COMPUTER SCIENCE
(JOINT DEGREE)

FACULTY OF SCIENCE

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This report was finalised on 17 April 2020.

REPORT ON THE MASTER'S PROGRAMME COMPUTER SCIENCE OF VRIJE UNIVERSITEIT AMSTERDAM AND THE UNIVERSITY OF AMSTERDAM (JOINT DEGREE)

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

ADMINISTRATIVE DATA REGARDING THE PROGRAMME

Master's programme Computer Science (joint degree)

Name of the programme:	Computer Science (joint degree)
CROHO number:	65014
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specialisations or tracks:	BDE: Big Data Engineering CSS: Computer Systems Security FCC: Foundations of Computing and Concurrency IWT: Internet and Web Technology PCS: Parallel Computing Systems SEG: Software Engineering and Green IT
Location(s):	Amsterdam
Mode(s) of study:	full time
Language of instruction:	English
Joint programme #1:	
partner institutions involved:	Vrije Universiteit Amsterdam University of Amsterdam
type of degree awarded:	joint degree
Joint programme #2:	
partner institution involved:	Università degli Studi dell'Aquila (Italy)
type of degree awarded:	double degree
Submission deadline NVAO:	01/05/2020

The visit of the assessment panel Computer Science took place at the Faculty of Science of Vrije Universiteit Amsterdam on 6 and 7 November 2019.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

Name of the institution:	Vrije Universiteit Amsterdam
Status of the institution:	publicly funded institution
Result institutional quality assurance assessment:	positive
Name of the institution:	University of Amsterdam
Status of the institution:	publicly funded institution
Result institutional quality assurance assessment:	positive

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has approved the composition of the panel on 15 april 2019. The panel that assessed the master's programme Computer Science (joint degree) consisted of:

- Em. prof. dr. T. (Theo) D'Hondt, emeritus professor in Software Languages and Software Engineering at the Faculty of Sciences and Bioengineering Sciences of Vrije Universiteit Brussel (Belgium) [chair];
- Prof. dr. ir. W.E.A. (Wim) van Petegem, professor and policy coordinator Learning Technologies at the Faculty of Industrial Engineering Technology of KU Leuven (Belgium);
- Prof. dr. S. (Sjouke) Mauw, professor in Security and Trust of Software Systems at the Department of Computer Science of the University of Luxembourg (Luxembourg);
- Drs. L. (Lennart) Herlaar, owner/director at Redbits.nl, a company specialised in software development and IT consultancy, and assistant professor Computer Science at the Faculty of Science of Utrecht University;
- E. (Evi) Sijben BSc, Master's student Computing Science in the specialisation track Data Science at Radboud University [student member].

The panel was supported by M. (Mark) Delmartino MA, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

The site visit to the master's programme Computer Science (joint degree) at the Faculty of Science of Vrije Universiteit Amsterdam was part of the cluster assessment Computer Science. Between June and December 2019 the panel assessed 29 programmes at 10 universities. The following universities participated in this cluster assessment: Leiden University, Delft University of Technology, University of Utrecht, Eindhoven University of Technology, Open University, University of Amsterdam, Vrije Universiteit Amsterdam, Radboud University, University of Groningen and University of Twente.

On behalf of the participating universities, quality assurance agency QANU was responsible for logistical support, panel guidance and the production of the reports. P.A. (Peter) Hildering MSc. was project coordinator for QANU. P.A. (Peter) Hildering MSc. and M. (Mark) Delmartino MA acted as secretary in the cluster assessment.

During the site visit in Amsterdam the panel was supported by M. (Mark) Delmartino MA, a certified NVAO secretary.

Panel members of the cluster assessment Computer Science
The members of the assessment panel were selected based on their expertise, availability and independence. The panel consisted of the following members:

- Em. prof. dr. T. (Theo) D'Hondt, emeritus professor in Software Languages and Software Engineering at the Faculty of Sciences and Bioengineering Sciences of Vrije Universiteit Brussel (Belgium) [chair];
- Prof. dr. ir. W.E.A. (Wim) van Petegem, professor and policy coordinator Learning Technologies at the Faculty of Industrial Engineering Technology of KU Leuven (Belgium);
- Prof. dr. S. (Sjouke) Mauw, professor in Security and Trust of Software Systems at the Department of Computer Science of the University of Luxembourg (Luxembourg);
- Prof. dr. J.J. (John-Jules) Meyer, full professor Computer Science and Artificial Intelligence at the University of Utrecht;
- Drs. L. (Lennart) Herlaar, owner/director at Redbits.nl, a company specialised in software development and IT consultancy, and assistant professor Computer Science at the Faculty of Science of Utrecht University;
- T.A. (Tonny) Wildvank, owner/CEO at Wildvank, Management en Advies, specialised in IT-management and -consultancy;

- Prof. dr. J. (Jan) Aerts, full professor Visual Data Analysis at the University of Hasselt and associate professor Visual Data Analysis at the faculty of Engineering Science at KU Leuven (Belgium);
- Drs. H.C. (Jeroen) Borst, senior consultant Smart Cities at TNO;
- Prof. dr. P. (Petros) Koumoutsakos, full professor Computational Science at ETH Zürich (Switserland);
- Prof. dr. ir. J.M.W. (Joost) Visser, Chief Product Officer at Software Improvement Group (SIG) Nederland and professor Large-scale Software Systems at the Radboud University Nijmegen;
- Ir. E.A.P. (Ewine) Smits, Senior Manager in Advanced Analytics & Big Data at KPMG Nederland;
- Prof. dr. D.P. (Danilo) Mandic, full professor Signal Processing at the department of Electrical and Electronic Engineering of Imperial College London (United Kingdom);
- Dr. ir. J.C. (Job) Oostveen, Research Manager at the Department Monitoring and Control Services at TNO;
- Prof. dr. B.A.M. (Ben) Schouten, full professor Playful Interactions at Eindhoven University of Technology;
- Dr. ir. N. (Nico) Plat, owner/CEO at Thanos IT-consultancy and architecture.
- N. (Nienke) Wessel BSc, master's student Computing Science and bachelor's student Mathematics and Linguistics at Radboud University [student member];
- E. (Evi) Sijben BSc, master's student Computing Science in the specialisation track Data Science at Radboud University [student member];
- B. (Baran) Erdogan, third-year bachelor's student Computing Science at University of Amsterdam [student member];
- M. (Martijn) Brehm, third-year bachelor's student Computing Science at University of Amsterdam [student member].

Preparation
On March 21st, 2019, the panel chair was briefed by QANU on his role, the assessment framework, the working method, and the planning of site visits and reports. A preparatory panel meeting was organised on May 9th, 2019. During this meeting, the panel members received instruction on the use of the assessment framework. The panel also discussed their working method and the planning of the site visits and reports.

The project coordinator and secretary composed a schedule for the site visit in consultation with the Faculty. Part of the visit was dedicated to the bachelor's programme Computer Science and the master's programme Parallel and Distributed Computer Systems, which are organised solely by the Vrije Universiteit Amsterdam. The panel's findings on these programmes are reported in a separate document. Prior to the site visit, the Faculty selected representative partners for the various interviews. See Appendix 4 for the final schedule.

Before the site visit to Amsterdam, QANU received the self-evaluation report of the programme and sent it to the panel. A thesis selection was made by the panel's chair and the secretary. The selection existed of 15 theses and their assessment forms, based on a provided list of graduates in the academic years 2016-2017, 2017-2018 and 2018-2019. A variety of topics and tracks and a diversity of examiners were included in the selection. The panel secretary and chair assured that the distribution of grades in the selection matched the distribution of grades of all available theses.

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

Site visit
The site visit to Amsterdam took place on 6 and 7 November 2019. At the start of the visit, the panel discussed its initial findings, identified the key issues to be discussed during the sessions, and agreed on a division of tasks during the site visit. During the site visit, the panel studied additional documents provided by the programme. An overview of these materials can be found in Appendix 5. The site

visit schedule included a tour across the campus visiting programme-specific learning facilities. The panel also conducted interviews with representatives of the programme: students and staff members, the programme's management, alumni and representatives of the Board of Examiners. It also offered students and staff members an opportunity for confidential discussion during a consultation hour. Nobody made use of this opportunity. The panel used the final part of the site visit to discuss its findings in an internal meeting. Afterwards, the panel chair publicly presented the panel's preliminary findings and general observations. The visit was concluded with a development conversation, organised jointly by VU and UvA, in which panel members and programme representatives discussed various development routes for the respective programmes. The result of this conversation is summarised in a separate report.

Consistency and calibration
In order to assure the consistency of assessment within the cluster, following measures were taken: the panel composition ensured regular attendance of (key) panel members, including the chair, and the project coordinator was present at the panel discussion leading to the preliminary findings of each programme at all site visits.

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

Definition of judgements standards
In accordance with the NVAO's Assessment framework for limited programme assessments, the panel used the following definitions for the assessment of the standards:

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

Meets the standard
The programme meets the generic quality standard.

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

Does not meet the standard
The programme does not meet the generic quality standard.

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

Positive
The programme meets all the standards.

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

Negative
In the following situations:
- The programme fails to meet one or more standards;

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

SUMMARY JUDGEMENT

This evaluation concerns the master's programme Computer Science, a two-year full-time 120 EC programme offered jointly by the Vrije Universiteit Amsterdam and the University of Amsterdam.

The master's programme has a clear profile: it combines attention to the broad field of computer science with the option for students to focus on one specialism. The panel appreciates the direct link between the specialisations in the programme and the domain expertise of the respective research groups at VU and UvA. The programme ambitions are properly reflected in the intended learning outcomes: the formulation of the exit qualifications is adequate in terms of domain, level and orientation of the programme. The five European-wide Dublin Descriptors are properly reflected in the programme ILOs. According to the panel, the programme could improve the functioning of the current Advisory Council of Professionals by turning it into a dedicated sounding board for computer science.

The teaching-learning environment of the programme is up to standard. In fact, the panel thinks highly of the relevant and coherent curriculum, where the courses are driven by the research agenda of the participating institutes and research groups. Moreover, students benefit from the comprehensive range of research specialisations in the tracks and the electives. The international composition of the student and staff body contributes to the atmosphere and the quality of the programme. The staff is highly qualified and appreciated by the students for their dedication, intensive guidance and supervision. Students and staff are actively involved in safeguarding the quality of the courses and the programme. Two issues require attention: the programme (tracks) may want to indicate more explicitly where students acquire research methodology skills in the curriculum; and the time staff can dedicate to the programme should be monitored carefully as the number of students is growing and may impact the quality of the course delivery and the intensity of thesis supervision.

Student assessment is organised adequately in the joint master's programme Computer Science. There are arrangements in place to synchronise the rules and regulations between the two institutions. The programme features a robust faculty-wide examination policy. The course assessments are valid, reliable and transparent. The programme is taking fraud seriously. The members of the faculty-wide Examination Board, its subcommittee for the computer science programmes and its assessment committee have adequate expertise to deal with their respective tasks. Based on its own sample review, the panel considers that the assessment process of the master project is up for improvement: assessors often do not provide feedback in their appreciations and scores. This in turn reduces accountability of the assessment towards external parties, an issue that requires even more attention in this programme because the only tangible element, the thesis product, accounts for only one third of the final grade. The panel welcomes the intentions of the management to adjust the thesis evaluation form accordingly and encourages the assessment committee to verify as part of its quality assurance activities that the written feedback is systematic and insightful.

Master students who graduate from the joint degree programme in Computer Science are adequately prepared for a career in industry or academia. Having established that each thesis in the sample meets at least the minimum requirements of what can be expected of a final project at master level—and often is of higher quality—it is fair to state that the intended learning outcomes of the programme are ultimately achieved at the end of the master's curriculum. The panel welcomes the attention of the programme for its graduates and considers that these alumni constitute a good basis for information and advice on the quality and relevance of the programme.

Across all standards, the panel noticed that there have been many developments in the Master Computer Science in recent years and that the programme has done a great job in addressing the recommendations of the previous accreditation committee. Hence the panel's overall positive appreciation of the programme quality. The panel acknowledges the added value of the current

collaboration between the two universities, their staff, research institutes and faculties in the framework of this programme. It does not express a preference for a single programme or joint degree construction, but is convinced that the advantages for students to benefit from a wide range of perspectives and expertise far outweigh the often cited problems of logistics and administration.

Notwithstanding its overall appreciation, the panel considers that the programme should develop a strategic vision for its future. This vision could be informed by a curriculum advice exercise similar to the one implemented recently in the bachelor's programme Computer Science, balance the breadth and depth of the programme (tracks), formalise the division of work within the joint degree, and do justice to the comprehensive range of in-house expertise available at both institutions.

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

Master's programme Computer Science (joint degree)

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

The chair, Em. Prof. Dr. T. (Theo) D'Hondt, and the secretary, M. (Mark) Delmartino MA, of the panel hereby declare that all panel members have studied this report and that they agree with the judgements laid down in the report. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

Date: 17 April 2020

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

Standard 1: Intended learning outcomes
The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Findings
The master's programme Computer Science is a joint degree offered by the Vrije Universiteit Amsterdam (VU) and the University of Amsterdam (UvA). Its origins go back to the master's programme Computer Science, which was first offered solely by VU before it became a joint degree programme with UvA in September 2013. VU is the "lead partner" (*penvoerder*) of the joint degree; the collaboration of the universities with regard to this joint degree programme is governed by an agreement of cooperation. The master's programme has strong ties with four master's programmes from the same Department at VU and with two other joint degree programmes with UvA.

The development of this joint degree was part of a larger endeavour: in 2011, the Informatics departments of both VU and UvA started exploring different forms of cooperation, including the plan to form a joint Amsterdam Department of Informatics at one central location on the current VU campus and to re-organise the portfolio of degree programmes accordingly. However, these plans were abandoned when the co-decision bodies (*medezeggenschapsraad*) at university level did not approve the envisaged merger in April 2017. While both universities have since revised their strategy focusing on the needs and interests of their respective departments, this master's programme—as well as the master's programme Computational Science with UvA as lead partner—continues to be offered as a joint degree.

