Netherlands Quality Agency
NQA

Hogeschool van Arnhem en Nijmegen

Hogeschool Arnhem en Nijmegen

Control Systems Engineering

Limited Study Programme Assessment

June 2014

Introduction

This is the assessment report of the master of Control Systems Engineering degree programme offered by Hogeschool van Arnhem en Nijmegen. The assessment was conducted by an audit panel compiled by NQA commissioned by Hogeschool van Arnhem en Nijmegen. The panel has been compiled in consultation with the study programme and has been approved prior to the assessment process by NVAO.
In this report Netherlands Quality Agency (NQA) gives account of its findings, considerations and conclusions. The assessment was undertaken according to the *Assessment frameworks for the higher education system* of NVAO (22 November 2011) and the *NQA Protocol 2014 for limited programme assessment*.

The site visit took place on 15 and 16 April 2014.
The audit panel consisted of:
Mr prof. dr. ir. P.P.J. van den Bosch (chairperson, representative profession/discipline)
Mr dr. ir. M.E.C. Mutsaers (representative profession/discipline)
Mr ir. P.A. Janssen (representative profession/discipline)
Mr J.G.S. van Uden (student member)

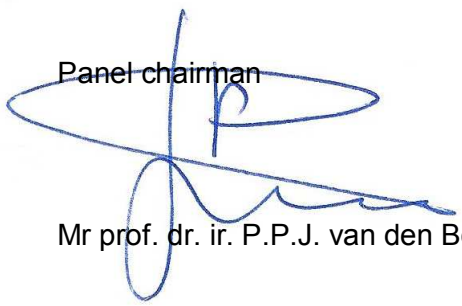
Mr P. van Achteren BLL, NQA-auditor, acted as secretary of the panel.

The study programme offered a critical reflection; form and content according to the requirements of the appropriate NVAO assessment framework and according to the requirements of the *NQA Protocol 2014*.
The panel studied the critical reflection and visited the study programme.
Critical reflection and all other (oral and written) information have enabled the panel to reach a deliberate judgement.

The panel declares the assessment of the study programme was carried out independently.

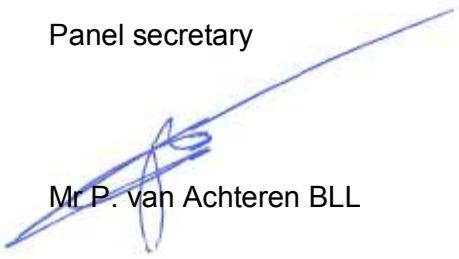
Utrecht, June 18th 2014

Panel chairman



Mr prof. dr. ir. P.P.J. van den Bosch

Panel secretary



Mr P. van Achteren BLL

Summary

The professional master Control Systems Engineering focuses on the application of control theory. The panel judged the 'intended learning outcomes', the 'teaching-learning environment' and the 'assessment and achieved learning outcomes' as good. Consistent with the regulations of the NVAO the panel assesses the quality of the hbo-master study programme Control Systems Engineering of Hogeschool Arnhem en Nijmegen as **good**.

Standard 1 Intended learning outcomes
The CSE programme derives its specific qualifications from a model of the essence of measurement and control engineering: the design-bow. Combined with seven generic engineering qualifications this results in a set of twelve qualifications. The set of qualifications have been discussed, verified and approved by the programme's Advisory Board. In the opinion of the panel, the set of qualifications is well suited to a professional master CSE regarding level and content. The panel specially applauds the explicit integration of the design-bow in the qualifications.

From an international point of view the professional orientation of the master CSE is a relatively unique feature. According to the panel, a key element of this unique feature is that CSE strives to enable students to understand and apply results of scientific research to solve issues in the field of control. The panel assesses standard 1 as ***good***.

Standard 2 Teaching-learning environment
The panel is convinced that the learning environment is coherent and challenging to students. The panel wants to emphasize that it was impressed by the positive feedback from stakeholders, among others, students, graduates and the industrial field, concerning the quality of the programme. This is consistent with the impression formed by the panel based on all inspected material and documents.

The CSE study programme is consistent with its exit qualifications. The content complies with the standards of a professional master's degree and is relevant to the industrial field. Initially CSE focuses on knowledge transfer and subsequently on the practical application thereof. This is adequately translated into working methods. The use of feedback from external (industry) experts to keep the curriculum up-to-date is applauded by the panel. It contributes greatly to how the study programme meets the demands of the professional field.

CSE has a clear view of the nature of its student population. This knowledge is used to regulate the content and structure of the curriculum. The panel has seen proof of this in the admittance procedure and in the system of student supervision. In the opinion of the panel these examples are exemplary for CSE's methodical approach. Moreover, the panel is positive about the quality of the staff and the facilities. The expertise required to execute the CSE programme is evident in the staff qualifications.

The few minor remarks by the panel, regarding the number of specializations and student self-dependence, do not alter the fact that the CSE educational learning environment makes it possible for students to realize the intended learning outcomes.The panel assesses standard 2 as ***good***.

Standard 3 Assessment and achieved learning outcomes
The panel is pleased with the system of assessments. CSE has a variety of measures to ensure the quality of assessments. There is a focus on validity, reliability, transparency and feedback. For example, this means that always two assessors are involved in the process of evaluation. The assessments represent the level and content of the programme. CSE offers a variety of assessments, which are suited to gauging the objectives of the course. In the event of an assessment where students have the opportunity to use non-original content (for example: take home exams), the panel is pleased to note that a second assessment is used. Critical remarks by the panel regard the involvement of the Central Exam Board and the quality of feedback given.

Next to the system of assessment, the panel has also studied in how far the intended learning outcomes are accomplished. The panel is impressed by the major projects it studied. The reports are clearly representative of the professional master degree level and the panel is pleased to see the elements of the design-bow in the projects. The projects show the capability of the students to find, analyze and apply relevant theory, sometimes even in specialized areas of expertise that are not covered in the curriculum. There are two points for improvement the panel would like to raise. These regard the conclusion of the major projects and the use of the references. The panel has taken into consideration the positive feedback of students, graduates and professionals from the industrial sector in its evaluation of this standard.Together with the positive appraisal of the assessment system the panel asssess standard 3 as ***good***.

