Development Plan

KTH School of Electrical Engineering and Computer Science 2018 – 2023

Final Version, June 29, 2018

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Preface

The School of Electrical Engineering and Computer Science (EECS) was recently formed by merging the schools of Electrical Engineering (EES), Computer Science and Communication (CSC) and Information and Communication Technology (ICT). Digital transformation and sustainable energy are rightfully buzzwords on everybody's lips these days and the strengths of our new School such as Information Technology, Electronics and Energy are right at the heart of these developments. The school merger provides excellent possibilities to form even stronger and unified research, and educational programmes in these areas that are of utmost importance to our country and planet.

The School of EECS stands strong on the international research arena, with top-100 ranking positions both in Electrical and Electronic Engineering as well as in Computer Science and Information Systems. The competition is fierce, though, and this development plan outlines strategies and activities to maintain and improve our positions.

The merger also provides a possibility to reshape our educational programmes to meet the requirements of the future. Our investigation "Curriculum 2025" addresses these issues. From having recruited most of our undergraduate and master students locally, EECS is since the last decade more and more exposed to international competition. Excellence in education will thus be even more important in the future.

This development plan has two parts. The first part describes the changes in the surrounding world and discusses the continued relevance of our School (Chapter 1), it outlines the School vision and our shared values (Chapter 2) and finally it provides some overarching strategies and some measures to be used to quantify our success (Chapter 3). The second part of the document describes operational strategies and specific planned activities in the areas of education (Chapter 4), research (Chapter 5). Chapter 6 outlines the future organisational structure. In chapter 7, we describe our professional support, whereas the final two chapters address our work environment and sustainability issues.

Welcome to EECS!

Professor Jens Zander
Head of School
School of Electrical Engineering and Computer Science (EECS)

1 Introduction

This introduction is split into three parts. Section 1.1 presents the new School. Section 1.2 describes the outlook for the new School. Finally, section 1.3 places the School in the context of the university.

1.1 A new school

The School of Electrical Engineering and Computer Science (EECS) is the largest of KTH's 5 schools, with almost 1000 employees (including employed doctoral students), around 2700 students and a 1,1 BSEK annual turnover. It was formed 2018 by combining the Schools of Computer Science and Communication (CSC), Electrical Engineering (EES) and Information and Communication Technology (ICT). The merged School encompasses a wide range of science and engineering subjects, from Electro Physics, via Low and High Power Electronics, Electric Power Systems, Communication Networks, Autonomous Systems, Data Science to Software Engineering (to name a few of the topics covered). EECS has academic activities on all levels in the fields of Computer Science and Electrical Engineering.

In this environment, EECS and its research partners conduct world-leading research, in particular in the areas of Electrical Power Engineering, Autonomous Systems, Social Robotics, Cloud Computing and Communication and Human Computer Interaction. The School's successful research has been internationally recognized. In subject based university rankings, KTH has consistently ranked among the top-30 universities in the world in Electrical & Electronic Engineering and in the top-100 in Computer Science and Information Systems.

The School is responsible for 22 educational programmes, both at the basic (1st cycle) level as well as the advanced (2nd cycle) levels. Moreover, these programmes are well connected to research, and range from being general engineering programmes in EE and CS to specialized Master's programmes in topics ranging from Electromagnetics, Embedded Systems, Communication System, Rob0tics, Machine Learning, Interactive Media Technology to Computer Science and Software Engineering. Research is coupled with several successful doctoral programmes. With its about 500 doctoral students, EECS is the largest supplier of doctoral graduates to Swedish society at KTH, delivering more than 80 graduates per year going to industry and academia.

The School has two main locations: the KTH main campus at Valhallavägen, where most of the staff and students work, and the Electrum campus, located in the midst of Kista, one of the leading industrial ICT clusters of the world. In Kista, many of Sweden's IT-related companies (including Ericsson's headquarters) and research institutes are located employing more than 10 000 engineers and researchers.

The School is responsible for two of KTH's larger research infrastructures: The first is PDC – Centre for High Performance Computing hosting the currently most potent supercomputer in Sweden, the Beskow Cray XC40 machine with a peak performance of 2.5 petaflops. The other is the Electrum Laboratory, one of Europe's most advanced cleanroom and semiconductor research facilities – provides excellent environments not only for experimental research, but also for the fabrication of prototypes and small series of products and components.

1.2 Outlook and continued relevance

The ongoing digitalisation of industry and society has the potential to create tremendous value. The lion's share of the productivity increases in industry and most of the increased quality of living in society can be directly attributed to the digital transformation of businesses. However, at the same time this raises some of the largest scientific and technological challenges of our time. After the introduction of the mobile internet, ubiquitous sensing and cloud computing, cyber-physical systems (CPS) have now the potential of taking digitalization to the next level. In these systems, the cyber infrastructure is tightly integrated with the physical environment through sensors and actuators. The “things” around us may not only be monitored, but now also controlled in order to create benefits for society by improving efficiency, lowering energy consumption and creating a safer environment.

In parallel to this digital development, the global community has started a transformation of the energy systems to a sustainable state. In regions all over the world, political policies and industry investments are turning away from fossil fuels to embrace renewable energy sources such as wind and solar power. The world is experiencing an energy revolution, this time focused on providing an energy thirsty society with clean and reliable electricity from non-fossil sources that cannot be directly controlled (e.g. wind and solar energy sources). From a situation where the generation of electricity has adapted to meet demand from industry and society, we are moving into a situation where demand must be flexible and based on the availability of energy generated from renewable sources. The same transition is taking place in the transportation sector, where fossil fuelled vehicles are more and more questioned, and the fleets of electric vehicles grow steadily.

The main challenge in the decade to come is to apply technology, both digital and renewable, not just to the current few exclusive, high-value applications, but rather make it affordable and usable at a societal scale. EECS is uniquely placed to contribute within both of these revolutions. We need to create a technology that is scalable such it can be used everywhere and from which everyone can benefit. What happens when billions and billions of users and “things” communicate, compute and store information? How can this be used to manage the energy needs and enable the necessary flexibility in energy use? Can we trust and rely on extremely large software systems? Can this planet scale digital systems, perhaps be what is needed to save the planet? Security as well as environmental and sustainability issues are taken into account in EECS research, as well as the possibilities and problems related to digitalization in an environmental and sustainability context. At the same time, almost 55000 employees within “Teknikföretagen” with technical education, will retire during 2016-2025. There will be shortage of competence when it comes to growth for Swedish companies.

EECS with is breadth in CS and EE has unique opportunities to create the knowledge needed and to prepare its students for the digital and sustainable future. Our research advances allow us to truly explore the enormous economic, environmental, and social potential of the smart society. They will contribute significantly to the vision of an autonomous transport system with electric vehicles communicating with each other and the infrastructure, a smart energy grid with a high penetration of renewable energy and flexible loads, and the growing need for home healthcare for elderly. The advances may also lead to completely new business opportunities and areas, unknown today, similarly to what we have seen happening in the mobile communication industry to which we contributed earlier.

As ICT is a pervasive technology, it is hard to distinguish advances within the field itself, from advances in those areas where ICT is being applied, such as energy and transportation. This has also caused the funding landscape to change. Neither Computer Science nor Electrical Engineering is any longer distinct separate disciplines in governmental research funding, nor in the European Commission’s long-term work plans (Horizon 2020). A consequence is that less funding is likely to go to specific technology projects, but rather more funding is going to large multidisciplinary endeavours such as “Digital Transformation of Society” where Electrical Engineering and Computer Science are critical components of the solution - but not necessarily the entire solution.

