient possibilities and training programmes for professional development in education.

During the site visit the Faculty management explained that plans are being developed to establish a teaching-based academic career, meaning that academic staff can be promoted to full professor based with an emphasis on their teaching qualities. The panel appreciates these plans and wants to encourage the Faculty to stimulate lecturers to professionalise by rewarding teachers who try to innovate their teaching. It learned that the Faculty also considers to pay attention to the engineering competences of the teaching staff and encourages the Faculty to recruit new staff members with experience in industry.

The bachelor students are guided and instructed by many teaching assistants, mostly master or PhD students. In the first semester of the first year, the students participate in mentor groups, which are mentored by teaching assistants. During the first year they receive a lot of guidance and supervision in small groups. Teaching assistants are involved in the guidance for the design projects and the design synthesis project. They are trained and supervised by academic staff members. During the interviews, the students indicated that there can be major differences between the quality of the teaching assistants. The panel points out to the programme that the training and selection of teaching assistants might need attention.

The panel noticed a shortage in support staff connected to the programme. The students were complaining that the academic advisors have limited availability. During the site visit it became clear that the academic advisors are understaffed. Counselling and coaching in the master's programme is mainly done by master track coordinators, profile coordinators, and sometimes other staff members. This is an ad-hoc activity and adds to the high workload of the academic staff. The panel recommends investigating this issue and taking appropriate measures.

The workload of the tenured academic staff is very high. The student-staff ratio is currently measured as 30:1. Considering the high student numbers, the panel admires the fact that the staff manages to offer a high-quality programme. It established that the bachelor's and master's programmes are taught by experts in the field with sufficient didactical training. The English language proficiency of all tenured staff is considered sufficient to good.

### *Facilities*

In the first year of study, the students spend most of the classroom time in the lecture halls at the faculty. In the second and third years, they attend courses and make assessments at various locations all over the campus. The increasing student numbers are forcing the Faculty to use lecture rooms in other buildings. This is considered a sub-optimal choice by the students; they prefer to have their classes in the Aerospace Engineering building, which makes it easier to meet lecturers and ask additional questions or explanation outside the classroom. They are aware, however, that it is not possible to accommodate all of them in the present Aerospace building. The panel finds that the faculty management has already taken all possible measures to find solutions that suit both the teachers and the students. It visited the lab facilities which are also used for teaching goals. It was impressed by the fact that the Faculty manages to facilitate practical work and experiments for all students as part of their education. The panel established that the Faculty has excellent experimental facilities for research and education and also makes excellent use of these facilities for the bachelor's and the master's programmes. The high student numbers, however, put some pressure on the facilities in particular the instructional labs.

## Considerations

The curriculum of the bachelor's programme Aerospace Engineering enables the students to achieve the ILOs. The panel found the curriculum to be well developed, managed and implemented, and there is a good alignment between it and the ILOs. It appreciates the clear lines in the curriculum and the opportunities the minor space offers to students to broaden or deepen their knowledge and focus. It is very positive, in particular, about the Design Synthesis Capstone Project. It recommends explicitly describing ethics in the learning goals and in the content of courses in the bachelor's programme and making sure that the students are prepared for this aspect of research.

The Faculty offers very diverse tracks and profiles in the master's programme Aerospace Engineering, accommodating the diverse interests of many students. The panel finds the master's curriculum to be well developed, enabling the students to achieve the ILOs, although it had some remarks concerning the scheduling of the internships. The panel is of the opinion that the programme is responsible for making it possible to finish the master in two years and therefore recommends the Faculty to pay special attention to the position of foreign students in regard to the planning of internships. It recommends reconsidering the scheduling of the internship in order to make this more flexible. It established that all tracks have the same structure, foundation and level, but differ in their specific substantive focus. All of the tracks prepare the students to achieve the ILOs.

The choice to offer both programmes in English is sufficiently substantiated according to the panel. The English language proficiency of all tenured staff is considered sufficient to good.

The panel was impressed by the way the programme manages to maintain a stimulating learning environment despite the growing student numbers. The didactic approach in the bachelor's programme with the design projects in each semester and the student-activating teaching methods used in the classrooms is truly student-centred according to the panel. It also appreciates the milestone test, which structures the student learning. The teaching methods in the master's programme are in line with the teachings methods used in the bachelor's programme, although a higher level of autonomy is expected of the students.

The panel established that the bachelor's programme and the master's programme are taught by experts in the field with sufficient didactical training. The workload of the teaching is very high, however. In particular, the bachelor students are guided and instructed by many teaching assistants; the panel advises paying attention to the training and selection of these assistants to make sure that their teaching qualities and personal guidance skills are adequate and equivalent. It also noticed a shortage in support staff.

The high student numbers have put some pressure on the facilities, in particular the instructional labs. The panel was impressed by the fact that the Faculty manages to facilitate practical work and experiments for all students as part of their education. It established that the Faculty has excellent experimental facilities for research and education and also makes excellent use of them for the bachelor's and the master's programmes.

## Conclusion

*Bachelor's programme Aerospace Engineering:* the panel assesses Standard 2 as 'meets the standard',

*Master's programme Aerospace Engineering:* the panel assesses Standard 2 as 'meets the standard',



**Standard 3: Student assessment**

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

**Findings***Assessment policy*

The assessment policy of the Faculty is based on the assumption that the staff is qualified and motivated to provide high-quality assessments and feedback. The Board of Examiners formally appoints the examiners for each module, course or project. Examiners are considered qualified when they have successfully completed the University Teaching Qualification (UTQ) or have an exemption based on proven educational and teaching qualities. The Faculty has an Assessment and Examination Policy Plan, which describes in detail how the teaching, assessments and examinations are aligned. Different forms of assessment (written examinations, assignments, reports, computer tests) are used to evaluate and assess students. In the construction process of the exam, the examiners have to apply the peer-review principle. The rule is that every written exam is approved and signed by the responsible examiner and a second lecturer. For each course the examiner has an assessment matrix available as a framework to ensure the constructive alignment between assessments and ILOs.

*Bachelor's programme*

In the bachelor's programme, foundational courses in mathematics, physics and engineering sciences with the understanding, application and integration of knowledge as their primary ILO's are usually assessed with a written examination. Some tests are taken electronically in dedicated examination halls. If a student fails, a re-sit is possible at the end of the next educational period. Project work in the bachelor programme always results in an individual mark. Usually, this is a weighted average of a mark for the group work and for the individual contribution. The individual score is based on technical quality, attitude, initiative and leadership the student has demonstrated in his or her project and sometimes on an individual test or interview. Teaching assistants support the coaching of design projects and may advise staff members, but are not permitted to issue marks.

