ASSESSMENT REPORT

Limited programme assessment

Master Smart Systems Engineering
Full time

Hanzehogeschool Groningen
Hanze University of Applied Sciences

De kracht van kennis.

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Croho registration: 40015

Hobéon Certificering BV
June 14th 2021

Audit Committee
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J.D. Schakenbos (secretary)

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1. GENERAL AND QUANTITATIVE DATA

General data

Institution

Name	Hanze University of Applied Sciences
Status	Funded
Outcome of Institutional Quality Assessment	Pass, February 26th 2018

Programme

Name of programme in Central Register of Higher Professional Education (CROHO)	Master Sensor Systems Engineering. On the 4th of July 2019 the NVAO agreed with the new name: Master Smart System Engineering
ISAT-code CROHO	40015
Orientation and level	HBO Master of Science
Number of credits	70E, after additional site-visit 90E
Variant(s)	fulltime
Language of instruction	English
Specialisations	n.a.
Relevant Professorships	Sensors & Smart Systems
Location(s)	Assen
Special Quality Feature	n.a.

Date of site-visit	February 8 2019 and April 16 2021

2. SUMMARY

The Master Sensor Systems Engineering is a Master's programme aiming at educating students to become engineers who build and develop smart systems that have the capability to interact with their environment. Graduates of the course take up (international) positions in the Smart Systems Industry and are able to implement intelligence at the point of data generation in order to enable smart interventions in response to changes in the environment.

Standard 1. Intended Learning Outcomes
The intended learning outcomes of the course reflect generic quality: (i) level-wise they are aligned with the Dublin Descriptors for Master programmes and the EUR-ACE Programme Outcomes for Professional Engineering Masters, (ii) they reflect the demands of and are validated by a qualified representation of the professional field and (iii) they have been detailed in a way that gives direction to programme content and assessments.

Currently, the programme is in the process of implementing its intended learning outcomes, as a result of its shift from Sensor to Smart Systems Engineering and a matching update of the curriculum, thus slightly altering its focus and profile. The panel rates Standard 1 as **'satisfactory'**.

Standard 2. Teaching and Learning Environment
Within the 70 EC curriculum there is an effective interaction with the professional field; research is firmly established in the programme and internationalization is a natural thing.
The didactic design of the programme is well thought-through and leads to different modes of learning. Its structure is supported by foundation and advanced modules, and the students appreciate the learning lines. The learning objectives of the course contribute to the realisation of all intended learning outcomes.
The faculty is composed of knowledgeable lecturers that make a fine team. Collaboration with the professorship is advisable in order to strengthen the faculty. Students appreciate their accessibility and their efforts to guide their students to end level.
The small-scale physical environment is valued by the students, although the facilities are limited, but sufficient to accommodate the achievement of the learning outcomes.
The programme is currently working on a promising new location to enhance its Assen branch.

Considering the fact that the programme is well structured and well balanced, conducted by a fine team of qualified lecturers and executed in a somewhat austere teaching and learning environment, the panel concludes that the quality of Standard 2 is **'satisfactory'**.

Standard 3. Learning Assessment System
Considering that the programme has designed a test and assessment scheme that basically safeguards the quality of tests and assessments; i.e. they are valid, reliable and transparent to the students. The quality assurance of tests and assessments is conducted in a proper manner, through an Examination Board at School level that commissions a Master Chamber to execute tasks aimed at the proactive and reactive safeguarding of the interim and final examinations.

Considering that the overall quality of the programme's assessment system meets generic standards, but that the assessment form for the thesis assignment still needs a critical review, the panel judgement on Standard 3 reads **'satisfactory'**.

Standard 4. Learning outcomes achieved
All of the reviewed theses were considered up to par: they represent Master's level and reflect the intended learning outcomes of the course. Still, with the chosen research approach, it was not always obvious to solve an engineering design problem. Also, students could be more critical in accepting and approaching their research assignments.

Considering all of these, the panel rates Standard 4 as **'satisfactory'**

Review of programme update
The programme assigned the panel to also review and assess its plans for the updated curriculum, comprising an extension of the programme to 90 EC and a change of course title.

The panel is of the opinion that the course, across the board, presents valid arguments to change its course title from *Master Sensor System Engineering* into *Master Smart Systems Engineering* and also brought forward relevant arguments to extend the programme from 70 to 90 EC. In addition, the programme satisfactorily worked out plans to align its intended learning outcomes, the curriculum design and the assessment system with the proposed change of title and the extension of the number of European credits.

Therefore, the panel recommended NVAO to endorse the application.

Update after additional site-visit
On the 4th of July 2019 the NVAO agreed with the change of the course title into Master Smart Systems Engineering.

After the additional site-visit the panel concludes that the extension of the programme to 90 EC has worked satisfactorily. The intended learning outcomes, the curriculum design, and the assessment system are well incorporated in the extended programme. Accordingly, students have more time and means to digest the curriculum, which was one of the main objectives. The panel read four Master Thesis of the 90 EC and concludes that the students graduate on a high level.

Overall conclusion
In accordance with NVAO's accreditation assessment rules the overall judgement on the Master of Science programme Smart System Engineering reads **'satisfactory'**.

The panel nominates the Master Smart Systems Engineering for reaccreditation for another six years.

Upon agreement with the panel members the chair in The Hague adopted this report on June 1st, 2021.

3. INTRODUCTION

In this Chapter a brief introduction to the course is given, its position within the School of Engineering/the Hanze University of Applied Sciences (UAS) is shared, as well as relevant historic and contextual information on the course. A conclusive paragraph is dedicated to the events that have taken place in the wake of previous accreditation and/or internal audits.

Hanze University of Applied Sciences
Hanze University of Applied Sciences Groningen was founded in 1798. It is the oldest multi-sectorial university of applied sciences in the Netherlands. In 2019 the University offers 51 bachelor degree, 17 master degree and 8 Associate degree programmes, both fulltime and part-time, in the social, economic and technical domain as well as in health care and the arts. Based in the northern city of Groningen, it has branches in Assen, Leeuwarden and Amsterdam. The Master Sensor System Engineering is located in Assen. The University has 3,323 staff members and 29,087 students. Applied research takes place in three Centres of Expertise and three Centres of Applied Research and Innovation, with a total of 55 professors in 58 professorships; 204 lecturers have received their PhD degree and 116 are PhD candidates (2017).

Hanze UAS is organised in 18 schools, one of which is the School of Engineering (1800 students, 150 employees). The school accommodates two Associate degree programmes, four Bachelors and four Masters, one of which is the Master Sensor System Engineering. The School is specifically connected to the Centres of Expertise Energy and Healthy Ageing and with the Research Centre Biobased Economy and Smart industries. A professor in Sensors & Smart Systems has recently been appointed.

Master Sensor System Engineering
The Master SSE of 70 EC was developed in 2012, initially accredited in 2014 and took off in 2015 as designed. The programme is located in Assen. The Master SSE trains students to become engineers who build and develop smart systems that have the capability to interact with their environment. Graduates of the course will move beyond simply generating data and, in fact, will be implementing intelligence at the point of data generation to enable smart interventions in response to changes in the environment. Since it set out, the SSE Master has seen major developments within the domain of system engineering that called for an update of the programme. A summary of adjustments is outlined in the following paragraph.

In the wake of initial accreditation: second wave
Since its initial accreditation in 2014, the SSE programme was impacted in several ways. First of all, the SSE domain is at the forefront of innovation and affected by rapid technological and societal developments. This made it necessary to critically evaluate the programme and to adjust and update its content and structure.

Also, as already had been advised by the initial visitation panel, the exclusive health specialisation required a rethink. As it turned out to be too restrictive to students, specialisation is now more student-centred and diverse. Of course, sensor systems are not confined to health issues only, but are the core of and applied in a large number of domains. The broadening of specialisation options marked the first tangible step from *sensor systems* to *smart systems*.
It implicated that the initial health specialisation modules had to be redesigned into a more generic module Product and Service Design and a Sensor Application Specialisation module in which students themselves can shape their own specialisation.
Due to this slight change of focus of the curriculum, the programme proposes to alter its title from Sensor System Engineering into Smart Systems Engineering.