Research excellence is today mainly measured by bibliometric parameters that are primarily tailored to meet the demands of the natural sciences. A trend is that research output and societal/industry impact (rather than success in getting funding) will play a larger role in assessments in future. Increasingly, innovation has a critical role in funding decisions. Most funders of research (including the traditional Science Councils, e.g. VR) are looking for direct evidence of societal benefits from research results.

Despite strong recruiting efforts and a recent positive trend, Sweden as a country is incapable of providing enough talent to fill the needs of the still growing IT-sector in Sweden. The introduction of tuition fees and other limitations has previously hampered the recruitment of students, but we are now showing good progress in attracting more and more paying students. Our graduates are in high demand in industry. Many are hired prior to graduation, which might be positive for society, but has a negative impact on the throughput statistics of degree programmes.

Increasingly, universities are global actors that are actively promoting and exploiting their brand names. Providing educational material on-line has been an important part of the marketing strategy of well-known universities. Their target is to increase their visibility, attract students and improve rankings. The increased availability of on-line educational material does not directly replace current education, but will most likely transform it.

1.3 The School's contribution to "A leading KTH"

KTH has set a number of overarching visions for the period 2018-2023 in its development plan "A leading KTH". The School of EECS will address these goals and provide contributions as follows:

- **"A leading KTH"**
  In research, education and collaboration. The School seeks to further improve its research. Top-notch faculty, high international visibility and clear demonstration of the impact our work will be of key importance. The School will reform it educational programmes to graduate top-level engineers ready to lead the digital transformation in society. Using the latest technologies to create successful learning environments is part of our creed.

- **"An integrated KTH"**
  The School creates a new organisational structure, aimed at a subject-wise organisation – thereby better integrating research and education.

- **"A visible KTH"**
  The School seeks to actively enhance KTH brand recognition and university ranking in the EECS areas. Further we seek to create significant and visible impact in industry and society.

- **"An open KTH"**
  The School will further strengthen collaboration with industry and the research institutes, by involving industry at the undergraduate level. The EECS student environments should be characterized by creativity and sustainability. Open Maker Spaces to attract students and prospective students play an important role in this.

- **"A KTH for a more digitalised world"**
  E-learning – is a natural tool in EECS's educational programmes. We will further improve our teaching methods and increase the use of top-class on-line material. We will also selectively produce on-line material that can strengthen the KTH brand.

- **"A KTH for a more sustainable world"**
  EECS covers sustainability development goals in a wide range of topics from energy supply to human-computer interaction in our education, research and in collaboration with surrounding society.

- **"A KTH in a global world"**
  With its many internationally recognized research groups EECS conducts many international collaboration project. Our faculty recruitment occurs almost exclusively on the international scene in a highly competitive environment. In many groups, English is the working language

and the School has a bilingual policy. Our international student recruitment is strong, leading KTH in recruitment of paying students.

- **"An equal-opportunities KTH"**
  Further increasing the number of women among faculty and students is one the targets of the School. Specific strategies are discussed in our faculty development plan and in section 4 on student recruitment. Equal opportunity is the baseline for the education and research performed at EECS.

2 Vision and core values

2.1 Vision 2023

In 2023, KTH School of Electrical Engineering and Computer Science is the premiere research, education and innovation environment in the area of EE and CS in Sweden, and one of the leading environments in Europe.

In 2023, the educational and scientific areas within the EECS School are of highest importance to our society, both locally and globally. The education at all levels is:

- of highest international quality,
- attracting national and international students,
- attracting higher ratio of female students,
- attracting higher ratio of paying students,
- addressing important societal needs,
- strongly integrated with our research and make full use of faculty's areas of expertise,
- handling administrative processes even more efficiently.

EECS education will empower students with skills to improve society by designing, building and implementing electrical engineering and computer science technologies. The education is broad and includes topics including catalysts for change in industry and society i.e. globalization, digitalization, sustainability and equality. Within these we teach our students:

- the basic mathematical, scientific and technical skills in engineering,
- the current and up-coming technologies in EE and CS in areas where the teachers are scientific leaders, e.g., Communication, Intelligent Systems, Electronics, Energy Systems, Electrical Machines, Micro and Nano Systems, Interactive Systems and Computer Science,
- generic skills, including complex problem solving, creativity, ethical awareness, collaboration, leadership, abilities for life-long learning, and addressing openly formulated problems based on critical thinking using scientific methodology,
- understanding and utilizing current catalysts for change in industry and society, i.e., globalization, digitalization, sustainability and equality.

The areas in the EECS domains change rapidly and our students need to be able to learn to learn new competences and be open to life-long learning.

The research quality of all divisions is on the highest international level.

- We research fundamental and relevant questions in our specific fields.
- We publish in journals and conferences of the highest standard in our fields.
- We are recognized leaders in our fields: the School's researchers are highly visible and in high demand as experts, as participants in multidisciplinary research programmes, as invited speakers, giving tutorials at international conferences, in programme committees for conferences, and as reviewers.

- Our impact on industry and society is strong and we are highly visible. Innovation plays an important role in our research output. Researchers and students start spin-offs on a regular basis, and entrepreneurship is held in high regard.

The research environment at the School is dynamic and attractive to visitors and doctoral students. Guest researchers and post-docs invigorate the research environment, create international bonds and form an important base for recruitment to faculty positions.

The EECS Professional Support is efficient, transparent and offers close-to-operations service. The division is a role model at KTH both when it comes to working environment and outreaching cooperation. As with their academic colleagues, administrative staff is encouraged to continuously develop their skills, improve efficiency of the organization and tackle new tasks.

2.2 Core values

KTH's shared values are democracy, equality and a free and open discussion. KTH should contribute to a society with peaceful co-existence – a sustainable society from an environmental, economic and social perspective. In addition EECS will promote the following:

- **Striving for excellence in all activities**
  KTH aspires to be a world leader in research and education. As a consequence all activities in these areas have to be of highest quality in the international context – we always strive for attracting the best faculty, we collaborate with internationally leading research groups, we are publishing in the top journals and conferences in the field, we use the best educational material and teaching methods, utilizing the best administrative tools and routines there are. The common "Not invented here"-paradigm does not apply at EECS.

- **Contributing to environment and the KTH brand**
  We expect all permanent faculty to actively contribute to the development of the School, sharing their enthusiasm in order to create a stimulating local environment and to enhancing the KTH brand. Visibility and active work to build research groups, developing and conducting education and making visible impact on society are seen as valuable contributions and are encouraged.

- **Promoting ethics in research and education**
  The School employs the highest standards in research ethics and expect the same from our students. We have zero-tolerance against plagiarism, cheating and other forms of unethical behaviour.

- **Embracing diversity**
  EECS is a kaleidoscope of nationalities, ethnic groups, men and women. This mixture is a natural consequence of looking for excellence in recruitment. We strive for open, international advertising to attract the best possible candidates for our academic positions. Search committees are assembled for each new position. Their task is to actively search out top researcher appropriate for the announced positions, providing equal opportunities regardless of gender and origin.

- **An attractive workplace – a sustainable faculty**
  EECS should strive for good working conditions for all employees in all categories, and a stable base funding for our faculty.