As described under Standard 2, The Design Synthesis Capstone project has a clear project structure, a timeline and clear learning objectives, including group work competences. Detailed rubric forms are available for the assessments. To ensure the uniform application of the grading criteria over the various teams, one member of the Design Synthesis Coordination Committee is always present during a final grading session. The panel discussed the grading of the Design Synthesis projects at length during the site visit, with the teachers, the Board of Examiners and the students. It had particular questions concerning the balance between individual and group grading of the project. The teachers explained that 70% of the final grade of the DSE is based on individual grading and 30% on the group grade. This balance between individual and group grading was adopted on the recommendations of the former programme assessment committee. Another consequence of the earlier assessment was that the rubrics were reviewed and changed. Peer review is also used in DSE and influences the grading.

Based on the Design Synthesis projects and the associated individual assessment forms that the panel studied, it was impressed by the detailed rubric form used for the assessment of the DSE project. For the projects it studied, it is of the opinion that the final grades of the individual students are a correct representation of the degree to which the individual student has achieved the ILOs. The panel notes that students do not always recognize this, as in the student chapter they state: 'Regarding the project-orientated courses, students question the balance between the group and individual assessments'. The panel speculates that this might stem from the fact that, although an elaborate individual grading system is used, the final grade of individual group members is often not far removed from the group grade. This might lead to the perception of imbalance. The panel recommends the programme to investigate whether this is the case, and if this is the case, find a suitable solution that makes the grading more transparent to students.

### *Master's programme*

The master's internship is evaluated at the half-way mark and the end of the internship project. The supervisor on site is asked to complete a detailed grading form. If there are significant deficiencies, the internship coordinator contacts the student, and corrective action can be taken. Upon completion of the internship, the student must submit a report, which is assessed by the internship coordinator and a report evaluator from the scientific staff with the use of a standardized grading form. The assessment leads to a pass or fail grade, and feedback is provided to the student. The panel discussed the assessment of the internship with teachers and the Board of Examiners during the site visit. It established that the opinion of the external supervisor is used as advice for the assessment of the internship. It also checked the grading form and is convinced that the assessment of the internship is sufficient.

The master's literature study results in a student report which is evaluated on six elements with the use of rubrics, which provide a reference for homogeneous grading. The literature study provides the preparation work for the thesis, but is graded separately.

The quality of the individual thesis project is checked at several moments during the whole project: at the kick-off meeting, the mid-term review and the green light meeting. A student has to receive a 'green light' before being allowed to request the official examination. The final examination has two elements: a public presentation lasting 35 – 45 minutes and a one-hour closed session in which the results are defended and the student is assessed by a graduation committee. This committee consists of a professor from the student's track, the project supervisor and an examiner from another research group than the research group of the chair of the committee within the Faculty of Aerospace Engineering or from another TU Delft faculty. It assesses the research by allocating separate grades for a total of 13 rubrics. The final mark is a weighted average of these sub-grades. In the case of the EWEM track, the graduation procedure of DTU might be used if the student performs his or her thesis there. In that case, there is always a supervisor from TU Delft involved to safeguard that the work is graded similar to the other master's theses.

The assessment procedure for the master's thesis project is well developed in the panel's opinion. It viewed the assessment form used for the thesis project and discussed the use of this form as well as the procedure followed by the examiners with the teachers and the Board of Examiners during the site visit. It noticed that some assessment forms lacked motivation for the grading and that the assessment forms invited assessors to indicate a combination of rubrics as applicable. It concluded that the use of the assessment form could be improved to make the final grade more transparent through argumentation about the grades on the rubrics and more written feedback to students. The Board of Examiners has already announced that the master rubrics will be reviewed.

### *Board of Examiners*

The Board of Examiners (BoE) consists of seven academic teaching staff members of the Faculty and one senior staff member of the Faculty of Civil Engineering and Geosciences as an external member. It monitors the assessment quality and the correct application of the Teaching and Examination Regulations. It has started a process of assessing the bachelor's courses, including the DSE project; the next step is to do that for the master's courses as well. It is the aim of the BoE to work on checking the validity and reliability of the assessment of all courses. Test matrices are a central element in checking whether all learning outcomes are met. Furthermore, every year the BoE collects a set of master's theses, including from the EWEM track, and checks the assessment and the grading. The panel is positive about the way the BoE is performing its tasks. It noted that the BoE members were unclear about their task load and how many hours they could spend on their BoE tasks. The panel thinks this might need clarification for the benefit of the BoE members.

The Board of Examiners reported to the panel that they are working on establishing a test matrix for the bachelor's programme. The panel welcomes this development and stimulates the BoE to develop a test matrix also for the master's programme. A fully developed test matrix and assessment plan would make the alignment between the ILOs and the assessments more transparent and could



indicate that the bachelor's programme guarantees that students are educated regarding the knowledge, skills and attitude specified in the programme's learning outcomes.

The panel is positive about the way the BoE is performing its tasks. It concluded that the Faculty has an adequate assessment policy and quality assurance mechanisms. Examinations, tests and the thesis assessment are sufficiently transparent, valid and reliable.

### **Considerations**

The panel is positive about the way the Board of Examiners is performing its tasks. It finds the assessment system and policy adequately developed and implemented. The courses use a variety of assessment methods, which are aligned with the learning outcomes and the curriculum. The procedures are transparent for teachers and students. The panel was impressed by the detailed rubric forms used for the assessment of the Design Synthesis Capstone Project of the bachelor's programme. It concluded that the examinations, tests and assessments are transparent, valid and reliable.

The assessment of the internship in the master's programme is sufficient, according to the panel, but it recommends checking the quality of the internship from the start of the project and in the midterm review as much as possible through personal contact between the academic supervisor, the external supervisor and the student for each internship. The panel was positive about the quality assurance of the theses conducted externally through the mandatory involvement of a TU Delft supervisor and the inclusion of all theses in the thesis check by the BoE.

The assessment procedure for the master's thesis project is very well developed in the panel's opinion. It noticed that some improvement is possible in the use of the rubric forms for the assessment of the master's thesis.

### **Conclusion**

*Bachelor's programme Aerospace Engineering:* the panel assesses Standard 3 as 'meets the standard'.

*Master's programme Aerospace Engineering:* the panel assesses Standard 3 as 'meets the standard'.

### **Standard 4: Achieved learning outcomes**

The programme demonstrates that the intended learning outcomes are achieved.

### **Findings**

In order to establish whether the bachelor's and the master's programme Aerospace Engineering demonstrate that the ILOs are achieved, the panel checked whether all ILOs are covered in the courses, projects and accompanying assessments that make up the curricula. It concluded that the curricula ensure that the graduates have achieved the ILOs.