In 2016 an internal review was carried out, grounded on the outcomes and recommendations of the initial visitation and the experiences with the programme so far. Among other things, the review resulted in the following adjustments: (i) as the research environment was not as vibrant as initially foreseen, due to the discontinuation of the development of a 'cluster sensor technology', integration in the research centre Biobased Economy and Smart Systems was initiated by appointing a full time professor Sensors and Smart Systems as a first step. Also, as a result of integrating staff of the various master programmes of Engineering, an energy specialization was added, resulting in the introduction of a personal specialization; (ii) the progress test was removed from the programme; (iii) an extension to 90 EC was designed, in order to align the programme with current developments in the professional field, such as Data Fusion Architectures and Models and Smart Systems; (iv) to open up the programme to a broader influx of students it is suggested that the deficiency minor will be integrated in the 90 EC curriculum, and (v) the internationalisation feature of the programme will be further enhanced by turning students' current participation in international communities on machine learning into a key-element of the programme.

Also, a review of the programme learning outcomes (PLOs) has led to several adjustments. The original ten PLOs were reformulated and partially combined into six revised programme learning outcomes. The revised PLOs are in tune with the shift from sensor systems to smart systems, and the abandonment of the specific specialisation in Health. The SSE Master, after approval, plans to materialise this as of September 2019, together with the change of course title. All of these adjustments to the programme will be considered under the respective Standards in Chapter 4 of this report.

Alignment with NVAO

As the panel at the time of the audit could not yet assess the full extent of the execution of the revised programme nor the achievement of the intended learning outcomes of the updated 90 EC curriculum, the programme prior to and in the process of the audit sought alignment with the NVAO on the desired assessment proceedings, the framework to be applied and the type of report to be delivered. The following procedure was agreed upon:

- A regular accreditation assessment will be conducted for the 70 EC programme parallel to an evaluation of the proposed 90 EC curriculum;
- Application for accreditation will be submitted through a single assessment report for both the existing and the updated programme. In the Standards section of the report the panel will present per Standard its findings and judgments on the attained quality of the 70 EC curriculum and, similarly, deal with the quality of the envisaged 90 EC programme in separate paragraphs. The change of study load and programme title will be briefly clarified in the Introduction section to the report (see above) and further substantiated in the texts of the applicable Standards of Chapter 4;
- Next, NVAO will take a decision on the panel's report and in a so called 4;5 letter will defer its decision on extended accreditation pending the assessment of the achieved learning outcomes of the 90 EC curriculum. Not only will the review panel then consider Standard 4, but also review the proper execution of Standards 2 and 3, as the adjustments will likely have impacted both the teaching-learning environment and the assessment system.
- If the new assessment report provides grounds, the NVAO will reaccredit the programme.

For readability's sake and to clearly differentiate between the current programme and its updated 90 EC version, the assessment of the latter is presented and evaluated in shaded boxes at the end of Standards 1, 2 and 3 as outlined in Chapter 4 of this report, and titled – in what the programme names – *'Update to the Second Wave'*.

Update after additional site-visit
On the 16th of April 2021 the same audit committee as in the initial site-visit conducted an additional site-visit to judge the implementation of the programme extension to 90 EC. Due to COVID-19 this site-visit took place through MS-Teams. The panel focused, in line with the letter of the NVAO (NVAO/20192214/LL, July 1 2019), on the Standards 2, 3 and 4 and spoke with the Management, lectures/researchers/Professor and Students and alumni. The panel used the self-evaluation 'Addition to the second wave' and 4 (graduated) Master Thesis as main preparation.

In the separate Standards the panel added the new information regarding the programme extension.

4. FINDINGS AND JUDGEMENTS

This chapter deals with the panel members' findings and judgements based on the documents delivered by the course faculty and management and the subsequent discussions during the site-visit. The text is ordered according to the four standards of the applicable NVAO assessment framework. In shaded frames at the end of each standard the panel discusses and evaluates the proposed updates to the 90 EC programme.

4.1. 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.

Explanation: As for level (Bachelors or Masters) and orientation (professional or academic), the intended learning outcomes fit into the Dutch qualifications framework. In addition, they tie in with the international perspective of the requirements currently set by the professional field and the discipline with regard to the contents of the programme. Insofar as is applicable, the intended learning outcomes are in accordance with relevant legislation and regulations.

Findings

The course aims at delivering graduates who have advanced technical knowledge of sensor technology with systems overview and a problem-oriented approach allowing them to take a user/service perspective. Graduates possess competences to design architectures for sensor systems and data-centric sensor applications, including the modelling of complex data flows and analysis algorithms. Furthermore, graduates must be aware of real world limitations and constraints, both physical, societal and regulatory. They are trained to deploy the professional skills to work in international, intercultural and multidisciplinary teams, and to excel in interaction with customers, colleagues and partners in the value chain.

The intended learning outcomes of the current SSE programme have been defined in terms of 10 competences, eight of which denoting professional capacities and two focussing on either 'Health' or 'Energy' (specialisations). The generic professional competences are: (i) modelling meaningful data, (ii) building intelligent architectures, (iii) creating reliable services, (iv) designing towards prototype, (v) professional skills, (vi) being aware of impact, (vii) performing responsible research and (viii) contributing to innovation. The specialisation-specific competencies are: (i) applying sensor technology in a specialisation of choice and (ii) developing applications for a specialisation of choice; up to now student's choice of specialisations has been largely confined to the health domain, one of Hanze UAS' profiling features.

Level and content
For level sake, the course profile has been aligned with the Dublin Descriptors for Masters courses. Moreover, the intended learning outcomes cover the so named EUR-ACE Programme Outcomes for a Professional Master of Engineering.
The Master's level becomes particularly apparent through the students' expertise in their specialism. Students are (semi) autonomous critical thinkers, demonstrating independence in the negotiation of assessment tasks (including the Master thesis project) and the ability to evaluate, challenge, modify and develop theory and practice.

Students are expected to demonstrate an ability to isolate and focus on the significant features of problems and to offer synthetic and coherent solutions, contribute to generalizable and transferrable knowledge, with some students producing original or innovative work in their specialism that is worthy of publication or public performance or display. In a table the programme presented to the panel illustrations of how each of the intended learning outcomes are linked to one or more of the Dublin Descriptors. The panel concludes that the intended learning outcomes of the course unquestionably meet the level as indicated by the Dublin Descriptors for Master programmes.

Research and orientation
SSE is a professional Master's course; meaning that the research part is applied and should help to solve a problem, improve society and/or the quality of life. The programme rightly holds the vision that at Master's level, students should be able to independently define a problem, which is complex, abstract, multidisciplinary or even trans-disciplinary. The applied research within the programme is based on existing knowledge and theories, and preferably adds knowledge and skills to the engineering domain; moreover the results of the applied research should be disseminated to the outside world.
The capacity of performing responsible research is featured explicitly in one of the intended learning outcomes and is further detailed in the Student Manual. Also, the set of competences, the elaboration thereof in the Student Manual and the Body of Knowledge and Skills of the course, in the eyes of the panel, clearly comprise the professional and research focus applicable to a Master SSE programme.

Internationalisation
Apart from the fact that the intended learning outcomes have been aligned with international frames of reference, such as the Dublin Descriptors and the intended learning outcomes for EUR-ACE, the phrasing of the 'Professional Skills' competency itself features the graduate's capability 'to perform as a leader of multi-disciplinary and *multinational teams'*.
And also, with regard to the competency 'Creating Reliable Services' the graduate must be able 'to take the lead in gathering requirements and boundary conditions…in a potentially *international environment'*. The panel believes that the current programme's intended learning outcomes feature an applicable focus on internationalisation.