- **Transparent and rule-based management**
  All important decisions at the School should be based on widely agreed and communicated

rules to have a predictable outcome. Decisions should be well motivated and openly communicated.

3 Strategies and key performance indicators

3.1 Visibility and promoting the KTH brand

In external communication, besides the own research group, the focus should be on promoting the KTH brand. This is of mutual benefit to all KTH faculty and researchers. The School as an internal organisation will play a lesser and lesser role to outside observers. Most research areas at our School are already recognized as among the world leading in the scientific community. However, many research groups will still need to improve their impact on society, others still need to improve their scientific impact in terms of bibliometric performance. Many research groups, although they perceive themselves strong in applied science, innovation and industrial/societal impact, fail to come through with their message in research assessments. Our analysis shows, that we actually have significant impact, but we have not been very good at demonstrating it. We have to improve the visibility of our research output - not only in the form of publications, but also for research impact and innovations. Besides the traditional scientific channels for announcements, we should extensively use websites, the "popular science" press, TV, radio. We need to change our traditional focus from only reporting to "have received funding, grant, etc." (input) to "have achieved important and useful" (output). As industrial impact is a significant strength of many of our research groups, we should also establish a better way to assess research and innovation impact for future research assessments.

3.2 Integrating research and education

In order to fully benefit from the international top-notch research that is conducted at the School, education has to be better integrated with the research programmes. Today student interaction with researchers may in some cases occur first in during the students Master Thesis project, if at all (if the student chooses to conduct the project in industry). The School will aim at involving more students earlier in their course of studies, in bachelor thesis projects, research related project courses and research internships. Further, active involvement of research leaders and full professors in courses in the early parts of our programmes is expected. In the long run, our educational programmes must reasonably match the research profiles and competences of our faculty such that our courses can be staffed with our faculty.

3.3 Research management

Shaping the research and education portfolio of the future

It is important for the School to determine and develop new areas for research, which in turn will lead to new educational subjects and courses. Which areas to develop and which to close down, cannot solely be a school management issue. This process must be driven from "below" by the divisions, by research teams and by individual researchers that put forward proposals. The mechanisms that can be used are

- Strategic initiatives ("särskilda satsningar")
  The divisions are annually invited to propose strategic initiatives with financing from KTH (President-) level or from the school level. Strategic initiatives funded by KTH or the School should in general benefit the School as a whole, and not only specific divisions or research groups. Strategic initiatives for specific research groups and division can be funded by division equity ("myndighetskapital").

- Strategic positions
  In the re-organization phase of the School, 3- 4 starting grants are available for assistant professors in strategic areas that renew and "bind" together divisions and research groups from different "old" schools and research environments.

3.3.1 Proactive research management

The researchers, research groups and divisions are encouraged to not only participate in project phases, but to engage in research programme design activities. This includes (but is not limited to) international research platforms, research agendas, and consultation activities. The aim is to volunteer our expertise to influence research programmes during their design phases. As research programmes tend to be more application oriented, rather than having a disciplinary focus, it is of critical importance that "our" EECS-related subjects become integral and important parts of these future programmes.

3.4 Faculty recruitment

Our faculty is one of our most important assets and recruitment is probably the most important strategic task for a university striving to be internationally leading. Faculty recruitment should be driven by the teaching needs of our programs within the context of our departments. Newly recruited junior faculty should receive attractive start-up packages. In areas where the teacher shortage is significant and where this problem cannot be solved by internally redistributing teaching assignments, the School will provide additional start-up funding for junior faculty to support the divisions and departments. To provide sustainable funding for faculty, i.e. all faculty is funded from the basic funding within education and research the faculty is not expected to grow from the present approximate 220 individuals in the coming period. Exceptions to this are those areas were the needs in the first and second cycle education is large, and to prepare for retirements of faculty in strategic areas for the School.

The School targets to recruit top-talent. The question that needs to be answered in every faculty hiring instance is "can this person add to our competence and improve the position of KTH?". If the answer is negative, we should refrain from hiring. The School needs to employ active search committees to find the best possible candidates on an international "market". The target is to have at least 10 candidates for each faculty position, of which the majority should be international candidates. Proactive measures to attract more female candidates are to be taken. Pedagogic experience, in relation to what can be expected at the level of the position, that is related to our educational programmes is seen as required. Ability to teach in first cycle and at the basic level of the second cycle will be an important criterion for new recruits.

3.5 Faculty development

The School employs deliberate career planning and mentoring for junior faculty and for aspiring tenured researchers according the KTH Future Faculty programme. Career planning and coaching efforts is also mandatory for post-docs, to make such positions attractive for researchers with faculty career ambitions.

The School encourages and may provide co-funding to host top-notch visiting senior researchers.

In the long term, all teachers at the School shall participate in some form of university teaching regarding environmental issues and sustainable development. This will be a condition for career advancement at the School.

Promotion to associate professor ("lektor") is seen as the target for all assistant professors and they are coached in this process. Promotion to "docent" is encouraged for all full-time faculty, with focus on those research areas with a shortage of main advisors for doctoral students. The school endorses promotion to full-professor only for candidates that effectively drive their own independent research agenda, e.g. those who already manage research groups of several researchers, post-docs and doctoral students. Such individuals should have demonstrated that they are able to sustain themselves over several years – beyond isolated project funding. There should be a clear need for promotion, e.g. that the candidate is opening a new research area that is sufficiently distinct from the area of the "parent group". The candidates should also have taken an active part in management, development and/or operation of education in the first cycle, second cycle and third cycle.

3.6 Resource allocation

In the longer term, the ambition is that the government allocation of resources for research (FoFU) and education (GRU) should cover the costs of all employed faculty. Due to the recent years' expansion of the university sector and previous principles for resource allocation, we are not at this stage yet. One important development towards this goal is fair and transparent principles for allocation of resources that support reaching the goals outlined in this development plan. It is also important that the allocation of resources for research and education are well coordinated, and that the allocation is predictable over a number of years.

For allocation of resources for research, which goes to the division level, is based on two principles, first a basic allocation related to the number and seniority of the faculty at the division. Second an incentive based principle which allocates resource in relation to the divisions' success in attracting external funds. These two principles are in line with the allocation models used at KTH, and will be the basis for the model within EECS.

For allocation of resources for education (GRU), which goes to the department level, is based on the principles: the course reimbursement for the department should be performance-oriented (HST / HPR) and a transparent and easy-to-understand standardized cost-sharing model for division fees. A majority of GRU funds will be allocated to the "departments" - a small part will be maintained at school level for development and joint ventures (GA, PA), programme development and pedagogical development. All course responsible teachers should have the required 15 hp of pedagogical courses. Full funding of costs will be received by the divisions in charge of a course when the course analyses are presented on the web.

3.7 Outreach, cooperation and impact

It is important to leverage the collaboration possibilities with RISE and in particular RISE-SICS. There is a long tradition of collaboration with SICS, with several of the School faculty currently holding part-time positions at SICS, and a long series of Doctoral students involved in projects at SICS. This collaboration is now being intensified by exploring new organisational structures similar to those found in the German Fraunhofer institutes. Such a model would simplify joint research projects and staff mobility between KTH and RISE-SICS.

Whereas collaboration with actors in the local environment research is already substantial, the School plans to leverage its contacts also in the education domain. This involves collaboration in undergraduate and master programmes, not only at the strategic (programme content) level but also in the practical execution of courses. The already good involvement of industry when it comes to master thesis projects needs to be extended into all facets of undergraduate and Master's programmes, e.g. bachelor theses, project courses, motivational guest lectures etc.