The panel studied a selection of nine Design Synthesis Project reports and the accompanying documentation from a total of 42 students. It chose this high number of students to be able to get a good overview of the differentiation in grading between individual students in the groups and between groups. It agreed with the assessments of all reports, as well as with the transparency of the differentiation between group members through the individual assessment. The reports showed that the students are competent in engineering design and have the ability to acquire and validate new knowledge as required for the project. The reports convinced the panel that the students are able to design a multidisciplinary system, subsystem or inventive arrangements of system elements.

Almost all bachelor graduates (95%) proceed to the master's programme Aerospace Engineering. Figures presented in the self-evaluation report showed that the bachelor graduates are well prepared for the master's programme, which was confirmed in the panel's interview with the master students.

The panel studied a selection of 15 master's theses, with at least two theses selected from each of the six tracks. In general, it agreed with the assessment and the grading, although it would have graded some theses lower than the graduation committee; this difference could be ascribed to the limited information available to the panel due to the limited feedback on some of the forms and the fact that in the rubrics the scores were frequently not given exact but as a circle around different levels of the rubric. All theses showed that the students achieved the intended learning outcomes. The panel has established that correct protocols are installed and that the quality of graduation work is sufficiently assured.

The graduates of the master's programme very easily find a job at the master's level within a short time. Some 75% find their first job within two months and 90% within 6 months, either in the Netherlands or abroad. A substantial proportion of graduates (10%) proceed to a PhD trajectory and feel very well prepared for it. Graduates are also sought after by various branches in industry and are much appreciated for their competences. The alumni are very proud to have studied at the Faculty Aerospace Engineering in TU Delft. The panel concluded that the graduates are well prepared for continuing in a PhD trajectory or a job in industry.

### **Considerations**

The panel concludes that graduates of the bachelor's programme in Aerospace Engineering have achieved the intended learning outcomes. Almost all bachelor graduates proceed to the Aerospace Engineering master's programme and are well prepared to successfully complete it.

The panel concludes that graduates of the master's programme in Aerospace Engineering have achieved the intended learning outcomes. It found the level of all master's theses to be good and on average agreed with their grading. It would have graded some theses a bit lower. The graduates are well prepared for continuing in a PhD trajectory or a job in industry.

### **Conclusion**

*Bachelor's programme Aerospace Engineering*: the panel assesses Standard 4 as 'meets the standard'.

*Master's programme Aerospace Engineering*: the panel assesses Standard 4 as 'meets the standard'.

## **GENERAL CONCLUSION**

The panel judged that the bachelor's programme in Aerospace Engineering offered by Delft University of Technology meets all standards of the NVAO assessment framework for limited programme assessment. It therefore advises positively about the re-accreditation of the programme.

The panel judged that the master's programme in Aerospace Engineering offered by Delft University of Technology meets all standards of the NVAO assessment framework for limited programme assessment. It therefore advises positively about the re-accreditation of the programme.

### **Conclusion**

The panel assesses the *bachelor's programme Aerospace Engineering* as 'positive.'

The panel assesses the *master's programme Aerospace Engineering* as 'positive.'







# APPENDICES



# APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

The Domain-Specific Framework of Reference is a slightly modified version of the framework adopted in the QANU Assessment Report of the Degree Courses Aerospace Engineering, February 2008.

## **What is to be expected from an aerospace engineer?**

### ***Basic sciences and technical tools***

*The aerospace engineer requires thorough knowledge of and insight into the basic sciences including their generic methods and tools insofar as these are relevant to engineering practice.*

- Knowledge of and insight into mathematics: calculus, ordinary and partial differential equations, linear algebra, numerical analysis and statistics;
- Knowledge of and insight into physics: statics and dynamics, solid and fluid mechanics, thermodynamics, electricity and chemistry;
- Knowledge of relevant aspects of computer science and software;
- Familiarity with and experience in physical modelling and using mathematical and numerical methods to solve engineering problems;
- Extended knowledge of and insight into mathematics, physics, and computer science insofar as these relate to the final studies in one of the Aerospace Engineering disciplines.

### ***General engineering sciences***

*The aerospace engineer requires thorough knowledge of and insight into general engineering sciences to be able to operate in 'non-standard' conditions.*

- Knowledge, insight, and skills concerning general engineering sciences: engineering mechanics, strength of materials, materials and manufacturing methods, engineering fluid dynamics, control theory & systems and design methods in general;
- Ability to relate general engineering sciences to Aerospace Engineering disciplines;
- Ability to apply knowledge of general engineering subjects to new situations and to use this knowledge to solve operational problems;
- Extended knowledge of and insight into general engineering sciences insofar as these relate to the final studies in one of the Aerospace Engineering disciplines.

### ***Aerospace Engineering disciplines***

*The aerospace engineer requires a broad knowledge of the demands on aerospace vehicles as regards safety, reliability, aerodynamic and structural design, and flight performance.*

- Thorough knowledge of and insight into the engineering sciences related to aerospace vehicles:
  - aerodynamics;
  - performance, stability, and control;
  - propulsion;
  - structures and materials;
  - strength and vibrations;
  - equipment and systems;
  - production, maintenance, and industrial process management;
  - operational use, including air traffic control;
  - structural design of aircraft and spacecraft.
- Acquaintance with the diversity and interdependence of problems (synthesis) within the aforementioned fields;
- Extended knowledge of and insight into Aerospace Engineering disciplines and their diversity, interdependence and coherence in problem solving activities (synthesis).

### ***General engineering and Aerospace Engineering applications***

*The aerospace engineer requires the skills to apply the acquired knowledge of engineering and aerospace sciences.*

- Knowledge, insight and skills concerning general engineering sciences applications through (lab) exercises:
  - illustration and visualisation through applications;
  - skills in applications;



- skills in problem solving.
- Knowledge, insight and skills concerning Aerospace Engineering applications through (lab) exercises:
- illustrations and applications of engineering practice;
- skills in applications;
- skills in problem-solving.
- use of scientific general engineering software;
- use and development of advanced scientific software for aerospace applications.

### **Scientific attitude in professional problem-solving**

*The aerospace engineer must be able to recognise, formulate, and analyse engineering problems and to offer one or more solutions to these problems. The engineer must be able to create a synthesis between diverse facets of the problem, to identify and to evaluate various possibilities.*

- Ability to synthesise and to integrate knowledge;
- Verifying developed theories and solutions through experiments;
- Selecting and analysing relevant sources independently and critically;
- Reporting conclusions and solutions.

### **Transfer of knowledge**

*The aerospace engineer must be able to report clearly on the technical-scientific work both orally and in writing. Proficiency in the Dutch language as well as in technical English is required.*

- Skills in writing reports in Dutch and English;
- Skills in oral reporting both in Dutch and in English using state-of-the-art presentation techniques;
- Ability to function in project teams and to contribute to the process of knowledge transfer.