Contents

1 Basic data of the study programme

Administrative data of the study programme

1. Name study programme as in CROHO	Control Systems Engineering
2. Registration number in CROHO	70148
3. Orientation and level study programme	hbo; master
4. Number of study credits	90
5. Variants	fulltime & parttime
6. Location	Arnhem
7. Previous year of audit visit and date decision NVAO	Previous visit: 2008 Decision NVAO: 5 October 2009
8. Code of conduct	Yes

*) Associate Degree, if applicable

Administratieve institutional data

9. Name institute	Hogeschool Arnhem en Nijmegen
10. Status institute	Unfunded
11. Result institute audit	Positive

Quantitative data regarding the study programme

Tabel 1: Masterrendement

Cohort		2009	2010	2011
Rendement	Voltijd	75%	100%	69%
	Deeltijd	29%	44%	29%

Tabel 2: Docentkwaliteit

Graad	MA	PhD
Percentage	100%	43%

The data regarding student-teacher ratio and contact hours are in annex 8.

2 Assessment

The panel describes the findings, considerations and conclusions of each standard of the NVAO assessment framework. The final judgement concerning the study programme will be presented in chapter 3.

Standard 1 Intended learning outcomes

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

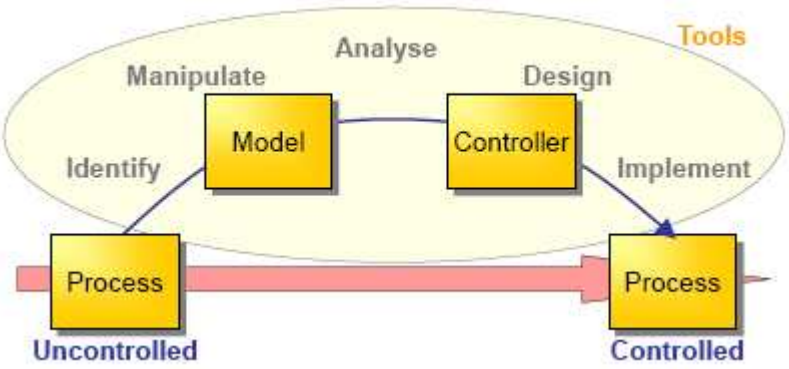
Findings

Control systems are part of everyday life. Some applications are recognized immediately; others are inherently present in an application in the background. Control systems are used in the field of the mechatronics and the process industry, such as a robotic applications in automation or combined control systems to monitor temperature, pressure and volume in a chemical process. The design and implementation of advanced control systems is the goal of a professional master of Engineering in Control Systems (CSE): applying scientific principles to make systems work as required. The programme focuses on enabling students to apply existing control theory to an industrial application.

The CSE programme derives its specific qualifications from a model of the essence of measurement and control engineering: the design-bow. Combined with seven generic engineering qualifications this results in a set of twelve qualifications (see annex 1). To assure the validity of the professional profile reflected by the qualifications, the Program Management consults independent experts, visits relevant companies and connects with other institutes in the field like the Royal Institute for Engineers in the Netherlands, KIVI NIRIA, section MRBT, and the ISPT TOP Technology Sectors discussion group Process System Engineering and Process Control. The qualifications have been aligned with the Dublin descriptors to ensure they carry master level status. Details are given in the summary 'Relation between Dublin descriptors and qualifications'. Furthermore, the set of qualifications have been discussed, verified and approved by the programme's Advisory Board. In the opinion of the panel, the set of qualifications is well suited to a professional master CSE regarding level and content. The panel specially applauds the explicit integration of the design-bow in the qualifications.

The design-bow the study programme uses is a model representing the fundamentals of measurement and control engineering. The design bow indicates the steps needed to convert an uncontrolled/insufficiently controlled process, via identification, modelling, model manipulation, analysis, controller design and finally controller implementation, into a controlled process, including the tools needed tot realize these steps like mathematics, software engineering and research skills.

The design-bow summarizes the tasks of a control system engineer. It relates directly to the specific qualifications (1.1 – 1.5). The design bow as model of measurement and control theory is shown in the figure below:



From an international point of view the professional orientation of the master of Control Systems Engineering is a relatively unique feature. Some Dutch and foreign universities include courses on systems and control in programmes like a master of science in electrical engineering or a master of science in mechanical engineering. In the Netherlands, scientific education in control systems at a master degree level is only offered by a few technical universities. HBO-institutes do not offer a comparable professional masterdegree programme. Some polytechnics provide post-graduate courses, including an introduction to control systems engineering, but these are not comparable in either scope or level. The panel agrees that the professional orientation of the CSE is unique and that this should be highly rated. According to the panel, a key element of this unique feature is that CSE strives to enable students to understand and apply the results of scientific research to solve issues in the field of control.

Considerations and conclusion
The panel is convinced that CSE has involved relevant profiles and parties in the development of their set of qualifications. The implementation of the design-bow in the qualifications is greatly appreciated by the panel, due to the clear definition of the development of a controlled process. Furthermore the panel has read and heard that the professional field/ the industry can influence the set of qualifications. For example, the Advisory Board has verified the qualifications. The panel notes that these mechanisms strengthen the set of qualifications regarding level and content and assure the relevancy for the industry.

The panel states that the professional orientation of master CSE is a relatively unique feature. The ambition to develop the ability of students to understand and apply the results of scientific research in industry helps class CSE as a true professional master. Based on these considerations the panel comes to the judgement ***good***.

Standard 2 Teaching-learning environment

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

Findings

Content of the curriculum

The programme consists of lectures (theory), labs, minor projects and a major project as proof of competence (see annex 2). The content of these courses is derived from the qualifications. The course descriptions show how each individual course relates to the qualifications. An overview is presented by CSE in the *Degree Statue for the HAN Master of Control Systems Engineering* (september 2013). The panel has studied this overview and states that the content of the courses corresponds satisfactorily with the qualifications. This connection was also clear in the course descriptions, which also showed further elaboration in terms of objectives and content.