Validation
The professional field of Sensor Technology is involved in both the graduation projects and the Professional Advisory Board of the course. Through their tight involvement in the (execution of the) programme work field representatives continually evaluate its results, which help them deliver input for improvement and adaptions to the curriculum and the intended learning outcomes.
As a result of the Board's input, among others, in 2018 the programme learning outcomes (PLOs) of the Master SSE were updated together with the Body of Knowledge and Skills, in order to better reflect the development within the professional field. The set of updated learning outcomes, as work field representatives confirm in the audit, is considered essential for future Sensor System Engineers, when it comes to understanding smart systems.

From the discussion with representatives from the professional field – one of them stood at the cradle of the programme in 2012 – and the alumni, it became clear that from the outset the course has intended to deliver *system integrators* and not the 'diehard' data scientists or hardware engineers, meaning that course graduates function as a liaison between the customer requirements department and the specialist-engineers who draw up the application requirements and those who design and develop the technical solutions or components, be it hardware or data. The panel believes this is definitely an appropriate course objective: to deliver system integrators that possess the capacity to apply critical thinking – i.e. the ability to reflect on and consider the best possible solution from a broad and overarching perspective.

The alumni with whom the panel spoke acknowledged and confirmed this specific profile of the Master's programme.

The panel was pleased to learn that stakeholder management is done carefully as it helps to keep up with external developments and innovations. In this context it is fruitful to the course to maintain links with stakeholders like the Northern Development Company (NOM), Antea engineering firm and Groningen University.

Considerations and Judgment

The intended learning outcomes of the course reflect standard quality: (i) level-wise they are aligned with the Dublin Descriptors for Master programmes and the EUR-ACE Programme Outcomes for Professional Engineering Masters, (ii) they reflect the demands of and were validated by a qualified representation of the professional field and (iii) they have been detailed in a way that gives direction to programme content and assessments.

Currently, the programme is in the process of implementing its intended learning outcomes, as a result of its shift from Sensor to Smart System Engineering and a matching update of the curriculum, thus slightly altering its focus and profile. The panel rates Standard 1 as **'satisfactory'**.

Update to 'Second Wave'

Revision of Programme Learning Outcomes
The update of the programme logically required a review of the Programme Learning Outcomes. Therefore, the initial Learning Outcomes were scrutinized in the light of topicality and current developments in the professional field. As a result, the 10 initial learning outcomes were reduced to six, mostly due to integration and merging of learning outcomes. The phrasing of the 'new' competencies emphasises the focus on smart systems. Also the ambition with regard to prototyping has been made more realistic and leadership is no longer an aspect of the Professional Skills competency, as the achievement of this skill appeared to be too ambitious and did not entirely fit the bill of the SSE alumni.

In a matrix the course illustrated to the panel how the six competencies relate to the initial ten. And what exact changes were made. The panel agrees to the newly designed set of competences that clearly reflect Masters level as indicated by the Dublin Descriptors; it is also well-directed to both the professional and the academic character of the programme, bearing an international focus as well as an alignment with the EUR-ACE programme outcomes for professional masters.

Conclusion
The panel concludes that the revised and updated intended learning outcomes tie in well with all of the criteria for solid programme qualifications. A further linkage with the three profiling themes of the Hanze UAS is recommended.

Change of course title
In a dedicated Appendix to its Self-evaluation, the course presented to the panel its motivation for its desire to change the course title. It puts forward three arguments: (i) the field of sensor systems is generally evolving into smart systems, (ii) the Master programme operates at the heart of the developing Smart Industry and will be embedded in the research centre Biobased Economy and Smart Industry, which is connected to the professorship Sensors and Smart Systems, and (iii) the course title should be aligned with those of similar, international, programmes.

Initially, the master Sensor Systems Engineering was developed as part of the educational portfolio in 'Sensor City', an endeavour that set out to create a thriving environment of entrepreneurship, research and education around the emerging technology of sensors. As an active member of this environment in Assen, Hanze UAS developed the unique international honours Bachelor programme in Advanced Sensor Applications (ASA) and the master programme in Sensor System Engineering (SSE). However, at this point in time the sensor cluster no longer exists in its original form.

Simultaneously, the course confirms that the field of knowledge that initially was given the name Sensor Technology is continuously evolving: sensor systems are developing into smart systems at the edge of the internet. Sensors and smart systems are becoming a founding layer of smart industry. Smart systems are the connecting layer between 'cyber space' or the virtual world and the real world. Among others, the course supports its view with a literature reviews on Industry 4.0, in which the evolving technology from a single sensor system to a smart system is clearly and convincingly described.

In the strategic plan of the School of Engineering, the need to focus on Smart Industry is further substantiated. The Smart Industry is considered the most important development for the engineering and manufacturing industry worldwide. An important step towards the focus on Smart Industry was to embed Smart Industry into the Hanze UAS research centre Biobased Economy, thus creating the research centre Biobased Economy and Smart Industry.

In its evidence based vision the course mentions three layers and focus areas for Smart Industry: Smart Systems, Smart Products and Smart Processing. To set out the development of the smart industry component of the aforementioned research centre, the course appointed a full professor for the founding layer who specialises in sensors & smart systems. Currently, the research centre is refocussing and expanding its research from sensor systems to Smart Industry. From the audit discussions, among others with the management and the newly appointed professor, it became clear that is the course's firm intention to embed the Master Smart Systems solidly into this research 'ecosystem'.

Another argument for the name change is the need to align with similar international programmes, so as to increase the influx into the course and provide a more viable economy of scale. Also, the course strongly adheres to its international character for which the attraction of international students is essential.
The course management also substantiated its request for the change of title by conducting a comparative research into the names and contents of similar Master programmes abroad. It appeared that the content and focus of the SSE Master compares best to programmes that carry Smart Systems in their name, more so than Sensor Systems or Sensor Technology. Therefore the course believes the title Smart Systems Engineering covers the 'cargo' best and will put the Master in the same search criteria for international students.

The panel, at length, discussed the considerations on the focus and name of the course with various participants in the audit and concluded that the representatives from the professional field firmly support the management's request to alter the course title.

Conclusion
The panel concludes that the course, across the board, has presented valid arguments in favour of a name change and recommends NVAO to honour the request.

4.2. Teaching and Learning Environment

Standard 2: The curriculum, staff and programme-specific services and facilities enable the incoming students to achieve the intended learning outcomes.

Explanation: The contents and structure of the curriculum enable the enrolled students to achieve the intended learning outcomes. The quality of the faculty and of the programme-specific services and facilities are essential to that end. Curriculum, staff, services and facilities provide a coherent teaching-learning environment to the students.

Findings

Programme outline and curriculum design
In the current programme, students of the Master Sensor System Engineering start their education in Assen with guided company visits and excursions to organisations of interest. In the first half-semester, the foundations of the programme are laid and technical skills developed. The subjects in the second half-semester advance the technical knowledge and understanding of the context, and the environment in which the knowledge is used, for instance through discussions on ethics issues, by creating awareness and training research skills. In addition, throughout the semester Professional Skills and community contribution prepare students for their master thesis project.

The curriculum of the Master Sensor System Engineering is organized in 13 modules, which incorporate and cover the programme learning outcomes. Students in the audit say they appreciate the clear outline of the programme. A detailed description of the content of all modules, the corresponding learning outcomes, the learning environment and the assessment methods, according to the panel, have clearly been outlined in the Student Manual Master SSE.

Semester 1	ECTS	Semester 2	ECTS
Introduction to SSE	5		
Applied Machine Learning	5	Professional Skills 2	1
Data Centric Architectures	5	Master Thesis	30
Adaptive Filtering	5		
Sensor Application Specialisation 1	4		
Sensor Application Specialisation 2	2		
Products and Services Design	5		
Professional Skills 1	2		
Research Skills	3		
Community Contribution	2		
Ethics in Engineering	2		

Table 1 Outline of programme modules

Lecturers bring their expertise and actual case studies from the professional field. Assignments are linked to real life scenarios and data; they challenge to apply the concepts of what students have learned. In the second semester, integration of most of the knowledge and skills takes place. For their thesis, students choose one of the specific technical subjects and combine this with other knowledge/skills in order to integrate their skills and knowledge. Students on the discussion panel spoke highly of the practical focus of the course and the relevant projects derived from real practice, the professional experience their lecturers bring in and their lab-work.