### **The Aerospace Engineering industry**

*The aerospace engineer requires knowledge and an understanding of the (national and international) aerospace industry and (research) institutes. Furthermore, a basic understanding is required of the context in which engineering is practised.*

Knowledge of:

- The most important 'actors' in the aerospace industry and their mutual contacts, both national and international;
- The social context of the aerospace industry;
- The implications of the aerospace industry on society;
- Industrial organisation and management processes;
- Sustainable development;
- The Aerospace Engineering profession and industrial practice;
- Economics.

### **Capability and interest**

*The aerospace engineer must obtain insight into the capabilities and interests required in view of his future professional position(s).*

### **Preparation for professional career**

*The aerospace engineer must be prepared for a broad range of engineering duties in various Aerospace Engineering or related disciplines following a certain period of on-the-job learning and training.*

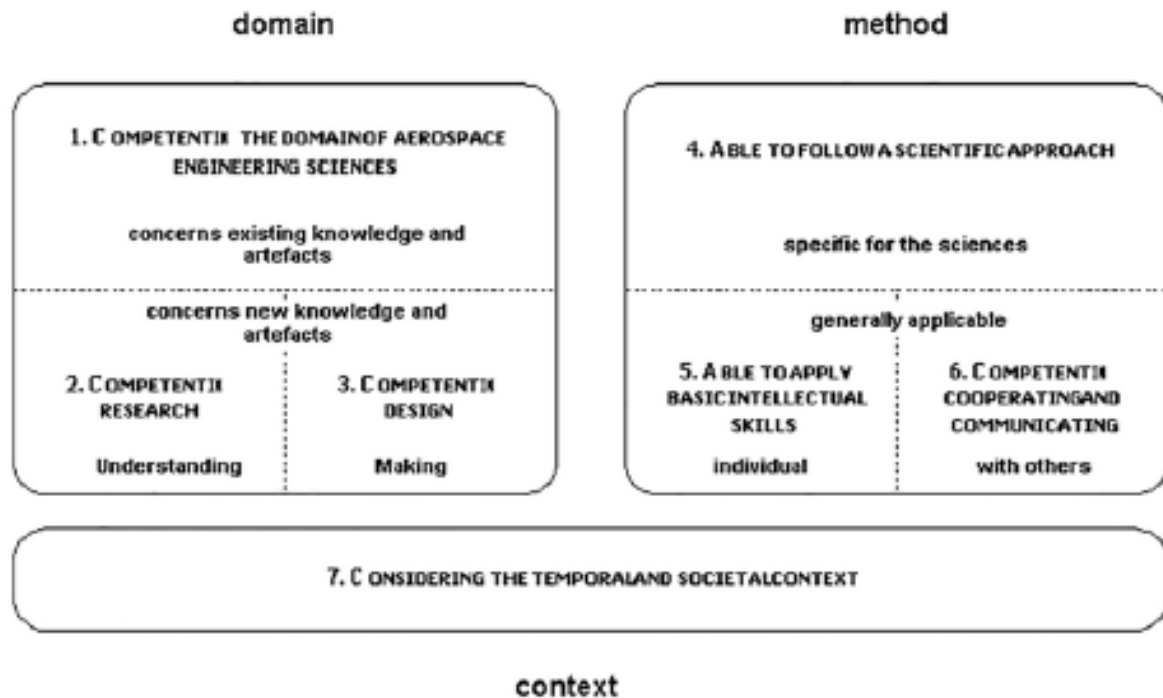
Final objectives must guarantee that the recently graduated aerospace engineer will achieve the following:

- a broad engineering education, including a good understanding of the design process and manufacturing;
- accessibility to a broad range of employment positions;
- sufficient flexibility as regards professional career;
- ability to think critically and creatively;
- understanding of the context in which engineering is practised;
- good communication skills;
- ability to function as a member of a team;
- curiosity and a desire to engage in life-long learning.

## APPENDIX 2: INTENDED LEARNING OUTCOMES

### Bachelor's programme Aerospace Engineering

The competence areas of a BSc university graduate are represented in the figure below, which was taken from the 3TU "Criteria for Academic Bachelor's and Master's Curricula".



For each competence, it is indicated whether the competence is knowledge-, skill- or attitude-related:

[k] = knowledge

[s] = skill

[a] = attitude



## ***BSc-I Competent in the domain of aerospace engineering sciences***

### ***The fields of major subjects in aerospace engineering sciences***

<b>A</b>	<b>Mathematics</b>	Calculus, differential equations, linear algebra, vector calculus, numerical methods, statistics, probability and observation theory.
<b>B</b>	<b>Thermodynamics</b>	Equations of state, entropy, constant pressure, volume temperature, 1st & 2nd laws, energy, exergy, efficiencies, power and cooling cycles, heat transfer.
<b>C</b>	<b>Electromagnetism and optics</b>	Electricity, magnetism, optics.
<b>D</b>	<b>Fluid Mechanics</b>	Conservation of mass, energy, momentum, boundary layer, laminar and turbulent flow, Bernoulli, Navier-Stokes, dimensionless analysis, compressible flow.
<b>E</b>	<b>Aerodynamics</b>	Aircraft aerodynamics, airfoil and wing theory, incompressible flow, compressible aerodynamics propeller theory, sub- and supersonic flow, Mach effects.
<b>F</b>	<b>Solid Mechanics</b>	Statics, kinematics, dynamics, stress analysis, strength and vibrations, finite-element methods.
<b>G</b>	<b>Flight Mechanics</b>	Stability, control, performance of aircraft, helicopters and hovers, flight performance optimisation.
<b>H</b>	<b>Propulsion</b>	Gas turbine, rocket.
<b>I</b>	<b>Materials Science / Aircraft Structures</b>	Relation between structure and properties for metals, plastics, ceramics, composites; failure, fracture, fatigue, wear, manufacture, production; buckling, shear panels, thin-walled structures.
<b>J</b>	<b>Systems &amp; Control Engineering</b>	Modelling, simulating, automation control, system identification, tools, avionics, fundamental and instrumental electronics, sensors and actuators, positioning, guidance and navigation.
<b>K</b>	<b>Design of aircraft, spacecraft and rockets</b>	Design methodologies, systems engineering, aircraft and spacecraft systems, vehicle engineering, reliability, safety, inspection and quality control, testing, engineering design standards, maintenance and (mission) operations, product life cycle.
<b>L</b>	<b>Astrodynamics</b>	Orbits and orbit dynamics, ascent, re-entry, interplanetary flight trajectories, space environment, space mission design.
<b>M</b>	<b>Space Science</b>	Observation requirements, measurement techniques, planetary space research, physical phenomena and principles.
<b>N</b>	<b>Information Technology</b>	Fundamentals, software architecture, programming techniques, tools for design, analysis and simulation.
<b>O</b>	<b>Management, economics &amp; communications</b>	Management and organisation, economics, aerospace business marketing, air and space law, sustainability.