The master's programme Computer Science is embedded in the Computer Science Department of the Faculty of Science at VU and the Graduate School of Informatics (GSI) of the Faculty of Science at UvA. The staff teaching in the programme belong to different research groups and institutes in both universities. The programme director and the programme co-ordinator are both employed by VU. The panel gathered from the discussions on site that all stakeholders see an added value in the collaboration between VU and UvA, their staff, research institutes and faculties in the framework of this programme. The panel understood that the advantages for students to benefit from a wide range of perspectives and expertise far outweighs the extra efforts of logistics and administration often associated with a joint degree. It concludes that the programme fulfils the criteria for a joint programme and reflects a joint effort by both institutions. It does however note that in practice, the VU as lead partner has the largest role in the programme, both in terms of organisation as in the number of teaching staff. It recommends the programme to reflect on what balance between the two institutions it deems desirable and to formalise this in the agreement of cooperation.

Since the previous accreditation in 2013, the programme has undergone significant changes: at that time the programme had recently started as a joint degree and was in the process of integrating UvA elements in the curriculum and the educational organisation. In the meantime two specialisations have been terminated—*Technical Artificial Intelligence* and *Multimedia*—and two new tracks were started: *Security* and *Big Data*.

Profile
The master's programme in Computer Science (MCS) provides students with knowledge, experience and insights to autonomously carry out professional roles as a computer scientist. It offers a solid basis for a career in business at an academic level, prepares for further education as a scientific researcher, and looks into the position of computer science in a broader social and scientific context. The programme combines breadth and depth: MCS educates students in the broad terrain of computer science and allows them to focus on one specialisation. The panel learned that this

approach is in line with the educational vision of the university to create a community of learners: programmes at the VU enable students to achieve core competences in their area of expertise, to familiarise themselves with a research culture, and to develop the necessary skills to become academic professionals.

The MCS features the following six specialisations (also called tracks) which reflect the research expertise of the teaching staff and the computer science research groups at VU and UvA:

- *Big Data Engineering (BDE)* studies the technology from which the global data processing infrastructures are built, with a focus to design and operate solutions for processing, analysing and managing large quantities of data;
- *Computer Systems Security (CSS)* focuses on system and security issues related to operating systems, hardware and applications;
- *Parallel Computing Systems (PCS)* covers the entire range of scale from laptops to computer servers, GPU accelerators, heterogeneous systems and large-scale high-performance computing infrastructures;
- *Internet and Web Technology (IWT)* teaches students to design, develop and evaluate the performance of distributed software- and service-based systems, and validate ideas by setting up experiments;
- *Software Engineering & Green IT (SEG)* provides students with instruments to gain a holistic understanding of large-scale and complex software systems, manage their evolution, assess their quality and environmental impact, quantify their value and sustainability potential, and organise their development in local and distributed contexts;
- *Foundations of Computing and Concurrency (FCC)* concerns the theory of computing and the application of formal methods for correct design of software systems.

The panel was informed that students with specific personal ambitions can also compose their own study programme in consultation with the programme director and upon approval by the Examination Board. According to the self-evaluation report, this so-called free track is chosen rarely. Furthermore, the panel learned that the SEG track participates in the Global Software Engineering European Master, a double degree programme specialising in Software Engineering: in this programme, students spend one year at the VU and one year at the University of l'Aquila in Italy.

Based on the information materials and the discussions, the panel thinks the profile is clear and relevant. The opportunity for students to choose among a wide range of specialisations is an asset of the programme, and so is the link of these tracks with the domain expertise of research groups at the VU and UvA.

Intended learning outcomes

The panel noticed that the programme objectives are properly reflected in the intended learning outcomes (ILOs), which are listed in Appendix 2 to this report. All MCS students are educated to achieve twelve ILOs. One learning outcome refers to knowledge, insight and skills in a specialist area of computer science; it is broken down in three exit qualifications with specific attainment levels per specialisation. According to the panel, the formulation of all ILOs is clear and relevant. Each learning outcome is related to and motivated by one or more Dublin Descriptors.

Looking into the formulation of these ILOs, the panel noticed with appreciation a similarity between the exit qualifications of this joint degree and those of the master's programme PDCS. Furthermore, there is a clear difference in expected attainment level between the bachelor's and master's programme Computer Science. Following the recommendation of the previous accreditation committee, the programme has included a separate ILO for carrying out research independently. Finally, the panel appreciates the reference (in the eleventh ILO) to students acquiring a societal perspective on information technology.

According to the information materials, the MCS educates its students for a career in business at an academic level. The panel noticed that the programme monitors the developments in the professional

field of computer science in different ways: informally via staff contacts with industry, and formally through alumni surveys and the Advisory Council of Professionals (*Werkveldadviesraad*). The panel learned that these formal inputs have been enhanced recently. It welcomes in this regard the efforts of the programme management and the Faculty to address the recommendation of the previous accreditation committee to make more and better use of the input of alumni. While it acknowledges both the contacts with the professional field and the relevant expertise of the individual members of the Council of Professionals, the panel encourages the programme management to extend the council's membership to cover the entire domain of computer science and the specialisations on offer at the VU; moreover, the programme could organise dedicated meetings of the council to discuss strategic developments that impact specifically on the courses and the tracks of this master's programme.

In line with its findings on other VU, UvA and joint VU-UvA programmes it reviewed in the framework of this cluster assessment, the panel thinks that the focus of this master's programme Computer Science and its respective tracks requires further elaboration in a strategic vision on the future of the programme, including on its character as a joint degree. In this regard the programme may benefit from a curriculum advice exercise similar to the one implemented recently in the bachelor's programme Computer Science at VU.

Considerations

The panel considers that the master's programme Computer Science has a clear and relevant profile: it combines attention to the broad field of computer science with the option for students to focus on one specialism. The panel appreciates the direct link between the specialisations in the programme and the domain expertise of the teaching staff and their respective research groups at the VU and UvA.

Moreover the programme ambitions are clear and properly reflected in the intended learning outcomes: the formulation of the exit qualifications is adequate in terms of domain (computer science), level (master) and orientation (academic) of the programme. The panel found that the five European-wide Dublin Descriptors are properly reflected in the programme ILOs. If anything, the programme could improve the functioning of the current Advisory Council of Professionals by turning it into a dedicated sounding board for computer science.

The MCS programme was initiated at a time when opportunities for a more comprehensive collaboration between the VU and UvA were discussed. While the merger did not take place, this joint degree programme lived on. Based on numerous discussions on site, the panel acknowledges the added value of the current collaboration between VU and UvA, their staff, research institutes and faculties in the framework of this programme. The panel does not express a preference for a single programme or joint degree construction, but is convinced that the advantages for students to benefit from a wide range of perspectives and expertise far outweighs the often cited problems of logistics and administration.

Notwithstanding the above appreciation, the panel considers that the programme should develop a strategic vision on its future. This vision could be informed by a curriculum advice exercise similar to the one implemented recently in the bachelor's programme Computer Science at VU, balance the breadth and depth of the programme (tracks), formalise the division of work within the joint degree, and do justice to the comprehensive range of in-house expertise available within VU and UvA.

Conclusion

Master's programme Computer Science (joint degree): the panel assesses Standard 1 as *meets the standard.*

Standard 2: Teaching-learning environment
The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.

Findings

Curriculum
The master's programme Computer Science amounts to 120 EC, which are distributed uniformly over two years of six blocks each. The curriculum consists of a shared core component (42 EC, including a 30 EC master project), six specialisation tracks with their respective mandatory courses (30 EC), constrained choice courses (12-18 EC) and electives (30-36 EC). Appendix 3 to this report provides an overview of the curriculum.

Studying the materials in the self-evaluation report and its annexes, the panel found that the curriculum is both relevant and coherent. The track coordinators play an important role in advising students in their track on composing a suitable study programme. Moreover, the panel appreciates the attention of the programme to societal perspectives: as part of a constrained choice course, students look at computer science from a particular perspective, such as history, law or ICT in developing countries.

The panel gathered from the information materials and discussions that there is a lot of attention in the programme to students deepening their knowledge and participating in research. In this regard the panel noticed the student interaction with active research groups and appreciates that each track is well connected to one or more research groups at VU and/or UvA. While students do acquire academic skills in the programme, notably in the Literature Study and Seminar course, it was not clear to the panel where and how in the curriculum students are trained in research methodology skills. Given its findings on the master thesis quality, the panel is convinced that students do acquire these skills, but advises the programme to make this more explicit and visible in the curriculum.

The previous accreditation committee recommended the programme to encourage students to study abroad. The panel gathered from the discussions with both staff and students that there are opportunities to do so in the curriculum and that students are properly and timely informed about these. Nonetheless very few students decide to spend a study period abroad: several international students travelled to the Netherlands for this MCS, a few students were already abroad during the bachelor's programme, and others prefer the quality of the VU-UvA master and the city of Amsterdam over a travel abroad that may not bring the envisaged added value in terms of learning experience.

Furthermore, the panel obtained very good information on the specific emphases of the respective tracks and concludes that each track has its own rationale and merit. While this was not entirely clear from the self-evaluation report, it is to the credit of the students that they managed to sketch precisely and convincingly the difference between the Parallel Computing Systems track and the stand-alone master's programme Parallel and Distributed Computer Systems. The panel was moreover informed about the international double degree master's programme which students from the Software Engineering & Green IT track can follow. Students spend one year at VU and one year in L'Aquila (Italy) following a predefined study programme that satisfies the requirements at both universities.

Finally, the panel noticed a clear link between the curriculum and the programme objectives/exit qualifications: the learning goals at course level are strongly connected to the learning outcomes at programme level. This finding was confirmed when it looked into several course files during the visit: the panel found that these materials are of adequate quality and at the proper level for an academic master's programme. Based on the sample review and the self-evaluation report, the panel is confident that all together the curriculum allows students to achieve the intended learning outcomes of the master's programme Computer Science.

Language of instruction
In line with all other master's programmes in the Graduate School of Informatics, the Faculty of Science and the corresponding programmes at the UvA, the language of instruction in the MCS is English. The panel understands from the self-evaluation report that apart from alignment, there are also other merits for this choice: the programme aims to prepare students for an international job market, to have international staff teach at all levels, and to create an international atmosphere among students and staff. It also aligns with the vision of the VU on internationalisation and its ambition to grow towards a community with an international culture where students and employees from different backgrounds meet. Students, most of whom were non-Dutch, indicated that they are satisfied with the level of English of the teaching staff. The panel subscribes to the rationale for offering the programme in English. The discussions on site, moreover, have demonstrated according to the panel that the international student and staff body is a value added for the programme.

Educational concept
According to the self-evaluation report, students are introduced step-by-step to the professional and scientific community of their specialisation track, culminating in their active participation in one of the research groups. During the visit, both students and staff confirmed that this incremental interaction with research and industry happens in reality and constitutes a particular strength of this master's programme. Although the growing number of students in some tracks is putting a strain on the frequency of staff-student interaction, students did feel that they are part of the community of researchers. Moreover, they appreciate the scientific and social activities that are organised per track and think highly of the track coordinators who facilitate their integration in the respective research communities. The panel noticed in this regard the enthusiasm of both master students and their teaching staff/track coordinators.

Further to its findings on the relevance and coherence of the curriculum, the panel found that from an educational point of view the programme structure is sound. The information materials and the discussions have moreover convinced the panel that the educational concept underlying the curriculum is relevant.

Intake
The panel learned that since the previous accreditation visit, the number of enrolments has been growing, with a noticeable increase from 72 students (in 2017-2018) to 103 (in 2018-2019). Compared to previous years, the number of students from other Dutch universities has increased by 250%, while the share of female students doubled in one year from almost 10% to almost 20%. Furthermore, the number of international students is increasing over time, both nominally and percentage-wise.

Students indicated that they appreciate the strong international environment in the programme: students from all over the world come together in Amsterdam and study the degree programme together. This allows students to meet people from new cultures and to broaden their perspectives on education, society, and life in general. The panel appreciates this international atmosphere and thinks that the combination with an international staff team adds to the quality of the programme.

Furthermore, the panel obtained detailed information on the admission criteria and the specific entry requirements. Bachelor graduates in computer science from a Dutch university have direct access to the programme. Students who obtained a similar bachelor's degree abroad submit their diploma for review and are judged by the International Office. If needed, international students follow a tailored pre-master programme of maximum 30 EC. Students from a Dutch University of Applied Science follow a pre-master that is tailored to their prior education and the envisaged track. Computer science students from the Amsterdam University of Applied Science can take a pre-defined minor during their studies, which allows direct admission in the Software Engineering & Green IT-track. The panel noticed that the entry requirements are clear; students who enrolled after a pre-master programme indicated that it prepared them well for the master's programme as they started at the same level as their academically educated colleagues.

Feasibility
The panel gathered from the discussions that on the one hand the workload of the programme is high; on the other hand, the programme is well structured providing a clear trajectory per specialisation track as well as sufficient monitoring and guidance to successfully finish the programme. Students mentioned to the panel that they appreciate the guidance they receive from the teaching staff, the track coordinator and the study advisor. According to the students there are no specific courses that systematically hinder a smooth and timely realisation of the curriculum. Hence, students consider that the overall programme is feasible.

The panel noticed that this overall feasibility is confirmed by the data available on success rate: while the dropout rate is about 15%, roughly 60% of students graduate within the nominal period of two year. Given the recommendation by the previous assessment committee that the average study duration (30 months) was too long in 2013, the panel discussed the current situation with management, staff and students. It seems that on the one hand more and more students finish the programme in time, while on the other hand a smaller group of students take an increasingly longer time to graduate. These students often combine study with a relevant position on the labour market and had no intention to finish the programme in time. The panel appreciates the efforts of the programme to reduce the average study length by organising the thesis project in a stricter fashion with clear start and end dates and a mid-way presentation. However, the panel is fully aware that very often reasons for completing the study with a considerable delay are outside the control of the programme.

Staff
The panel learned that 20 staff members from VU and 6 staff members from UvA play an important role in teaching the joint MCS. Almost all teaching staff are member of a research group and most teaching staff either have a teaching qualification or are in the process of obtaining one. While the English language skills of teaching staff is adequate, according to the students, the panel appreciates that there is an English language proficiency requirement of C1 level for new staff. According to the panel it is very important for a truly international programme to set the bar high in terms of language skills.