Internationalization is a matter of course in the SSE programme: with a nice mix of nationalities, the English language is the lingua franca; the SSE domain is global and all literature of the course is international. Also contacts in the professional fields and the project conducted very often have an international angle. When asked whether students would have preferred the more vibrant intercultural life at the Groningen campus, they said to prefer 'to be on the same plane' with all engineering students of the Assen branch.

The panel appreciates the links of the course with foreign partners like Osnabrück – although still in an early stage of development – and others; it would recommend to only seek international contacts and exchanges when it benefits both parties, with the EUREC consortium as a shining example of how European partnerships may work out mutually beneficial. In this respect also Dutch partners within the engineering domain could be sought.

With regard to the study load of the programme – presumably caused by an overloaded test scheme – students say the curriculum is tough – over 40 hours per week is not uncommon – but still doable.

Coverage of intended learning outcomes
As already stated in Standard 1, the current Master Sensor System Engineering has 10 programme learning outcomes, eight of which are general (M1-M8) and two are meant for the specialization Health (H1-H2). In all educational modules students are working on these programme learning outcomes. The course has presented to the panel a matrix showing how each of the modules contributes to the programme learning outcomes. The panel established that the programme is in fact a thorough and detailed elaboration of the intended learning outcomes, thus covering them all.

		Modules										
PLO		1 Intro-duction to SSE	2 Applied Machine Learning	3 Adaptive Filtering	4 Data Centric Architec-tures	5 Product Services Design	6 Sensor Applica-tion Specia-lisation	7 Profes-sional Skills	8 Research Skills	9 Ethics in Engi-neering	10 Com-munity Contri-bution	11 Master Thesis
M1	Modeling Meaning-ful Data	X	X	X	•							•
M2	Building Intelligent Architectures	•	•	X	X	•						•
M3	Creating Reliable Services					X		X				•
M4	Designing Towards Prototype					X	X					•
M5	Professional Skills					•		X			•	X
M6	Being Aware of Impact					X	X		X	X	•	X
M7	Performing Re-sponsible Research			•	•	X	X		X			X
M8	Contributing to innovation					X	•		•	•	X	X
H1	Applying Sensor Technology in a sepcialisation			•		•	X					X
H2	Developing Sensor application					X	X					•/X

X indicate the primary Programme Learning Outcome addressed in each Module;

• indicates small contribution.

Table 2 Coverage of intended learning outcomes by the curriculum

Modes of learning

The programme features four modes of learning: integral learning, conceptual learning, learning by training and learning of professional skills. Each way of learning is targeted at a different set of educational goals, accommodating the different phases of learning as indicated by Kolb's learning cycle. Conceptual learning, learning by training and the learning of professional skills all contribute to integral learning, which is continually aimed at broadening and deepening students' knowledge, both in the field of fundamental knowledge as well as applied knowledge.

Learning by training

In the Learning by training part students acquire and practice skills and working methods. Lecturers guide their students in exercising practical skills, give instructions with regard to the issues dealt with, demonstrate by example the skills that students need to possess and provide feedback. An example of this procedure is the Introduction module to SSE, in which students have to set up the programming environment with which they have to work for the remaining semester. This includes assignments e.g. in Machine learning where they have to apply the concepts to real (sound)data provided by the lecturer.

In the curriculum, a division is made between conceptual programmes, practical training programmes and combination programmes in which conceptual learning and learning by training naturally interchanges. Using a combination of instructional approaches is based on the assumption that it facilitates the acquisition of better-organized, multifaceted knowledge. For example, learning by training for the acquisition of factual and procedural knowledge is combined with inquiry learning for building deep, conceptual understanding.

Professional learning

In professional learning, students work on their professional skills, such as critical thinking and their personal strengths and weaknesses, with a focus on becoming appropriate professionals at Masters level. The course encourages student's development in professional learning by having them demonstrate those skills in order to collect feedback and appraisal. Also, students are invited to reflect on their personal development, thus gradually enhancing their professional competences. Each student has a mentor to support him/her in establishing individual learning objectives to achieve the learning outcomes. Students in the audit say they explicitly exercise their networking skills during visits to conferences. The assignment in professional skills in which students reflect on their behaviour and development during the graduation phase is a prerequisite to the graduation assessment.

Integral learning

Through integral learning the student develops his/her competences. The integral learning line is all about integrating knowledge, skills and professional attitude in any specific professional situation. This is particularly done during the Master thesis phase. The student is supposed to work individually on a Master thesis project that reflects a realistic task or he solves a problem in a professional environment. When completing their Master's thesis projects, students receive direction and support from the network they set up in the first semester, composed of stakeholders and practitioners working in the relevant part of the field.

The panel thinks the course has adopted the right didactical approach to suit the needs of full time Master engineering students; it appears that all nationalities in the course can cope with the more student-centred approach within the Dutch education system. Students confirm this.

Research

The SSE research activities mainly take place in the learning and research community in Assen; research happens in e.g. dedicated classes, at the Research Centre Biobased Economy and

Smart Industries, within the Innovation workplaces and within the facilities of the network (UMCG, Innovatiecluster Drachten).
Through this infrastructure students experience the mind-set of working in a research environment. In reviewing the course materials, the panel observed a substantial number of assignments that featured elements of research.
Specific to the SSE research environment is the trans-disciplinary context within which research is conducted. The panel learned that lecturers and the recently appointed Professor consider students' ability to think in integrated, open innovation chains from an engineer's perspective, one of the key objectives of the course. Student say they recognize this perspective, although the panel members could not always explicitly perceive this ability in the theses.

Faculty
The panel received an overview of the faculty, among other things providing information on lecturers' background, qualifications, experience and their programme involvement in terms of FTEs. In all, the faculty is composed of 10 lecturers with a total of 7.8FTE. Judging from their various backgrounds, the programme has been able to commit a truly international and dedicated staff of experienced lecturers and professionals in their field. The image that had arisen from the documentation in advance of the site visit was further reinforced by the quality of the audit discussions. The fact that the course had recently been able to hire a research professor to lead the programme specific Professorship and, from his position, contribute to the Master programme as a leading expert in the field, in the eyes of the panel, is definitely one of the future important assets of the course. All of the lecturers hold a Master's degree; nine faculty members currently have a PhD; the remaining lecturer will also soon qualify for a doctorate degree.

Students on the auditee panel express their general satisfaction with the lecturers. They describe them as highly approachable, knowledgeable and very committed to teaching them new skills and supporting and stimulating them to make the most of their time at the SSE programme. Also students recall to memory their lecturers' involvement in the professional field as well as in research, and how they benefit from this in classes.

As it appears, many lecturers have their own businesses and also participate actively in Hanze-wide activities within the research centres; this enables them to constantly professionalise and stay in touch with the professional field and sensor engineering developments. The panel spoke with a selection of faculty members who demonstrated to be well connected with the latest developments in het SSE domain.

Furthermore, the panel met a relatively small and close-knit core team that is well-focussed on the benefit of their students. Lecturers, students say, practice direct lines of communication. From the audit, the panel gathered that this not only applies to their students, but also to their colleagues. In all, the panel is convinced that the teaching staff is doing a fine job, also bearing in mind the small scale of the course. At the same time, the panel would recommend to strengthen the faculty in the sense that it synchronises activities with the research agenda of the professorship. The panel believes this could be profitable for both parties and might enhance and even better facilitate the so desired next step ('next wave'). Also, a close collaboration with the professorship might have an effect of an 'outboard motor', giving thrust to the course, providing it with a critical mass, even at such a small scale.