Regarding the qualifications, the main components of the CSE curriculum cover:

- Identification: theoretical modelling, energy/mass balance, model validation, model estimators, ARMA/ARMAX, Kalman filters, non-linear behaviour;
- Dynamic model: transfer functions, state space, FIR, MIMO, model transformations, model reduction, linearization, covering delays, simulation models, prediction models;
- Control theory: classical control, pole placement and root locus techniques, optimal control, cost functions, model predictive control, non-linear control, phase plane and bang-bang theory, anti-windup, robust control, H2/H-norm based design, adaptive control, model reference control, fuzzy control;
- Implementation: Sensors and actuators, servo motors, control valves, PLC, SCADA, real-time PC or embedded targets;
- Tools: research skills (scientific literature search, patent research, report writing, presentation), mathematics (vector algebra, differential equations, frequency behaviour, matrix calculus and singular value decomposition, Laplace and z-transform, homogeneous transformations), and software (Matlab/Simulink, LabVIEW, Ipcos).

Part of the curriculum consists of a selection programme. The student can choose one of the following two programmes, which are made up of theoretical courses and a minor project:

- Mechatronics: vision and motion, servo control;
- Process Industry: industry batch control, ISA S88/S95.

Till recently a third option was offered: Paper Industry in cooperation with the Dutch Association for the Paper Industry, VAPA. However in 2014 this specialization will be replaced by Energy Management. This specialization will address the conversion of the fossil fuel-based electrical infrastructure into a sustainable and reliable infrastructure for producing electrical power. Energy is also a focus point of HAN's policy.

Based on a discussion held with the CSE management, the panel thinks that implementing this new specialization has a proper connection to this focus point. Furthermore, the panel appreciates how this theme connects with the regional industry. CSE has developed this specialization in close cooperation with relevant regional Energy partners. A minor remark of the panel concerns the number of specializations. The more specializations a programme has to manage, the bigger the risk of loss in quality.

Textbooks, readers, manuals and software serve as educational aids. A summary is given in the *Literature List Master of Control Systems Engineering 2013-2014*. The English textbooks are internationally acknowledged. Some courses have readers as reference aids. For example the course 'Non-Linear Control'. The Labs and minor project use manuals. According to the panel, the programme's theoretical component is well-founded in keeping with a professional master degree. The lab- and minor projects allow students to deepen their knowledge and skills in specific subjects. This became clear to the panel through their inspection of student material (e.g. poster presentations) on subjects like A.I.R. (Autonomous Inspection Robot), vision based object tracking with AR-drone and servo sound (optimize low-frequency response of a loudspeaker by feedback-control). The content and level of knowledge and skills is adequate for a professional master degree.

In 2010, the HAN voiced its ambitions to become a University of Applied Science. A number of study programmes offered by the HAN, like CSE, already fulfilled this ambition. The document *Policy on applied research* (2011) explains how applied research is used in the CSE programme. The course 'Research skills' teaches students how to look for relevant scientific literature, how to value and judge this scientific information and how to communicate technical results obtained through research. In the minor projects, students have to combine a number of research skills, like searching appropriate specialist literature, applying control theory in new application areas, and presenting their results at a mini-symposium by means of an oral presentation, a poster presentation and a dialogue session. CSE focuses on applied research to solve control system issues in the industry. The panel thinks that the content of the curriculum with regard to applied research is an adequate reflection of the ambition. The programme has sufficient attention for adequate use of scientific research. Furthermore, the panel notes that the design-bow (see standard 1) is well integrated in the curriculum. The remarks of the panel regarding the major projects (see standard 3) can be used for further development of this course.

Interviews with students and alumni showed the panel that they are pleased with the content of the curriculum. Although the panel found it difficult to gain a detailed insight in the weekly study content (for example: sections in textbooks, parts of readers, additional literature), students declared this to be very clear. The lecturer gives a list of subjects and literature to be studied for each lecture. Student satisfaction regarding content of the curriculum is also shown in the results of the evaluation cycle.

Structure of the curriculum

Didactic concept and methods

The structure of the curriculum is adjusted to suit the student population. This population roughly exists of Dutch part-time students with a technical profession related to control systems and foreign students in the possession of a bachelor's degree in a relevant technical domain. The students are generally mature, motivated, self-reliant and committed to finish the programme. This allows the CSE to focus on optimizing knowledge transfer and effecting learning competences/qualifications. This is in line with the policy of the HAN Master Programmes (HMP) and of the HAN Faculty of Technology.

As a small programme, in terms of students and staff, CSE has a basic didactic approach. This results in limited types of courses, assessment methods and didactic practices. Theory courses are the core of CSE, in line with its focus on knowledge transfer. The courses are underpinned by theory lectures. Practical application of theory occurs in the laboratories (labs), in small student teams (2 or 3 students) and in minor projects (3 or 4 students). Laboratory work and minor projects are backed-up by textbooks, papers, hardware, models and data. The didactic approach shifts progressively from task-driven to self-dependent learning. This is evident in the structure of the CSE programme which shifts from classical education in the initial theory courses to more self-dependent projects in the laboratories and minor projects, and the individual major project to conclude the study programme. The panel is of the opinion that the work methods are in line with the objectives of the courses. There is a clear distinction between methods focussed on knowledge transfer and methods that focus on practical application. During interviews, students made clear to the panel that they appreciate the diversity and types of courses.

Student supervision

Supervision begins before students are actually admitted to the CSE study programme. Only students with a relevant technical bachelor's degree, such as Automotive, Chemical Engineering, Embedded Systems Engineering, Electrical Engineering, Mechanical Engineering and Physics, are admitted. The qualifications of prospective international students are specially scrutinized. When uncertainties arise, the Program Management will base the admittance of an applicant on the course descriptions of his/her bachelor degree. The panel observes that CSE uses the experience it has gained in past years in this process. CSE has noticed that regarding mathematics, students differ in their level and specialiasation. Therefore, CSE offers a preliminary course that offers a selection of mathematics relating to control systems engineering. Results of this course can influence whether or not an applicant is judged to be suitable for admittance to the study programme. Furthermore, because the programme is taught in English, a sufficient command of the language is required. For foreign students, CSE demands an international recognized level of English, reflected in a TOEFL score of 550 or more.
In the opinion of the panel, the admittance procedure is well worked out. The degrees an applicant must possess are relevant and there is sufficient attention in the admittance procedure for the qualifications and background of the applicant.

The study programme's supervision system is tuned to its student population, who are largely self-reliant. When issues arise, students are encouraged to first contact their lecturer. When student and lecturer are unable to solve the issue adequately, either one of them should contact the Program Management. A third option is to contact student support, whose contact details are available on the HAN website and in the degree statue. This system of supervision is explained to students during the introduction.
Nevertheless, especially during the first term of the initial year, the Program Management closely observes the progress and well-being of all students. If necessary a student will be invited for a talk. The attendance list used in every course and feedback from lecturers are means to monitor the study efforts and progress of the students.