The panel gathered from the discussions that students appreciate the quality of the staff, their dedication to the educational concept of incremental exposure to track-specific research, and the intensity of graduation project supervision. Based on its meetings with the enthusiastic teaching staff, the panel fully subscribes to this appreciation. Moreover, students indicated that staff cares about them, an impression that was confirmed when listening to the teaching staff.

Several staff members indicated moreover that VU and UvA colleagues work in positive cooperation, notwithstanding the failed plans to merge the institutes. According to the panel, the programme draws much added value from the involvement of teaching staff who are linked to different research institutes; students also appreciate the opportunity to choose from a wide variety of electives/specialisations as a result of the collaboration.

The programme management indicated that the current size of the cohort still suits the character and educational concept of the programme. However, any further growth should be met with additional staffing to maintain the quality of the education and safeguard the interaction between students and staff in the research groups and during thesis supervision. According to the panel, the current number of staff and their contribution to the programme is sufficient. Nonetheless, the panel is aware that in a programme that is built around six tracks, the intake per track and per year is different and can fluctuate considerably. The panel therefore understands the concern of the management and supports the intention of the programme to maintain the track-related interaction between students and staff throughout the programme and in particular during thesis supervision.

Facilities
The programme uses common facilities on the VU campus and the Science Park campus of the UvA. As the current building at the VU is out-of-date, the programme will move to modern educational facilities in 2020. The panel noticed furthermore that the programme has access to a good research infrastructure and collaborations supporting (computationally intensive) research.

The panel gathered from the information materials and the discussions that students play an important role in the quality system of the programme. They fill in course evaluations and are an active part of the programme committee. On several occasions during the visit, the panel noticed that this committee of students and staff takes its role seriously and has grown in stature compared to the previous visit of the accreditation committee. Moreover, students indicated that because of the approachable—and safe—education environment they feel taken seriously by the teaching staff and the programme management, and are at ease to address issues of concern.

Considerations
The panel considers that the teaching-learning environment of the master's programme Computer Science is up to standard. In fact, the panel thinks highly of most components of the curriculum, staff and facilities: the curriculum is relevant and coherent; the courses are driven by the research agenda of the participating institutes and research groups; students benefit from the comprehensive range of research specialisations in the tracks and the electives; there is a clear relation between the learning goals at course level and the learning outcomes at programme level; the educational concept of incremental exposure to and participation in track-specific research befits the objectives of the programme; the admission procedure is clear; the international composition of the student and staff body contributes to the atmosphere and the quality of the programme; the programme is feasible for those students who are fully dedicated to their studies; the staff is highly qualified covering a wide range of research specialisms and is appreciated by the students for their dedication, intensive guidance and supervision; students and staff are actively involved in safeguarding the quality of the courses and the programme.

In addition to these positive elements, the panel found two issues that require attention: the programme (tracks) may want to indicate more explicitly where students acquire research methodology skills in the curriculum; and the time staff can dedicate to the programme is sufficient for now but should be monitored carefully as the number of students is growing and may impact on the quality of the course delivery and the intensity of thesis supervision.

Conclusion
Master's programme Computer Science (joint degree): the panel assesses Standard 2 as *meets the standard.*

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

Findings

Assessment system
The panel noticed in the self-evaluation report that the assessment system of the joint master's degree Computer Science is based on the provisions set by the Faculty of Science at the VU. The Faculty provides guidelines on how to set up valid tests and assessments. There is a clear link between the content of the course, the learning goals to be assessed and the chosen assessment method, which ranges from written exams to reports, presentations and practical assignments. Most courses use multiple assessment types in order to stimulate the active learning process of students. Written exams consist usually of open questions, although some exams also feature multiple-choice questions.

In order to synchronise rules, regulations and policies between the VU and UvA, regular discussions take place at the central university level, at the faculty level and at the level of the Examination Board subcommittees. The panel understood from the discussions that the arrangements between the two institutions are adequate and followed-up in a satisfactory way.

In 2014, the Faculty of Science established an examination policy for all degree programmes requiring each course to have two examiners and each course coordinator to keep documentation of the exam, including the answer model, assessment matrix and graded results. Because this examination policy was still being rolled out according to the self-evaluation report, the panel inquired about its status in several sessions: it seems that by now the principles of the policy are clear to all course coordinators/examiners and that this common understanding is reflected in the level of completeness of the individual course dossiers. However, keeping track of the course files is difficult: archiving a complete hardcopy of each dossier with the education office proved to be too laborious, while maintaining a digital dossier is not sufficiently secure. The Faculty is now looking into other options to ensure that the course dossiers can be archived and thus retrieved easily for quality control and completeness. Based on the discussions, the panel thinks that making the core components of the course dossiers digitally available would be an efficient solution for both course coordinators/examiners and quality control bodies.

The panel gathered from the information materials and the discussions that master students are informed in class about fraud and plagiarism. There are only a limited number of fraud cases, which are handled according to strict procedures by the Examination Board.

Course and thesis assessments
The panel noticed that the assessment principles underlying the joint master's programme are sound and have been implemented in all courses. On site the panel looked into course files and their respective assessment forms and found these to be appropriate: the questions were valid and reliable. Students indicated during the visit that assessment is transparent: they know in advance what they need to study for the exam and how they will be assessed.

As part of its thesis review, the panel studied a sample of 15 master projects and their respective assessment forms. Every thesis is graded by two assessors who are staff members of the departments at VU or UvA and use a dedicated form with 20 criteria clustered around three components: research, thesis and presentation. Assessors give an appreciation for each criterion ranging from excellent to insufficient, as well as a grade per component. These grades are translated into a final grade according to a fixed weighting. While each criterion is briefly defined, there is hardly any room on the evaluation form to provide qualitative feedback to motivate the appreciations on the criteria or the grades per component. According to the self-evaluation report, the two assessors attend the final presentation and determine grades for the respective components independently, after which they need to come to a consensus on the final grading.

In almost all cases the panel agreed to the final score and to the constituent sub-scores per component, and found that the criteria had been completed properly. However, the panel found that only in a handful of cases, the evaluation form contained insightful feedback that explained the assessors' appreciation of the criteria or the grades. According to the panel additional feedback is all the more important for the accountability of the assessment towards external reviewers given that the thesis product, which is reviewed by an external body like the panel, only counts for one third of the grade. In this way, there is no feedback—apart from ticked appreciations per criterion—on the thesis work or the presentation that together account for two thirds of the final grade.

Students mentioned to the panel that in addition to formative feedback during the thesis trajectory, they also received oral feedback after the presentation. The management and staff admitted that the evaluation form does not invite qualitative feedback. They indicated moreover that they are looking into adapting the form following comments from the assessment committee, who had recently

recommended to use rubrics and stimulate the use of free text to motivate the rationale behind the marks.

The panel welcomes these intentions and strongly encourages management and staff to make the thesis evaluation form more insightful and thus to enhance its accountability both internally and externally. Furthermore, the panel could not establish on the basis of the evaluation forms whether the assessors had come to an independent judgement before settling for a common final grade after the thesis presentation. The panel therefore suggests the programme management to reflect how the independent opinions can be reported on the evaluation form.

Examination Board
The quality of assessment and the end level of the joint master's programme Computer Science are safeguarded by a subcommittee of the Examination Board at faculty level. There is one subcommittee, which consists of three members, for all bachelor and master programmes in Information Science. The panel learned that in view of the joint degree, it is provided that a staff member of the UvA can join the subcommittee but that currently nobody is officially appointed. The panel acknowledges that the arrangements at university and faculty level are sufficient to coordinate the assessment rules and regulations among the two institutions. Nonetheless, the panel would welcome a systematic presence of an UvA representative on the Examination subcommittee: similar arrangements at the UvA show that the involvement of the VU member of the Examination Board adds value to the deliberations on the joint degree master's programme Computational Science.

In order to safeguard the quality of assessment and implement the above-mentioned examination policy, the Examination Board has established an assessment committee which is composed of one member per subcommittee. Its tasks are to check through samples of courses and theses that examiners adhere to the provisions of the examination policy. The panel gathered from the discussion with representatives of the Examination Board and assessment committee that the quality assurance of student assessment is organised properly and that the individual members have adequate experience to fulfil their various tasks. The panel learned that the assessment committee's checks of the courses did not raise particular concerns, whereas it did have recommendations on the way thesis evaluation forms were completed. The panel shares the concerns and recommendations of the assessment committee in this regard and suggests that the committee continue to monitor and report on the quality of the written feedback in the thesis evaluation.

Considerations
The panel considers that student assessment is well organised in the joint master's programme Computer Science. There are adequate arrangements in place to synchronise the rules and regulations between the two institutions. In so far as the VU is concerned, the programme features a clear faculty-wide examination policy that is respected by the course coordinators and controlled by the assessment committee, but still requires a secure administrative reporting system. According to the panel, this examination policy will provide a strong foundation for the quality and validity of the assessment when it has been fully implemented.

The policy and principles underlying course assessments are up to standard. The course assessments are valid, reliable and transparent. Moreover, the panel appreciates that the programme is taking fraud seriously.

Based on its own sample review, the panel considers that the grading process of the theses is clear but that the evaluation form does not invite assessors to motivate their grades. Moreover, given that the thesis product only accounts for one third of the final grade, the overall accountability of the thesis assessment towards external bodies is limited. In this regard, the panel welcomes the intentions of the management to adjust the thesis evaluation form accordingly. Moreover, the panel suggests to further increase the quality of the thesis assessment by asking each assessor to report his/her independent opinion separately on the evaluation form.

According to the panel, the quality of the assessment is safeguarded properly by the faculty-wide Examination Board, its subcommittee for the computer science programmes and its assessment committee. The individual members have good expertise to deal with their respective tasks. The panel invites UvA to delegate a member to the Examination subcommittee. Moreover, it encourages the assessment committee to verify in its thesis review sample that the scores on the assessment criteria and components are motivated in an insightful way.

Conclusion
Master's programme Computer Science (joint degree): the panel assesses Standard 3 as *meets the standard.*

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

Findings

Thesis quality
In order to establish whether students achieve the intended learning outcomes, the panel reviewed a sample of fifteen master's theses representing all specialisation tracks that were accepted in the academic years 2016-2017, 2017-2018 and 2018-2019. The master project is an individual research project of 30 EC and intended as a final proof of competence involving an element of originality or creativity; students are expected to select a suitable thesis subject and find a staff member at VU or UvA who acts as supervisor. Students who wish to do so, can perform their thesis research at a company.

The panel found that each of the fifteen theses were of a quality that can be expected of a final project at master's level. In several cases the quality of the work was high and the topics were varied and interesting. The theses that according to the panel deserved a high score had a strong research question, a decent methodological approach and a thorough analysis of the research question. In a few cases the panel thought that the thesis could have referred more explicitly to the ethical and legal aspects of the research.

In a previous section, the panel considered that through the individual courses, the curriculum allows students to acquire the programme's intended learning outcomes. Having reviewed a selection of master's projects, the panel considers that students who successfully pass the thesis have indeed achieved all intended learning outcomes. Moreover, the panel noticed that the master's thesis delivers on its rationale: it is a final test where students demonstrate through an individual research endeavour that they have the competences to bring together the knowledge and insights they have acquired before.

Alumni
In addition to verifying the quality of the final deliverables, the academic and/or labour market performance of master graduates is another way to establish whether students achieve the intended learning outcomes upon completion of the programme. Both the information materials and the discussions indicated that master graduates are effective in pursuing a career in either academia or industry. While most alumni find relevant employment on the labour market, a few graduates do enter a PhD programme. In this regard the panel acknowledges with satisfaction that the programme is delivering on its double ambition, i.e. to prepare its students for entering a PhD trajectory and for taking up an IT-related position in industry.

Furthermore, the panel welcomes the efforts of the programme, in reply to the recommendation of the previous accreditation committee, to develop an alumni network and organise alumni events, together with the study association, in such a way that alumni become role models for current computer science students.

Considerations
Based on its review of the final thesis projects and the discussions on site, the panel considers that master's students who graduate from the joint degree programme in Computer Science are adequately prepared for a career in industry or academia.

Having established that each thesis in the sample meets at least the minimum requirements of what can be expected of a final project at master level—and often is of higher quality—it is fair to state that the intended learning outcomes of the programme are eventually achieved at the end of the master's curriculum.

The panel welcomes the attention of the programme for its master graduates and considers that these alumni constitute a good basis for information and advice on the quality and relevance of the programme. Furthermore, the panel appreciates that some of the events recently initiated by the programme and the study association are set up in such a way that alumni become role models for current computer science students.

Conclusion
Master's programme Computer Science (joint degree): the panel assesses Standard 4 as *meets the standard.*

GENERAL CONCLUSION

In the previous sections, the panel has come to the conclusion that the master's programme Computer Science, which is offered as a joint degree by the Vrije Universiteit Amsterdam and the University of Amsterdam, fulfils the quality requirements with regard to each of the four standards set by the NVAO's Assessment Framework for the higher Education Accreditation System of The Netherlands for limited programme assessments: intended learning outcomes, teaching-learning environment, student assessment, and achieved learning outcomes. Hence, the panel's overall assessment of the *master's programme Computer Science (joint degree)* is 'positive'.

APPENDICES

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

Not applicable.

APPENDIX 2: INTENDED LEARNING OUTCOMES

Master's programme Computer Science (joint degree)

A graduate of the Masters programme in Computer Science:

1. Possesses solid academic knowledge and insight in the field of computer science, including the required background knowledge from other academic disciplines, which builds upon and goes beyond the level of a Bachelor's degree.
2. Has knowledge, insight and skills of a specialist nature in at least one area of computer science (additional final attainment levels to be given for each specialisation separately).
3. Is able to acquire specialist knowledge, insights and skills in other areas of computer science within a reasonable period of time.
4. Has acquired practical skills in relevant sub-areas of the field of computer science at Master level.
5. Is aware of the applications of computer science in general and of the chosen specialisation in particular, and is able to apply his/her knowledge and skills to new or otherwise unknown problems.
6. Is capable of designing a research or project plan on the basis of a realistic problem description in the field of computer science and can contribute to its progress with original solutions.
7. Is able to carry out research independently, both individually and in small teams.
8. Is able to consult and use the international professional literature in the relevant sub-areas of the field of computer science.
9. Is able to formulate, analyse and evaluate scientific results, and to use them to draw conclusions.
10. Is able to function in professional situations in an international context where scientific knowledge and skills in computer science are required.
11. Has developed a critical, scientific attitude and has a societal perspective on information technology.
12. Is able to communicate with others at a professional level and can give clear oral and written presentations of the results of his/her work.