Facilities
Part of the site visit was a guided tour on the school premises in Assen and the available course specific facilities. The panel concluded that the facilities suffice: all students require for conducting experiments, making designs and developing prototypes is available to them, although the panel considered the laboratories modest in size. Like all students at Hanze UAS, SSE students have digital access to the learning environment where they find all study materials and library facilities.

The panel was happy to learn that the course/school is in the process of being relocated to a somewhat 'richer' and more vibrant environment in Assen, where an Innovation workshop will be opened in September 2019, and the programme can seek further alliances with companies and partners.

Student satisfaction
Students are satisfied with the level, the content and the international character of the programme; not only could this be deducted from the audit discussion with students, but also did it become apparent from the programme's regular Student Evaluations and the ranking of the course in the Keuzegids Masters 2018, that ranks the SSE Master as the number one of four comparable programmes. Students are particularly happy with the real-life assignments which they consider inspiring and challenging. They explicitly make mention of their close interaction with the lecturers. They say to appreciate the small-scale of the course. The students with whom the panel spoke, denote the course as tough, but still doable, which indicates that the removal of the progress test has had a positive effect on the students' perceived study load.

Considerations and Judgement

Within the 70 EC curriculum there is an effective interaction with the professional field; research is firmly established in the programme and internationalization is a natural thing.
The didactic design of the programme is well thought-out and leads to different modes of learning. Student appreciate the programme structure, supported by foundation and advanced modules and learning lines. The learning objectives of the course contribute to the realisation of all intended learning outcomes.
The faculty is composed of knowledgeable lecturers that make a fine team. Collaboration with the professorship is advisable in order to further strengthen the faculty. Students appreciate their accessibility and their efforts to guide their students to end level.
Students value the small-scale physical environment; the facilities are limited, but still sufficient to accommodate the achievement of the learning outcomes. The programme is currently working on a promising new location to enhance its Assen branch.

Considering the fact that the programme is well-structured and well thought-out, conducted by a fine team of qualified lecturers and executed in a somewhat austere teaching and learning environment, the panel deems the quality of Standard 2 **'satisfactory'**.

Update to 'Second Wave'

Programme extension from 70 to 90EC
The initial choice for a 70 EC programme was predominantly based on the idea that the programme was built upon the honours bachelor programme of Advanced Sensor Applications, and that the influx would consist of talented students, who are accustomed to a higher study load, and who are capable of handling 70 EC in one year. The Bachelor-Master programme in Assen was positioned as a 5-year programme.

The programme raises four arguments for extension of the programme to 90 EC:
First, it argues that the emerging standard for technical professional Master programmes in The Netherlands is 90 EC, referring to comparable 90 EC Masters, such as the Master Engineering Systems and Control Systems Engineering of Hogeschool van Arnhem Nijmegen and the Master River Delta Development, which is a joint programme of Hogeschool Rotterdam, Hogeschool Zeeland and Hogeschool Van Hall Larenstein. Also, at Hanze UAS the Masters in Renewable Energy and Data Science for Life Sciences comprise 90EC.
Lecturers of these Master programmes experience that 90 EC allow for a good balance between sufficient depth and educational feasibility.

Second, the course would like to raise and broaden the student influx by broadening its profile.
The course management argues that the low influx is probably caused by the specific entry requirements for students with a non-ASA-bachelor degree who first had to do a minor programme to meet the entry requirements. The programme intends to integrate this minor programme into the updated Master programme, thus opening up the programme for a broader group of students, such as mechanical engineers, mechatronics engineers and computer science engineers with a background in embedded engineering.

Third, the programme would prefer to enhance educational feasibility, which ties in with what students said in the audit, suggesting that the schedule was too tight and did not allow for enough 'processing' time. The programme wishes to solve this issue by using half of the extra 20EC for two projects of 5 EC each allowing more processing time. The first project will be linked to the module 'Introduction to SSE' and allows hands-on integrated experience with digital signal processing, programming tools and linear algebra, creating a common core of knowledge and skills to build upon.
The second project will be a so called 'capstone' project, a concept that is taken from the European Master in Renewable Energy, where knowledge from core modules is integrated by working on a real-life case. This concept has proven its merits and prepares students well for their thesis. And also, to lighten the study load of the modules Machine Learning and Data Centric Architectures some of the content will be redistributed to a new 5 EC module (Data Fusion Architectures & Models).

And last but not least, the programme management argues that it would like to extend the curriculum to update and strengthen its content in order to keep up with developments.
The management notes that the field of sensor technology is continuously and rapidly evolving. In 2014, the key to knowledge was the intelligent sensor system that would collect precisely the data required by the customer or user. Today, the sensor system has become part of virtually any smart system i.e. data handling questions, design questions and smart systems thus requiring high level thinking. The extension will therefore also be used to add two new 5 EC modules that feature new knowledge: Smart Systems, Data fusion architectures & Models, and in updated module Data Centric Architectures. In addition, the Smart Systems project will also be highly topical as students will be working on actual real-life cases with the professional field.

Conclusion
The course management has convincingly provided substantiated arguments to extend the programme from 70 to 90EC. The panel recommends NVAO to endorse the extension.

Design of the updated programme
The aforementioned adjustments to the programme, were presented to the panel in a table featuring the revised curriculum set-up (table 3). The table clarifies for each module its origin and its purpose, i.e. how the modules relate to each of the aforementioned arguments.

Master Smart Systems Engineering	90 EC	Origin of component	Purpose of new compo
Intro to SSE			
Digital Signal Processing, Linear Algebra, Programming Tools	5	Minor SSE, Master SSE (70 EC)	Broader influx
Project Introduction to SSE (building community of learners)	5	Minor SSE	Ease of study
Smart Systems	5	New	Update
Data Fusion Architectures & Models	5	New	Update, Ease of study
Adaptive Filtering	5	Master SSE (70 EC)	Ease of study
Data Centric Architectures	5	Master SSE (70 EC)	Update
Machine Learning	5	Master SSE (70 EC)	Update, Ease of study
Product & Services Design	5	Master SSE (70 EC)	
Sensor Applications Specialisation	5	Master SSE (70 EC)	
Sustainable Research Skills	5	Master SSE (70 EC)	
Professional Skills & Community Contribution	5	Master SSE (70 EC)	
Smart Systems Project (in and with workfield)	5	New	Update, Ease of study
Thesis	30	Master SSE (70 EC)	

Table 3 Revised design of the curriculum

Alignment of Educational Modules with the revised intended learning outcomes
The course also provided a matrix (table 4) indicating how the updated curriculum (and the learning objectives of its 13 modules) provides full coverage of the six intended learning outcomes. In an appendix to its Self-evaluation the programme, too, provided insight into the updated module content, so that the panel was able to link module content to learning objectives and specific learning outcomes.

Conclusion
The information presented by the programme convinced the panel that the 90EC curriculum is coherent in its design and offers full coverage of the intended learning outcomes, thus enabling students to fully achieve the intended learning outcomes of the Master programme Smart System Engineering.

PLO		Modules												
		Introduction to SSE	Introduction to SSE Project	Smart Systems	Applied Machine Learning	Adaptive Filtering	Data Fusion Architectures and Models	Data Centric Architecture	Products & Services Design	Sensor Application Specialisation	Professional Skills & Community Contribution	Sustainable Research Skills	Smart Systems Project	Master Thesis
SSE1	Giving Meaning to Sensor Data	X	•	X	X	X	X	•					•/X	•/X
SSE2	Building Intelligent Architectures	•	•	X	•	X	X	X					•/X	•/X
SSE3	Creating Reliable Services		•						X		•		•/X	•/X
SSE4	Professional Skills		•						•	X	X	•	•/X	X
SSE5	Performing Applied Research for System Design		•						X	X		•	X	X
SSE6	Contributing to Sustainable Innovation							•	X	•	•	X	X	X

Table 4 Relationship between intended learning outcomes and module objectives

Updated Admission criteria
Broadening the scope of the programme targeted at attracting (i) a more diverse student population and thus (ii) a more substantial influx, also required revision of the current admission criteria. These changes already came into force in 2018.