3.8 Benchmarking and key performance indicators

3.8.1 Benchmarking

The School of EECS will compare its performance with similar schools/departments at our closest international competitors – universities that have similar economies and similar subject ranking and with which KTH already has agreements/good relations. The universities chosen for benchmarking are (QS 2018 subject rankings in Electrical & Electronic Engineering and Computer Science).

- Delft University (32 EEE, 51-100 CS)
- Technical University of Munich (37 EEE, 42 CS)
- University College London (32 CS, 51-100 EEE)
- KAIST – Korea Advanced Institute of Science and Technology (17 EEE, 34 CS)
- University of Illinois at Urbana-Champaign (22 EEE, 28 CS)

As reference, KTH rankings were 28 in EEE and 51-100 in CS. In subsequent revisions and follow-ups of the development plan, the development of ranking parameters as well as relative strengths and weaknesses of these schools/universities in relation to the EECS School will be followed up.

3.8.2 Key performance indicators

EECS will include the performance indicators developed by the Swedish Research Council (VR) together with the Swedish Higher Education Authority (UKÄ) amongst its chosen key indicators. All indicators will be followed up at subsequent revisions of the development plan to spot improvements made.

Indicators: Research quality

- Number of highly cited publications
- Proportion of funding from EU
- Subject-wise University ranking in Electrical & Electronic Engineering and Computer Science

Indicators: Interaction/impact on society

- Financial contributions from society
- Number of collaborating companies with innovation activities
- Number of adjunct/affiliated professors, faculty
- Number of industrial doctoral students
- Number of joint publications with industry/society
- Number of open access publications
- Number of participants in impact related seminars and courses
- Number of developed impact cases

Education related KPIs

- Number of applicants/place
- Throughput in civ ing programmes
- Throughput in courses
- Fail rate (proportion of students not graduating)
- Average study time to doctoral degree
- Proportion of female doctoral students

Gender equality KPIs

- Proportion of female faculty
- Proportion of recruited female/male faculty
- Proportion of female/male faculty promoted to professor within 12 years
- Proportion of female/male doctoral graduates
- Proportion of female/male students in undergraduate and master programmes

Professional support related KPIs

- Evaluation results of the support (internal)
- Staff mobility
- People who quit that stay at (other parts of) KTH
- Number of internal applicants for each position

Work environment related KPIs

- Results from the Employee Satisfaction Survey (MUS)

4 Education

The School has education in all three cycles of education and is planning to organise education that supports life-long learning. EECS uses the quality assurance model for increasing quality in education and adds impact of education to it. This section includes a presentation of program development on first, second and third cycle education. This is followed by description of departments view on subject area strategy and development. The section ends with a description on impact of education at EECS.

4.1 Programme development (first and second cycle)

The challenges in society require engineers with skills that span several traditional disciplines such as system engineering, communication, human-computer interaction, energy engineering, electrical engineering and computer science. The EECS School has a unique combination of competences and will change its educational programmes to give students the possibility to get the competence needed to take on these challenges. The School will augment its well-developed quality system with the new quality assurance tool that KTH recently introduced in order to further improve the quality of the courses, programmes and educational environment of EECS.

An investigation (2018) focuses on a review of our programmes with regard to future education (students who pass 2025) and quality, where we are committed to being leaders in modern educational and didactic methods. The areas the EECS School represents are developing very fast and in order for our alumni to "keep up to date" life-long learning education should be offered. Two challenges today are that no viable financial model for this type of education has been presented and further we have a teacher shortage in popular subject areas. While these issues are being resolved, the School will need focus on contract education whenever teaching resources are available.

In order to facilitate the creation of broad educational programmes, the programmes are owned and planned at school level. Courses are owned and planned at the level of Departments.

In short, it is about changing course offerings and programme content - and establishing a common planning of staffing over unit and departmental boundaries. We already know today that there are overlapping courses and programmes competing for the same students.

In our programmes student contacts with the labour market are strengthened. Different ways to achieve this is to let students work with tasks in industry in their bachelor thesis, master thesis, during different project assignments and by inviting representatives from the industry to give motivational guest lectures.

In all EECS programmes sustainability is included as learning outcomes and is based on UN's Sustainable Development Goals. One way to work with SDG is to collaborate with industry via Challenge Driven Education where students work in groups on a challenge defined by the industrial partner.

The education is going through a transformation driven by digitalization. Tools to support this transformation in terms of e-learning and on-line education are for instance flipped class room, streamed and recorded lecture. The goal is to be excellent in teaching and to maximize the learning, for example using digitalization. Pedagogical seminars will be offered where scientific results as well as proven experience can be shared among faculty.

All students at KTH are having access to maker spaces and at EECS a number of laboratories, experimental environments, mentor spaces and maker spaces are offered.

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainable development must be integrated into all education programmes at all levels, so that students after graduation can contribute to sustainable social development. In all engineering and Master of Science engineering programmes there should be an opportunity to get a sustainability profile in their education through elective courses or the opportunity to choose a Master's programme or track with sustainability focus. Linked to the environmental management systems, action programmes are drawn up to strengthen the integration of sustainable development into education programmes. In key assignments and studies related to education, sustainable development must be integrated into the work. A teaching and learning course in Learning for Sustainable Development is offered at least annually. Seminars and networking meetings for teaching staff are organised. KTH will provide employees and students with knowledge and awareness about sustainable development in their daily work and study life. Future quality evaluations include sustainable development. EECS will continue to integrate sustainability in programmes by offering progression, i.e. course packages that offer both introduction and depth. Courses shall have a sustainability classification.

At EECS our programmes and courses shall be based on the Swedish government political goals on equality and focus on this: Equality is about letting women and men have the same opportunity to shape society and their own lives. The area includes other issues such as power, influence, education, work and physical integrity, and, socio economical aspects. In terms of education, women and men regardless of socio-economical background must have the same opportunities and conditions in terms of education, study and personal development.

4.2 Programme development (third cycle)

During 2018, EECS targets the unification of administrative and academic procedures in the aftermath of the school merger between the CSC, EES and ICT schools.

For 2019 the focus is planned to shift towards the development of the course curriculum. The merger opens up opportunities for synergies between the old Schools' doctoral programmes: It gives a broader base for existing courses, allowing them to be offered more frequently. However, this requires improving visibility and access to the courses. Modifications of its contents may also be required for a course to be attractive to other programmes. A systematic survey of our courses from this perspective, together with an action plan will be a major effort.

The School is involved in a number of large new research initiatives in the general area of digitalization, e.g. WASP, WASP-AI, SRA-TNG, CASTOR and the SweGrids programme. Renewal of the curriculum will be necessary to meet the challenges and opportunities these initiatives entail. Follow up of the objectives that have been set with respect to sustainability and equality is another activity planned for 2019. Resources are also to be devoted to improving the system for how student feedback is incorporated in course development. We are also interested in automating indicators for the 3rd cycle education so that one more easily can follow up, e.g., drop-out rates, throughput, and publication standards. For 2019, one focus for the doctoral programmes will be the psychosocial conditions for doctoral students.

Long term plans, i.e. 2020 and beyond, includes reviewing the doctoral programmes and the third cycle subjects as to ensure that they meet the needs for the rapidly developing areas that comprise Electrical Engineering and Computer Science. They also include activities to foster young faculty in supervision of doctoral students, as well as a renewed effort to improve the process of recruiting doctoral students.