Is thoroughly prepared for further education at doctorate level or for further postgraduate education as a professional computer scientist.

Beyond the general requirements of a Computer Science Master, the graduate of **Big Data Engineering** is expected to have acquired knowledge, competences, and insight on:

- BDE-1. Architecture and scalability of data processing platforms and their programming models;
- BDE-2. The world wide web as a global information source;
- BDE-3. Conducting experiments on data processing systems, and be able to properly interpret data that result from such experiments.

Beyond the general requirements of a Computer Science Master, the graduate of **Computer Systems Security** is expected to have acquired knowledge, competences, and insight on:

- CSS-1. Security issues in system-level software including weaknesses and defences;
- CSS-2. Static and dynamic analysis techniques for software (benign and malicious);
- CSS-3. Security implications of modern hardware features (side channels, hardware bugs, and hardware-based protection).

Beyond the general requirements of a Computer Science Master, the graduate of **Foundations of Computing and Concurrency** is expected to have acquired knowledge, competences, and insight on:

- FCC-1. Models of computation;
- FCC-2. Models of concurrency;

- FCC-3. Automated verification.

Beyond the general requirements of a Computer Science Master, the graduate of **Internet and Web Technology** is expected to have acquired knowledge, competences, and insight on:

- IWT-1. Distributed computer systems, notably in the form of capabilities for designing networked systems and with emphasis on efficient information processing on the Internet;
- IWT-2. Programming large and complex pieces of (possibly low-level) systems-oriented software.
- IWT-3. Conducting experiments on networked applications and distributed systems, and be able to properly interpret data that result from such experiments.

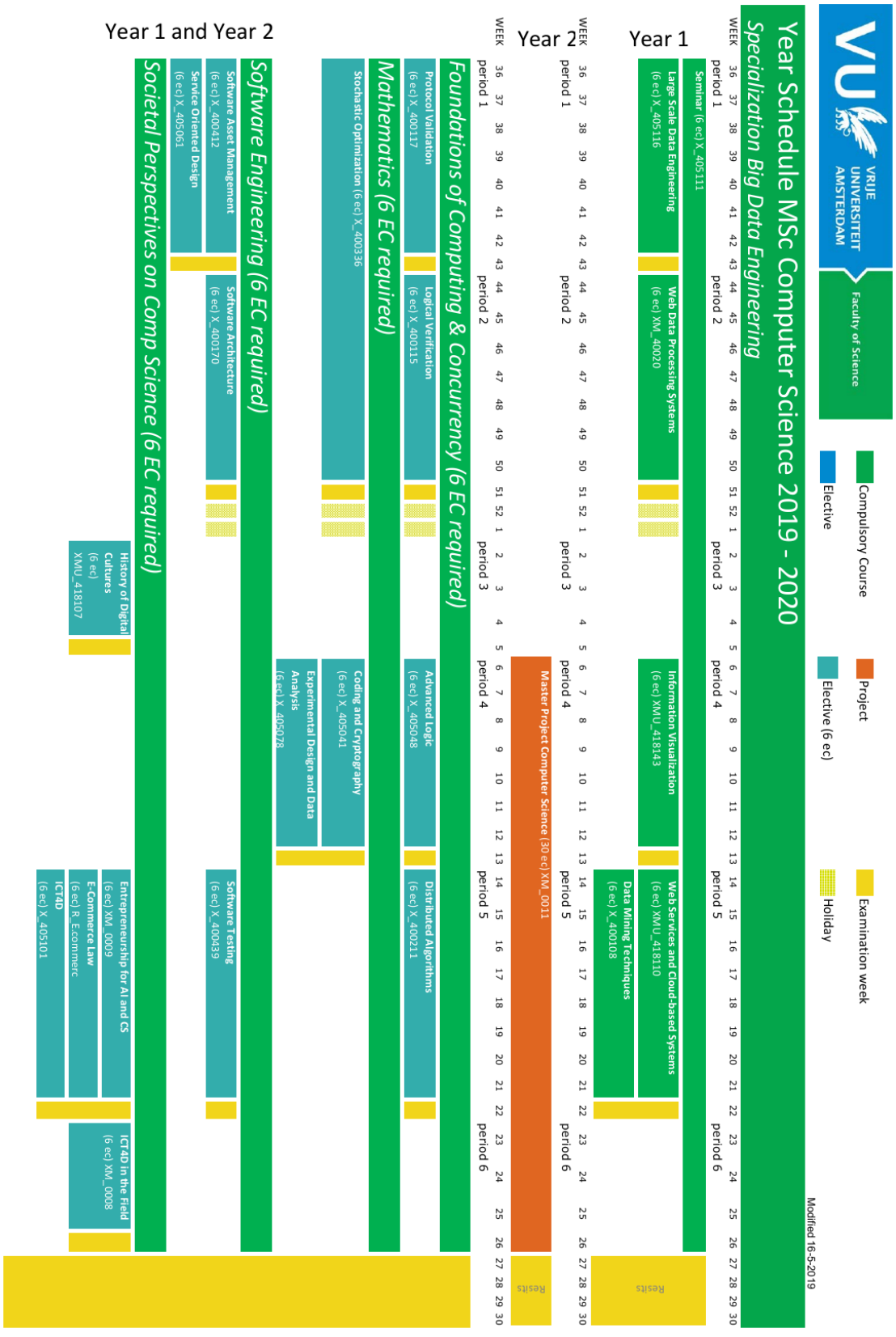
Beyond the general requirements of a Computer Science Master, the graduate **Parallel Computing Systems** is expected to have acquired knowledge, competences, and insight on:

- PCS-1. Design and architecture of parallel and distributed computing systems;
- PCS-2. Performance and efficiency of application programs and the related runtime systems and middleware services;
- PCS-3. Conducting experiments as a means for the analysis of high-performance systems, and be able to properly interpret data that result from such experiments.

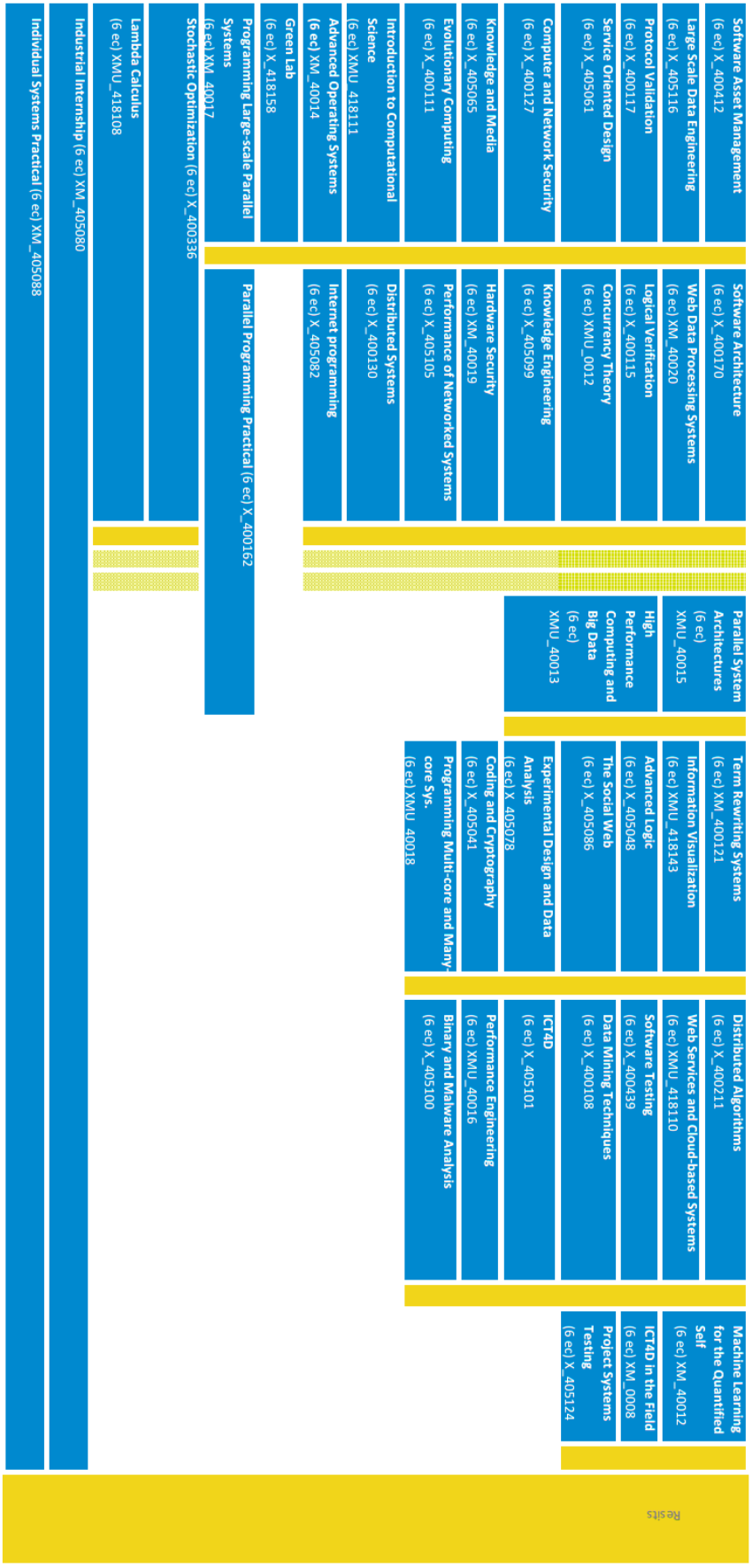
Beyond the general requirements of a Computer Science Master, the graduate of **Software Engineering and Green IT** is expected to have acquired knowledge, competences, and insight on:

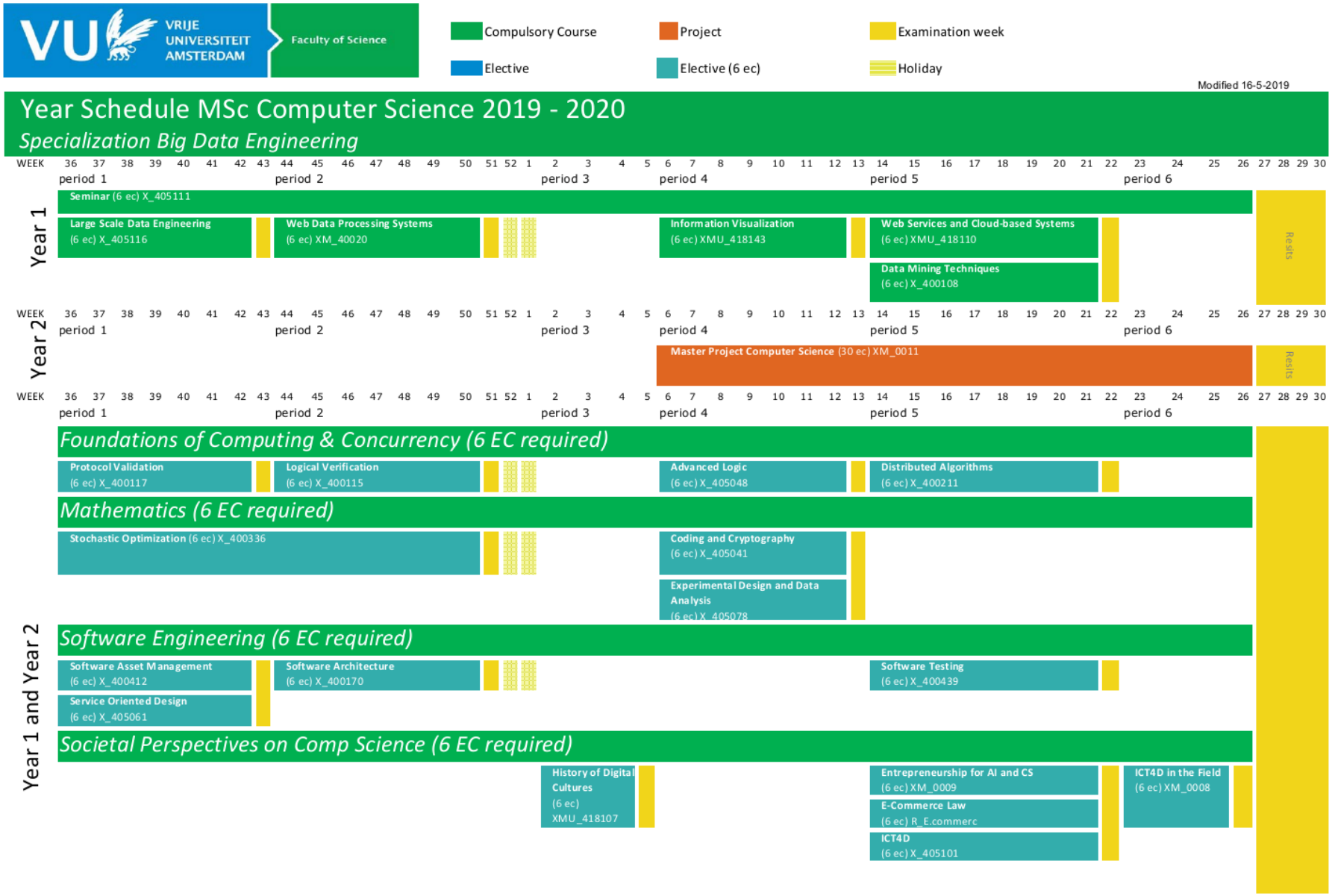
- SEG-1. Reconciling conflicting software project objectives, finding acceptable compromises within limitations of cost, time, knowledge, existing systems, organisations, and societal aspects of software technology;
- SEG-2. Understanding and applying current theories, models and techniques that provide a basis for decision making on IT investment issues, problem identification and analysis, software architecture, software design, development, implementation, testing, documentation and reengineering;
- SEG-3. Designing and conducting experiments (and empirical studies in general) to analyse and assess the relation between software systems, energy efficiency and sustainability issues.