In interviews with students and lecturers the panel also discussed the didactic approach (from task-driven to self-dependent learning) in relation to student supervision. Due to the small scale of CSE (in terms of number of students) an informal setting can be maintained. Close connections between lecturers and students make it easy for students to make a continuous appeal on the expertise of the lecturers. In general the panel appreciates this. On the other hand, too much supervision can go against the self-dependency expected of a professional master student. The panel would like to point this out to stimulate CSE to discuss this contradiction.

Different learning paths
The CSE programme offers both full-time (1,5 years) and part-time (2,5-3 years) courses. The content of both learning paths is identical; students follow the same lectures. Part-time students follow the first and second year sequentially; full-time students follow the first and second year concurrently. In the interviews with students the panel addressed the subject of feasibility. It became clear that the experiences of the feasibility differs, but always explicable. Backgrounds of the students, degrees and professional experience cause these differences. All students agree that the feasibility of the study is within an accepted limits and fulfills their expectations.

A specific topic the panel discussed with the Program Management was their policy on exemptions. In the Critical Reflection, CSE wrote that no exemptions were permitted. However, the *Degree Statue* describes an exemption policy. The Program Management told the panel that formally exemptions are possible, but that in practice this is discouraged. In the past five years no students has applied for a exemption. This was confirmed by the Exam Committee chairman.

Staff quality
The CSE programme has no lecturers on its pay roll. All lecturers are contracted externally from the industrial sector or universities, or internally from research groups or bachelor programmes within the HAN. This construction allows CSE to select lecturers solely on the strenght of their expertise. To select suitable lecturers, a profile has been drawn up listing necessary job requirements. In addition to specialist expertise on the relevant subject, the lecturers should be able to teach in English. A degree or a valid C.V. that can affirm this is requested. CSE specifically demands that the lecturers have a master's degree. All fourteen CSE lecturers have a master's degree, six also hold a PhD title.

A consequence of hiring lecturers, is that the study programme can only exert a limited influence on the different staff policies that hold for the individual lecturers. The CSE staff policy can be considered 'service-based' instead of 'procedure-based'. This means that CSE focuses on adapting to the needs and interests of individual lecturers. For example, the panel has seen in documents that CSE supports the master education of a lecturer.

After having studied the resumés and spoken with several lecturers, the panel wants to emphasise that it has confidence in their expertise, ability and commitment. The lecturers' backgrounds, both in education and professional experience, ensure they have the necessary expertise to execute the curriculum. The panel finds the lecturers motivated and very committed. This is shown, for example, in their availability. The students are also very positive about the lecturers. In interviews, students list expertise, ability to relate to the professional field and motivational attitude, as being the lecturers' strongest qualities. This is also shown in results of evaluations.

Quality of study programme-specific facilities
The panel has inspected the study programme facilities and confirms that these are adequate for the education offered. Specific facilities for CSE are provided, such as laboratory setups. Another example is the supporting software needed for studying control system engineering. Time is specially reserved for correct installation of the advanced software. Although the panel is satisfied with the facilities, it does have a minor remark to make regarding the ability to perform other experiments as a default setting in the laboratory.

Guarantee of the quality of the educational learning environment
A system for quality assurance, consisting of different evaluations, is used by CSE to maintain the quality of the curriculum, staff and facilities. Each term, for example, all students complete a questionnaire about every separate course. The quality related activities and tasks of day-to-day operations are reported in the minutes of the regular Program Management meetings. The panel has seen (in minutes) and heard (in interviews) that there is an active system of quality assurance. CSE not only involves students in this process, the industrial field, lecturers and graduates are also asked to give their opinion. Findings by the panel show that CSE acts on the feedback it receives. A current example is the status of the course Fuzzy Control in the curriculum. Based on feedback given by the Advisory Board, CSE is considering replacement. The panel appreciates the use of feedback given by external experts to keep the curriculum up-to-date.

All the interviews with stakeholders made it clear to the panel that CSE has a proper system of quality assurance, tuned to the scale of the programme.

Results of evaluations show a high degree of satisfaction with the CSE programme. From 2011 through 2013, CSE was awarded with the highest score in the 'Keuzegids Masters'. In 2013, CSE scored 92, along with the Nano Science Department of the University of Groningen; the highest score of all technical master study programmes in The Netherlands.

Considerations and conclusion
The panel is convinced that the learning environment is coherent and challenging to students. The panel wants to emphasize that it was impressed by the positive feedback from stakeholders, among others, students, graduates and the industrial field, concerning the quality of the programme. This is consistent with the impression formed by the panel based on all inspected material and documents.

The CSE study programme is consistent with its (exit)qualifications. The content complies with the standards of a professional master's degree and is relevant to the industrial field. Initially CSE focuses on knowledge transfer and subsequently on the practical application thereof. This is adequately translated into working methods. The use of feedback from external (industry) experts to keep the curriculum up-to-date is applauded by the panel. It contributes greatly to how the study programme meets the demands of the professional field.

CSE has a clear view of the nature of its student population. This knowledge is used to regulate the content and structure of the curriculum. The panel has seen proof of this in the admittance procedure and in the system of student supervision. In the opinion of the panel these examples are exemplary for CSE's methodical approach. Moreover, the panel is positive about the quality of the staff and the facilities. The expertise required to execute the CSE programme is evident in the staff qualifications.

The few minor critical remarks by the panel, regarding the number of specializations and student self-dependency, do not alter the fact that the CSE educational learning environment makes it possible for students to realize the intended learning outcomes.

Based on the above mentioned considerations the panel comes to the judgement ***good.***

Standard 3 Assessment and achieved learning outcomes

The programme has an adequate assessment system in place and demonstrates that the intended learning outcomes are achieved.

Findings

Assessment system

The policy for assessments is derived from the documents 'Unity through diversity' (HAN, 2009) and 'Kaderstellend Toetsbeleid Masteropleidingen HAN' (HMP, 2012). Principles from these documents are also included in the CSE document 'Assessment: Why and How' (HAN, 2013). This policy document describes elements like validity, reliability, transparency and feedback that are essential to uphold the quality of assessments.