Direct admission is granted to students with a Bachelor of Science degree in Electrical and Electronic Engineering, Mechanical Engineering or Computer Science (technical/embedded) from a university in the Netherlands or another EU member state.
Students with one of the aforementioned Bachelor of Science degrees, but awarded at a non-EU university will be assessed on the basis of a comparison of curricula and a detailed list of grades.
In addition, an appropriate affinity with mathematics and computing should be demonstrated in the transcript of the degree and/or by the applicant's resume and/or by a convincing motivation letter. A minor/major in Electronics, Embedded Systems, Mechatronics, Industrial Automation or Internet of Things will demonstrate such affinity.
In revising the admission criteria, the course also laid down stricter English language proficiency requirements: an IELTS score of 6.5 minimum is required, with no sub score below 6.0 or a TOEFL Internet Based Test score of 90 or equivalents in Cambridge ESOL/TOEIC.

Conclusion
The panel concludes that the programme has revised its admission criteria in such a way that enrolment could be more appealing to a broader group of students. The panel believes that the revised admission requirements may well mitigate the effects of the more restrictive entrance criteria of the 70 EC programme.

Update after additional site-visit
In line with the site-visit in 2019 the panel concludes that the extended programme is an adequate realisation of the PLO's. The programme gives the opportunity to extend the

module of research skills and adjust 2 new modules. These adjustments gave the student also more opportunity to write, in an earlier stage 2 essays and discuss these with the lectures. This improves the Academic writing of the students. The new programme provides enough freedom for students to develop their own learning path.
The students also mentioned that the extension of the programme gave them extra time and ability's to deepen the teaching material and to stimulate critical thinking. Despite COVID-19, students still experience being part of a learning community. The management appointed an alumnus of the programme to accompany the students in the difficult time. This alumnus has been very valuable for the students, not only for his intellectual capacity but also for his guidance. Furthermore, students are still able to evaluate the programme in multiple feedback sessions and experience that their recommendations are being followed up.
For the further development of the programme there has to be attention for actual themes like Edge-computing, Cloud Service and Virtual Sensing.

4.3. Assessment

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

Explanation: The tests and assessments are valid, reliable and transparent to the students. The programme's Examination Board safeguards the quality of the interim and final examinations.

Findings

The Master SSE adheres to Hanze's institutional assessment policy in organizing and conducting assessments of learning outcomes. The School of Engineering transferred the institutional assessment policy into an assessment framework for the entire school. This assessment framework among other things comprises the commonly used 'test cycle', following a cyclic process (PDCA) of test/assessment construction, determination of norms, deployment/execution, grading, analysis and communication of results. The panel, in reviewing the institutional assessment framework, established that clear safeguards are in place for the validity, reliability and variety of the tests. Also, transparency to students about content and format of tests is an issue dealt with in the assessment framework document. The panel observed that, at least in writing, the programme has all mechanisms in place to deliver a solid test and assessment system that definitely meets the current HBO standards. Also, the panel concludes that the Education and Examination Regulations of the Institute of Engineering comply with relevant legal requirements.

Safeguarding quality
In the audit the panel learned that in safeguarding the quality of assessments the Examination Board, the Assessment Committee and also the Professional Board play a pivotal role. Due to the relatively limited number of students and lecturers, and the in-depth specialist knowledge that is taught, the course has chosen to rigorously implement the four-eyes principle in the thesis process, but not always in the rest of the programme, which the panel approves.

Initially the test programme consisted of, mostly group, assignments for the modules, leaving individual assessment for a so called 'progress test'. The progress test was a written exam, which covered the core of all previously taught knowledge and theories. Students would take the exam four times a year (at the start of the programme, after 10, 20 and after 40 weeks). The scores of the exam indicated the level of knowledge students had acquired in the different domains, how much their level of knowledge had enhanced, which part of the knowledge base had been internalised and which deficiencies still had to be repaired. The final exam determined the overall end score of the student.
The concept of the progress test was considered effective at first, but never worked out as designed. Students did not feel that testing four times per year allowed them to gain insight in their level and it did not stimulate them to study more or better. Students, above all, experienced it as a study load enhancing mechanism, rather than a stimulus to study more or harder. For teachers the progress test meant a higher workload.

After three consecutive years, the progress test was abandoned as of cohort 2018 and the eight credits involved were transferred to the modules. The consequence of this step was that every module at end level needed to have an individual assessment, for which the faculty developed a rubrics template, covering the marking of all assessments. The rubrics template will be fully implemented for cohort 2019; the panel reviewed a draft version of the rubrics in the audit, and considers it elaborate and meaningful.

Still, only one written exam is left and, including a retake, students will sit for this at the end of the first period. All other modules are assessed and graded through different testing modes. For student transparency sake, the programme has outlined all of the test/assessment modes in its Student Manual; the panel, as a part of the audit, reviewed a sample of tests, usually written assignments, and considered them of an applicable quality for the Masters programme, both level and content wise. Among others, the panel looked into the assignments for the modules Applied Machine Learning and Adaptive Filtering. For each assignment a rubric specifies how the delivered work will be graded. The rubric descriptions tie in well with the module learning outcomes and requirements, thus ensuring a valid assessment. To students, the assignments and rubrics are made available on blackboard.

Examination Board
The School has an institutional Examination Board that covers all Master and Bachelor programmes. Commissioned by the central Examination Board there is a specific Chamber for the four Master programmes, which takes responsibility for both the executive tasks of a formal Examination Board, as well as the duties of a regular Assessment Committee. The Chamber took effect in 2016. It has three members with thorough understanding of all four engineering Master programmes. A side effect of the formation of the Master Chamber has been the alignment of the Teaching and Examination Regulations between the four Master programmes.

The Master Chamber reports to the chair of the School's Examination Board, who attends the meetings of the Chamber at regular intervals to assure alignment with overarching (WHW) policies. The Master Chamber has an annual plan for safe guarding assessment quality which, in the opinion of the panel, is firm, consistent and meaningful.

The Master Chamber features an external member as well. He is chair of the Examination Board of the Academy for Social Studies and from this position brings in experience with other master programmes. In recent years, the Master Chamber issued advice on assessment methods for the various Masters.
Furthermore, the Examination Board's Annual Report to the management shows that members of the Master Chamber took part in alignment sessions for end level work of the Master SSE.

It also indicates that the Examination Board has drawn up directions for assessors and examiners of Master programmes. Lecturers must at least have Masters level and are required to participate in current research within the SSE domain and as for the thesis they need to hold a PhD or PD-Eng. qualification or at least be a PhD candidate. Also, the panel established that the institutional Examination Board officially appoints assessors and examiners.

Assessment at end-level: graduation programme
The graduation programme incorporates a thesis, as outlined in the TER of the course, and the successful completion of the so-called Professionals Skills 2 module, through which the student demonstrates to have reached the intended professional level.

Student's thesis research project is conducted within the industry, at a research institute or within research programmes at a university department. The SSE thesis project must be sufficiently challenging, at the forefront of current scientific technological research and directly related to and applicable in the relevant domain, such as Health, Energy and High-Tech Systems and Materials (HTSM). The subject of the thesis is determined in consultation with, and approved by, the supervisor. By complying with the criteria, laid down in the Thesis Manual, the thesis builds on the knowledge and skills developed during student's choice of specialisation and, according to the panel, enabling the student to demonstrate mastery of the intended learning outcomes.

Students must justify actions and choices in the completion of the project. The assessment of the Thesis project involves (i) the research approach, (ii) quality of industry-standard products and/or services and (iii) students' individual development of competencies. Thus, knowledge, skills, and professional behaviour are integrally assessed during the thesis phase.