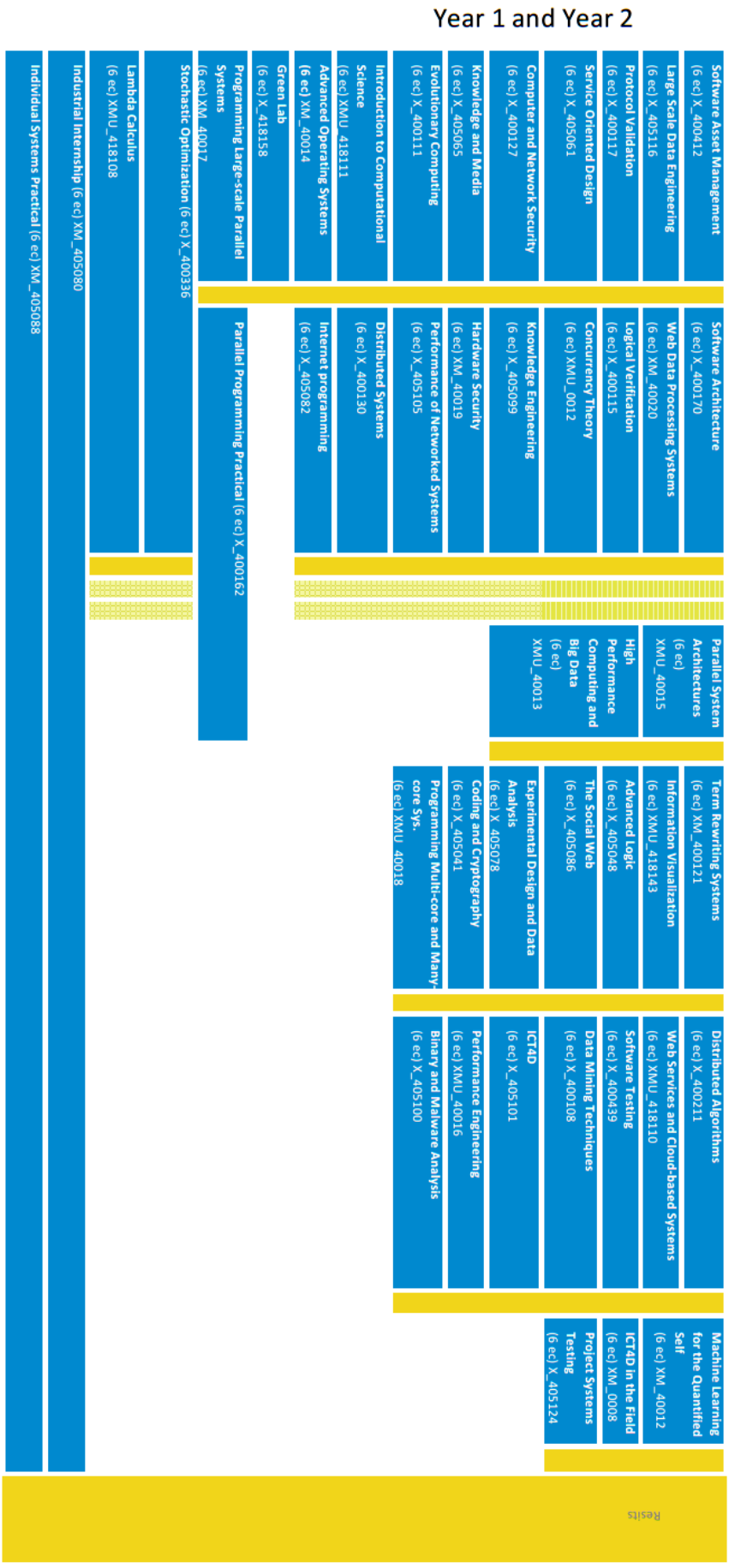
APPENDIX 3: OVERVIEW OF THE CURRICULUM



Year 1 and Year 2




VU VRIJE UNIVERSITEIT AMSTERDAM
Faculty of Science
Compulsory Course
Project
Examination week
Elective
Elective (6 ec)
Holiday
Modified 16-5-2019
Year Schedule MSc Computer Science 2019 - 2020
Specialization Big Data Engineering
WEEK 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
period 1 period 2 period 3 period 4 period 5 period 6
Year 1
Seminar (6 ec) X_405111
Large Scale Data Engineering (6 ec) X_405116
Web Data Processing Systems (6 ec) XM_40020
Information Visualization (6 ec) XMU_418143
Web Services and Cloud-based Systems (6 ec) XMU_418110
Data Mining Techniques (6 ec) X_400108
Resits
Year 2
Master Project Computer Science (30 ec) XM_0011
Resits
Year 1 and Year 2
Foundations of Computing & Concurrency (6 EC required)
Protocol Validation (6 ec) X_400117
Logical Verification (6 ec) X_400115
Advanced Logic (6 ec) X_405048
Distributed Algorithms (6 ec) X_400211
Mathematics (6 EC required)
Stochastic Optimization (6 ec) X_400336
Coding and Cryptography (6 ec) X_405041
Experimental Design and Data Analysis (6 ec) X_405078
Software Engineering (6 EC required)
Software Asset Management (6 ec) X_400412
Service Oriented Design (6 ec) X_405061
Software Architecture (6 ec) X_400170
Software Testing (6 ec) X_400439
Societal Perspectives on Comp Science (6 EC required)
History of Digital Cultures (6 ec) XMU_418107
Entrepreneurship for AI and CS (6 ec) XM_0009
E-Commerce Law (6 ec) R_E.commerc
ICT4D (6 ec) X_405101
ICT4D in the Field (6 ec) XM_0008


Year 1 and Year 2
Software Asset Management (6 ec) X_400412
Large Scale Data Engineering (6 ec) X_405116
Protocol Validation (6 ec) X_400117
Service Oriented Design (6 ec) X_405061
Computer and Network Security (6 ec) X_400127
Knowledge and Media (6 ec) X_405065
Evolutionary Computing (6 ec) X_400111
Introduction to Computational Science (6 ec) XMU_418111
Advanced Operating Systems (6 ec) XM_40014
Green Lab (6 ec) X_418158
Programming Large-scale Parallel Systems (6 ec) XM_40017
Stochastic Optimization (6 ec) X_400336
Lambda Calculus (6 ec) XMU_418108
Industrial Internship (6 ec) XM_405080
Individual Systems Practical (6 ec) XM_405088
Software Architecture (6 ec) X_400170
Web Data Processing Systems (6 ec) XM_40020
Logical Verification (6 ec) X_400115
Concurrency Theory (6 ec) XMU_0012
Knowledge Engineering (6 ec) X_405099
Hardware Security (6 ec) XM_40019
Performance of Networked Systems (6 ec) X_405105
Distributed Systems (6 ec) X_400130
Internet programming (6 ec) X_405082
Parallel Programming Practical (6 ec) X_400162
Parallel System Architectures (6 ec) XMU_40015
High Performance Computing and Big Data (6 ec) XMU_40013
Term Rewriting Systems (6 ec) XM_400121
Information Visualization (6 ec) XMU_418143
Advanced Logic (6 ec) X_405048
The Social Web (6 ec) X_405086
Experimental Design and Data Analysis (6 ec) X_405078
Coding and Cryptography (6 ec) X_405041
Programming Multi-core and Many-core Sys. (6 ec) XMU_40018
Distributed Algorithms (6 ec) X_400211
Web Services and Cloud-based Systems (6 ec) XMU_418110
Software Testing (6 ec) X_400439
Data Mining Techniques (6 ec) X_400108
ICT4D (6 ec) X_405101
Performance Engineering (6 ec) XMU_40016
Binary and Malware Analysis (6 ec) X_405100
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ICT4D in the Field (6 ec) XM_0008
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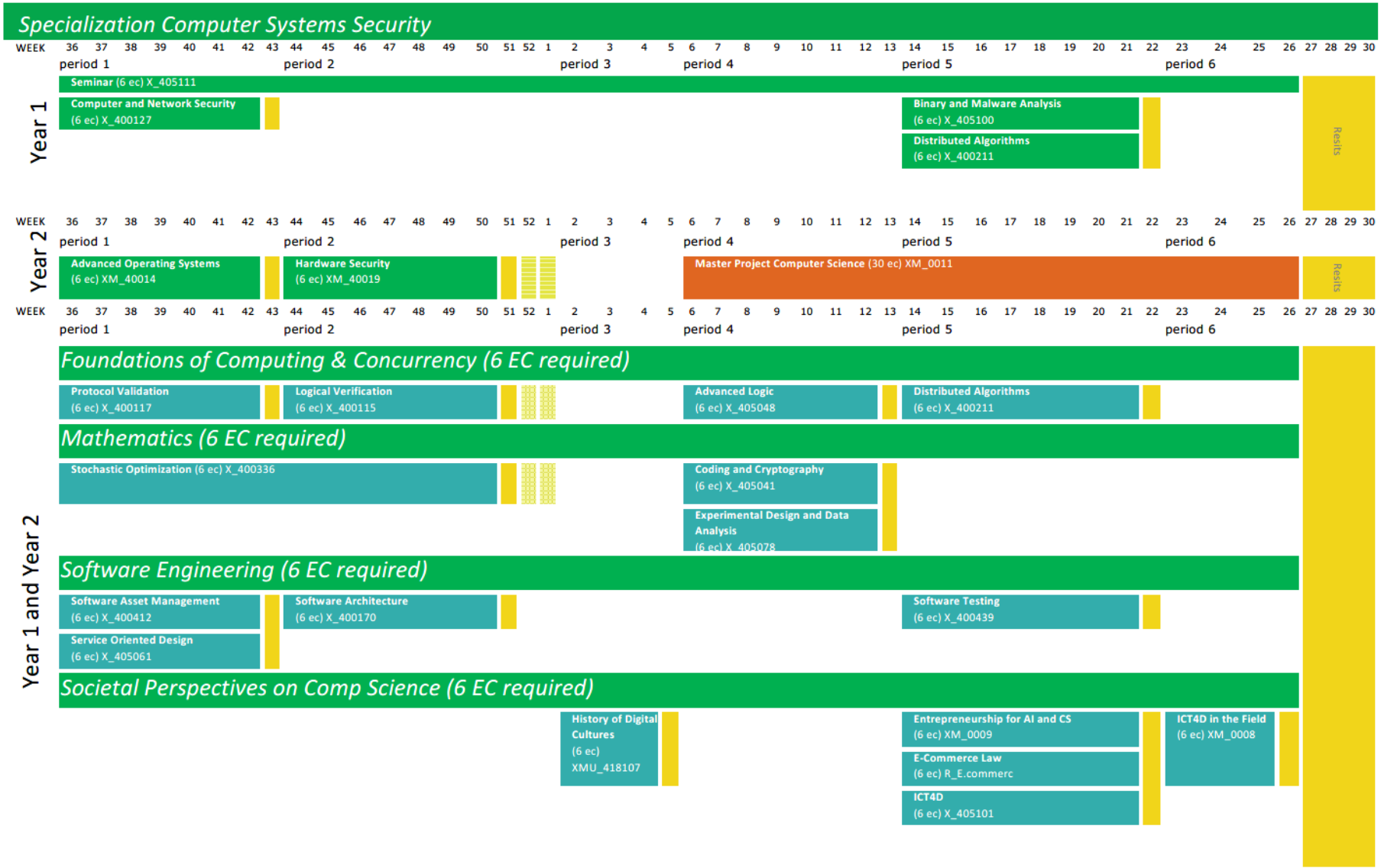
Results


