

MSc programme  
Science and Technology of  
Nuclear Fusion  
**Eindhoven University of  
Technology**

9<sup>th</sup> August 2012 (revised: 19<sup>th</sup> March 2013)

Initial accreditation

Panel report

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## Executive summary

The Accreditation Organisation of the Netherlands and Flanders (NVAO) received a request for an initial accreditation procedure, including programme documents, regarding a proposed Master's programme 'Science and Technology of Nuclear Fusion' at Eindhoven University of Technology. NVAO convened an expert panel, which studied the information available and discussed the proposed programme with representatives of the institution and the programme management during a site visit.

The following considerations have played an important role in the panel's assessment.

The primary motivation for the proposal to launch the MSc programme 'Science and Technology of Nuclear Fusion' (the Fusion MSc in short), is that the applicant believes it offers unique opportunities to the Netherlands. The opportunities arise because the Netherlands is presently at the forefront of the European developments in fusion education. Moreover, with ITER, the large international fusion experimental reactor presently under construction in France, the need for highly trained physicists and engineers in the fusion programme is growing.

The programme delivers scientific engineers at the MSc level who have been trained in the set of competences and expertise that are characteristic of the field Science and Technology of Nuclear Fusion. Key characteristics of the engineers are interdisciplinarity (physics – mechanical engineering – electrical engineering), goal-oriented, ability to work in international and interdisciplinary teams, flexibility and socio-economical awareness. The programme prepares for a career in fusion research and development as well as for a career in innovative high-tech industry. The panel is of the opinion that the Fusion MSc is an ambitious and challenging programme, unique in its combination of breadth and depth. The programme is timely relevant. It will make an important contribution in the field of nuclear fusion and is setting standards for other fusion-energy Master's programmes around the world to follow.

To define the learning outcomes of the Fusion MSc, the applicant makes use of the ACQA framework 'Criteria for Academic Bachelor and Master Curricula'. The panel is satisfied with the use of the competence areas, submitted within this framework, as intended learning outcomes. However, the panel is of the opinion that the competence areas are rather broad and non-specific. The panel would like to advise the programme management to further elaborate the competence areas into intended learning outcomes that reflect the relevant domain concerned and also reflect the profile of the Fusion MSc.

The institution has suggested to classify the Fusion MSc in the CROHO section Technology (Techniek). According to the panel, this is a correct choice. The panel advises the NVAO to follow this proposal.

The Fusion MSc offers an integral training in nuclear fusion science and technology, consisting of a homologation programme for students from different bachelor's programmes, a compulsory programme of core fusion courses, including hands-on lab experience, a programme of elective fusion courses, an external project and a graduation project. The panel is of the opinion that the contents of the curriculum ensure the students' achievement of the intended learning outcomes. However, the panel recommends to enlarge the scope of the Computational Engineering courses in the generic core of the programme in view of the highly interdisciplinary character of the master and the important engineering problems of fusion reactors. In addition, the panel advises to pay more attention to risk management, social relevance and economic issues in the programme.

In the programme a balance is sought between lectures and practical work on the one hand, and problem-oriented projects and research assignments on the other. In the opinion of the panel, the educational concept is in line with the aims and objectives. The panel is convinced that the staff is able to provide modern teaching methods. The panel feels that the curriculum can be successfully completed within the time set.

The teaching staff possesses the competences to cover all of the curricular areas of the programme, but the number of lecturers is rather small in the opinion of the panel. The staff will need to handle a huge number of projects. The programme management assured that with a growing number of students, more staff will be made available.

The panel thinks the facilities are adequate for realising the programme. The panel was impressed by the quality of the experimental setups with which students can have excellent hands-on experience. Also, the availability of external facilities is really good.

Most courses will be assessed by an examination, which can be either written (mostly) or oral. Depending on the type of course, there can be additional assessments of assignments, oral presentations, written reports and/or essays, and assessments of the performance as working group member, or in plenary discussion sessions. Besides, the students have a two-monthly interview with their supervisor. This interview follows a systematic pattern, organised around the seven competence areas. In the opinion of the panel, the students are assessed, by means of the portfolio interviews and examinations, in an adequate and for them transparent way to determine whether they have achieved the intended learning outcomes of the Fusion MSc or parts thereof. The panel appreciates the attention given to the growth in competences of the students in the two-monthly interviews.

Since the TU/e already offers a fusion track as part of the Applied Physics MSc programme, which is quite similar to the proposed Fusion MSc, the panel considered in its overall judgement whether this track demonstrates that the intended learning outcomes are achieved. The panel studied the three written theses of this track. The overall conclusion is that the quality and level of the theses are satisfactory. By and large, the panel agreed with the grades awarded by the supervisors.

The applicant provides assurances that the students will be able to complete the MSc programme. The information in the application shows that there are sufficient financial guarantees for the programme to be realised.

The intended Fusion MSc is a two-year master's programme of 120 EC. The panel was asked to bring out its advice on the duration of the programme because of the request of TU/e for course duration extension according to the Master's Degree Course Duration protocol. In the accreditation proposal additional information is given. The TU/e articulates its seven arguments for this request.

The panel has reviewed the intended curriculum and the institute's arguments and finds that the programme is very ambitious. In the view of the panel the programme equips the students to a high international standard. The panel confirms all the arguments given by the TU/e to extend the course duration: the multidisciplinary approach and the specialisation are a necessity considering the (international) developments in the Nuclear Fusion application and the demands from the (international) field of Nuclear Fusion for more highly qualified professionals. Also, because of the absence of a bachelor-level programme in Nuclear Fusion at the three Dutch universities of technology, a two-year programme is needed.

The panel concludes that the duration of 120 credits is the minimum that is needed for realising such a high standard programme in engineering. Based on the information regarding the course duration, the panel considers course duration of two years for the programme Nuclear Fusion justified.

Given these considerations, the panel advises NVAO to take a positive decision regarding the quality of the proposed programme 'Science and Technology of Nuclear Fusion' at Eindhoven University of Technology and the extension of course duration.

The Hague, 19<sup>th</sup> March 2013

On behalf of the Initial Accreditation panel convened to assess the Master's programme Science and Technology of Nuclear Fusion at Eindhoven University of Technology,

Prof. dr. M.N. Harakeh  
(chair)

Drs. L. van der Grijspaarde  
(secretary)

# Introduction

## The procedure

NVAO received a request for an initial accreditation procedure including programme documents regarding a proposed Master's programme 'Science and Technology of Nuclear Fusion' (the Fusion MSc in short). The request was received on 31<sup>st</sup> January 2012 from the Eindhoven University of Technology (TU/e).

An initial accreditation procedure is required when a recognised institution wants to offer a programme and award a recognised bachelor or master's degree. To a certain extent, initial accreditation demands a different approach to the accreditation procedure for programmes already being offered. Initial accreditation is in fact an *ex ante* assessment of a programme, and a programme becomes subject to the normal accreditation procedures once initial accreditation has been granted.