*The BSc graduate has a consolidated body of knowledge in the fields of basic and engineering sciences, and aerospace engineering sciences in particular, and has the skills to increase and develop this further through study.*

- a. 1 - Understands the knowledge base of the critical fields to the extent that the student can apply it in basic physical and mathematical models that adequately simulate reality. [k]
- 2 - Is able to validate models following an accepted scientific approach. [ks]
- b. Is able to relate and apply general engineering sciences to disciplines using appropriate methods and tools. [ks]
- c. 1 - Has basic knowledge and skills in assessing theories and models in the field of aerospace engineering sciences. [ks]
- 2 - Has basic knowledge and skills in applying theories and developing models in the field of aerospace engineering sciences. [ks]
- d. Has basic knowledge and skills in conducting experiments and simulations and gathering data in the relevant fields of aerospace engineering sciences. [ks]
- e. Has basic knowledge and skills in deducing knowledge from data, text, problems and results in the field of aerospace engineering sciences. [ks]
- f. Has basic knowledge and skills of accepted criteria on which decisions are based within the specific fields of aerospace engineering sciences. [ks]
- g. Is aware of the limits of usability of standard methods and procedures used in aerospace engineering sciences. [ksa]

### ***BSc-II Competent in research***

The BSc graduate has an understanding at an introductory level of the most important research issues in the aerospace related sciences, and is aware of the connections with other disciplines. For this purpose, research means: the development of new knowledge and new insights in a purposeful and methodical way.

- a. Is able to spot deficiencies in a problem statement, to indicate how to reformulate the problem and to justify his choices. [ksa]
- b. Is observant, and has the creativity and the capacity to discover connections and views from different perspectives. [ksa]
- c. Is able to contribute to the execution of a research plan. [ks]
- d. Is able to work at different levels of abstraction, in relation to the research question at hand. [ks]
- e. Is aware of the importance of other disciplines. [ka]

### ***BSc-III Competent in design***

Designing is a synthetic activity aimed at the realisation of new or modified products or systems, with the intention of creating value in accordance with predefined requirements.

The BSc graduate aerospace engineering is able to recognise, formulate and analyse engineering problems independently and to offer one or more acceptable solutions for new or modified items or systems, with the intention of creating value in accordance with predefined requirements.

- a. Is able to spot deficiencies in a design problem definition, to indicate how to mitigate these and to justify his choices. [ksa]
- b. 1 - Has sufficient creativity to come up with several solutions to a theoretical and/or practical design problem. [ka]
- 2. Has basic synthetic skills with respect to theoretical and practical design problems. [ks]
- c. 1 - Is able to interpret a set of requirements and translate these into a design plan containing at least planning, work breakdown and activity flow. [ks]
- 2 -Is able to execute the design plan according to accepted standards. [ks]
- d. Is able to work at different levels of abstraction, including systems level. [ks]
- e. 1 - Is aware of the importance of other disciplines. [ks]
- 2 - Is able to synthesise disciplines in a design, such that a compliant (sub-)system design is accomplished. [ks]
- f. Is aware of the changeability of the design process through external circumstances or advancing insight and is able to keep the design process under control (working in a team under guidance of a professional). [ka]
- g. Is able to integrate existing knowledge, information and numerical data from different sources in an efficient way into a design project. [ks]



h. Has the skill to take design decisions, and to justify and evaluate these in a systematic manner. [ks]

#### ***BSc-IV Able to follow a scientific approach***

The BSc graduate has a systematic approach characterised by the application of theories, development of models and the making of coherent interpretations, has a critical attitude and insight into science and technology in the aerospace domain.

a. Is inquisitive and has an attitude of lifelong learning. [a]

b. Has a systematic approach characterised by applying theories and developing models and making interpretations. [ksa]

c. Has the knowledge and the skill to use, justify and assess as to their value models for research and design in the aerospace domain (model understood broadly: from mathematical model to scale-model). Is able to adapt and validate models for his or her own use. [ks]

d. Has insight into the aerospace related sciences and technology and has an appreciation of uncertainty, ambiguity and limitations of knowledge. [k]

e. Is able to report adequately the results of research and design. [ksa]

#### ***BSc-V Able to apply basic intellectual skills***

The BSc graduate is competent in reasoning, reflecting, and forming a judgment. These are skills which are learnt in the context of aerospace problems, questions or environment, and which are generically applicable from then on.

Is able to critically reflect on his or her own thinking, decision-making, and acting and to adjust these on the basis of this reflection. [ks]

Is able to reason logically within the field and beyond; both “why” and “what-if” reasoning. [ks]

Is able to ask adequate questions, and has a critical yet constructive attitude towards analysing and solving simple problems in the field. [ks]

Is able to form a well-reasoned opinion in the case of incomplete or irrelevant data. [ks]

Is able to comment meaningfully on a scientific argument in the field of aerospace engineering sciences. [ksa]

Possesses basic numerical skills, and has an understanding of orders of magnitude. [ks]

#### ***BSc-VI Competent in cooperating and communicating***

The BSc graduate has the competence of being able to work with and for others. This requires not only adequate interaction, a sense of responsibility, and preferably leadership, but also good communication with colleagues and non-colleagues. He is also able to follow a scientific or public debate.

a. Is able to communicate both verbally and in writing about the results of learning, thinking and decision making with colleagues and non-colleagues. [ks]

b. Is able to present verbally the solutions and conclusions of his or her work using state-of-the-art presentation techniques. [s]

c. Is able to follow debates about the aerospace engineering sciences and its place in society. [ks]

d. Is characterised by professional behaviour. This includes: drive, integrity, reliability, commitment, accuracy, perseverance and independence. [ksa]

e. Is pragmatic and has a sense of responsibility; is able to deal with limited resources; is able to deal with risks; is able to compromise. [ksa]

f. Is able to work within an interdisciplinary team. [ks]

g. Has insight into, and is able to deal with team roles and social dynamics. [ks]

#### ***BSc-VII Considering the temporal and societal context***

The aerospace engineering sciences are not isolated and always have a temporal and societal context. Beliefs and methods have their origins; decisions have societal consequences in time.