Specialization Computer Systems Security
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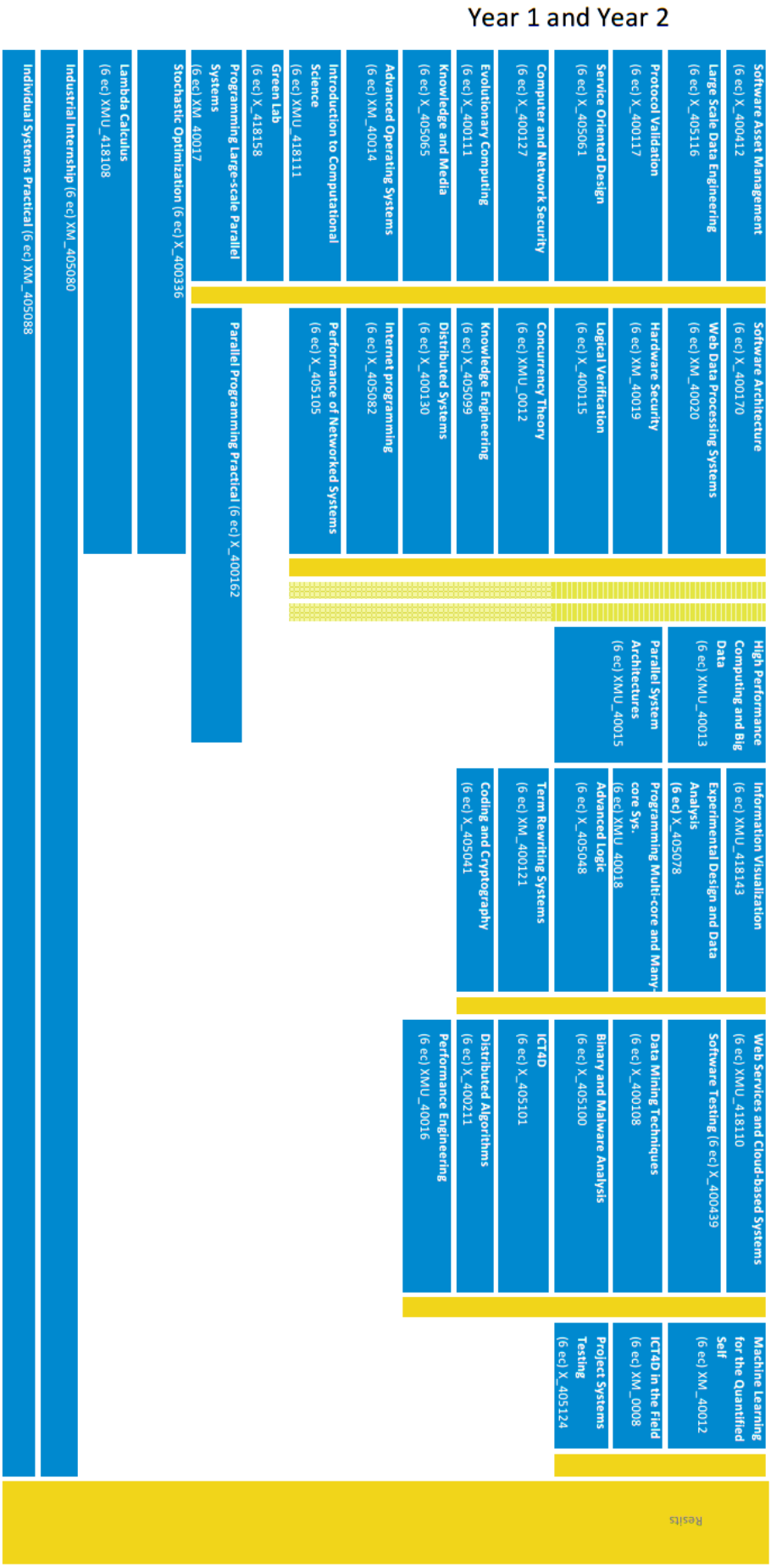
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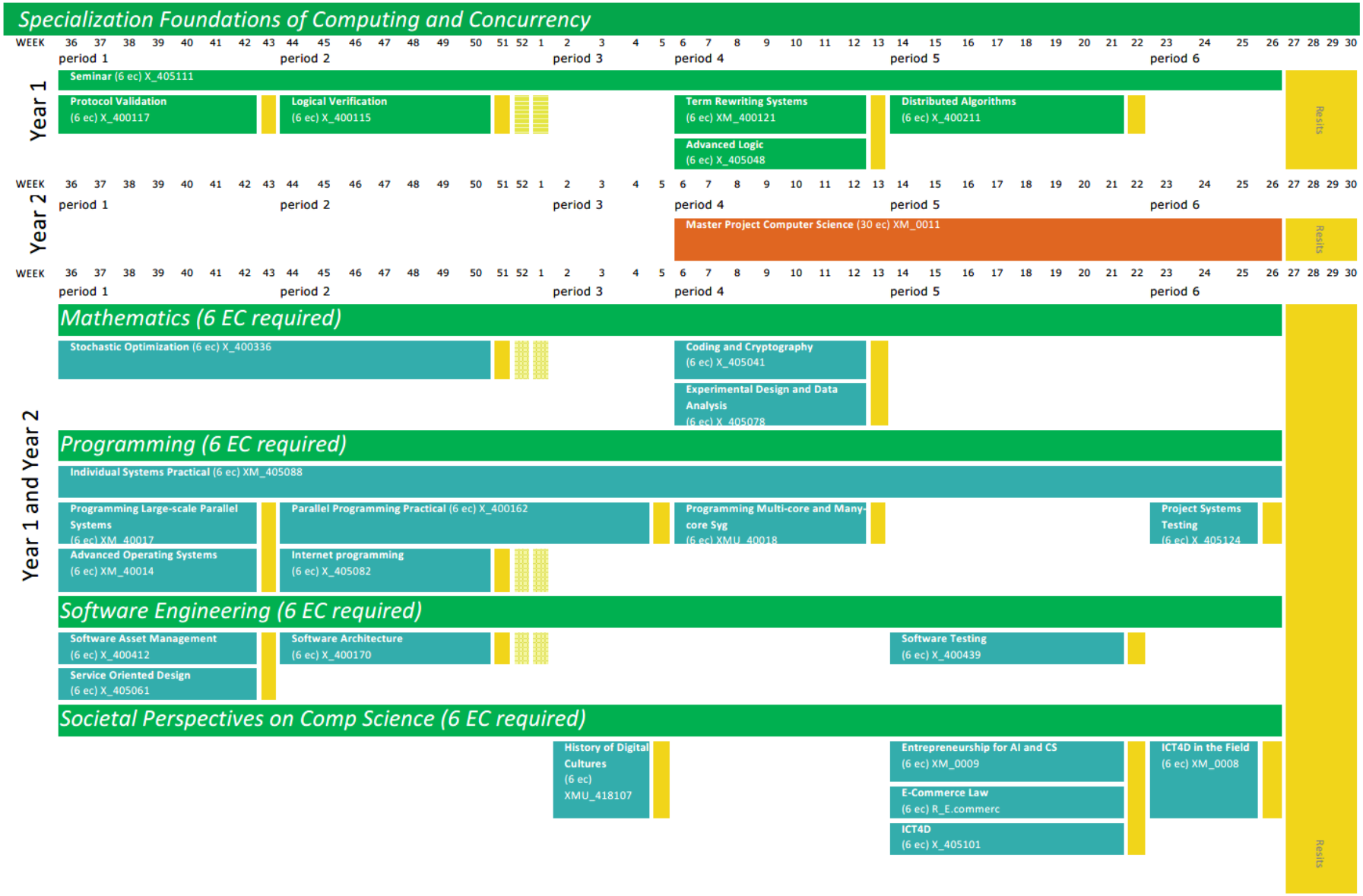
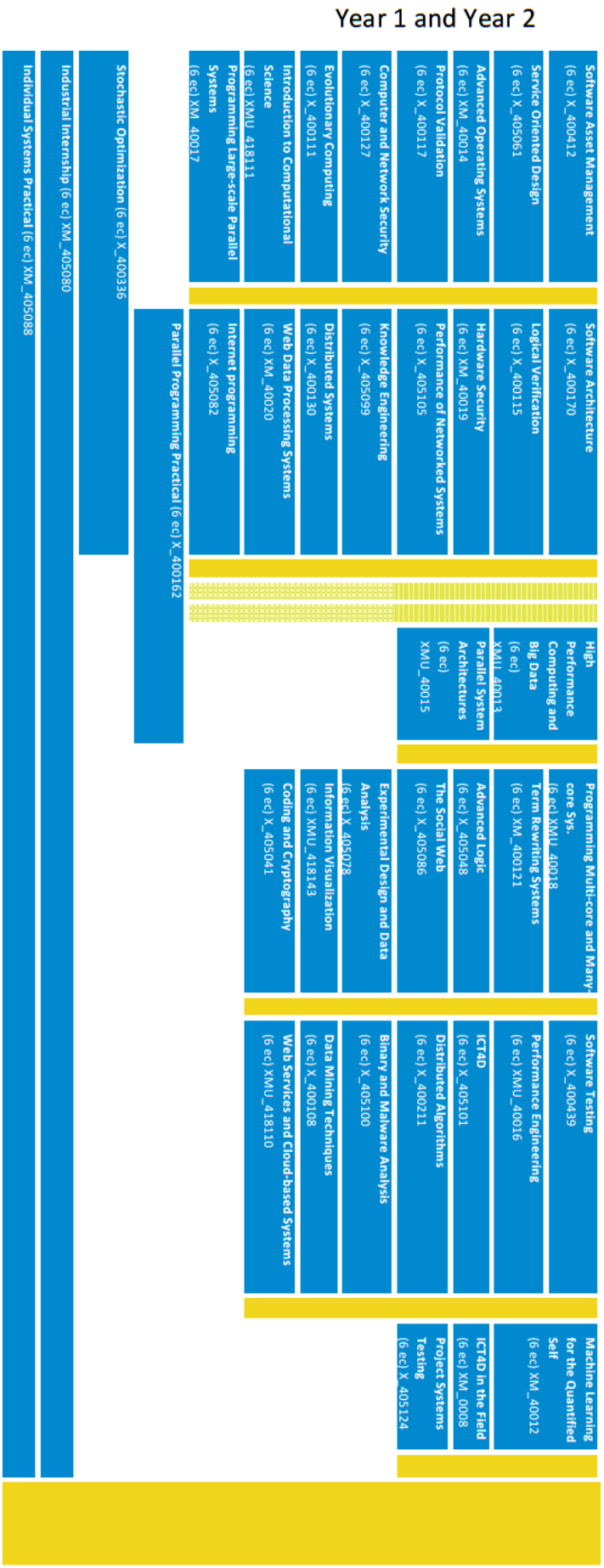
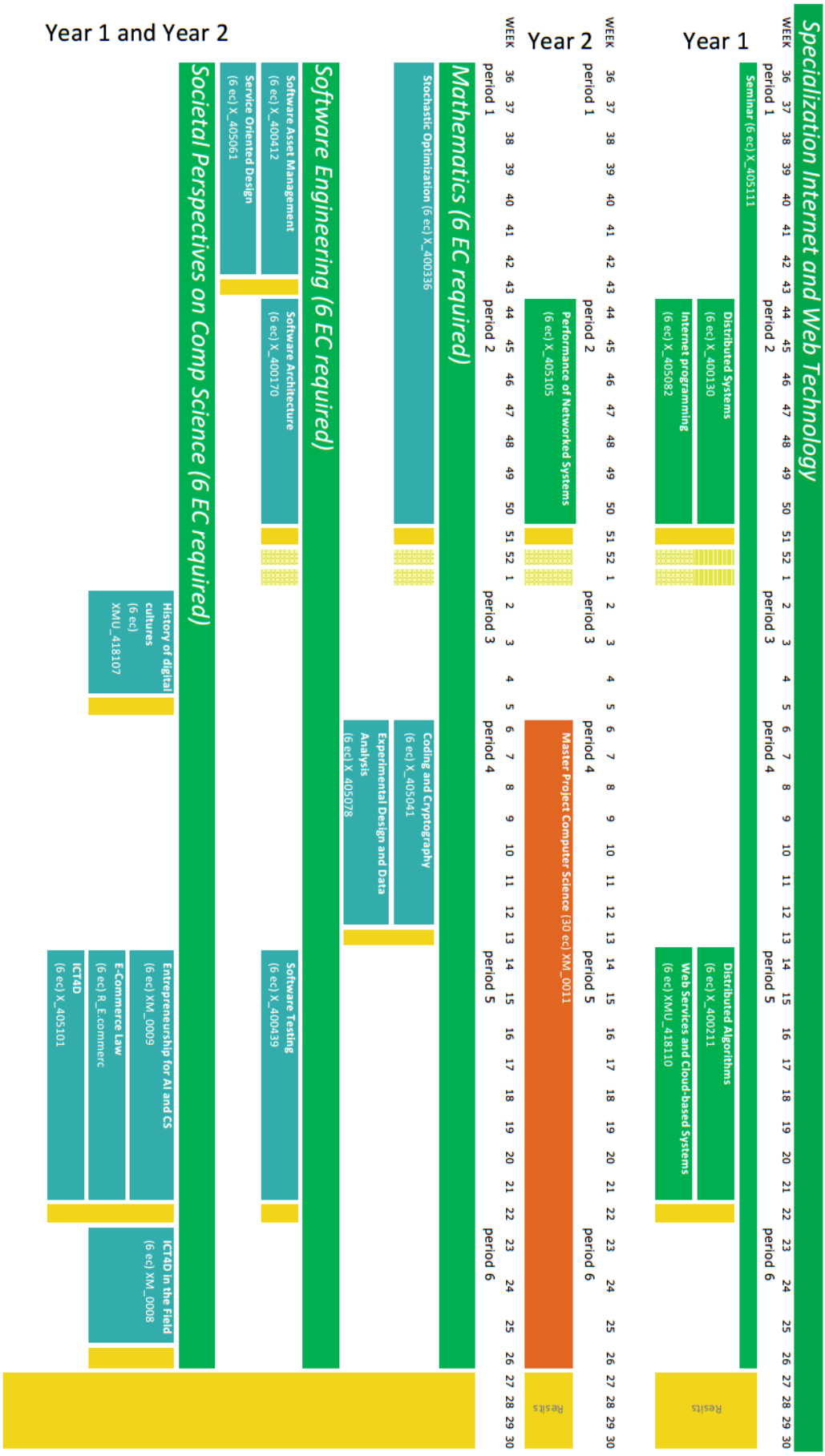
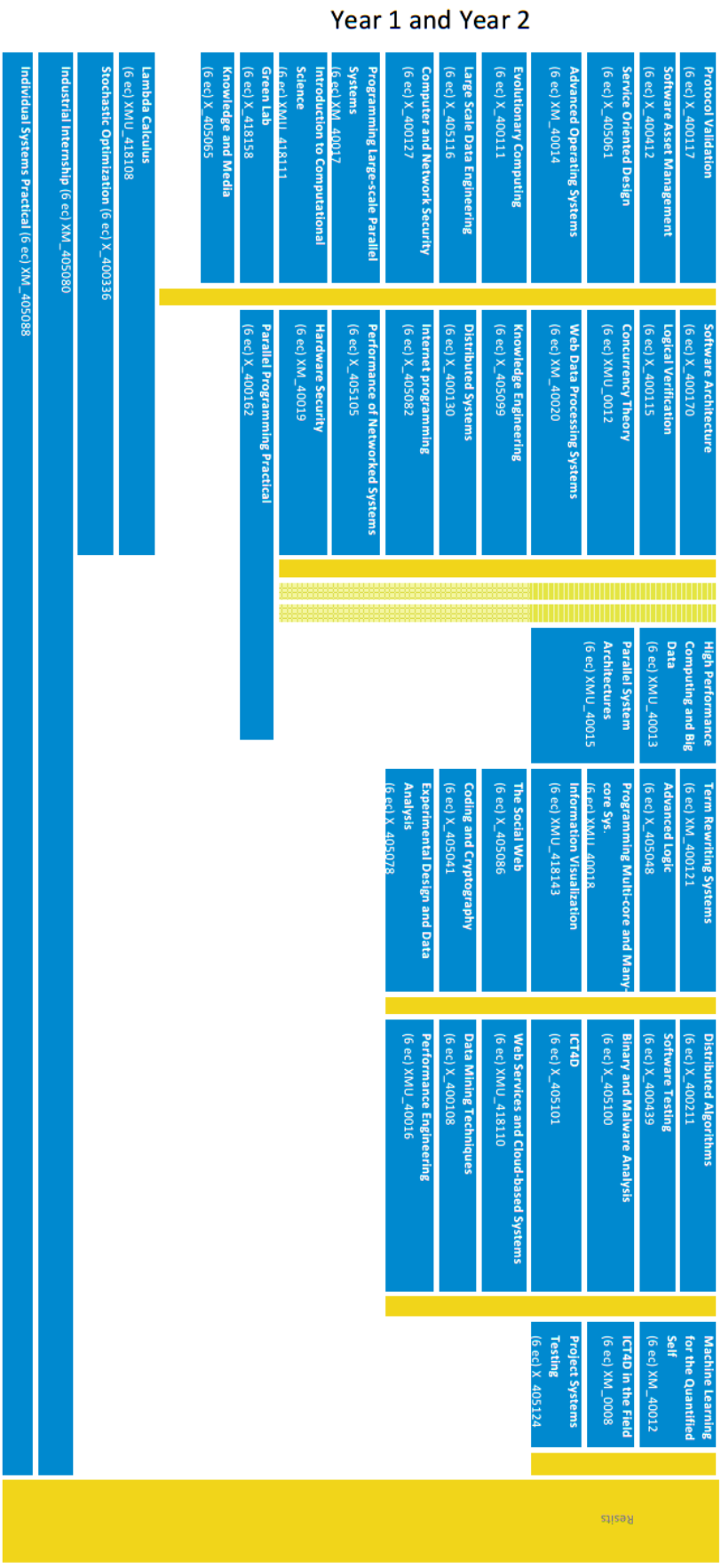
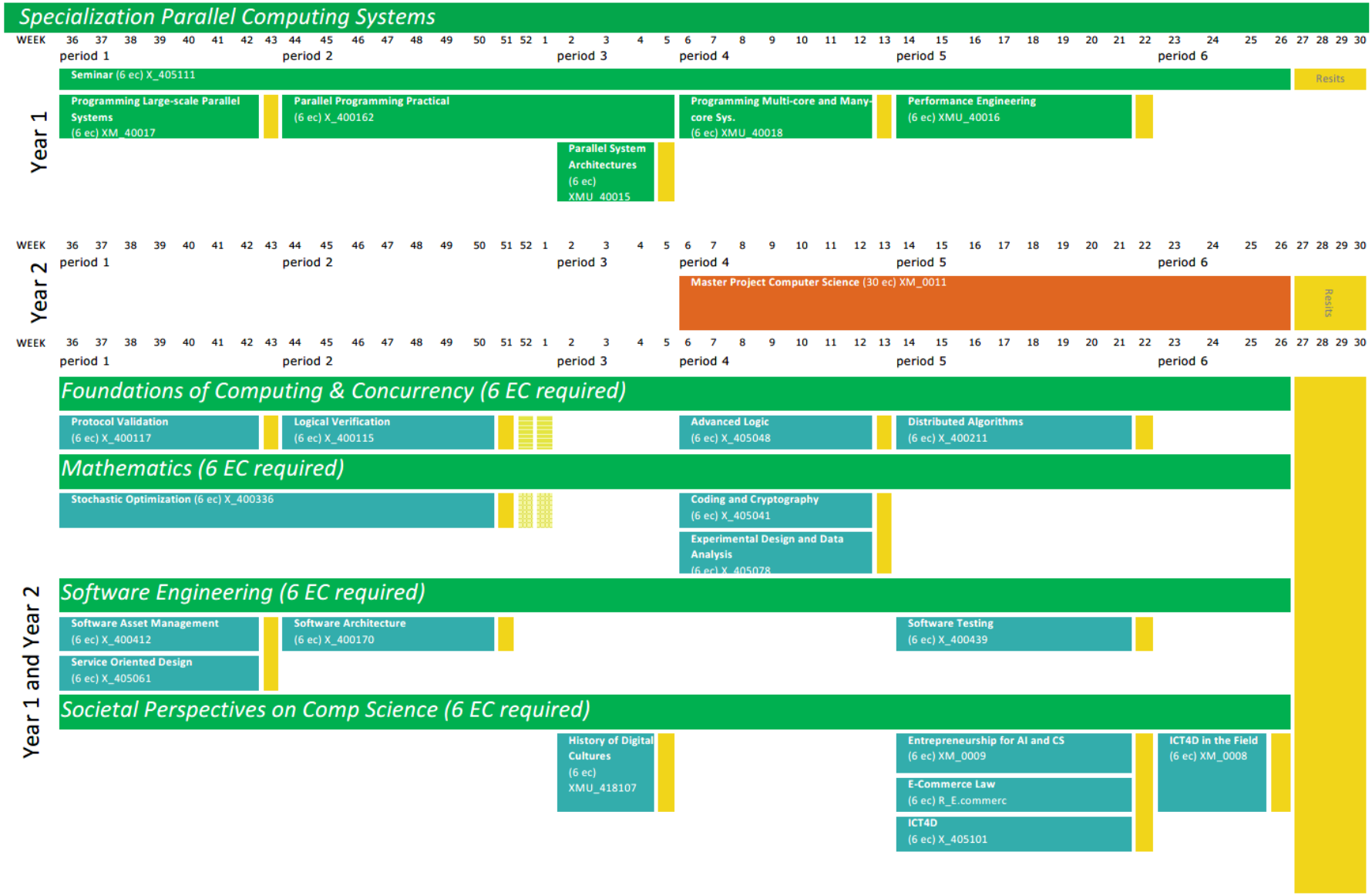
Parallel Programming Practical (6 ec) X_400162
High Performance Computing and Big Data (6 ec) XMU_40013
Parallel System Architectures (6 ec) XMU_40015
Information Visualization (6 ec) XMU_418143
Experimental Design and Data Analysis (6 ec) X_405078
Programming Multi-core and Many-core Sys. (6 ec) XMU_40018
Advanced Logic (6 ec) X_405048
Term Rewriting Systems (6 ec) XM_400121
Coding and Cryptography (6 ec) X_405041
Web Services and Cloud-based Systems (6 ec) XMU_418110
Software Testing (6 ec) X_400439
Data Mining Techniques (6 ec) X_400108
Binary and Malware Analysis (6 ec) X_405100
ICT4D (6 ec) X_405101
Distributed Algorithms (6 ec) X_400211
Performance Engineering (6 ec) XMU_40016
Machine Learning for the Quantified Self (6 ec) XM_40012
ICT4D in the Field (6 ec) XM_0008
Project Systems Testing (6 ec) X_405124
Results