In its review of the assessment of graduates' work, the panel perceived an abundant number of assessment criteria, some of which were of an administrative nature and some overlapping or redundant. The elaborate number of assessment criteria may be risky as it could eventually result in a sufficient mark for a relatively meagre end product. The panel believes this calls for meticulous screening and reduction of the assessment criteria and the critical review of the set-up of the assessment form. Still the panel concluded that the overall marking was done transparent and precise, containing substantiated judgements with a great deal of alignment between the two assessors and the panel judgements (see Standard 4)

Considerations and judgement

The programme has designed a test and assessment scheme that basically safeguards the quality of tests and assessments; i.e. they are valid, reliable and transparent to the students. The quality assurance of tests and assessments is conducted in a proper manner, through an Examination Board at School level that commissions a Master Chamber to execute tasks aimed at the proactive and reactive safeguarding of the interim and final examinations.

Considering that the overall quality of the programme's assessment system meets the basic standards, but that the assessment form for the thesis assignment still needs a critical review, the panel judgement on Standard 3 reads **'satisfactory'**.

Update to 'Second Wave'

As in the updated programme the intended, and thus the achieved, learning outcomes required revising (refer to Standard 1), the graduation programme and the thesis assessment form had to be redefined and required adjustment as well.

Because explicit assessment of PLO's at end level takes place in some of the modules, the modules concerned required inclusion in the graduation programme. In a dedicated Appendix to its Self-evaluation the programme presented an overview of the revised PLO's, mapping them to the current educational modules as well as to the modules of the 90EC curriculum and the accompanying graduation programme. At the time of the audit, the programme is still to finalise the redesign of the thesis evaluation form that will fully match the revised PLO's to be assessed in the graduation programme and lend optimal transparency to students. The course, however, had already developed a standardised rubrics scale, functioning as a framework to be filled with module specific assessment criteria. The programme provided the panel with an overview of the graduation programme as foreseen in the 90 EC curriculum; the panel believes the redesigned graduation programme ties in well with the proposed revisions indicated under Standards 1 and 2.

At the introduction of the 90EC curriculum as of cohort 2019, the programme management intends to fully implement the four-eye principle. The panel members consider this a wise decision, considering that all (interim) exams of the graduation programme will then be assessed by at least two examiners. The panel would like to note that if the faculty is too small to deploy two examiners consistently, it might consider calling upon examiners from other universities of applied science, a system that by now quite a number of other UAS' have implemented as part of the QA cycle. The panel is pleased to learn that oral tests will be recorded, to ensure that – if so required – a four-eye judgment may be invoked afterwards.

Conclusion
The panel is of the opinion that the SSE programme has put in place the right measures to ensure that, within the updated 90 EC programme, the achievement of all of the intended learning outcomes will be rightly assessed through a graduation programme.

Update after additional site-visit
The panel concludes that all the learning outcomes of the updated 90 EC programme are rightly assessed. The students are well prepared for completing the Master Thesis at the end of the programme. The full implementation of the four-eye principle has been a good decision to secure the quality of the assessments of the students. The grading system for the master thesis is appropriate; there were no significant differences between the grades of the examiners and of the panel. A point of attention is the quality of the feedback students get; this ranges from non-existent or unclear to appropriate.

4.4. Achieved Learning Outcomes

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

Explanation*:* The level achieved is demonstrated by interim and final tests, graduation projects and the performance of graduates in actual practice or in further education.

Findings

As part of the audit process the panel reviewed all 11 thesis files that were available prior to the site visit. Six of them dated from the 2016-2017-graduation cohort, the other five graduated in 2017-2018.

Panel observations of the graduation level
Of all reviewed work the panel was generally in accord with the relevance of the subjects dealt with and the methodological rigour of the research, as well as with the marking and thus with the level obtained. In a few cases the panel would have marked the graduation projects slightly lower, but this never affected the caesura.

A question that particularly arose from the theses was whether the course is a true engineering Master and how it relates to its ambitions in the field of research, i.e. the balance between engineering and research. This issue was prominently discussed in the audit as most students appeared to use a sheer research format to approach an engineering-*design* problem.
The lecturers/members of the Examination Board with whom the panel spoke acknowledged this observation and expect this to change in the updated curriculum with a far less restrictive specialisation/graduation phase.

Another issue the panel would like to raise is the fact that students sometimes appear to obediently execute a client's wish. The panel would recommend to challenge students to reflect more on the issue to be solved and the possible directions for a solution. This recommendation also ties in nicely with the course's objective to further enhance students' high-level thinking.

Graduates' performance in the professional field
The alumni of the course are inclined to stay in The Netherlands, as some of them confirmed in the audit. Without exception, graduates have been able to rapidly find interesting positions in the professional field and are highly appreciated for their competences. Testimonials presented in the course Self-evaluation report clearly demonstrate that the course prepares students well for a position in the SSE industry.

Considerations and Judgement

All of the reviewed theses were considered up to the mark: they represent Master's level and reflect the intended learning outcomes of the course. Still, the chosen research approach was not always obvious to solve an engineering design problem. Also, students could be more critical in accepting and approaching their research assignments.

Considering all of these, the panel rates Standard 4 as **'satisfactory'**.

Update after additional site-visit
In the preparation phase before the additional site-visit the Panel read 4 Master Theses of graduate students who participated in the 90 EC programme. After reading these Theses the panel concludes that the students show the intended learning outcomes of the course. Also, the students are more reflective and show a more critical approach. The panel considered the Theses of a high level. Alumni reflected that the master programme provided them with enough content, tools and approaches to tackle new problems and issues.
The panel recommends to safeguard the very distinctive profile and added value of the Master, being totally dedicated to smart systems engineering, and not becoming a more general ICT or applied data science master.

Considering the focus on *smart* solutions – i.e. solutions for the successful implementation of technology – the panel recommends to broaden the scope in the Theses to all relevant aspects, such as legal, societal, economical, ethical (incl. privacy) and recommend to adjust the style of the Theses to prevent that the Theses become a thick book work.

5. OVERALL CONCLUSION

The panel reviewed a Masters course that was clearly in transition, without losing control. The present programme definitely delivers generic quality and meets all four standards.

In accordance with NVAO's accreditation assessment rules the overall judgement on the MSc programme Sensor System Engineering reads **'satisfactory'**.

The panel nominates the Master Sensor System Engineering for reaccreditation for another six years.

Update to second wave
The panel established that the course, across the board, presented valid arguments for updating its course title from *Master Sensor System Engineering* to *Master Smart System Engineering* as well as for the extension of the programme study load from 70 to 90 EC. Also, the programme satisfactorily worked out plans to align its intended learning outcomes, the curriculum design and the assessment system with the proposed change of title and the extension of the number of European credits.

Therefore, the panel recommended NVAO to give approval to the adjustments.

Update after additional site-visit
On the 4th of July 2019 the NVAO agreed with the change of the course title into Master Smart Systems Engineering.

After the additional site-visit the panel concludes that the extension of the programme to 90 EC has worked satisfactorily. The intended learning outcomes, the curriculum design, and the assessment system are well incorporated in the extended programme. Accordingly, students have more time and means to digest the curriculum, which was one of the main objectives. The panel read 4 Master Theses of the 90 EC and concludes that the students graduate on a high level.

Overall conclusion
In accordance with NVAO's accreditation assessment rules the overall judgement on the Master of Science programme Smart Systems Engineering reads **'satisfactory'**.

The panel nominates the Master Smart Systems Engineering for reaccreditation for another six years.

Upon agreement with the panel members the chair in The Hague adopted this report on June 1st, 2021.

6. RECOMMENDATIONS

The panel would like to make the following key-recommendations for the further development of the course.

- In the rapidly evolving domain of sensor technology the panel for the sake of knowledge management and benchmarking would consider it desirable to enhance the programme's network perspective, both nationally and internationally. This is the more at stake, when taking into account the international unique position of the Master. Both Hanze and other parties may benefit substantially from this networking. For this reason, too, the panel suggested under Standard 3 to engage in its assessment system assessors from other universities. Also, European consortia may pave the road to European funding, as is already the case with the European Master in Renewable Energy;
- Intensify the dissemination of research papers and research results, also by attending or organising conferences and seminars. Consider participating in Summer schools. Strengthen your visibility and positioning in the national and international field.