Because of the international orientation of the Fusion MSc, NVAO convened an international panel of experts. The panel consisted of:

- Prof. dr. M.N. (Muhsin) Harakeh (chair), full Professor in Experimental Nuclear Physics, Rijksuniversiteit Groningen, Groningen
- Prof. H. (Howard) Wilson, Fellow of the Institute of Physics, Chair of Departmental Research Committee, Director of York Plasma Institute, Director of Fusion Doctoral Training Network, University of York
- Prof. H. (Herman) Deconinck, Dean of the faculty Aeronautics & Aerospace Department, Professor Toegepaste Wetenschappen, Vrije Universiteit Brussel
- R. P. (Ruud) Verbij, BSc; student of MSc Computer Science of Twente University

On behalf of the NVAO, drs. A.N. (Astrid) Koster was responsible for the process-coordination. Drs. L. (Linda) van der Grijspaarde acted as secretary and was responsible for the drafting of the expert's report.

This composition reflects the expertise deemed necessary by NVAO. (Annex 1: Composition of the panel). All the panel members signed a statement of independence and confidentiality.

The panel has based its assessment on the standards and criteria described in the NVAO Initial Accreditation Framework (Stcrt. 2010, nr 21523), and the Master's Degree Course Duration Protocol (8 October 2003).

The following procedure was undertaken. The panel members studied the programme documents (Annex 3: Documents reviewed) regarding the proposed programme. Their first impressions were sent to the secretary of NVAO, in order to put these remarks within the accreditation framework and select the items to be clarified during the site visit.

Based on its first findings, the panel organised a preparatory meeting in the morning of the site visit. The site visit took place on 29<sup>th</sup> June 2012 at TU/e (Annex 2: Schedule of the site visit).

The panel formulated its preliminary assessments per standard immediately after the site visit. These are based on the findings of the site visit, and building on the assessment of the programme documents. After the site visit, the panel received supplementary documentation on the intended learning outcomes, the programme and the assessment. The final judgement of the panel is based on the information in the application, the interviews at the site visit and the supplementary documentation.

On 18<sup>th</sup> July 2012, the draft version of this report was finalised, taking into account the available information and relevant findings of the assessment. Where necessary the panel corrected and amended the report. The panel finalised the report on 9<sup>th</sup> August 2012. On 19<sup>th</sup> March 2013, a supplement about the need for a two year programme has completed the report.

## **Panel report**

The first chapter of this report is the executive summary of the report, while the current chapter is the introduction.

The third chapter gives a description of the programme including its position within the TU/e and within the higher education system of the Netherlands.

The panel presents its assessments in the fourth chapter. The programme is evaluated by assessing the standards in the Initial Accreditation Framework. For each standard the panel presents an outline of its findings, considerations and a conclusion.

The *outline of the findings* are the objective facts as found by the panel in the programme documents, in the additional documents and during the site visit. The panel's *considerations* are the panel's subjective evaluations regarding these findings and the importance of each. The *considerations* presented by the panel logically lead to a concluding assessment.

The panel concludes the report with a table containing an overview of its assessments per standard.

## Description of the programme

### Overview

Country	The Netherlands
Institution	Eindhoven University of Technology
Programme	Science and Technology of Nuclear Fusion
Level	master
Orientation	academic (wo)
Degree	MSc
Location(s)	Eindhoven
Mode of study	Full-time
Field of study	Technology (In Dutch: Techniek)

### Profile of the institution

Eindhoven University of Technology (TU/e) is a research university specialising in engineering science & technology. The education, research and knowledge valorisation contribute to:

- science for society: solving the major societal issues and boosting prosperity and welfare by focusing on the Strategic Areas of Energy, Health and Smart Mobility;
- science for industry: the development of technological innovation in cooperation with industry;
- science for science: progress in engineering sciences through excellence in key research cores and innovation in education.

### Profile of the programme

The primary motivation for the proposal to launch the MSc programme 'Science and Technology of Nuclear Fusion' (the Fusion MSc in short) is that the applicant believes it offers unique opportunities to the Netherlands. The opportunities arise because the Netherlands is presently at the forefront of the European developments in fusion education. By acting now and starting the Fusion MSc, the Netherlands can set a standard for Europe, establish its name as a centre for high quality education of fusion engineers, and attract talented international students. Moreover, with ITER, the large international fusion experimental reactor presently under construction in France, the need for highly trained physicists and engineers in the fusion programme is growing.

The emphasis on fusion is in line with the TU/e strategy for 2020, in which 'Energy' is one of the three strategic thrust areas. This profile will be further enhanced when the Dutch Institute for Fundamental Energy Research (DIFFER)<sup>1</sup> will move to the campus of the TU/e. DIFFER is the national centre of mass of the fusion research, which makes up about 50% of its research programme.

The Fusion MSc offers an integral training in nuclear fusion science and technology, consisting of a homologation programme for students from different Bachelor's programmes, a compulsory programme of core fusion courses, including hands-on lab experience, a programme of elective fusion courses, a 3-months external project and a graduation project.

The programme delivers engineers at the MSc level who have been trained in the set of competences and expertise that are characteristic of the field 'Science and Technology of Nuclear Fusion'. According to the application, key characteristics of the engineers are interdisciplinarity (physics – mechanical engineering – electrical engineering), goal-oriented, ability to work in international and interdisciplinary teams, flexibility and socio-economical awareness. The programme prepares for a career in fusion research and development as well as for a career in innovative high-tech industry.

#### *New programme in the Netherlands*

The application indicates that no other institution of higher education in the Netherlands offers a programme with a similar profile.

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<sup>1</sup> DIFFER is a FOM-institute. FOM is the Foundation for Fundamental Research on Matter.

*New programme for the institution*

The proposed programme can be regarded as a new Master of Science programme to the institution.

*Credits*

The programme will be offered as a full-time course with a total course load of 120 EC.

*CROHO section*

The institution has suggested to classify the Master of Science programme "Science and Technology of Nuclear Fusion" in the CROHO section Technology (Techniek). According to the panel, this is a correct choice. The panel advises the NVAO to follow this proposal.



## Assessment per standard

This chapter presents the evaluation by the assessment panel of the four standards. The panel has reproduced the criteria for each standard. For each standard the panel presents (1) a brief outline of its findings based on the programme documents and on documents provided by the institution and the site visit, (2) the considerations the panel has taken into account and (3) the conclusion of the panel.

The panel presents a conclusion for each of the four standards.

### Intended learning outcomes (standard 1)

*The intended learning outcomes of the programme have been concretised with regard to content, level and orientation; they meet international requirements.*

#### *Outline of findings*

For this standard, the positioning of the programme, the goal of the programme and the intended learning outcomes are discussed.

#### Positioning of the Fusion MSc

According to the application, the Fusion MSc is unique worldwide in its combination of breadth and depth, but there are parallel developments in Europe. Recently, an Erasmus Mundus master programme was launched on 'Science and engineering of nuclear fusion'; a cluster of French universities is offering a fusion master specialisation and, in the UK, York University offers a one-year fusion master programme.