4.3 Subject area strategies (departments)

4.3.1 Communication (COM)

4.3.1.1 Area definition

The communication area entails teaching and research in all seven layers of the classic ISO/OSI stack, starting from the physical, via the network and transport layers, and all the way to the application layer. Modern communications consider the whole networking stack because achieving the desired performance, reliability, and power consumption goals cannot be achieved in an isolated manner. Additionally, the area also encompasses wired and wireless communication, computer communication (within a chip/SoC/board/data centre), distributed systems, and the modern view of network services implemented using open source software running on commodity hardware, potentially geo-distributed across multiple cloud data centres.

4.3.1.2 Subject area strategy

Strategic outlook - societal/industry needs, student interest, expected impact

Over the last two decades the area of communication has transformed from an area dominated by technology and economics to an area that is increasingly ubiquitous. Today there are few individuals who do not make use of some communications technology during the course of their day, whether it be internet browsing, accessing social media or streaming media, IP TV or IP telephony/multimedia conferencing, on-line shopping, cloud computing, RFID/NFC payments/tickets, big data analytics on distributed data or electronic trading and crypto currencies. At the same time there is an increasing deployment of Internet of Things technologies, Industry 4.0, aircraft/bridge/building/traffic/... monitoring and management systems, and other efforts that rely on communications between sensors and actuators and remote systems that make decisions based upon the sensor data and then act upon the world. As a result, all of today's architecture and engineering students need to understand the fundamental concepts underlying communication systems.

Area development (new sub-areas, sub-areas to be closed)

We structure the area as six main, closely-tied sub-areas. As these sub-areas are very generic we do not foresee substantial structural changes in the development plan timespan. The sub-areas are: Internetworking, Wireless communication and networks, Communication theory, Communication software and services, Network security and Distributed systems. The areas with the highest priority for new recruitments are Network security, Distributed systems and Communication software and services in that order.

4.3.1.3 Educational development

Area "course package" description

Our course packages are organized according to the subareas defined above. Apart from the sub-areas, we introduce a 7th course-package termed General Communication topic.

Course package development plan (new courses, cancelled courses)

The focus in Communications is so far on advanced courses of the 2nd cycle. For the coming period, we need to focus more on: specialized 1st cycle courses given in English and 2nd cycle courses with shorter prerequisite chains. As an example, we plan a common 1s cycle course for all non EECS-programmes to introduce the concept of digital communications, security and networking to all students in engineering. In Internetworking a new course is planned on Machine Learning for Communications. The course IK2554, Practical Voice Over IP (VoIP) will be cancelled. Within Wireless Communication and Networks the course IL2219 Radio Electronics will be replaced with the two updated courses: IL25xx, Radio Design and IK25xx, Software Defined Radio. Furthermore the following a new course IK1332 Internet of Things is planned. Within Communications theory a new course on Coding and Inference is planned. This course will partly be based on the PhD course EO3220, Coding for Wireless Communications. Within Communication Software and services, the course IC2005, Methods for Interaction Design, will be replaced by two new courses: IC2006, Mobile Interaction Design and IK2515, Mobile Services. There is also an urgent need to expand the education in Communication security due to the increasingly critical natures of modern cyber-physical systems and networked systems handling sensitive data.

4.3.2 Computer Science (CS)

4.3.2.1 Area definition

The subject of Computer Science provides the technological basis for modern digitized societies from public service to businesses and science. Education in computer science is as essential as mathematics in all technical disciplines.

The subject area covers all aspects of design, operation, and use of computer systems and software. We cover the field from theoretical foundations to software and physical systems using analytic as well as experimental methods. This includes formal methods, algorithms, computer architecture and networks, parallel and distributed systems, computational science, data science, and software engineering. We develop methods and tools for designing, verifying and evaluating computer-based systems and services with respect to application properties, such as performance, security, privacy and trust.

4.3.2.2 Subject area strategy

Strategic outlook - societal/industry needs, student interest, expected impact:
For those industries that increasingly rely on software adapted to their products and services providing them with staff that can meet demands for developing reliable, secure, trustworthy systems is a challenge.

There is a huge and growing need for educated students in various aspects of software development, from traditional tasks such as programming, data processing, user oriented services, to newer skills.

In Europe alone a million programmes are needed the coming decade, according to recent press figures. In Sweden, and particularly in the Stockholm region, the need for educated staff with IT-skills, mostly referring to software development, deployment and maintenance, is repeatedly expressed from companies and public sector alike.

Area development (new subareas, subareas to be closed)
Novel modelling and programming methods as well as providing good environments for developing and maintaining software remains a need where our education and research is and will be of crucial importance. Due to digitalization and technology development, in particular Software Development, Security and privacy, Data Science, Machine learning, and Artificial Intelligence are expected to grow. The combination of big data analytics with powerful and flexible platforms for processing real-time or almost real-time data in new ways is important. High performance computation using distributed systems is increasingly important.

4.3.2.3 Educational development

Area "course package" description
In total 13 course packages are included in the area. Current suggested areas are: (1) Computer Science Education, (2) Software Engineering, (3) Project and technology management, (4) Enterprise IT modelling and computing, (5) Computational complexity, (6) Software construction and analysis, (7) Model-based Computing Systems, (8) System design, analysis, performance, resource management,

(9) System security and privacy, (10) Scientific computing, (11) Distributed and Parallel Systems, (12) Data Science and Applied AI, (13) Computer Engineering and Computer Systems.

Course package development plan (new courses, cancelled courses)
A modernized package of mandatory courses in programming should be provided. A modernized curriculum for courses in computer engineering should cover new systems. Starting a master programme in software technology, a new master programme and specializations within some existing programmes on Data Science, development of a programme in autonomous systems are all ongoing efforts. We also wish to develop new courses on Network Science, System design: Performance of computing systems, Security, Project and technology management, Game theory, and Network Optimization. We will try to achieve a better exposition to research in our courses.

4.3.3 Electrical Energy Engineering (EEE)

4.3.3.1 Area definition

The education provided by the department of Electrical Energy Engineering spans from fundamental electric circuit courses (which is of fundamental importance for many higher courses) over electromagnetic field theory to advanced courses in the four subject areas of the department: Fusion Plasma Physics, Space and Plasma Physics, Electromagnetic Engineering and Electric Power and Energy Systems.

Electrical engineering is the key technology for a sustainable world. Of outmost importance is the contribution with new and improved technologies and systems that contributes to reduction of CO2 emissions. This implies transformation of the energy field from the use of fossil energy fuels like carbon and oil towards renewable forms of energy like power from sun, wind and waves that all involves the conversion step of the primary energy form to electrical energy. In the long term, fusion power generation may also be realized. Moreover, our electrical power system is being transformed through digitalization, which requires among other things high-frequency electromagnetic devices for efficient communication.

An example of an emerging field is the transportation sector for a transition towards more electrified solutions. Automotive technologies follows both battery-operated systems for cars as well as galvanic connected vehicles that target the heavy transportation sector with several demonstration projects on-going in Sweden and Europe. Other examples can be found in the umbrella of “Smart Grid” projects that include any change of electric power sector; including all from new market models, microgrids, demand response, system changes due to distributed generation up to visions of world-wide HVDC supergrids.