To assess all objectives derived from the intended learning outcomes (the qualifications) CSE makes use of five types of assessments: written exams, oral exams, take home exams, presentations and reports. The panel studied the properties of the assessments and inspected a selection of finished assessments. The panel has ascertained that the types of assessments are suitable for gauging if the intended objectives have been achieved. The panel is satisfied with the level of the assessments. Specific attention was devoted to the take home exams. In a discussion with lecturers, it became clear to the panel that take home assessments are used when time-consuming assignments are required, like extensive data-analysis or assignments that require (data) manipulation. The take home assessments are always combined with a report or an oral exam. The panel is pleased with this method because it ensures the individual achievement of students. In the opinion of the panel, another strong aspect of the assessment system is the involvement of multiple assessors to bolster its reliability. For oral exams and presentations, at least two assessors are present at the assessment itself. The students interviewed by the panel, confirmed this. At random a second assessor is involved at the other assessments. Students generally see the process of assessments as being fair, to-the-point and clear. This is reflected in the course evaluations and supported by NSE results.

The panel is critical about feedback offered by CSE on the work of students. According to the panel this can be improved. The marks given are generally in line with the expectations of the panel, and are linked to the qualifications. This said, the panel nonetheless recommends that CSE expands the level of written feedback by motivating the grades.

Exam Board

The exam board establishes whether a student meets the conditions specified in the Education and Examination Regulations (for CSE: Degree Statute) with regard to the knowledge, insight and skills needed to obtain a professional master's degree. Since the establishment of the HMP, one Exam Board for all technology related master programmes has been appointed.

This Central Exam Board, for instance, is responsible for implementing HAN policy relating to assessments, defining the outline of such assessments, monitoring the quality of assessments within each individual technical master study programme and the appointment of assessors/examiners. To support the Central Exam Board, a board of delegates has been appointed. This board consists of a group of staff members that evaluate assessments and, major project proposals leading to a go/no-go decision and evaluate the concept major projects deciding whether or not a student is sufficiently prepared to defend his master degree thesis before the Major Project Committee. The panel states that the Exam Board is aware of its responsibilities and perfoms in line with these. Due to the delegation of certain tasks, the panel was under the impression that the distance between the Exam Board and the actual study programme was a risk. This was discussed during the audit visit. The panel concludes that the current system provides just enough guarentees to assure the quality of the programme. A further in-depth investigation of the formal Central Exam Board as to the actual realization of the intended learning outcomes is desirable to strengthen quality assurance. The panel would like to suggest that the Central Exam Board inspects samples of graduates' major projects.

Realisation of the intended learning outcomes

The CSE study programme is concluded with a major project. This project validates the professional master level of the individual student. It is conducted at a professional company or a research group. The students are expected to analyze, model and simulate processes to be controlled. They must look for prior relevant articles in (scientific) literature and judge their findings using a helicopter view and up-to-date knowledge while applying general and/or fundamental theory on a given process enabling it to be controlled. To make sure student projects are suitable, approval is needed for a major project proposal, which on completion is is assessed (70%) by the Major Project Committee. The evaluation forms show the panel that the points for assessment include: attitude and organization, method of execution, intellectual quality and written presentation. In the presentation and defence (30%), an assessor/examiner and an external assessor make an in-depth assessments of the objectives and autonomy of the student. Graduates describe this assessment as demanding. They are cross-examined on their knowledge of the specific topic and how they justify the choices made (for example: methods) during the project.

The panel studied the major projects (and other materials) of nineteen graduates (see annex 6). The panel concludes that students clearly graduated in accordance with the standards of the CSE professional master level. There is clear distinction with the bachelor level. In their major project students they have attained the intended qualifications. Although not every project contains all components of the design-bow, the panel has seen that relevant elements of the design-bow have explicitly been employed. In the opinion of the panel, a few projects had potential for a further use of the design-bow (for example the elements: specification & design). The projects show that students are capable of finding, analysing and applying relevant theory, sometimes even in specific areas of expertise that are not covered in the curriculum. Moreover, the panel appreciates the reporting skills of the students. The reports are well structured and offer a clear insight in the research process.

There are two points for improvement the panel would like to raise: A small number of projects lacked a precisely formulated conclusion. More attention should be paid to this. The other point regards the use of references. In the appendix of every project a list of references was given. When studying the reports, the use of these references was not always clear to the panel. The panel suggests that supervisors should focus particularly on remedying this in the future.

Graduates are well equipped to enter the professional field or function at a higher level than they did before completing the programme. This was clearly voiced in interviews with them. This opinion is seconded by graduates, experts from the industrial sector, among them a long-serving external assessor and borne out by the minutes of Advisory Board meeting.

Considerations and conclusion
The panel is pleased with the system of assessments. CSE has a variety of measures to ensure the quality of assessments. There is a focus on validity, reliability, transparency and feedback. For example, this means that always two assessors are involved in the process of evaluation. The assessments represent the level and content of the programme. CSE offers a variety of assessments, which are suited to gauging the objectives of the courses. In the event of an assessment where students have the opportunity to use non-original content (for example: take home exams), the panel is pleased to note that a subsequent second assessment is used. Critical remarks by the panel regard the involvement of the Central Exam Board and the quality of feedback given.

Next to the system of assessment, the panel has also studied in how far the intended learning outcomes are accomplished. The panel is impressed by the major projects it studied. The reports are clearly representative of the professional master degree level and the panel is pleased to see the elements of the design-bow in the projects. The projects show the capability of the students to find, analyze and apply relevant theory, sometimes even in specialized areas of expertise that are not covered in the curriculum. The panel has taken into consideration the positive feedback of students, graduates and professionals from the industrial sector, in its evaluation of this standard. Together with a positive appraisal of the assessment system, the panel asesses this standard as ***good***.

3 Final judgement of the study programme

Assessments of the standards

The audit team comes to the following judgements with regard to the standards:

Standard	Assessment
1 Intended learning outcomes	Good (fulltime & parttime)
2 Teaching-learning environment	Good (fulltime & parttime)
3 Assessment and achieved learning outcomes	Good (fulltime & parttime)

Conclusion
The panel judged the Intended learning outcomes, the teaching-learning environment and the Assessment and achieved learning outcomes as good. Consistent with the regulations of the NVAO the panel assesses the quality of the hbo-master study programme Control Systems Engineering of Hogeschool Arnhem en Nijmegen as **good**.