Specialization Foundations of Computing and Concurrency
WEEK 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
period 1 period 2 period 3 period 4 period 5 period 6
Year 1
Seminar (6 ec) X_405111
Protocol Validation (6 ec) X_400117
Logical Verification (6 ec) X_400115
Term Rewriting Systems (6 ec) XM_400121
Advanced Logic (6 ec) X_405048
Distributed Algorithms (6 ec) X_400211
Resits
Year 2
Master Project Computer Science (30 ec) XM_0011
Year 1 and Year 2
Mathematics (6 EC required)
Stochastic Optimization (6 ec) X_400336
Coding and Cryptography (6 ec) X_405041
Experimental Design and Data Analysis (6 ec) X_405078
Programming (6 EC required)
Individual Systems Practical (6 ec) XM_405088
Programming Large-scale Parallel Systems (6 ec) XM_40017
Advanced Operating Systems (6 ec) XM_40014
Parallel Programming Practical (6 ec) X_400162
Internet programming (6 ec) X_405082
Programming Multi-core and Many-core Syg (6 ec) XMU_40018
Project Systems Testing (6 ec) X_405124
Software Engineering (6 EC required)
Software Asset Management (6 ec) X_400412
Service Oriented Design (6 ec) X_405061
Software Architecture (6 ec) X_400170
Software Testing (6 ec) X_400439
Societal Perspectives on Comp Science (6 EC required)
History of Digital Cultures (6 ec) XMU_418107
Entrepreneurship for AI and CS (6 ec) XM_0009
E-Commerce Law (6 ec) R_E.commerc
ICT4D (6 ec) X_405101
ICT4D in the Field (6 ec) XM_0008
Resits

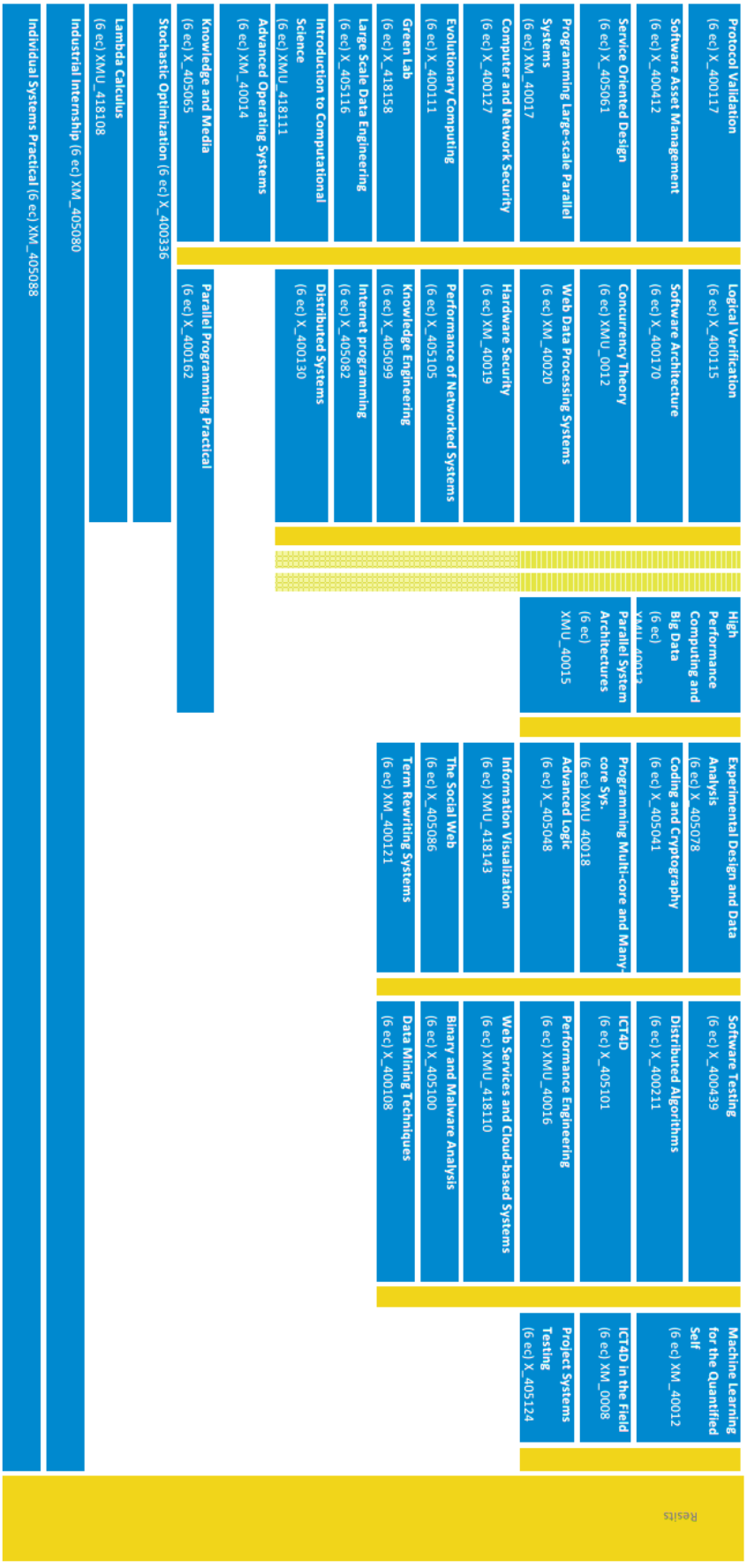

Year 1 and Year 2
Software Asset Management (6 ec) X_400412
Service Oriented Design (6 ec) X_405061
Advanced Operating Systems (6 ec) XM_40014
Protocol Validation (6 ec) X_400117
Computer and Network Security (6 ec) X_400127
Evolutionary Computing (6 ec) X_400111
Introduction to Computational Science (6 ec) XMU_418111
Programming Large-scale Parallel Systems (6 ec) XM_40017
Software Architecture (6 ec) X_400170
Logical Verification (6 ec) X_400115
Hardware Security (6 ec) XM_40019
Performance of Networked Systems (6 ec) X_405105
Knowledge Engineering (6 ec) X_405099
Distributed Systems (6 ec) X_400130
Web Data Processing Systems (6 ec) XM_40020
Internet programming (6 ec) X_405082
High Performance Computing and Big Data (6 ec) XMU_40013
Parallel System Architectures (6 ec) XMU_40015
Programming Multi-core and Many-core Sys. (6 ec) XMU_40018
Term Rewriting Systems (6 ec) XM_400121
Advanced Logic (6 ec) X_405048
The Social Web (6 ec) X_405086
Experimental Design and Data Analysis (6 ec) X_405078
Information Visualization (6 ec) XMU_418143
Coding and Cryptography (6 ec) X_405041
Software Testing (6 ec) X_400439
Performance Engineering (6 ec) XMU_40016
ICT4D (6 ec) X_405101
Distributed Algorithms (6 ec) X_400211
Binary and Malware Analysis (6 ec) X_405100
Data Mining Techniques (6 ec) X_400108
Web Services and Cloud-based Systems (6 ec) XMU_418110
Machine Learning for the Quantified Self (6 ec) XM_40012
ICT4D in the Field (6 ec) XM_0008
Project Systems Testing (6 ec) X_405124
Parallel Programming Practical (6 ec) X_400162
Stochastic Optimization (6 ec) X_400336
Industrial Internship (6 ec) XM_405080
Individual Systems Practical (6 ec) XM_405088