The start of the global ITER-project (situated in France), and the resulting acceleration of the fusion programme have led to the above initiatives in fusion education. At ITER the science of extreme conditions – extreme temperatures of around 150 million degrees, extreme heat fluxes, extremely large magnetic fields, extreme complexity - has to be translated into technological solutions. According to the application, this provides both a challenge and a career perspective to Master students, and calls for the training of a new generation of fusion researchers.

The Netherlands has taken the initiative to apply for a coordination action on fusion education, which has led to the project FuseNet (European Fusion Education Network). In FuseNet 36 parties – both universities and national research labs from across Europe – collaborate with the aim to develop and coordinate higher education in the field of nuclear fusion. The TU/e is coordinator of this network. In FuseNet, best practices are shared, educational tools – courses, experiments, multi-media materials - are developed together, and joint educational activities are organised. FuseNet also offers a transparent portal for students who want to specialise in fusion. Importantly, FuseNet has also defined joint educational goals and criteria for both the Master and PhD levels, and is preparing a 'European Fusion Master certificate'.

The proposed Fusion MSc is in line with the guidelines and criteria defined by FuseNet. According to the application, this will guarantee the attractiveness for international students who know their degree will have European recognition, while the European recognition of the fusion-MSc will also establish the master outside the field. It will be a quality brand.

TU/e already offers a fusion track in the Applied Physics programme, which is quite similar to the proposed Fusion MSc. The fusion track offers a total of eight specialised fusion courses: six within Applied Physics and two within Mechanical Engineering. The panel asked the programme management what will become of this track, after the fusion programme has started. The programme management expects a shift of students from the fusion track to the Fusion MSc programme. They will stop offering the fusion track after a couple of years.

### Goal of the Fusion MSc

The goal of the programme is to prepare the master students for a career in fusion research, but also to a broad range of high-tech, innovative industry. To summarise, the fusion field is:

- interdisciplinary; it encompasses physics, mechanical engineering and electrical engineering, as well as aspects of the socio-economics of a new energy source.
- international; even more than other scientific fields, fusion is characterised by international collaborative networks spanning the globe, with the ITER project as the ultimate example.
- goal-oriented; although ranging from the very fundamental to the very applied, the approach of fusion research and development is always directed at a very concrete goal, i.e. the construction of a working fusion reactor. All work derives from that.

Scientists and engineers who are active in this field are:

- used to working in large international, interdisciplinary teams;
- flexible; the field of fusion is so broad that the fusion scientist or engineer often has to learn new skills. Therefore, apart from the sound set of basic skills and competences, the ability to learn new skills and technologies, and to identify the relevant experts and communicate with them, is strongly developed in the fusion scientific engineer.
- well aware of the societal value of their work; fusion students are often (partly) motivated by a wish to contribute to a clean and sustainable energy supply. This aspect of societal value – which translates into a keen awareness of the role of fusion R&D in society – is also an important aspect of the field.

### Intended learning outcomes of the Fusion MSc

To define the learning outcomes of the Fusion MSc, the applicant makes use of the ACQA (Academic Competences and Quality Assurance) framework 'Criteria for Academic Bachelor and Master Curricula' (Meijers, van Overveld and Perrenet, 2007). This elaboration of the Dublin descriptors, which is widely used by technical universities in the Netherlands, Germany and Belgium, was formally accepted by the NVAO by letter of 29 June 2006.

The ACQA framework proposes seven competence areas, representing the domains of (intended) competence development of BSc or MSc students during their study. The competence areas are presented below.

The student:

1. *is competent in one or more scientific disciplines*  
A university graduate is familiar with existing scientific knowledge, and has the competence to increase and develop this through study.
2. *is competent in doing research*  
A university 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.
3. *is competent in designing*  
As well as carrying out research, many university graduates will also design. Designing is a synthetic activity aimed at the realisation of new or modified artefacts or systems with the intention of creating value in accordance with predefined requirements and desires (e.g. mobility, health).
4. *has a scientific approach*  
A university graduate has a systematic approach characterised 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.
5. *possesses basic intellectual skills*  
A university 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.
6. *is competent in co-operating and communicating*  
A university 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.
7. *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.

In the application, the applicant presents programme objectives of the Fusion MSc, distilled from the goal of the Fusion MSc and from the competence areas. The programme objectives are the following:

1. *technical and engineering knowledge*
  - a) fusion specific knowledge
    - i) knowledge of the fusion physics canon → Objective A
    - ii) knowledge of fusion specific engineering → Objective B
  - b) generic technical knowledge
    - i) physics methodology → Objective C
    - ii) engineering methodology → Objective D
2. *professional competences*
  - c) Communication, Teamwork, Social Context → Objective E
  - d) Project management → Objective F
  - e) Modelling and designing → Objective G

The panel is of the opinion that the competence areas as presented on the previous page correspond to general, internationally accepted descriptions of a Master's qualification. However, the panel feels the competence areas are quite generic. The presented programme objectives above are more focussed on the fusion domain, but are quite concise. Therefore, the panel assessed the intended learning outcomes as unsatisfactory at the moment of the site visit and requested more detailed information about the intended learning outcomes. On July 5<sup>th</sup>, the panel was handed over a response to this request. In the response, a brief generic description is given of each of the academic competence areas. In addition, the specification for the Fusion MSc is given and the most important programme elements are indicated where the competences are taught. However, in the response, the link between the competence areas and the programme objectives is not described in detail.

In the opinion of the panel, the programme meets the request of the panel for more detailed information with the clarification per competence area. However, the panel still feels the competence areas could be specified further by developing intended learning outcomes per competence area, at the MSc level and matching the specific intention and profile of the Fusion MSc. The programme objectives as presented in the application can be used as a beginning for these intended learning outcomes.

#### *Considerations*

According to the panel, the Fusion MSc is an ambitious and challenging programme, unique in its combination of breadth and depth. The programme is timely relevant. It will make an interesting contribution in the field of nuclear fusion and is setting standards for other fusion energy Master's programmes around the world to follow. The panel has a positive opinion about the possibilities for students after finishing the programme, in following a PhD-programme as well as on the labour market in a career in fusion research or in other high-tech, innovative industry.

The panel is of the opinion that the strong ties of the Fusion MSc with FuseNet and ITER will have a positive impact on the possibilities within the programme. Not only does this influence the expected increase in influx of international students, but this provides as well education and training within an international framework and enlarges the opportunities for students to follow PhD programmes or careers at research institutes elsewhere.

The institution has suggested to classify the Fusion MSc in the CROHO (Central Register of Higher Education Study Programmes) section Technology (Techniek). According to the panel, this is a correct choice. The panel advises the NVAO to follow this proposal.