4 Recommendations

Standard 2

- The panel recommends that CSE adressess the contradiction between a student's need for supervision and the large degree of self-sufficiency also expected of him/her.

Standard 3

- The panel suggests that CSE improves the quality of the written feedback with regard to the assessments.
- The panel recommends that CSE encourages the Central Exam Board to obtain a better in-depth view of the actual realization of the intended learning outcomes. The panel suggests that the Central Exam Board inspects samples of graduates' major projects
- The panel also recommends that CSE makes a priority of including (references to) specification & design (elements of the design-bow) in the major project.

5 Annexes

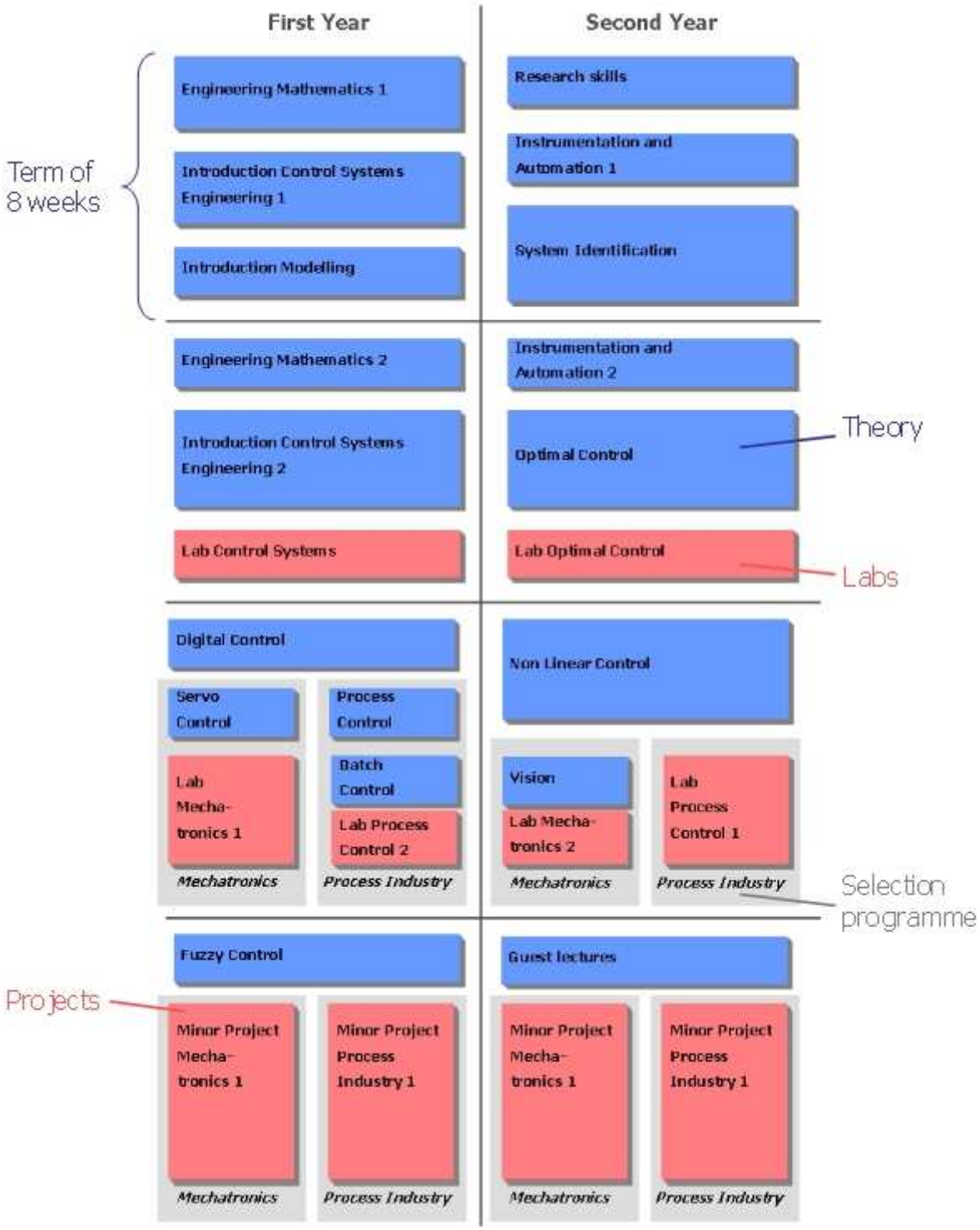
Annex 1: Final qualifications of the study programme

The programme has grouped the qualifications into a specific and generic set of qualifications. The specific qualifications have been established by the staff of the master programme and are directly derived from the design curve as generally recognized by control systems professionals. The generic qualifications are based on general qualifications of a Master (level: Dublin Descriptors) and are applicable to the Master of Engineering in Control Systems.

1. The *specific* qualifications are:
   1.1. Be able to analyse complex dynamic systems.
   1.2. Be able to model and simulate both linear and nonlinear process behaviour.
   1.3. Be able to specify the desired functionality of the control system to be designed.
   1.4. Be able to design a control strategy using modern control techniques.
   1.5. Be able to implement advanced control strategies.

2. The *generic master* qualifications are:
   2.1. Search, judge and report on scientific literature, internet resources and patents systematically.
   2.2. Act as a professional within new or unknown circumstances.
   2.3. Think and work creatively beyond the boundaries of the personal profession.
   2.4. Be able to work in an international, multidisciplinary and/or multicultural project environment.
   2.5. Apply results from scientific research.
   2.6. Be able to keep one's professional expertise up to date, to expand and to propagate it.
   2.7. Judge new developments in the field of control systems engineering, based on overview.

Annex 2: Survey study programme



Annex 3: Expertise members auditpanel and secretary

Additional information concerning panel members and secretary:

Mr prof. dr. ir. P.P.J. van den Bosch, chairman
Mr Van den Bosch has primarily been asked in the panel because of his professional area of expertise in the domain of electro technology and control systems engineering. Mr Van den Bosch is professor of Control Systems at the University of Technology in Eindhoven and has written many publications. He has many contacts with foreign colleagues through shared editorships and EU-projects. Mr Van den Bosch received our manual for panel members and has been briefed individually on the audit visit process, accreditation in higher education and NQA's working method.