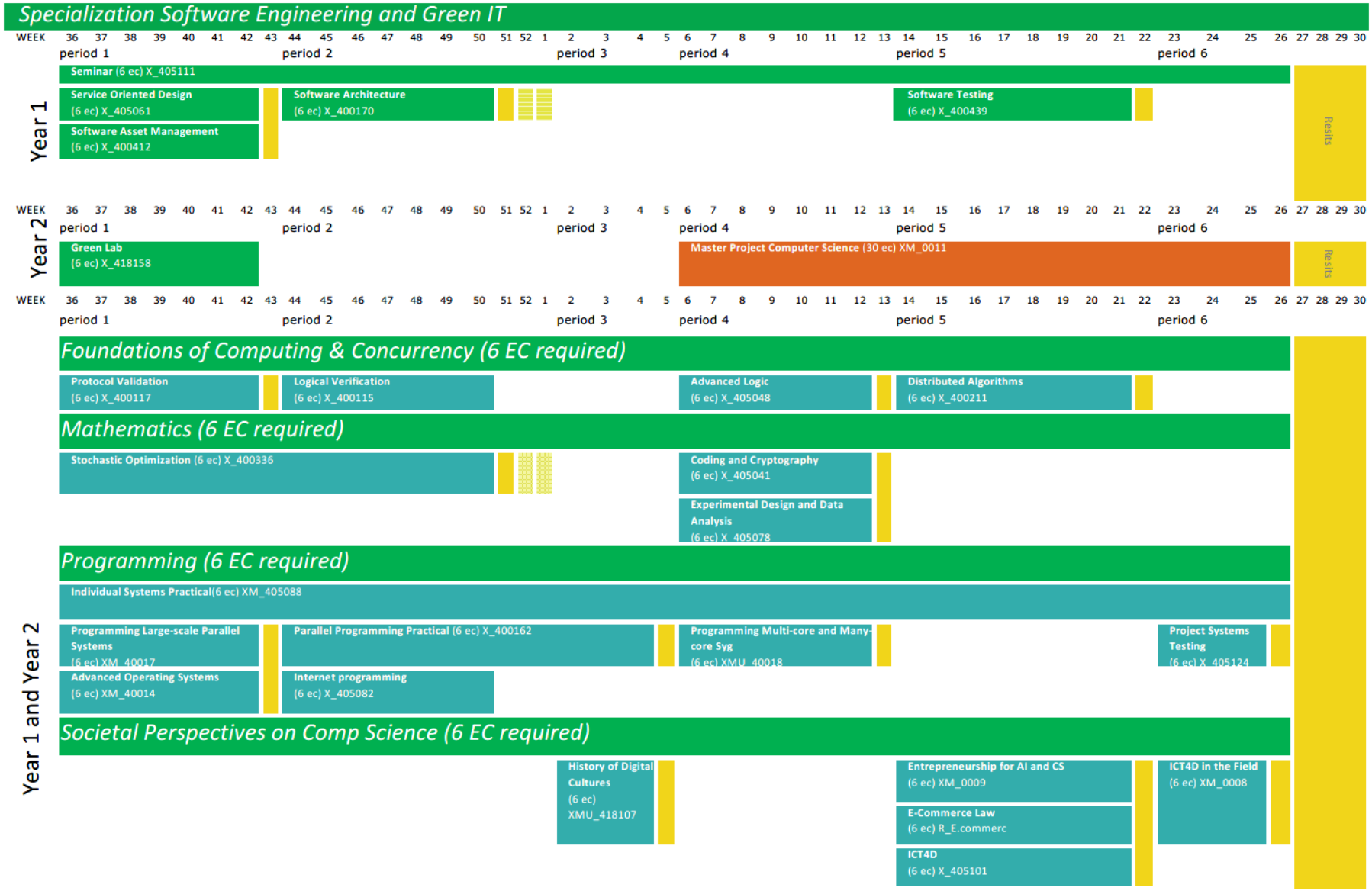

Specialization Internet and Web Technology
Year 1
Year 2
Year 1 and Year 2
Seminar (6 ec) X_405111
Distributed Systems (6 ec) X_400130
Internet programming (6 ec) X_405082
Distributed Algorithms (6 ec) X_400211
Web Services and Cloud-based Systems (6 ec) XMU_418110
Performance of Networked Systems (6 ec) X_405105
Master Project Computer Science (30 ec) XM_0011
Results
Mathematics (6 EC required)
Stochastic Optimization (6 ec) X_400336
Coding and Cryptography (6 ec) X_405041
Experimental Design and Data Analysis (6 ec) X_405078
Software Engineering (6 EC required)
Software Asset Management (6 ec) X_400412
Software Architecture (6 ec) X_400170
Software Testing (6 ec) X_400439
Societal Perspectives on Comp Science (6 EC required)
Service Oriented Design (6 ec) X_405061
History of digital cultures (6 ec) XMU_418107
Entrepreneurship for AI and CS (6 ec) XM_0009
E-Commerce Law (6 ec) R_E.commerc
ICT4D (6 ec) X_405101
ICT4D in the Field (6 ec) XM_0008


Year 1 and Year 2
Protocol Validation (6 ec) X_400117
Software Asset Management (6 ec) X_400412
Service Oriented Design (6 ec) X_405061
Advanced Operating Systems (6 ec) XM_40014
Evolutionary Computing (6 ec) X_400111
Large Scale Data Engineering (6 ec) X_405116
Computer and Network Security (6 ec) X_400127
Programming Large-scale Parallel Systems (6 ec) XM_40017
Introduction to Computational Science (6 ec) XMU_418111
Green Lab (6 ec) X_418158
Knowledge and Media (6 ec) X_405065
Lambda Calculus (6 ec) XMU_418108
Stochastic Optimization (6 ec) X_400336
Industrial Internship (6 ec) XM_405080
Individual Systems Practical (6 ec) XM_405088
Software Architecture (6 ec) X_400170
Logical Verification (6 ec) X_400115
Concurrency Theory (6 ec) XMU_0012
Web Data Processing Systems (6 ec) XM_40020
Knowledge Engineering (6 ec) X_405099
Distributed Systems (6 ec) X_400130
Internet programming (6 ec) X_405082
Performance of Networked Systems (6 ec) X_405105
Hardware Security (6 ec) XM_40019
Parallel Programming Practical (6 ec) X_400162
High Performance Computing and Big Data (6 ec) XMU_40013
Parallel System Architectures (6 ec) XMU_40015
Term Rewriting Systems (6 ec) XM_400121
Advanced Logic (6 ec) X_405048
Programming Multi-core and Many-core Sys. (6 ec) XMU_40018
Information Visualization (6 ec) XMU_418143
The Social Web (6 ec) X_405086
Coding and Cryptography (6 ec) X_405041
Experimental Design and Data Analysis (6 ec) X_405078
Distributed Algorithms (6 ec) X_400211
Software Testing (6 ec) X_400439
Binary and Malware Analysis (6 ec) X_405100
ICT4D (6 ec) X_405101
Web Services and Cloud-based Systems (6 ec) XMU_418110
Data Mining Techniques (6 ec) X_400108
Performance Engineering (6 ec) XMU_40016
Machine Learning for the Quantified Self (6 ec) XM_40012
ICT4D in the Field (6 ec) XM_0008
Project Systems Testing (6 ec) X_405124
Results


Specialization Parallel Computing Systems
WEEK 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
period 1 period 2 period 3 period 4 period 5 period 6
Year 1
Seminar (6 ec) X_405111
Resits
Programming Large-scale Parallel Systems (6 ec) XM_40017
Parallel Programming Practical (6 ec) X_400162
Programming Multi-core and Many-core Sys. (6 ec) XMU_40018
Performance Engineering (6 ec) XMU_40016
Parallel System Architectures (6 ec) XMU_40015
Year 2
Master Project Computer Science (30 ec) XM_0011
Resits
Year 1 and Year 2
Foundations of Computing & Concurrency (6 EC required)
Protocol Validation (6 ec) X_400117
Logical Verification (6 ec) X_400115
Advanced Logic (6 ec) X_405048
Distributed Algorithms (6 ec) X_400211
Mathematics (6 EC required)
Stochastic Optimization (6 ec) X_400336
Coding and Cryptography (6 ec) X_405041
Experimental Design and Data Analysis (6 ec) X_405078
Software Engineering (6 EC required)
Software Asset Management (6 ec) X_400412
Service Oriented Design (6 ec) X_405061
Software Architecture (6 ec) X_400170
Software Testing (6 ec) X_400439
Societal Perspectives on Comp Science (6 EC required)
History of Digital Cultures (6 ec) XMU_418107
Entrepreneurship for AI and CS (6 ec) XM_0009
E-Commerce Law (6 ec) R_E.commerc
ICT4D (6 ec) X_405101
ICT4D in the Field (6 ec) XM_0008

Year 1 and Year 2




Specialization Software Engineering and Green IT
WEEK 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
period 1 period 2 period 3 period 4 period 5 period 6
Year 1
Seminar (6 ec) X_405111
Service Oriented Design (6 ec) X_405061
Software Asset Management (6 ec) X_400412
Software Architecture (6 ec) X_400170
Software Testing (6 ec) X_400439
Resits
Year 2
Green Lab (6 ec) X_418158
Master Project Computer Science (30 ec) XM_0011
Resits
Year 1 and Year 2
Foundations of Computing & Concurrency (6 EC required)
Protocol Validation (6 ec) X_400117
Logical Verification (6 ec) X_400115
Advanced Logic (6 ec) X_405048
Distributed Algorithms (6 ec) X_400211
Mathematics (6 EC required)
Stochastic Optimization (6 ec) X_400336
Coding and Cryptography (6 ec) X_405041
Experimental Design and Data Analysis (6 ec) X_405078
Programming (6 EC required)
Individual Systems Practical(6 ec) XM_405088
Programming Large-scale Parallel Systems (6 ec) XM_40017
Advanced Operating Systems (6 ec) XM_40014
Parallel Programming Practical (6 ec) X_400162
Internet programming (6 ec) X_405082
Programming Multi-core and Many-core Syg (6 ec) XMU_40018
Project Systems Testing (6 ec) X_405124
Societal Perspectives on Comp Science (6 EC required)
History of Digital Cultures (6 ec) XMU_418107
Entrepreneurship for AI and CS (6 ec) XM_0009
E-Commerce Law (6 ec) R_E.commerc
ICT4D (6 ec) X_405101
ICT4D in the Field (6 ec) XM_0008

Year 1 and Year 2

Programming Large-scale Parallel Systems (6 ec) XM_40017	**Internet programming** (6 ec) X_405082	**Parallel System Architectures** (6 ec) XMU_40015	**Programming Multi-core and Many-core Sys.** (6 ec) XMU_40018	**Distributed Algorithms** (6 ec) X_400211	**Machine Learning for the Quantified Self** (6 ec) XM_40012
Advanced Operating Systems (6 ec) XM_40014	**Logical Verification** (6 ec) X_400115		**Experimental Design and Data Analysis** (6 ec) X_405078	**Software Testing** (6 ec) X_400439	
Service Oriented Design (6 ec) X_405061	**Software Architecture** (6 ec) X_400170	**High Performance Computing and Big Data** (6 ec)	**Coding and Cryptography** (6 ec) X_405041	**ICT4D** (6 ec) X_405101	**ICT4D in the Field** (6 ec) XM_0008
Software Asset Management (6 ec) X_400412	**Concurrency Theory** (6 ec) XMU_0012		**Advanced Logic** (6 ec) X_405048	**Performance Engineering** (6 ec) XMU_40016	**Project Systems Testing** (6 ec) X_405124
Protocol Validation (6 ec) X_400117	**Web Data Processing Systems** (6 ec) XM_40020		**Information Visualization** (6 ec) XMU_418143	**Web Services and Cloud-based Systems** (6 ec) XMU_418110	
Green Lab (6 ec) X_418158	**Hardware Security** (6 ec) XM_40019		**The Social Web** (6 ec) X_405086	**Binary and Malware Analysis** (6 ec) X_405100	
Large Scale Data Engineering (6 ec) X_405116	**Performance of Networked Systems** (6 ec) X_405105		**Term Rewriting Systems** (6 ec) XM_400121	**Data Mining Techniques** (6 ec) X_400108	
Introduction to Computational Science (6 ec) XMU_418111	**Knowledge Engineering** (6 ec) X_405099				
Knowledge and Media (6 ec) X_405065	**Distributed Systems** (6 ec) X_400130				
Computer and Network Security (6 ec) X_400127					
Evolutionary Computing (6 ec) X_400111	**Parallel Programming Practical** (6 ec) X_400162				

Stochastic Optimization (6 ec) X_400336

Lambda Calculus
(6 ec) XMU_418108

Industrial Internship (6 ec) XM_405080

Individual Systems Practical (6 ec) XM_405088

Resits

Resits	P1	P2	P3	P4	P5	P6
Information Sciences	wk 2	wk 6	wk 14	wk 23	wk 27	wk 29
Natural Sciences & Mathematics	wk 2	wk 6	wk 14	wk 23	wk 27	wk 29
Health & Life Sciences	wk 2	wk 6	wk 14	wk 23	wk 27	wk 29
Earth, Ecological & Environmental Sciences	wk 2	wk 12*	wk 12*	wk 28**	wk 27/28***	wk 29

*week 12 for Programmes with Fieldwork
**week 28 for Programmes with Fieldwork
***week 27/28 for Programmes with Fieldwork

APPENDIX 4: PROGRAMME OF THE SITE VISIT

6 November 2019

09.00 Arrival panel
09.15 Internal panel meeting
11.15 Session with programme management
12.00 Lunch
12.50 Guided tour
13.30 Session with bachelor students
14.30 Session with lecturers bachelor programme
15.30 Session with students master programmes PDCS & CS
16.45 Session with lecturers master programmes PDCS & CS
17.45 Open consultation hour (no appointments)
18.00 Additional session with programme director PDCS
18.45 Internal panel meeting
19.00 End of day 1

7 November 2019

09.00 Session with alumni and professional advisory board
10.00 Session with Examination Board
11.15 Session with programme management
12.00 Lunch & Internal panel meeting
14.00 Plenary feedback
15.00 Development dialogue VU & UvA
16.30 End of site visit

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 15 theses of the master's programme Computer Science (joint degree). Information on the selected theses is available from QANU upon request.

The following materials were made available either as appendices to the self-evaluation reports through the QANU portal or as background information during the site visit:

- Intended learning outcomes of the programme
- Overview of international students
- Data tables on student intake, drop-out, throughput and success rate
- Overview of staff
- Overview of the curriculum 2019-2020
- Assessment plan
- Teaching and Examination Regulation 2019-2020
- Rules and Guidelines for Examination
- Examination Policy of the Faculty of Science
- Pre-assessment form master project
- Assessment form master project
- Study guide—description of the course components
- List of graduates
- Annual Report Examination Board 2018-2019
- Minutes Examination Board subcommittee
- Overview of recent theses leading to publication
- International track Global Software Engineering
- Information sheet Green Lab @ VU
- Minutes Examination Board subcommittee
- Quality Assurance policy
- Annual report Programme Committee 2018-2019
- Annual report master's programme 2017-2018
- Course materials and assessment dossiers on:
    - Research proposal writing
    - Logical verification
    - Computer & network security
    - Advanced operating systems
    - Service oriented design
    - Advanced logic