The panel is of the opinion that the competence areas of the ACQA framework correspond with general, internationally accepted descriptions of a Master's qualification. The panel is satisfied with the use of the competence areas as intended learning outcomes. However, the panel is of the opinion that the competence areas are rather broad and non-specific. The panel would like to advise the programme management to further elaborate the competence areas into intended learning outcomes, reflecting the profile of the Master MSc.

#### *Conclusion*

The panel assesses standard 1 'Intended learning outcomes' as satisfactory.

## Teaching-learning environment (standard 2)

*The curriculum, staff and programme-specific services and facilities enable incoming students to achieve the intended learning outcomes*

### *Outline of findings*

For this standard, successively the content of the programme, the learning environment, the quality of the staff and the facilities are described and discussed.

### Duration of the programme

The intended Fusion MSc is a two-year master's programme of 120 EC. The panel was asked to bring out its advice on the duration of the programme because of the request of TU/e for course duration extension. The NVAO provided criteria that need to be fulfilled for a programme to be able to apply for an extended duration. These criteria are found in the Master's Degree Course Duration protocol, as well as guidelines for the information provided in an overview.

In the accreditation proposal additional information is given regarding the request for course duration extension and the demands of the field of Nuclear Fusion. The TU/e articulates its arguments for this request as follows:

1. First of all, the programme is a beta oriented, engineering study. At the 3 universities of technology in The Netherlands all these studies have a duration of two years/120 ECTS. The arguments that hold for these are equally valid for the Fusion Master.
2. In particular, these studies are characterised by extensive stays in research groups. At the TU/e, applied physics students do a three-month internship in a company and a full year – 60 ECTS – project in a research group. These stays are considered to be essential for the academic formation of the student. Likewise, for the *fusion* MSc programme a 50 ECTS research project is an essential part of the programme, in which many of the competences are developed.
3. As already emphasised above, the field of fusion science and technology is strongly interdisciplinary by nature. Socio-economical aspects, organisational considerations and management methodologies all need to be integrated with technology as such, resulting in a comprehensive systems approach also focusing on process development. Expertise in a wide range of subjects is a precondition in order to be able to work in this particular field at the level of professionalism an academic master degree should warrant.
4. This interdisciplinarity cannot be accommodated within the constraints imposed by a 60 EC total workload. An academic master degree presupposes a substantial graduation project, incompatible with insufficient in-depth study of the wide range of subjects required for a sound basis in fusion science and technology. The participating departments are not prepared to compromise on either the scientific (research) basis for the master programme or the level of professionalism of Fusion Science and Technology graduates.
5. The three Dutch universities of technology do not offer any bachelor-level programmes in fusion. This means that the students taken in will not have a significant knowledge base in the entire range of subjects that are relevant for the field of fusion technology. As a result, a rather large part of the total study load has to be devoted to the completion of the student's knowledge base across the relevant disciplines. This takes more time than would be available within the constraints of a 60 EC total study load without compromising the final level of the programme.
6. The fusion community, as do most industrial settings, demands from graduates a combination of a solid knowledge base in a broad range of subjects on the one hand and a wide variety of technical and management skills on the other. Both knowledge and skills from a number of academic disciplines have to be mastered in a coherent way. To try and do so within a one-year programme would result in a level of mastery that would not have sufficient added value for industry. To have a full-fledged two-year programme is vital to be able to meet the needs of the fusion community and the industry in a broad sense.
7. FuseNet has defined the minimum requirements for awarding the Fusion certificate. Here already a minimum of 60 ECTS is required, to obtain the certificate, i.e. not necessarily a master. These requirements were setup such as to allow also countries with a different educational system to qualify for this. It is our ambition to arrive at a higher qualified educational standard, since we regard this essential to prepare our students for a successful career, as follows from the above arguments.

The panel has reviewed the intended curriculum and the institute's arguments and find the programme is very ambitious. In the view of the panel the programme equips the students to a high international standard. The panel confirms all the arguments given by the TU/e to extend the course duration: the multidisciplinary approach and

the specialisation are a necessity considering the (international) developments in the Nuclear Fusion application and the demands from the (international) field of Nuclear Fusion for more highly qualified professionals. Also, because of the absence of a bachelor-level programme in Nuclear Fusion at the three Dutch universities of technology, a two-year programme is needed.

The panel concludes that the duration of 120 credits is the minimum that is needed for realising such a high standard programme in engineering. Based on the information regarding the course duration, the panel considers course duration of two years for the programme Nuclear Fusion justified.

#### Content of the programme

The curriculum and the correspondence between intended learning outcomes and the curriculum are discussed below.

#### - Curriculum

Students are able to enrol in September or February.

According to the application, the curriculum has been designed with the following considerations:

- to fulfil the FuseNet requirements set for master's programmes in fusion, but providing much more depth and more interdisciplinarity;
- to ensure that the students will acquire a balanced mix of all the academic competences;
- to have an integrated approach of the three main disciplines applied physics, electrical engineering and mechanical engineering;
- to use 'intentionality' as the guiding principle in the educational approach.

These considerations led to a structure of the programme with a homologation part (6 EC), a generic core (12 EC), a fusion core (17 EC), fusion electives (10 EC), free choice electives (10 EC), an internship (15 EC) and a graduation project (50 EC).

In order to accommodate the different backgrounds of the students participating in the programme, the *homologation part* is introduced. A course is set up of the type 'capita selecta of Electric engineering /physics/ mechanical engineering for fusion students'. The intention of this course is to take the students to the required starting level in the complementary disciplines. The panel agrees with starting out the programme with this homologation programme. However, the panel feels the programme will not manage to get the students on the same level for the three disciplines with only this 6 EC part of the programme. The management is aware of this and promises that they will monitor if students show enough skills in the three disciplines to be able to complete the rest of the Fusion master programme.

Several essential methodologies will be treated in the *generic core*. These are methods and knowledge that are broadly applicable and indispensable for a successful career in research in a scientific or technological setting. Computational physics, translating physics models into powerful computer codes, is one of these. The physics reasoning, as exemplified in so-called Fermi Problems is another generic tool. Furthermore, since electrodynamics, as described by Maxwell's theory, is an essential ingredient in many technological areas, especially fusion, this should be part of the compulsory part of the curriculum, according to the application.

The *fusion core* consists of two sets of activities in parallel. Specific knowledge is provided through courses aimed at deepening and diversifying students' prior knowledge. The integrating (systems) character of the programme is assured by the project work and by the 'problem-based learning item', in which the students tackle a multidisciplinary problem from the real fusion research world, in a group.

In addition to the common generic fusion programme, the necessary depth is the reason for having the *fusion electives* in the programme. Within their elective courses students are given ample opportunities to prepare themselves for their graduation project.

Finally, 10 EC can be spent on *free choice electives*, i.e. any university course, which offers the student the possibility to broaden his view outside the fusion or engineering world. This electives part will accommodate the programme to the special needs and wishes of the students. Consultation of and approval of the electives part of the programme by the academic supervisor is required.

The *internship* is primarily meant as an introduction into the professional environment.