Education:

1965	Electro Technology - University of Technology Eindhoven
1960	HBS-B

Work Experience:

1993 – present	Professor Control Systems - University of Technology Eindhoven
1988 – 1993	Professor Control Engineering - University of Technology Delft
1972 – 1988	Scientific employee - University of Technology Delft

Publications 2011-2013 (more on request):

- Ezzeldin Mahdy Abdelmonem, M., Bosch, P.P.J. van den & Weiland, S. (2013). Experimental-based feedforward control for a DoD inkjet printhead. Control Engineering Practice, 21(7), 940-952.
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Mr dr.ir. M.E.C. Mutsaers

Mr Mutsaers has primarily been asked due to his professional area of expertise in the domain of control systems engineering. Mr Mutsaers is mechatronics engineer at ASML, where he is working at the development and implementation of control-strategies within different modules of ASML lithographic machines. He is coach of starting employees at ASML and accompanies students at their internship and graduation. He is graduated at PhD Control Systems at Technical University Eindhoven and finished the DISC-programmes. Mr Mutsaers contributes regularly at conferences at home and abroad and delivers peer reviews of articles. Mr Mutsaers has received our manual for panel members and has been briefed individually on the audit visit process, accreditation in higher education and NQA's working method.

Education:

2012	TNO Automotive, Helmond
2008 – 2010	DISC-programme for PhD-students in Systems and Control in The Netherlands - Dutch Institute for Systems and Control
2008 – 2012	PhD Control systems - Technical University Eindhoven
2007	Internship - University of Graz, Austria
2002 – 2008	WO Electrical Engineering - Technical University Eindhoven

Work Experience:

2012 – present	Mechatronics Engineer - ASML

Publications:

- 2012, Mark Mutsaers & Siep Weiland, Rational representations and controller synthesis of L2 behaviors, Automatica, Volume 48, Issue 1 (January), 1-14.
- 2008, Mark Mutsaers, Mostafa Bachar, Jerry Batzel, Franz Kappel & Stefan Volkwein, Receding horizon controller for the baroreceptor loop in a model for the cardiovascular system, Cardiovascular Engineering, 8(1), 14-22.

Mr ir. P.A. Janssen

Mr Janssen has primarily been asked in the panel because of his professional area of expertise in the domain of Control Systems Engineering. Mr Janssen is technical director at Q-Performance, teacher at Automotive and manager Center for Technology and Innovation at Fontys Hogescholen and advisor at Procmod. He has developed, in cooperation with an English University, the master of Mechatronics. Besides he contributes to the development of TOP*ACE education. Mr Janssen received our manual for panel members and has been briefed individually on the audit visit process, accreditation in higher education and NQA's working method.

Education:

2006 – 2008	Black Belt - Lean Six Sigma
2006	Account Management - Fontys Hogescholen
2004 – 2005	TOP Traject - Fontys Hogescholen
1981 – 1987	Physics systems and control engineering – Technical University Eindhoven

Work experience:

2011 – present	Chief Technology Officer (CTO) - Q-Performance BV
2011 – present	Teacher Automotive - Fontys Hogescholen
2010 – present	Advisor - Settels Savenije van Amelsvoort (SSvA)

2010 – present Manager Center for Technology and Innovation - Fontys Hogescholen
2006 – 2010 Interim lector and associate lector mechatronica design - Fontys Hogescholen
2001 – 2005 Manager Center IT and Mechanical Engineering - Fontys Hogescholen
1995 – present Advisor - Procmod
1995 – 2001 Manager Business Services - Ceditec en Ceditec Engineering
1993 – 1996 Teacher - Hogeschool Eindhoven
1990 – 1993 Process Control and Design Department - Dow Benelux NV
1988 – 1990 Process technologist - SIPM
1987 – 1988 ROAG KMA

Mr J.G.S. van Uden

Mr Van Uden has been invited as a student panel member. He studies the master degree of Automotive Technology at Technical University in Eindhoven. As a team member of University Racing Eindhoven (URE) Mr Van Uden is responsible for the electronics in the racing car of URE. This year, after five petrol cars, URE is working for the second time on an electrical formula racing car, which has been designed, built and tested by students. His role within the team includes: designing, making and testing the electronic systems. This requires close cooperation with other disciplines within the team. Mr Van Uden represents the students' view on teaching methods, facilities and quality of field work. He has been given additional individual briefing about audit visit procedures and NQA's working method.

Education:

2011 – 2013 Master Automotive Technology, Technical University, Eindhoven
2004 – 2011 Bachelor Electrical Engineering, Technical University, Eindhoven
1997 – 2004 VWO, Strabrecht College, Geldrop

Work experience:

2006 – present Employee sales kitchen department - IKEA
2005 – 2006 Employee technical service and sales - Computerland
2004 – 2005 Employee Production & Repair - Prodrive Electronics
2002 – 2004 Sales employee - Slijterij De Wijnhoeve

Other activities:

2006 – present Team member Electronics - University Racing Eindhoven
2006 – 2008 Board Member (secretary) - ESRAC (Eindhovense Studenten Radio Amateur Club)
2007 – 2009 Editor of Faculty Magazine Connecthor – Technical University Eindhoven
2008 – 2009 Financial Control Committee - e.t.s.v. Thor, Eindhoven
2006 – 2007 Yearbook Committee - e.t.s.v. Thor, Eindhoven
2005 – 2006 Activities Committee - e.t.s.v. Thor, Eindhoven
2004 – 2006 Team Member Public Relations - Formula Student Racing Team Eindhoven (FSRTE)

Mr P. van Achteren BLL

Mr Van Achteren has been asked to serve as NQA auditor. He has experience with audit visits and consultancy in almost all sections of higher professional education. Beside audit visits he compilates panels and is accountmanager. From his training and experience Mr Van Achteren has knowledge of educational and business processes.

In the autumn of 2010 Mr Van Achteren completed an NVAO training course which made him a qualified secretary. In addition to the educational audit visits Mr Van Achteren is also involved in audit visits of real estate corporations.