4.3.3.2 Subject area strategy

Strategic outlook - societal/industry needs, student interest, expected impact
Large energy storage solutions in the form of electrical energy have been hard to achieve in the electric power grid. Renewable energy sources in the form of wind and solar power will fluctuate much with time. The power balance can be ensured either by connections to grids that can compensate for the variations from other sources connected to the grid or from energy storage.

The need for engineers with an electric power and electromagnetic competence is foreseen to be high and even increasing for the coming decades, this is among elsewhere visual in the fact that the Master’s programme in Electric Power Engineering is the most popular Master’s programme at KTH in number of applicants.

The security and reliability of electric power system is affected by many things – among the disturbances with a physical origin can be mentioned geomagnetic induced currents in near-earth plasmas. These plasma environments will also affect satellite communication and GPS operation. There is a need for engineers with insight in plasma physics and electromagnetics, for development of fusion energy, technical plasma and microwave applications and the space science area.

Area development (new subareas, subareas to be closed)
At the moment, the department doesn't foresee any areas to be closed or any new areas to open. Some variations may come over the years depending on the success in the process to replace the upcoming retirements and the interest of the new faculty.

4.3.3.3 Educational development

Area "course package" description
On first cycle level, the department provide courses on Vector Analysis, Engineering Science, Circuit Analysis and Simulations, Global Impact of Electrical Engineering, Electric Power Systems and different variants of Electromagnetic Theory, adapted to the programme the students are following. Besides, several project courses are offered to students as well as first cycle degree projects in Electrical Engineering and Electromagnetic Theory.

The course packages are dominated by second cycle courses where the subjects reflect the different areas and sub-areas of the divisions. Courses span from fundamental courses in each subject area to more highly specialized courses that interface the subjects with the on-going research in the different fields. The course Sustainable Electric Power Engineering is a course where many teachers are involved to provide students with insights in the electric power engineering contribution to development of the society towards sustainability.

Course package development plan (new courses, cancelled course, etc.)
The needs are on ensuring a high quality in the courses in general, to ensure that appropriate pedagogical and didactical methods are used when so is relevant. There is a general need for upgrades in laboratory infrastructures that can provide undergraduate and graduate students with state-of-the art equipment for advanced scientific studies and access to labs for developments of creative ideas that can be further developed into new innovations. There is a need for coordination of courses in the third cycle with courses on Master's level and there is a need for a better planned third cycle course packages.
The engagement within EIT/InnoEnergy and the SENSE programme will be strengthened and developed in line with the thematic field of Smart Grids and in connection to the overarching learning outcomes on innovation, entrepreneurship and business creation required for that programme.

4.3.4 Electronics and Embedded Systems (EES)

4.3.4.1 Area definition

Electronics and Embedded Systems (EES) cover courses in what would typically be called electronics system design, including both the design of the hardware and the embedded software. From basic courses in circuit theory, to analogue and digital electronics, circuit design on various levels of system complexity to issues of embedded system architectures, embedded real-time systems, embedded software, hardware security, system design, system verification and system modelling. Practical courses cover printed circuit board design, product realization and sensor systems. Courses in semiconductor devices and physics, including design, simulation, fabrication, and characterization are also included. These courses are prerequisites for many of the courses in Intelligent Systems, Computer Science, Communication and Computer Engineering.

4.3.4.2 Subject area strategy

Strategic outlook - societal/industry needs, student interest, expected impact

Electronics and embedded systems are key enabling technologies for a large part of Swedish industry. It has been estimated that 28% of Swedish industry is in electronics, and more than 11% of Swedish export relies on advanced electronics production. To assure that Swedish industry, including the KTH partners ABB, Bombardier, Ericsson, Saab, Scania and Vattenfall, have a supply of electronics and embedded systems engineers, it is important that this educational area grows. One important goal must be to increase the number of women applicants to and graduates of our programmes. This includes EECS programmes in bachelor of engineering (TIEDB, TIDAB, TIELA), Master of Scince in Engineering (CINTE, CELTE) and international master (TEBSM, TNTEM).

Area development (new subareas, subareas to be closed)

There are no new specific areas for development, but all courses are continuously updated to present industry needs where applicable, see 2.2 below. Presently two math courses are included in the teaching responsibility of the Electronics department (IX1303 and IX1304) but the ownership of these could change. They are not necessarily part of Electronics and Embedded Systems. Continuing education is also requested, in line with the roadmap. We consider offering courses in VHDL and PCB design, similar to the COS radio course.

4.3.4.3 Educational development

Area "course package" description

Basic electronics, including one or more of the following: Circuit Theory, Digital Design, Analogue Electronics, Measurement Technology, Embedded Systems. Practical electronics and sensor based systems, Semiconductor devices and integrated electronics.

Course package development plan (new courses, cancelled courses)

The classic topics of Electronics and Embedded Systems are currently being revised by newly instated course teams. Prerequisites between courses will be followed up, and labs and pedagogy are being modernized in basic electronics. Planned changes in Basic electronics are including new pedagogical theories: Student recitations (Studenträkneövningar), Peer Instruction, Home labs in Digital design. Planned changes in embedded systems include formation of course team and repackaging of course material. Planned changes in Practical electronics and Semiconductor devices include increased focus and adapted learning outcomes on Environment and Sustainability.

4.3.5 Interactive IT (IIT)

4.3.5.1 Area definition

The department for Interactive IT will be responsible for education in design, implementation and evaluation of human-interactive digital systems and applications. Students train and practice the design, prototyping and implementation of creative, provocative and highly usable interactive systems and products, based on knowledge of digital materials: sensors, algorithms, operating systems, software architectures and machine learning, with their possibilities and limitations. For that, students learn about the human (cognition, perception, conceptual models), socio-technical systems, techniques for design and evaluation with and without users, and societal and sustainability impact of various technologies. Students are also trained in reflective design processes which, unlike many engineering processes, feature co-occurrence of problem and solution. Such processes are often user-centred and the Scandinavian tradition of participatory design, with its more recent co-design conceptualizations, is still influential.

4.3.5.2 Subject area strategy

Strategic outlook – societal/industry needs, student interest, expected impact

The case for the influence of highly usable software on the success of an enterprise or public agency was still a topic of debate two decades ago but it is not so any longer. Take for example the example of smartphones: while they existed long before the first commercial success, only focus on usability and innovative application and graphical design could bring them into the mainstream. Scholars argue that a user and design-oriented strategy also drives the innovation process and can significantly transform the way companies develop products, services, processes (Tim Brown, Design Thinking).

"IT-kompetensbristen En rapport om den svenska digitala sektorns behov av spetskompetens" places the need for User experience and User Interface developers in 3rd place in its list of "Seven driving forces" after Rapid service delivery (and services are often interactive) and Data Security. User experience, usability and design are expected to grow most in the next 3 years by 80% of professionals surveyed, and front-end programming by 90%, second only to qualified data-analysis and semi-structured data, expected to grow by 96%, which is also represented in the Interactive IT domain by our visualization competencies. There are an estimate 2000 usability experts today in Sweden, expected to grow with 800 in 4 years.

Area development (new subareas, subareas to be closed)

In Interactive IT, we value all things that help humans and groups of humans in different roles, whether or not they exhibit "intelligence" or "learning". A spreadsheet is not really intelligent, but it is extremely helpful in many situations, and although it was designed for accountants, it is used far beyond that domain. We thus teach our students to complement human capabilities in required or unexpected ways, rather than trying to replace human capabilities. If advances of AI or ML can play a role there, they can be one of our design materials.