In the second year, the master's thesis *graduation project* is primarily meant to gain experience in the international fusion field by experimenting, modelling, analysis, and/or design of new diagnostic systems or to explore new research questions. In the graduation project, students conduct independent academic research, which includes a study of the literature and of discussions in the field at an academic level.

The panel studied the intended curriculum and is of the opinion that the programme will be extremely strong, setting standards for other fusion energy Master's programmes around the world to follow. The panel is enthusiastic about the internship, the science lunches and about other field trips that students will make; the panel feels the students will get acquainted with the state-of-the-art research or technology in fusion. The duration of 120 credits is, in the opinion of the panel, the minimum that is needed for realising such a programme. However, the panel has some comments. These are given below.

The panel recommends to enlarge the scope of the Computational Engineering courses in the generic core of the programme, in view of the highly interdisciplinary character of the master and the important engineering problems of fusion reactors. The panel advises to create an additional course in Engineering simulation and/or design optimisation (Computational mechanics and heat transfer) with emphasis on the engineering problems in Fusion reactor and ITER in particular.

In addition, the panel advises the programme management to pay more attention to elements that are missing and/or have not been explicitly discussed in the presented master programme. These include risk management, e.g. technical aspects of catastrophic management. These also include hard core risk analyses of nuclear fusion (such as what happens if it fails or when gas is formed in liquid circuits), hard core economics issues (such as aspects of project management and how to handle large projects) and social relevance and context.

- Correspondence between intended learning outcomes and the curriculum  
In the response handed over on July 5<sup>th</sup> (as mentioned with standard 1), the programme presents a matrix in which the relationship between specific courses and the intended learning outcomes (competences) becomes clear.

The panel is of the opinion that competence area 3: 'is competent in designing', probably deserves more attention in the programme, since it also reflects the need for interdisciplinary interactions. The panel feels this can be achieved best in the thesis and in assignments. Nevertheless, it could also be further improved by including the engineering simulation/design course material (design problems in plasma hydrodynamics, thermal hydraulics, strength of the structures, cooling circuits, heat exchange and interdisciplinary coupling between these).

Though the issue of social relevance appears several times in the presented material, and is part of the competence area 7: 'takes account of the temporal and the social context', this has not been worked out in detail. The panel advises the programme management to work this issue more explicitly in the lecture material.

The intended learning outcomes (competences) of the programme are translated per course into specific learning objectives. However, it is not made clear how these learning objectives meet the intended learning outcomes. The panel is of the opinion that the connection between the specific learning objectives per course and the intended learning outcomes could be made even more explicit

#### Learning environment

For the learning environment, the didactical concept, the study load, the programme schedule and the admission requirements are discussed.

- Didactical concept  
According to the application, the didactic concept consists of:
  - a gradual transition from guided learning to independent learning;
  - a balanced combination of lectures and project assignments;
  - a graduation project to prepare for an individual research task;
  - an internship in a company or research laboratory external to the University.

In the MSc programme a balance is sought between lectures and practical work on the one hand, and problem-oriented projects and research assignments on the other. Several core lectures will have practical work to develop the modelling and research abilities of the students. Parts of the lectures refer to research papers and some of the lectures require reports and papers to be made and presented by the students. In the lectures, teachers will place their subject in a broader context to motivate their students, and to transfer basic knowledge that the students need for further knowledge acquisition. In many occasions, the different learning objectives and academic competences are addressed in a coherent and integrated way, instead of a stand-alone item.

During the site visit, the panel discussed the intended didactical concept with staff and students of the fusion track. The panel discovered that the students are very satisfied with the way the staff is providing the current courses on fusion in the fusion track. Furthermore, FuseNet provides the platform to exchange students to go abroad for training and for doing their master theses.

- Study load

As said before, the study load of the fusion MSc programme will comprise a total of 120 EC. The first year is mainly intended for the homologation phase, the compulsory and elective courses and projects. According to the application, sufficient allowance has been made for students to schedule their elective courses throughout the year, taking both planning sequence (homologation courses first, specialisation courses last) and study pace into consideration. The individual student programme is discussed with the study advisor so that it is evenly distributed over the four semesters. All courses are limited to half a semester (a quartile), as is the internship. The last quarter of the first year is devoted exclusively to internships, so that there is no conflict with the taught course programme.

The largest part of the second year is devoted to the master thesis work. The rather intensive feedback, (self-)assessment and supervision should ensure that the students would complete their project on schedule.

The study load will be continuously monitored using evaluation forms and interviews, which for existing curricula consistently show that students complete most of the courses well within the prescribed time. The monitoring of the study load gets attention within the quality management system. The programme director is responsible for detecting and tackling structural problems in the programme.

The panel feels the intended study load is realistic and students can complete the programme in the nominal time. This opinion is also based on the experience with the fusion track in the Applied Physics programme. In the opinion of the panel, the supervision will be sufficient.

- Programme schedule: two intakes

Two moments for intake during the year are possible. Students starting in September can follow the complete curriculum in the nominal time, starting with the lecture courses in the first three quartiles and the internship in the final quartile of the first year. For students starting in the second semester during the university year, an adapted schedule is possible which will allow them to finish the programme with a minimal delay. Those students start with the homologation programme and some generic courses in their first quartile, followed by the internship in the second quartile and the remaining fusion courses in the second part of their first year. According to the application, care should be taken in the definition of the internships in this case, since some of the basic fusion courses are missing, but this is still regarded as feasible.

The panel thinks the February group may miss out on the possibility to learn from other students of different backgrounds in the homologation part, since the February group might be very small. The management agrees with the comments of the panel and has changed the February programme, but since having two moments for intake is TU/e policy, the applicant is not able to offer the programme with one intake moment per year.

- Admission requirements

The expected number of incoming students is set at (at least) thirty additional students a year, of which approximately thirty per cent are international students. With a gradual build-up, this could be reached within four years. There are several ways to be admitted to the programme. Usually, the programme is a continuation of an academic BSc-programme in applied physics, mechanical engineering or electrical engineering.

For all applying students, an intake interview will be part of the admission process. The panel wondered how the intake interview is done with international students. The programme management explained to the panel that they

will recruit directly in China. Other international students will be interviewed by e-mail. The panel is of the opinion that this will be sufficient to judge the student's knowledge and skills.

If the background of a student is considered to be insufficient, in particular if a student has a BSc degree from another discipline than the three mentioned before, a premaster bridging programme could be a necessary prerequisite. An individual plan will be made in those cases, comprising at least all three homologation courses of the involved disciplines.

#### Quality and quantity of staff

The academic staff consists of eight persons (6,1 fte). With (at least) thirty additional students a year the staff student ratio is approximately 1:5. All teaching staff members have a PhD level and an assistant, associate or full professorship. Apart from the permanent staff, also post-docs and PhD students are involved in teaching. According to the application, the staff is highly qualified and demonstrates authority for continuing improvement of the programme. The panel noticed that the teaching staff members, who were interviewed during the site visit, are all very enthusiastic about the new programme. The curriculum vitae show that they are qualified to provide the programme. As the programme will be linked to different faculties the applicant has a large resource of teachers, which can play a role in the programme. As all have been involved in research, and some have strong international reputations as researchers, the panel is convinced that they will be able to incorporate recent developments in their education.