ANNEX I Overview of judgements

Overview of judgements on the Master Sensor System Engineering (fulltime) of the Hanze University of Applied Sciences	
Standard	**Judgements**
Standard 1. Intended Learning Outcomes	S
Standard 2. Teaching and Learning Environment	S
Standard 3. Assessment	S
Standard 4. Learning Outcomes Achieved	S
Overall judgement	**S**

ANNEX II Programme of site-visit and audit approach

Programme of site-visit

Date: Friday 8 February 2019
Location: Assen

Time	Subject	Discussion partners[1]
08.30	Welcome panel	
08.45 – 09.30	Positioning Master Sensor Systems Engineering	Executive board and management team and leading professor Biobased Economy: • Chair Executive Board Board • Dean, Institute of Engineering • Head of Education, Masters Engineering • Professor Knowledge Centre Biobased Economy
09.30 – 09.40	*Internal consultation panel*	
09.40 – 10.40	Discussion with **students**	• SSE student • SSE student • SSE student • SSE student • SSE student
10.40 – 10.50	*Internal consultation panel*	
10.50 – 11.50	Discussion with **lecturers** *Teaching curriculum and end level*	• Professor Sensor Technology and Smart Systems • Programme manager master SSE • and five Lecturers
11.50 – 12.00	*Internal consultation panel*	
12.00 – 12.45	Discussion **quality assurance**	• Member Programme Committee • Vice chair Programme Committee • Chair examination board • Member examination board • Examiner, lecturer • chair Master chamber
12.45 – 13.45	*Internal consultation panel, lunch and guided tour (13.15 – 13.45)*	• SSE student • SSE student • Dean, Institute of Engineering • Head of Education, Masters Engineering
13.45 – 14.30	Discussion with **professional field and alumni**	Professional field: • Business Developer, NOM • Programme Manager, Target Holding • Two Alumni
14.30 – 14.45	*Internal consultation panel*	
14.45 – 15.00	**Pending issues**	All

[1] For reasons of privacy no names the discussion partners are mentioned here. They are known to the panel secretary of course.

Time	Subject	Discussion partners[1]
15.00 – 16.00	*Internal consultation panel*	
16.00 – 16.30	**Feedback**	All
16.30	Closing of programme	

Programme Friday 16th of April 2021 – MS Teams

Time	Activity	Discussion partners
09.00 - 09.20	Welcome panel	Dean, Institute of Engineering Head of Education, Masters Engineering Programme manager Masters Engineering
09.25 - 10.10	Lectures/researchers/Professor	
10.15 - 10.30	*Internal consultation panel*	
10.35 - 11.20	Students and alumni	Alumni Students
11.25 – 12.15	*Internal consultation panel and lunch break*	
12.20 – 13.00	Possibility for pending issues Feedback	All participants

Auditing approach

Selection of the delegations / the auditees
In compliance with the NVAO regulations the audit panel prior to the audit decided on the composition of the delegations (auditees) in consultation with the course management and on the basis of the points of focus that had arisen from the panel's analysis of the course documents.

Auditing process
The following procedure was adopted. The panel studied the documents regarding the programme (Annex III: Review of documents) and a selection of theses. The panel secretary

organised input from the auditors and distributed the preliminary findings among the panel members prior to the audit. A preparatory meeting of the panel was part of the site-visit.

The panel formulated its preliminary considerations and judgements per standard immediately after the site-visit. These were based on the findings during the site visit, and building on the assessment of the programme documents.

A first version of the assessment report was drafted by the secretary and circulated among the members of the panel for review and comments. The final draft was subsequently forwarded to the programme management to correct factual inaccuracies. The panel finalised the report on 18 April, 2019.

Update after additional site-visit
On behalf of Hanzehogeschool Groningen the panel carried out an additional site-visit for the extension of the Master programme from 70EC to 90EC. A first version of the adjusted assessment report was drafted by the secretary and circulated among the members of the panel for review and comments. The final draft was subsequently forwarded to the programme management to correct factual inaccuracies. The panel finalised the report on June 1st, 2021.

Assessment rules
The assessment panel evaluates the programme against the standards of the applicable assessment framework using a four-point scale: unsatisfactory - satisfactory - good – excellent. For a positive final conclusion regarding the programme, each theme must at least be judged satisfactory.

The final outcome of the programme assessment will always be "unsatisfactory" if standards 1, 3 or 4 are judged "unsatisfactory". In case standard 1 is considered unsatisfactory, no improvement period will be assigned and the programme is forced to close down.

The final conclusion regarding a programme can only be "good" if at least two standards are judged "good", one of which must be standard 4.

The final conclusion regarding a programme can only be "excellent" if at least two standards are judged "excellent", one of which must be standard 4.

ANNEX III Review of documents

- Addition to The second wave, March 2021;
- Self-evaluation;
- Policy and strategy documents;
- Internal organisation, annual report Examination Board, minutes Student Programme Committee, minutes Academic Board and Professional Board, TER 2016-2017;
- Staff, overviews of employees, allocated staff, boards and committees, organisation chart of School of Engineering, staff resumes;
- Additional documents on change of title and extension of number of credits; several documents on education and research;
- Quality assurance plans and evaluations;
- Samples of assessments with corresponding assessment criteria and requirements (answer models) and a representative selection of actual tests administered
- representative selection of final projects, selected by the panel, of the past two years with corresponding assessment criteria and requirements;
- Reference books, booklists and other study materials;
- List of 15 graduation projects/papers examined prior to the audit;[2]
- Four Master Theses of the extended 90EC programme.

[2] For reasons of privacy no names of students and graduation projects selected are mentioned here; the reviewed selection of theses is known to the panel members and panel secretary only.

ANNEX IV Composition of the audit panel

Name	Role	Capabilites						
		Discipline	Education	Assessment	International	Prof. field	Auditing & QA	Student-related
Ir. A.T. (Fred) de Bruijn	Chair			X			X	
Prof. dr. C.R. (Cees) Ronda	Expert member	X	X	X	X	X	X	
A.J. (Aart-Jan) de Graaf, PhD	Expert member	X	X	(X)	X	X		
M. (Martijn) Hoep	Student member							X
H.R. (Rob) van der Made	Secretary							
J.D. (Bob) Schakenbos	Secretary							

Succinct CVs of panel members

Ir. A.T. (Fred) de Bruijn	Mr. De Bruijn has chaired numerous accreditation audits in Higher Education.
Prof. dr. C.R. (Cees) Ronda	Mr. Ronda is professor at Zhejiang University (Hangzhou, China) in the field of Electromagnetism. He is scientific advisor to the Technical University Eindhoven, where he also gives lectures; also he is a researcher at Philips Research in the field of Sensorization and is heading the Center of Excellence Sensorization of Philips. Earlier in his career, professor Ronda contributed to the development of improved and new luminescent materials for lamps, medical equipment and LEDs.
A.J. (Aart-Jan) de Graaf, PhD	Mr. De Graaf is lector control systems engineering at the University of Applied Science in Arnhem and Nijmegen (HAN). He currently leads two research groups: control systems engineering; sustainable energy. He has been chair of the master engineering systems, currently incorporated in the school of engineering and automotive of the HAN where he takes a position in the management team as leading lector. He conducted Art in Control, a business in consultancy, design and prototyping of control systems.
M. (Martijn) Hoep	Mr. Hoep successfully followed (finished 2020) the Master Automotive Systems at the University of Applied Science of Arnhem and Nijmegen (HAN).

On 20 November 2018 the NVAO endorsed the composition of the panel to assess the Master Sensor System Engineering of the Hanze University of Applied Sciences Groningen, registration 007589.

Prior to the audit all panel members undersigned declarations of independence and confidentiality which are in possession of the NVAO. This declaration certifies, among other things, that panel members do not currently maintain or have not maintained for the last five years any (family) connections or ties of a personal nature or as a researcher/teacher, professional or consultant with the institution in question, which could affect a fully independent judgement regarding the quality of the programme in either a positive or negative sense.

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