There are important challenges in using AI when designing human-interactive applications, and these need to be explored further. We are thus focusing on "humanistic AI" rather than "engineering AI". We foresee a development with autonomous systems, natural language processing, robotic materials, as well as interactions that engage with full body interaction, shape-changing interfaces, wearables and movement tracking apps.

It will be important to explore the design possibilities brought by devices, possibly in conjunction with AI, Machine learning (for example from data given by biosensors worn by users), data-driven design and the Internet of Things.

Many of our courses are tech-designerly explorations, where the students build mock-ups and prototypes to learn and master the materials as well as using them as design or testing vehicles. This approach requires access to studio- and lab-environments equipped with a plethora of hard- and software and other digital and electronic tools. We foresee that many of the new courses will adopt these highly interactive and problem-based pedagogical principles, e.g. Problem-Based Learning (PBL) and Studio-Based Learning (SBL) etc.

4.3.5.3 Educational development

Area "course package" description

Nine different course packages are described and the areas are HCI: Usability, Perception, Cognition, Evaluation; Front-End Development (Interaction Programming); Design Process, Methods, Materials and Practice; Advanced Interactive Technologies; Computer Graphics and Visualization; Media Technology; Media Management; Sustainability; Communication.

Course package development plan (new courses, cancelled course)

Digitalisation poses enormous challenges e.g. lack of standardisation between Swedish municipalities has important consequences in how data can be collected and analysed, and setting up standardization has consequences on the activities supported. We are all living through the digitalization of media, advertorial content, with their social consequences like fake news. All these pose important challenges on our research and must be present in education. Enhancing our teaching with technology, as well as teaching about technology enhanced learning are possible Digitalisation developments.

Several new courses are planned (a number around AI as design material and other novel materials as Internet of Things, augmented reality technologies, etc.). One Master programme is discussed to be moved to another school.

4.3.6 Intelligent Systems (IS)

4.3.6.1 Area Definition

An Intelligent System is an engineered or naturally occurring system, usually in interaction with its environment via sensors and actuators, with operation based on data and signals collected, sensed or perceived from the environment. The system performs one or several overarching tasks, where actuation on the environment is usually a crucial component. The operation of the system can be passive, supervised, actively controlled or fully autonomous. Central to the operation is decision-making based on signals and information flowing between different parts of the system and its environment, often in feedback mode. Engineered intelligent systems are usually implemented through a combination of software and hardware, and can be of nano-, micro-, or macro scale, virtual or physical, and contain mechanical, electrical and biological elements. The design often strives to optimize the operation of the system, based on various metrics and subject to constraints and cost. In modern systems, learning in interaction with the environment is a key component. When these systems share space with humans they should ideally communicate using human speech and language, understand human actions, and the significance of items that occupy the common environment. When they are physically integrated with humans or other biological systems, they have to be biocompatible.

4.3.6.2 Subject area strategy

Strategic outlook - societal/industry needs, student interest, expected impact

Intelligent systems are the enabler for societal, industrial and personal digitalization. Software technology and algorithm development are the primary drivers in the development of the future Intelligent Systems. Thus, the previous advances in “computational power” are now facilitating a paradigm shift where “intelligence” is key. Our society relies on very complex systems, ranging from micro and nanosystems to large infrastructure systems. These systems are more and more digitalized, automated and self-organising, with the possibility to make intelligent decisions on the basis of continuous, heterogeneous, multi-source data. We expect these systems to be safe, efficient and reliable. Key challenges involve scalability, resilience and safety for heterogonous autonomous systems. During the past few years, society at large has begun to react proactively to the increased importance of intelligent systems. Recent examples in Sweden are the Wallenberg/WASP initiative, the investment in digitalization described in the 2017 research bill, and the upcoming governmental investment in continued education for AI. As Sweden’s major university environment in the area, Intelligent Systems at KTH/EECS has a crucial role to play, and our strategic duty is to stay at the forefront of this development.

Society and industry is currently experiencing an unprecedented shortage of engineers skilled in the design of intelligent systems needed in order to capitalize on recent breakthroughs in this domain, and needed to facilitate the transition into the service economy fuelled by increased digitalization. Students clearly see these needs and respond to the advancements, as evidenced by the rapidly increasing interest in course offerings in areas such as machine learning, reinforcement learning and AI, but also in areas such as signal processing, decision and control. As these subject areas also currently undergo rapid development, KTH/EECS has a responsibility to provide students with a strong theoretical foundation in order to ensure the long-term viability and competiveness of their knowledge, and to best facilitate their future development. A strong theoretical background is also needed for those that select a research career and who will facilitate the next set of breakthroughs.

Area development (new subareas, subareas to be closed)
The area progresses on four major fronts: 1) The application of intelligent systems in new technological and societal areas, such as health care and life science, energy systems, transportation systems and education, including the development of new techniques and algorithms for decision-making, control, learning, perception and interaction tailored to these new areas. Here the interaction between humans and algorithms is often at the centre; 2) Progress in the fundamental understanding and analysis of information flow, processing and machine intelligence including decision and control; 3) The distribution and integration of intelligence and computation in large networked systems, such as intelligent transportation systems; 4) The use of intelligent systems to enable self-driving vehicles and other autonomous robots. These systems integrate concepts from decision-making, control, information fusion, perception, learning and interaction. Autonomous or semi-autonomous systems with humans in the loop will inevitably need to interpret and learn from increasingly large quantities of sensor data and auxiliary information to take informed decisions and actions. This is closely related to the area of intelligence augmentation. A challenge is real-time verification and decision making in order to develop safe intelligent systems. One topic of crucial societal importance that goes across the four fronts is security, privacy reliability, resilience and trust in the context of intelligent systems. In this area, there is a need for new courses.

Additional or modified courses are further needed in the new areas that appear with the spread of machine learning and AI applications. For the KTH faculty and students in the area of Intelligent Systems, it will be important to learn more, and continuously reflect upon, the future role of AI in relation to humans and society. Another development we see is the application of state-of-the art machine learning tools to solving problems that were traditionally handled by tailored algorithms, for example in communications and control. One example is reinforcement learning that builds on dynamical programming and adaptive control. The Intelligent Systems division currently provides a large number of course offerings in machine learning, spanning from traditional approaches such as decision trees and support vector machines, currently favoured data driven machine learning methods such as deep neural networks, and model based approached such as hidden Markov models and Gaussian processes. Aspects of these methods are covered in many courses, but EECS lacks a coherency that would help to focus pedagogical efforts and to help student select among courses. This is further exacerbated by the rapid development in the field and the rush to cover it. EECS, and students, would benefit from a logical division of the fundamental content and different methodologies into separate courses, which may also lead to a reduction in the sheer number of courses, and by the creation of less technically deep overview courses offered during the bachelor level. The latter would facilitate the students' selection of specialization within the areas of systems, control and robotics, machine learning, AI, and intelligent systems.

4.3.6.3 Educational development

Area "course package" description
Courses in the first and second cycle are given by the ten participating divisions and on relatively low ratio of first cycle (Bachelor level). Courses are organized in packages according to the following research subject areas: Artificial Intelligence, Machine Learning, Computational Brain Science, Robotics and Autonomous Systems, Computer Vision and Image Analysis, Speech Technology and Image Processing, Language Technology and Search Engines, Micro System Technology, Decision and Control, Signals and Systems, and Information Science and Theory. See figure below for an illustration of how they relate.