According to the application, the programme will be strongly connected to the participating departments at TU/e. From an organisational point of view it is necessary that the programme is formally accommodated in one of the departments, which is Applied Physics. The participating departments have all committed themselves to providing the necessary teaching capacity.

In many courses guest lecturers contribute to the teaching. They are selected on grounds of international stature in their specialisation as well as an educational approach that is in line with the philosophy of the programme.

The panel is of the opinion that the teaching staff possesses the competences to cover all of the curricular areas of the programme. The panel is convinced the staff is able to provide modern teaching methods and the staff is internationally oriented. However, the panel feels the number of staff calculated for the new programme might be a bit small. The staff will need to handle a huge number of projects for example. The programme management explained to the panel the projects are supervised by an external supervisor for the most part. Besides, with a growing number of students, more staff will be made available, including a fulltime professor.

#### Facilities

Apart from the generic facilities of the university, the fusion master students have unique, specifically built facilities at their disposal. The panel visited these facilities of the Fusion MSc. The facilities are discussed below.

In the fusion department, a 'joint fusion study room' has been created, in which all students who enter the programme have a desk, while there is also a central table for group work. This room will be the home of the fusion master students in their first year. The working together as a group will foster a collaborative atmosphere in which the traditional boundaries between disciplines will quickly dissolve.

The four plasma physics groups at TU/e have jointly built a hands-on plasma lab. In this laboratory, housed in a large experimental hall, ten different plasma physics experiments – all relevant to the fusion training – are set up for use by students. These range from elementary experiments on break-down (Paschen curve) to quite advanced spectroscopic experiments, experiments involving the excitation of waves in plasmas, and e.g. the measurement of currents using magnetic pick-up coils.

Presently under development at TU/e, is a 'flight simulator', i.e. a virtual environment that allows students to be the operator of a virtual fusion reactor. They can set up the plasma discharges, design the equilibrium and steer the reactor through operational space in a way that mimics the work of a real operator quite closely. In fact, operators in large fusion experiments such as JET use such flight simulators to test their pulse schedules before they are allowed to run the real experiment.



The Fusion group at TU/e is in the process of designing and building a so-called Fusor experiment. This is a table-top fusion experiment, in which charged particles are confined by means of electrostatic fields. This type of experiment will not lead to net power production, but it is a very efficient scheme when it comes to creating conditions in which fusion reactions occur. According to the application, it requires fairly sophisticated technology – including the use of high voltages and the safety aspects associated with that, and with the generation of neutron radiation when fusion reactions are produced - offers vast opportunities for research: diagnostics, modelling, experimentation.

The fusion group will have access to fusion labs in Europe and around the world.

The panel thinks the facilities are more than adequate for realising the programme. Not only the facilities in Eindhoven are very good, also the quality of the facilities and accommodation abroad can be guaranteed. The panel was impressed by the quality of the experimental setups with which students can have excellent hands-on experience. Also the availability of the external facilities is really good, according to the panel.

#### *Considerations*

The panel is satisfied with the contents of the proposed curriculum. The courses, the internship and the graduation project ensure the students' achievement of the intended learning outcomes (competence areas). The panel has some recommendations for enriching the curriculum. The panel recommends to enlarge the scope of the Computational Engineering courses in the generic core of the programme in view of the highly interdisciplinary character of the master and the important engineering problems of fusion reactors. In addition, the panel advises to pay more attention to risk management, social relevance and economic issues in the programme.

In the opinion of the panel, the educational concept is in line with the aims and objectives. The panel is convinced the staff is able to provide modern teaching methods. The curriculum can be successfully completed within the time set.

The teaching staff possesses the competences to cover all of the curricular areas of the programme, but the number of lecturers is rather small in the opinion of the panel. The staff will need to handle a huge number of projects. The programme management assured that with a growing number of students, more staff will be made available.

The panel thinks the facilities are adequate for realising the programme. The panel was impressed by the quality of the experimental setups with which students can have excellent hands-on experience. Also the availability of the external facilities is really good.

#### *Conclusion*

The panel assesses standard 2 'Teaching-learning environment' as satisfactory.

### Assessment (standard 3)

*The programme has an adequate assessment system in place.*

#### Outline of findings

For this standard, the assessment methods and the assessment of the thesis are described. Besides, the achieved learning outcomes of the fusion track of the Applied Physics programme are discussed.

#### Assessment methods

Most courses are assessed by an examination, which can be either written (mostly) or oral. Depending on the type of course, there can be additional assessments of assignments, oral presentations, written reports and/or essays, and assessments of the performance as working group member, or in plenary discussion sessions. The panel discussed the assessment methods at the site visit with the staff. Also, the panel viewed some of the assessments of the fusion track, and discussed these with students of the fusion track, since the assessment methods are similar to the assessments of the Fusion MSc.

The type of assessment and how the different elements of the assessment will lead to the final mark, is always laid down and published before the course, so that the students know what to expect. For the research stays, in particular the graduation project, the assessment is done on the basis of the final report, final and mid-way oral presentations, and a final interrogation session.

In the Fusion MSc, the students have a two-monthly interview with their supervisor. This interview follows a systematic pattern, organised around the seven competence areas. The first time this self-assessment form is completed together with the supervisor, considerable attention is given to the meaning of the competences and the goals of the educational programme. After this starting point has been established, the self-assessment concentrates on areas in which the student and/or supervisor feels progress has been made, or should have been made. In the two-monthly interview the focus is on progress or lack thereof, and measures are discussed to strengthen weaknesses.

The panel discussed the assessment methods at the site visit with the staff. Also, the panel viewed some of the assessments of the fusion track, and discussed these with students of the fusion track, since the assessment methods are similar to the assessments of the Fusion MSc. Based on the findings, the panel considers the assessment methods sufficient. The panel feels the assessments will be valid, reliable and transparent to the students. The panel appreciates the attention to the growth in competences of the students in the two-monthly interviews. Maybe it is a little bit too ambitious to implement such an innovative assessment method, but the panel feels this cannot be judged yet.

#### Thesis assessment

After the site visit it was not clear to the panel how exactly the thesis and the internships will be assessed. Therefore, the applicant provided a detailed explanation in writing on July 5<sup>th</sup>. The explanation is displayed below.

In the graduation project the students can apply and further develop the knowledge, skills and attitudes they have acquired during the preceding period, and exercise their creativity and ambition. With the completion of the project the student can show that he/she has reached the required level of proficiency of a professional MSc in Fusion Science and Technology, in all competence areas. The assessment of the graduation project is done with this purpose in mind: quite a variety of aspects have to be assessed in an objective way.