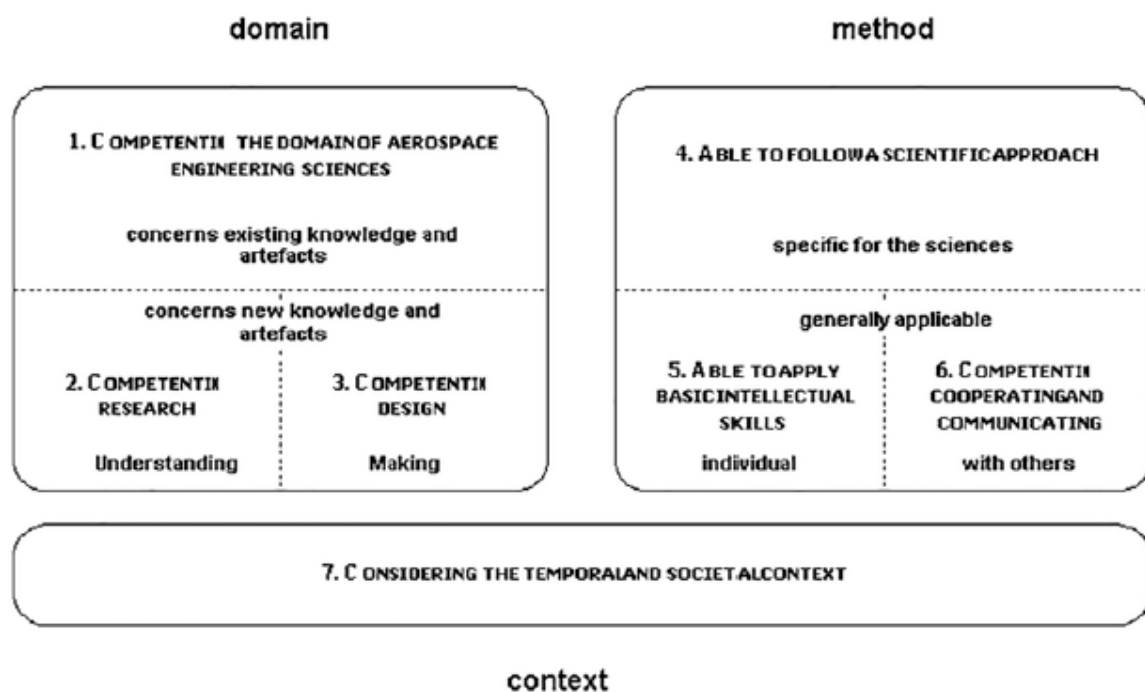
The BSc graduate is aware of the fact that aerospace engineering sciences are not isolated and always have a temporal and societal context. He has knowledge and understanding of the context in which aerospace engineering and utilisation is practised by industry, institutes and organisations. He has the competence to integrate these insights into his work.



- a. Understands relevant (internal and external) developments in the history of aeronautics and spaceflight. This includes the interaction between the internal developments (of ideas) and the external (societal) developments, both national and international. [ks]
- b. Is able to analyse the societal context of the aerospace industry (economic, social, cultural) and the consequences of new developments and applications in the domain of aerospace engineering sciences and to discuss these with colleagues and non-colleagues. [ks]
- c. Is able to analyse and discuss the ethical, safety and sustainability consequences of professional activities in the domain of aerospace with colleagues and non-colleagues (both in research and in designing). [ks]
- d. Has an eye for the different stakeholders in the fields of the aerospace engineering sciences. [ks]

**Master’s programme Aerospace Engineering**

The competence areas of an MSc university graduate are represented in the figure below, that was taken from “Criteria for Academic Bachelor’s and Master’s Curricula”.



For each competence an indication is given whether it is knowledge, skill or attitude related:

- [k] = knowledge
- [s] = skill
- [a] = attitude

The MSc Final Qualifications are an elaboration of the following seven competences:

He or she

- a. is competent in one or more scientific disciplines

The Aerospace Engineering graduate is familiar with existing scientific knowledge, and has the competence to increase and develop this through study.

- b. is competent in doing research

The Aerospace Engineering graduate has the competence to acquire new scientific knowledge through research. For this purpose, research means: the development of new knowledge and new insights in a purposeful and methodical way.



c. is competent in designing

The Aerospace Engineering graduate is familiar with the principles of design. Designing is a synthetic activity aimed at the realization of new or modified artifacts or systems with the intention of creating value in accordance with predefined requirements and desires (e.g. mobility, health).

d. has a scientific approach

The Aerospace Engineering graduate has a systematic approach characterized by the development and use of theories, models and coherent interpretations, has a critical attitude, and has insight into the nature of science and technology.

e. possesses basic intellectual skills

The Aerospace Engineering graduate is competent in reasoning, reflecting, and forming a judgment. These are skills which are learned or sharpened in the context of a discipline, and which are generically applicable from then on.

f. is competent in co-operating and communicating

The Aerospace Engineering graduate has the competence of being able to work with and for others. This requires not only adequate interaction, a sense of responsibility, and leadership, but also good communication with colleagues and non-colleagues. He or she is also able to participate in a scientific or public debate.

g. takes account of the temporal and the social context

Science and technology are not isolated, and always have a temporal and social context. Beliefs and methods have their origins; decisions have social consequences in time. A university graduate is aware of this, and has the competence to integrate these insights into his or her scientific work.

### ***MSc-I Competent in the domain of aerospace engineering sciences***

The Aerospace Engineering graduate is familiar with existing scientific knowledge, and has the competence to increase and develop this through study.

a. Has a thorough Mastery of a particular field in Aerospace Engineering extending to the forefront of knowledge (latest theories, methods, techniques and topical questions). [ks]

b. Looks actively for structure and connections in a particular field of Aerospace Engineering and related scientific disciplines. [ksa]

c. Has knowledge of and skill in the way in which truth-finding and the development of theories and models take place in a particular field of Aerospace Engineering. Has the skill and the attitude to apply these methods independently in the context of more advanced ideas or applications. [ksa]

d. Has knowledge of and skill in the way in which interpretations (texts, data, problems, results) take place in a particular field of Aerospace Engineering. Has the skill and the attitude to apply these methods independently in the context of more advanced ideas or applications. [ksa]

e. Has knowledge of and some skill in the way in which experiments, gathering of data and simulations take place in a particular field of Aerospace Engineering. Has the skill and the attitude to apply these methods independently in the context of more advanced ideas or applications. [ksa]

f. Has knowledge of and some skill in the way in which decision-making takes place in a particular field of Aerospace Engineering. Has the skill and the attitude to apply these methods independently in the context of more advanced ideas or applications. [ksa]

g. Is able to reflect on standard methods and their presuppositions; is able to question these; is able to propose adjustments, and to estimate their implications. [ksa]

h. Is able (with supervision) to spot gaps in his / her own knowledge, and to revise and extend it through study, independently. [ks]

### ***MSc-II Competent in doing research***

The Aerospace Engineering graduate has the competence to acquire new scientific knowledge through research. For this purpose, research means: the development of new knowledge and new insights in a purposeful and methodical way.