Education:

2012 – 2013	Business Administration (abbreviated) - Avans+, Breda
2006 – 2009	Political science – University of Amsterdam, Amsterdam
2006 – 2007	Didactics - University of Amsterdam, Amsterdam
2002 – 2006	Social Legal Services, Hogeschool Utrecht, Utrecht
2001 – 2002	Business Management Studies - Christelijke Hogeschool Windesheim, Zwolle

Work Experience:

2008 – present	Auditor/Consultant - Netherlands Quality Agency
2008 – present	Secretary audit visits of real estate corporations - Raeflex
2006 – 2007	Teacher auditor - ISBW opleidingen
2006 – 2007	Student panel member - Netherlands Quality Agency
2005 – 2007	Chair educational committee Social Legal Services - Hogeschool Utrecht
2004 – 2005	Trainee staff member/public information officer – Dutch House of Representatives Party D66

Annex 4: Program for the site visit

Voorbereidingsmiddag (15 april)

Tijdstip	*Thema*	*Deelnemers*
12.30-13.30	Ontvangst, lunch en voorbereiding	Panel Ir. Peter Ypma (opleidingscoördinator) Dr. ir. Edwin Tazelaar (lid kernteam) Francis v/d Heijden (procescoördinator)
13.30-14.00	Presentatie van maximaal 20 minuten door opleiding waarin zij zich positioneert ten aanzien van gemaakte keuzes, stand van zaken en openstaande wensen & voornemens. Het panel kan toelichtende vragen stellen.	Panel Ir. Peter Ypma (opleidingscoördinator) Dr. ir. Edwin Tazelaar (lid kernteam) Drs. Ans Gielen (directeur HMP)
14.00-18.00	Voorbereiding en materiaalbestudering Spreekuur en rondleiding: 14:00 – 14:30 uur	Panel

Gespreksdag (16 april)

Tijdstip	*Thema*	*Deelnemers*
08.30-09.15	Inhoud, gehele opleiding	Panel Studenten propedeuse en hoofdfase: Cor Leuken (student leerjaar 1) Hans Nas (student leerjaar 1) Hatim Mala (student leerjaar 1) Miel Stapel (student leerjaar 1) Jeroen Krooswijk (student leerjaar 1) Michel Roumans (student leerjaar 1)
09.30-10.15	Inhoud, gehele opleiding	Panel Docenten: spreiding naar studiejaren, vakgebieden en speciale taken zoals SLB en lectoraat: Ir. Egon Haffmans Dr. ir. Carolien Stroomer Kattenbelt Dr ir. Aart Jan de Graaf Ir. Peter Ypma Dr. ir. Hans Stigter
10.30-11.00	Inhoud, programma & toetsing	Panel Alumni en afstudeerders: Hans Timmerarends (alumnus 2012) Bert van Oosten (alumnus 2014) Menno Merts (alumnus 2014) Arthur rondeel (alumnus 2014) Pascal Jansen (alumnus 2013)
11:30-12:00	Telefonisch interview met dr. ir. Pieter Nuij (voormalig external expert)	Panel Dr. ir. Pieter Nuij

12.00-13.00	Overleg + lunch	Panel
13.00-13.45	Inhoud, toetsing & afstuderen	Panel Examinatoren: spreiding naar toetsing en specifiek afstuderen: Ir. Egon Haffmans Dr ir. Aart Jan de Graaf Ir. Peter Ypma
14.00-14.30	Inhoud & aan inhoud gerelateerde processen: aansturing	Panel Opleidingsmanagement: Ir. Peter Ypma (opleidingscoördinator) Dr. ir. Edwin Tazelaar (lid kernteam) Drs. Ans Gielen (directeur HMP)
14.45-15.30	Inhoud & aan inhoud gerelateerde processen: borging	Panel Dr. ir. Edwin Tazelaar (curriculumcommissie) Dr. ir. Carolien Stroomer Kattenbelt (opleidingscommissie) Prof. dr. ir. Joop Pauwelussen (examencommissie) Ir. Peter Ypma (toetscommissie)
15.30-16.30	Beoordelingsoverleg panel	Panel
16.30-17.00	Laatste gesprek opleidingsmanagement en terugkoppeling bevindingen	Panel Opleidingsmanagement, aangevuld met enkele kerndocenten en medewerker kwaliteitszorg.

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[121] Weggemans M., Leiding geven aan professionals? Niet doen! Over kenniswerkers, vakmanschap en innovatie, *Scriptum*, 2008 (in Dutch)

Annex 6: Summary theses

Below a summary of the students whose theses have been examined by the panel. According to NVAO's rules only studentnumbers are included.

473022
155114
501518
501516
501510
501508
487103
487109
487107
487135
473041
473039
473042
473065
102485
501502
487122
501517
473020

Annex 7: Declaration of Comprehensiveness and Accuracy

Netherlands Quality Agency

NQA

Verklaring van volledigheid en correctheid van de informatie

Betreffende de visitatie van de opleiding:

Control Systems Engineering

Instelling: Hogeschool van Arnhem en Nijmegen

Visitatiedatum: 15 en 16 april 2014

Ondergetekende: . A P M Gielen - van Bommel

vertegenwoordigend het management van de genoemde opleiding,

in de functie van: . directeur HAN Masterprogramma's

verklaart hierbij dat alle informatie ten behoeve van de visitatie van de genoemde opleiding in volledigheid en correctheid ter beschikking wordt gesteld, *waaronder informatie over alternatieve afstudeerroutes die momenteel en/of gedurende de afgelopen 6 jaar (hebben) bestaan,* zodat het visitatiepanel tot een op juiste feiten gebaseerde oordeelsvorming kan komen.

Handtekening: Hogeschool van Arnhem en Nijmegen HAN Masterprogramma's

A. Gielen
directeur Mastergeleidingen

Datum: 17-3-14

Annex 8: Additional quantative data

Quantative data regarding student-teacher ratio & contact hours

	terms	weeks	hours		time	factor	dbu	fte	aantal	fte totaal	student aantal	ratio
lessen	7	8	16		0,75	2	1344	0,81	1	0,81		
totaal FT/jaar				896								
totaal PT/jaat				448								
afstuderen							35	0,02	20	0,42		
							totaal direct			1,23	40	**32**
intern management							900	0,54	1	0,54		
							totaal incl man. int.			1,77	40	**23**
extern management	30% van totaal incl. man. int							0,59	1	0,59		
							totaal incl man. extern			2,37	40	**17**