These aspects, like the thesis, final presentation, writing assignment and interrogation, are all assessed by an examination committee ('afstudeercommissie') composed of four professors or associate professors, of which at least one is from an external research group. In the fusion master, the committee normally draws from the three participating departments. In this way, the level of the grading is also kept in line with those in the Applied Physics, Electrical and Mechanical engineering departments.

The procedure for the thesis assessment is the following: five 'elements' get an individual assessment, leading to a single final grade. The grading system for each of those elements are being developed, partly in the form of criteria, and partly in the form of rubrics (scaled criteria). All learning outcomes are represented in the overall assessment. More specifically, these 'elements' and criteria are:

1. the Project Approach (weight: 20 %);
2. the Conduct during project execution (weight: 25 %);
3. the Master Thesis (weight: 25 %);
4. the Transfer of Result (weight: 15 %);
5. the Exam Interrogation (weight: 15 %).

For the internship a similar system will be used to grade the work, except that items 1 and 5 are absent.

The method of grading of the final thesis seems very thorough to the panel. The panel is also positive about the fact that, to enhance the reliability of the assessment, the master thesis will be assessed by more than one staff member. This is an improvement with regard to the way of assessment in the master track. The rubrics of assessment are well developed, but not implemented yet. The panel reflected that it is hard to judge if these rubrics will be strictly followed in practice. Therefore, the panel advises the applicant to analyse the practical application aspects of the rubrics.

#### Achieved learning outcomes of the fusion track

Since two years, the TU/e offers the fusion track as part of the Applied Physics programme, which is quite similar to the proposed Fusion MSc. Therefore, the panel has to judge if this track demonstrates that the intended learning outcomes are achieved. The panel assessed the achieved learning outcomes by inspecting all the three theses written by students from the fusion track. The panel read the theses, and assessed their presentation of the problem and review of the literature, methods and their justification, conclusion and discussion, structure, legibility and verification.

The panel found that the theses meet the aims and objectives regarding level, orientation and subject/discipline-specific requirements. The theses cover important problems, aiming at advancing the research in the field of nuclear fusion. The subjects involve complex physics and mathematics and use sophisticated modelling tools. The research topics are all original in their approach to solve certain aspects of plasma problems that arise in Tokamak<sup>2</sup> operations, with the ultimate aim to provide solutions that could be used in the design and construction of ITER in order to ensure a smooth operation with high fusion yields.

The overall conclusion of the panel is that the quality and level of the theses are satisfactory. By and large, the panel agreed with the grades awarded by the supervisors.

#### *Considerations*

According to the panel, the students are assessed, by means of portfolio interviews, tests and examinations, in an adequate and for them transparent way to determine whether they have achieved the intended learning outcomes of the Fusion MSc or parts thereof. The panel appreciates the attention given to the growth in competences of the students in the two-monthly interviews.

The quality and level of theses of the fusion track (which is part of the Applied Physics programme) are satisfactory. The panel feels the scientific level of these master theses give a good example of what to expect in the future when the Fusion MSc is established.

#### *Conclusion*

The panel assesses standard 3 'Assessment' as satisfactory.

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<sup>2</sup> The tokamak is one of several types of magnetic confinement devices, and is one of the most-researched candidates for producing controlled thermonuclear fusion power.

#### **Graduation guarantee and financial provisions (standard 4)**

*The institution guarantees students that they can complete the entire curriculum and makes sufficient financial provisions available.*

##### Outline of findings

For this standard, the financial analysis, the graduation guarantee and the continuity is discussed.

##### Financial Analysis

Financial break-even at faculty level is reached for a steady state influx of eighteen master students/year. For the envisaged growth scenario, the influx will exceed this minimum requirement in the second year, but due to the fact that the revenues are based on post-calculation and therefore have a time lag of approximately two years, the revenues – of the university - will balance the cost only in the third year. The integrated upfront investment amounts to about 400 k€ in total for the university. Since the aim is to attract more than thirty students a year, it is concluded that the Fusion master will be sustainable. The Executive Board of the TU/e agreed to provide the necessary backing of the initial investment costs.

##### Graduation guarantee

In line with customary procedures in the Netherlands, there will be no provision of guaranteed graduation, as such. However, current policies guarantee, as laid down in the Educational and Exam Regulations (OER), that qualified students will be able to complete the programme within two years. Of course, actual study progress will depend on the abilities and performance of the students. Courses and exams are offered with sufficient frequency for students to complete the programme in a timely manner.

The setting up of a master programme in Fusion is a strategic choice of the university and reflects as such its long-term vision. Moreover, as the financial analysis has shown, this venture is sustainable. If however, due to as yet unforeseen reasons, a discontinuation or rearrangement of the master will occur, it is guaranteed that the students that have started the Fusion master can complete their curriculum within a reasonable term.

##### Continuity

The expectation of long- time continuity of the programme is based on a few factors, both international and local in nature.

First, the decision to build ITER with a consortium of seven partners – making it the largest international scientific collaboration ever – entails a long-term international political commitment to the development of fusion power. In fact, the ITER agreement (ITER is an International Organisation, like e.g. the UN) is for at least 35 years. Consequently, according to the application, fusion research is not a hype and the extreme challenges it poses will continue to be a driver for the development of innovative technology for decades. And as a result, fusion will continue to offer an excellent context for the training of highly qualified engineers for the foreseeable future.

Likewise, Europe is organising its fusion education through the FuseNet Association, issuing certificates for the European Fusion Master and Fusion Doctorate. This system, which involves a European scientific council, procedures and administration, is according to the application clearly set up with a long-term vision and is meant to last.

In the Netherlands, and in particular at TU/e, the choice to invest in fusion education is a lasting one, too. For TU/e it was the result of a very deliberate strategic consideration. With its fusion education programme, TU/e aims to reinforce its profile in the Dutch landscape. This is fully in agreement with the political pressure towards more differentiation between the universities. The fusion master is unique in the Netherlands and should be a reason for students to select this university.

Moreover, with its unique fusion master TU/e aims at attracting more international students. These will come from Europe – no other European university offers such a comprehensive fusion programme – but also from outside Europe. Again, this is a strategic choice of TU/e and one that only makes sense in a long-term vision.

*Considerations*

The panel trusts the applicant has taken sufficient measures to ensure that students can complete the whole programme. The panel thinks the financial provisions are sufficient to cover the initial losses within a reasonable span of time.

*Conclusion*

The panel assesses standard 4 'Graduation guarantee and financial provisions' as satisfactory.

## Overview of the assessments

The panel presents its assessments per standard, as outlined in chapter 4, in the following table.