a. Is able to reformulate ill-structured research problems in multi-disciplinary context such as Aerospace Engineering. Also takes account of the system boundaries in this. Is able to defend the new interpretation against involved parties, for problems of a more complex nature. [ksa]

- b. Is observant, and has the creativity and the capacity to discover in apparently trivial matters certain connections and new viewpoints and is able to put these viewpoints into practice for new applications. [ksa]
- c. Is able to produce and execute independently a research plan. [ks]
- d. Is able to work at different levels of abstraction. Given the process stage of the research problem, chooses the appropriate level of abstraction. [ksa]
- e. Understands, where necessary, the importance of other disciplines (interdisciplinarity). Is able, and has the attitude to, where necessary, draw upon other disciplines in his or her own research. [ksa]
- f. Is able to deal with the changeability of the research process through external circumstances or advancing insight. Is able to steer the process on the basis of this. [ksa]
- g. Is able to assess research within a particular field of Aerospace Engineering on its scientific value. [ksa]
- h. Is able to independently contribute to the development of scientific knowledge in one or more areas of the disciplines involved in a particular field of Aerospace Engineering. [ksa]

### ***MSc-III Competent in designing***

The Aerospace Engineering graduate is familiar with the principles of design. Designing is a synthetic activity aimed at the realization of new or modified artifacts or systems with the intention of creating value in accordance with predefined requirements and desires (e.g. mobility, health).

- a. Is able to reformulate ill-structured design problems in the field of Aerospace Engineering. Also takes account of the system boundaries in this. Is able to defend this new interpretation against the parties involved for design problems of a more complex nature. [ksa]
- b. Has creativity and synthetic skills with respect to multi-disciplinary design problems, such as they occur in the field of Aerospace Engineering. [ksa]
- c. Is able to independently produce and execute a design plan. [ks]
- d. Is able to work at different levels of abstraction including the system level. Given the process stage of the design problem, chooses the appropriate level of abstraction. [ksa]
- e. Is able, and has the attitude, where necessary, to draw upon other disciplines in his or her own design. [ksa]
- f. Is able to deal with the changeability of the design process through external circumstances or advancing insight. Is able to steer the process on the basis of this. [ksa]
- g. Is able to formulate new research questions on the basis of a design problem. [ks]
- h. Has the skill to take design decisions, and to justify and evaluate these in a systematic manner. [ksa]

### ***MSc-IV A scientific approach***

The Aerospace Engineering graduate has a systematic approach characterized by the development and use of theories, models and coherent interpretations, has a critical attitude, and has insight into the nature of science and technology.

- a. Is able to identify and take in relevant developments in a particular field of Aerospace Engineering. [ksa]
- b. Is able to critically examine existing theories, models or interpretations in the area of his or her graduation subject. [ksa]
- c. Has great skill in, and affinity with the use, development and validation of models; is able to consciously and conscientiously choose between alternative modeling techniques. [ksa]
- d. Has insight into the nature of science and technology (purpose, methods, differences and similarities between scientific fields, nature of laws, theories, explanations, role of the experiment, objectivity etc.) and has knowledge of current debates about this. [k]
- e. Has insight into the scientific practice (research system, relation with clients, publication system, importance of integrity etc.) and has knowledge of current debates about this. [k]
- f. Is able to document adequately the results of research and design with a view to contributing to the development of knowledge in the field and beyond and is able to publish these results. [ksa]



### ***MSc-V Basic intellectual skills***

The Aerospace Engineering graduate is competent in reasoning, reflecting, and forming a judgment. These are skills which are learned or sharpened in the context of a discipline, and which are generically applicable from then on.

- a. Is able (with supervision) to critically reflect on his or her own thinking, decision-making, and acting and to adjust these on the basis of this reflection, independently. [ksa]
- b. Is able to reason logically within the field and beyond; both 'why' and 'what-if' reasoning. Is able to recognize fallacies. [ks]
- c. Is able to recognize modes of reasoning (induction, deduction, analogy etc.) within the field. Is able to apply these modes of reasoning. [ksa]
- d. Is able to ask adequate questions, and has a critical yet constructive attitude towards analyzing and solving more complex (real-life) problems in the field . [ksa]
- e. Is able to form a well-reasoned opinion in the case of incomplete or irrelevant data and taking account of the way in which that data came into being [ks]
- f. Is able to take a standpoint with regard to a scientific argument in the field of aerospace (engineering) sciences and is able to assess this critically as to its value. [ksa]
- g. Possesses basic numerical skills, and has an understanding of orders of magnitude. [ksa]

### ***MSc-VI Competent in cooperating and communicating***

The Aerospace Engineering graduate has the competence of being able to work with and for others. This requires not only adequate interaction, a sense of responsibility, and leadership, but also good communication with colleagues and non-colleagues. He or she is also able to participate in a scientific or public debate.

- a. Is able to communicate in writing about research and solutions to problems with colleagues, non-colleagues and other involved parties. [ksa]
- b. Is able to communicate verbally about research and solutions to problems with colleagues, non-colleagues and other involved parties. Is able to do so in second language. [ksa]
- c. Is able to debate about both the Aerospace Science and Technology and its place in society. [ksa]
- d. Is characterized by professional behaviour, showing flair in performing experimental and other project work. This includes: drive, reliability, commitment, accuracy, perseverance and independence. [ksa]
- e. Is able to perform project-based work: is pragmatic and has a sense of responsibility; is able to deal with limited sources; is able to deal with risks; is able to compromise for more complex problems [ksa]
- f. Is able to work within an interdisciplinary team and for a team with great disciplinary diversity. [ksa]
- g. Has insight into, and is able to deal with, team roles and social dynamics. Is able to assume the role of team leader. [ks]

### ***MSc-VII Takes account of the temporal and societal context***

Aerospace science and technology are not isolated, and always have a temporal and societal context. Beliefs and methods have their origins; decisions have societal consequences in time. The MSc graduate is aware of this and therefore has knowledge and understanding of the context in which Aerospace Engineering and utilization is practiced by industry, institutes and organizations. He or she has the competence to integrate these insights into his or her work.