<b>Standard</b>	<b>Assessment</b>
<b>1 Intended learning outcomes</b>	Satisfactory
<b>2 Teaching-learning environment</b>	Satisfactory
<b>3 Assessment</b>	Satisfactory
<b>4 Graduation guarantee and financial provisions</b>	Satisfactory
<b>Conclusion</b>	Satisfactory

## Annex 1: Composition of the panel

### *Chair*

prof. dr. M.N. (Muhsin) Harakeh

Full Professor (B) in Experimental Nuclear Physics Rijksuniversiteit Groningen, Groningen  
PhD SUNY at Stony Brook December 1974; postdoc periods at Nuclear Physics Accelerator Institute (KVI), University of Groningen (RuG) the Netherlands and NBI, Copenhagen, Denmark (January 1975 to June 1978); appointed assistant and associate professor at KVI in June 1978 and January 1982; appointed full professor at Free University of Amsterdam January 1986; appointed Full Professor and Deputy Director KVI January 1993; appointed Director of KVI January 1996 to December 2008; two-year sabbatical leave at GANIL, Caen, France and GSI, Darmstadt, Germany January 2009 to December 2010. His research interests are in nuclear structure, nuclear reactions, few-body physics, nuclear astrophysics and astroparticle physics; served on many programme and scientific advisory committees of international facilities, and evaluation committees/panels of institutes, physics departments, etc., and many times as chairman; first director of the International Research School FANTOM (1994-1995); served as chairman of the Editorial Board of Nuclear Physics News International, and as associate editor of two international nuclear physics journals; member of NuPECC (Nuclear Physics European Collaboration Committee), 1996 to 2008 and chair 2003-2005; fellow of the American Physical Society since 1994 and member of the Academy of Europe (Academia Europaea) since 2008 and chair of its Physics and Engineering Section 2012; decorated as Officer in the order of Oranje-Nassau in 2008.

### *Member*

Prof. H. (Howard) Wilson

Fellow of the Institute of Physics, Chair of Departmental Research Committee (2011-2012), Director of York Plasma Institute, Director of Fusion Doctoral Training Network, chair of International Tokamak Physics Activity (2007-2011) Pedestal Group, member of MAST Programme Advisory Committee. His research interests are in theory of fusion plasmas, with particular interest in plasmas instabilities, turbulence and also designs of future fusion devices. Following a PhD at Cambridge University (1988) in high energy particle physics, he was employed at UKAEA Culham to work on the UK fusion programme until 2005. He was then appointed as Chair of Plasma Physics at the University of York. In 2011 he was awarded a Wolfson Research Merit Award by the Royal Society.

### *Member*

Prof. H. (Herman) Deconinck

Dean of the faculty Aeronautics & Aerospace Department

Professor Dr. Toegepaste Wetenschappen, Vrije Universiteit Brussel

### *Member*

R. (Ruud) Verbij BSc

Ruud Verbij is a sixth year student Computer Science at the University of Twente, specialisation IT security. In his student career Ruud has been a fulltime board member of his study association, responsible for external relations and PR. Among this, he has been a member of the educational committee for two years and was in the quality assurance committee for three years. Aside from his commitment for education, Ruud has been in the promo team of the computer science bachelor for five years. Since September 2010 Ruud works as a student in initial accreditation boards for the NVAO.

### *Secretaries*

Drs. L. (Linda) van der Grijspaarde, Educationalist (the Netherlands), acted as secretary.

On behalf of the NVAO, drs. A.N. (Astrid) Koster was responsible for the process-coordination and the drafting of the expert's report.

## Annex 2: Schedule of the site visit

The panel undertook a site visit on Friday 29<sup>th</sup> June 2012 as part of the external assessment procedure regarding the Fusion MSc at TU/e. Address: De Rondon 1, Eindhoven

### Agenda:

Time	Programme	Participants
8.30-11.00	Preparatory meeting of the panel	All panel members
11.00-11.20	Session 1- Institutional Board	mr. J.P. van Ham (Executive Board TU/e) prof.dr.ir. K. Kopinga (Dean Faculty of Applied Physics) prof.dr. K.A.H. van Leeuwen (Director of Education)
11.20-12.15	Session 2 –Programme Management	prof.dr. N.J. Lopes Cardozo (Head Fusion Group, chair EC) dr. R.J.E. Jaspers (Programme Coordinator, chair OC) dr.ir. C. van Overveld (Quality management)
12.45-13.30	Session 3 – Lecturers Team	dr. R.J.E. Jaspers (Applied Physics, Programme Coordinator) dr.ir. M.F.M. de Bock (Applied Physics) prof. dr. M.R. de Baar (Mechanical Engineering) prof.dr. E. Lomonova (Electrical Engineering)
13.45-14.15	Session 4 – Stakeholders	dr.ir. E.J. Sol - TNO mr. C. Ibbott - European Commission – Research DG. Dr. A.C. Maas - ITER representative
14.15-14.45	Site tour	dr.ing. J.W. Oosterbeek /ing. H.M.M. de Jong E.C.G. Hermans T. Minea dr.ir. M.F.M. de Bock
15.00-15.30	Session 5 - Students	T. Minea (student) H. van den Brand (PhD student) E.C.G. Hermans (student)
15.30-15.45	Session 6 – Programme Management	prof.dr. N.J. Lopes Cardozo (Head Fusion Group, chair EC) dr. R.J.E. Jaspers (Programme Coordinator, chair OC) dr.ir. C. van Overveld (Quality management) prof.dr. K.A.H. van Leeuwen (Director of Education)
15.45-17.15	Internal deliberation	All panel members
17.15 – 17.30	Brief feedback	prof.dr. N.J. Lopes Cardozo (Head Fusion Group, chair EC) dr. R.J.E. Jaspers (Programme Coordinator, chair OC) dr.ir. C. van Overveld (Quality management) prof.dr. K.A.H. van Leeuwen (Director of Education)



## Annex 3: Documents reviewed

### *Programme documents presented by the institution*

- Application for accreditation by the NVAO of the new MSc programme of the Eindhoven University of Technology: Science and Technology of Nuclear Fusion.

### *Documents made available during the site visit*

- Overview of elective courses for the Fusion master
- Lecture notes 'Fusion on the back of an envelope'
- Written exams of fusion track
- Bachelor theses
- Master Theses
- Internship reports

### *Document made available after the site visit*

- Reply to NVAO panel (response to the five questions formulated by the NVAO panel during the site visit on 29<sup>th</sup> June 2012 at TU/e in Eindhoven for the accreditation of the new master programme: Science and Technology of Nuclear Fusion)

## Annex 4: List of abbreviations

ACQA	Academic Competences and Quality Assurance
CROHO	Central Register of Higher Education Study Programmes
DIFFER	Dutch Institute for Fundamental Energy Research
FOM	Foundation for Fundamental Research on Matter
Fusion MSc	MSc programme 'Science and Technology of Nuclear Fusion'
FuseNet	European Fusion Education Network
ITER	International Thermonuclear Experimental Reactor (abbreviation not used as such any more)
NVAO	Accreditation Organisation of the Netherlands and Flanders
OER	Educational and Exam Regulations
TU/e	University of Technology Eindhoven

The panel report has been ordered by NVAO for the initial accreditation of the MSc programme 'Science and Technology of Nuclear Fusion' of Eindhoven University of Technology.

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