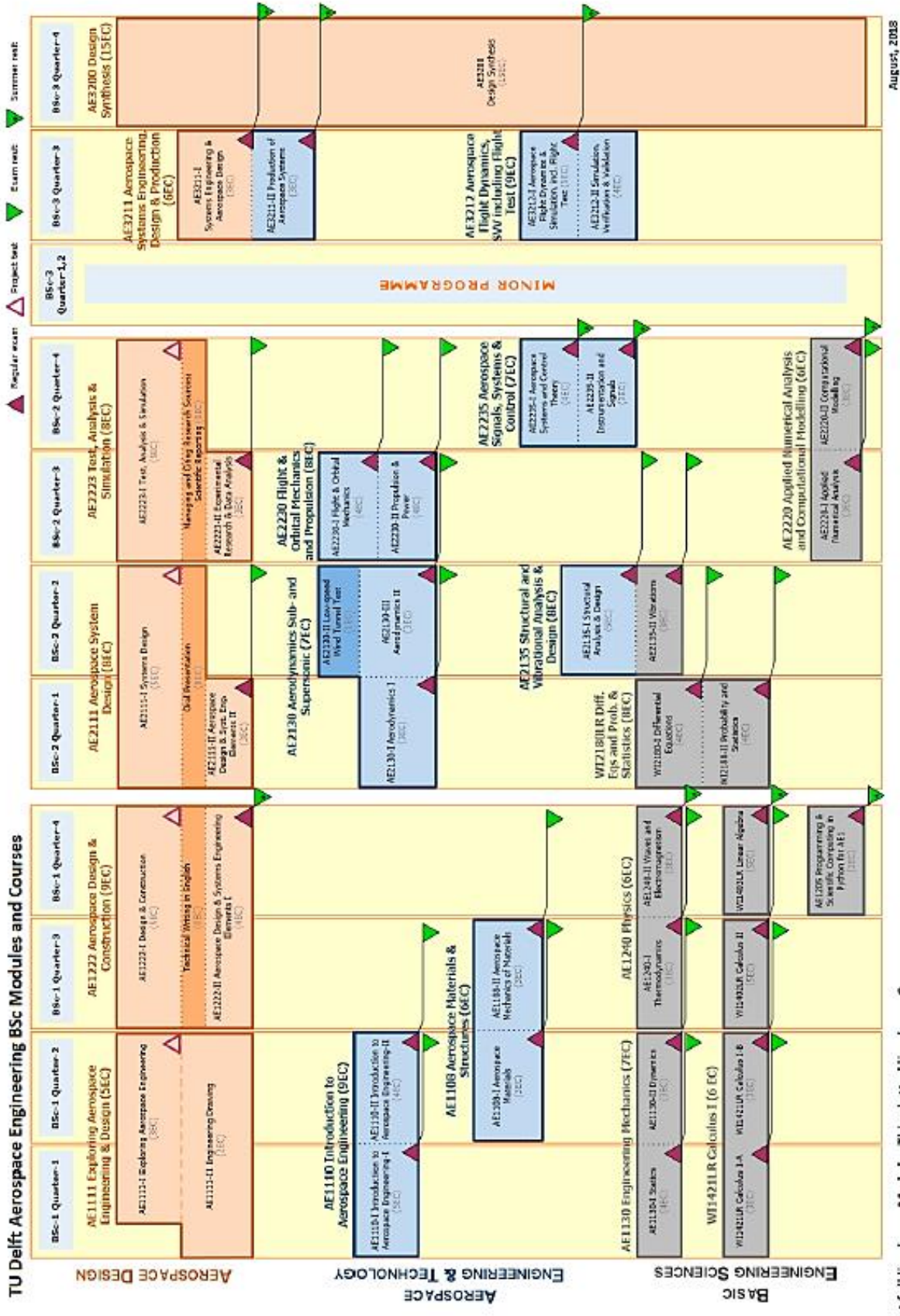
- a. Understands relevant (internal and external) developments in the history of aeronautics and spaceflight. This includes the interaction between the internal developments (of ideas) and the external (societal) developments, both national and international. Integrates aspects of this in scientific work [ksa]
- b. Is able to analyse the societal context of the Aerospace industry (economic, social, cultural) and the consequences of new developments and applications of aerospace science and technology and to discuss these with colleagues and non-colleagues. Integrates aspects of this in scientific work. [ksa]
- c. Is able to analyse the consequences of scientific thinking and acting on the environment and sustainable development. Integrates aspects of this in scientific work. [ksa]

d. Is able to analyse and to discuss the ethical, safety and aesthetic aspects of the consequences and assumptions of scientific thinking and acting in the domain of Aerospace Engineering with colleagues and non-colleagues (both in research and in designing). Integrates these ethical and normative aspects in scientific work. [ksa]

e. Has an eye for the different roles of the “actors” in the fields of Aerospace Engineering, Technology and Space Sciences. Chooses a place as a professional in society. [ksa]

# APPENDIX 3: OVERVIEW OF THE CURRICULUM

## Bachelor's programme Aerospace Engineering



**Master's programme Aerospace Engineering**

Core Courses	Profile Courses	Elective Courses	Literature study	Internship 18 EC
10-14 EC	8-20 EC	~15 EC	12 EC	MSc Thesis project 42 EC
No choice	No choice	Choice in consultation with Profile Coordinator	+ Research Methods 2 EC	

## APPENDIX 4: PROGRAMME OF THE SITE VISIT

<b>DAY 0</b>		<b>TUESDAY 18 JUNE 2019</b>
15.30	17.00	Panel instruction
17.00	17.30	Welcome by programme management
17.30	19.00	Preliminary panel discussion
19.00	21.00	Panel dinner (closed)
<b>DAY 1</b>		<b>WEDNESDAY 19 JUNE 2019</b>
08.30	09.00	Arrival
09.00	09.45	<b>Interview programme management</b>
09.45	10.00	Break
10.00	10.45	<b>Interview bachelor students</b>
10.45	11.00	Break
11.00	11.45	<b>Interview teaching staff bachelor</b>
11.45	12.30	<b>Tour of the facilities</b>
12.30	13.30	Lunch
13.30	14.15	<b>Interview master students</b>
14.15	14.30	Break
14.30	15.15	<b>Interview teaching staff master</b>
15.15	15.30	Break
15.30	16.00	<b>Interview Board of Examiners</b>
16.00	16.15	Break
16.15	17.00	<b>Interview alumni + professional field</b>
17.00	17.30	Open consultation hour
<b>DAY 2</b>		<b>THURSDAY 20 JUNE 2019</b>
08.30	09.15	Arrival
09.15	10.00	<b>Second interview programme management</b>
10.00	11.45	Concluding session
11.45	12.00	<b>Oral report preliminary findings</b>
12.00	12.15	Break
12.15	13.45	<b>Development dialogue (incl. lunch)</b>
13.45	14.00	Farewells



## APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 9 bachelor theses of the bachelor's programme Aerospace Engineering and 15 theses of the master's programme Aerospace Engineering. 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):

- Course evaluations
- Minutes of the Examination Committee and the Programme Committee
- Reports of the Examination Committee and the Programme Committee
- Volume 2018 Delft Aerospace Design Synthesis Bachelor Projects
- Reports and policy documents