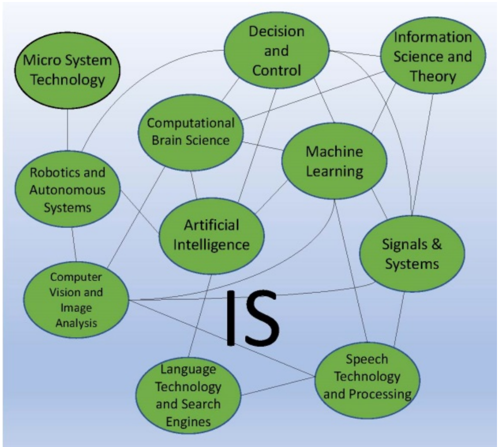


Figure 1: Illustration of research subjects' areas and course packages relations.

Course package development plan
On a short perspective (2019-2021) adjustments in each course package are planned. New courses are planned and the number of courses on bachelor level will increase. We will actively work towards making the course offering more non-redundant by if possible coordinating or concatenating similar courses - thus using our teaching resources well. On a higher level long-term course development (2021-2023) is planned. Suggested courses are based on indications of student interests. Many of the new courses are in machine learning and related areas, which have become increasingly important in recent years, and where both industry and the students themselves request more education. Also interest from a wider group of students, from Engineering Physics, Engineering Mathematics, Biology via Solid State Physics to Financial Mathematics is experienced.

4.4 Education impact – activity plan

Impact for education: Efforts within Impact for education should focus on establishing KTH's image as an important actor contributing to alleviating the challenges society is facing. In particular impact work should focus on showing/supporting that the EECS School is able to contribute to solving:

- The severe shortage of competency in the ICT area.
- Issues of sustainability according to the UN goals.
- Issues of equality and gender.

Impact work should focus on:

- Identifying and assisting in communicating Impact related efforts/Impact cases within the school and externally.
- Assisting in creating new and innovative activities supporting the goals above.

Impact for education is created both internally within the school by its education related activities and by definition in collaboration with external actors. We see a large potential in strengthening and building on external contacts. These contacts should be organised so that they can be maintained and benefit the school and its activities (i.e. other than Impact) in a long term perspective. In particular it is important to facilitate the usage of external contact for the staff of the School. This implies that the Impact work could contribute directly or indirectly to several problem areas related to education:

A: Recruitment of students to the education programmes of the School
Impact activities should be aligned with and support recruitment activities to maintain and strengthen recruitment of students.

B: Increased throughput of students
To establish the school as a credible major provider of competence the throughput of the education programmes needs to be improved. Impact activities should support and strengthen this.

C: Increase interest for research studies among Swedish and female students
We should investigate the possibility to better match thesis projects with interesting external partners and research interests of younger faculty to facilitate for younger faculty to establish industry collaboration.

4.4.1 Proposed actions

A, B: Build and organise contacts with selected partners from industry, society, KTH Alumni and organisations such as Almega. These contacts should be informed about the school activities within education and in particular in how thesis projects should be organised and conducted. These contacts should not only support Impacts but they should be made available to assist the school before, during and after education, i.e. in recruitment activities, programme/course development, projects for courses, thesis projects and possibly research projects.

B: Stimulate the creation of challenge driven courses/education in collaboration with partners from industry.

B: Organise seminars for students and faculty to meet with interesting alumni from the school education programmes, in collaboration with KTH Alumni, to stimulate students study efforts and entrepreneurial spirits.

B, C: Investigate the possibility of and establish an excellence programme for talented students at the five year programmes in collaboration with external partners. For students the programme would consist of education in scientific methods, bachelor and master thesis projects and summer internships at the external partners. Supervision should be done by younger faculty who are also to interact with the external partner and investigate the possibility of generating research projects. External partners should be informed of how thesis projects are organised, what is expected from them and participate in discussions on possibilities to extend this to research collaborations. Similar programmes exist in industry such as Scania Student Intro.

5 Research

The School's research is organised into 16 divisions supported by two national infrastructures and a large variety of laboratory premises at the university level. The research activities cover a wide range of activities from Space and Plasma Physics, via Electromagnetic Engineering to Electronics, Automatic Control and Robotics to Information Science and Engineering and Software Engineering and Computer Science.

The School is also host to four large research centres within next generation ICT, Software Engineering, Smart Electric Grids and the intersection of Art and Technology. These research centres integrate, in various forms, a large share of the industry collaboration and funding that forms an important platform for the research in the School. Through the centres, industry partners and other collaborators can provide input to research strategies and interact with EECS faculty and researchers increasing the impact of the research within the School.

This section contains a presentation of the research at the divisions, and brief summaries of their research plans. Thereafter the research centres and infrastructure hosted at the School is presented and brief plans for the future are given. The section is concluded with the plans for impact in research that are foreseen for the coming period.

5.1 Research action plans

5.1.1 Automatic Control (AC)

The research activities of the Division of Automatic Control are focused on system identification, control, machine learning and optimization of dynamical systems, with applications in autonomous systems, networked system, process control, robotics and secure systems. KTH is currently ranked number 12 in the world in automation and control by the Shanghai Global Ranking of Academic Subjects 2017. In *Control of Transport Systems* we study many applications of connected and automated vehicles and transport systems, where we apply methods from classical, optimal and model predictive control, but also learning-based algorithms and graph-search methods. Within *modern machine learning techniques and algorithms*, we currently develop tools for dimensionality reduction and clustering, neural networks, and reinforcement learning. Our projects in machine learning are often motivated by applications in communication systems and networks, online services, and social networks. Research on *Networked Control and Robotics* spans a wide variety of related topics with theoretical as well as practical relevance. On the networked control side, research involves control and task planning of multi-agent systems under sensing and communication constraints. Within the general area of *control and optimization* we are developing fundamental theory for dynamical systems and are constantly attempting to push the boundaries for advanced control strategies such as networked, hybrid and asynchronous control. A significant effort is devoted to developing algorithms for distributed optimization. *Dynamical process models* underpin advanced process control and obtaining this type of model is typically very costly and time consuming for the complex processes in question. One focus of our research is thus to develop efficient methods to combine first principle models with data-driven modelling. Control engineering has traditionally developed theory and practice where certain properties of the cyber and physical world are assumed to have negligible impact on the resulting control performance. Given the continued convergence of the information sciences, and the emergence of large-scale networked control systems, we can no longer afford to rely on such assumptions. In fact, a central thesis in our work is that new important constraints in control design have emerged with respect to *security, privacy, and information access*. Finally, *System identification* is about constructing models of dynamical systems from experimental data. System Identification, or the discipline of learning dynamical systems, is an area closely related to cyber-physical systems as well as real-time big data analytics, and it provides backbone algorithms for digitalization of industry and society.

Research action plan in summary

The division is currently involved in a large number of national and international research projects with a total annual budget of about 60 million SEK. In addition, the division is taking a leading role in several large inter-disciplinary initiatives of major importance for EECS, such as WASP, ICT TNG, TRENOP, Horizon 2020, and Digital Demo Stockholm. Of particular importance is the planning of the new strategic research environment in digitalization proposed by the Government to be located at KTH. The division has been participating and even coordinating several FP7 and H2020 projects in robotics and control in recent years. A strategic area for renewal of faculty is learning and in particular sequential decision making, reinforcement learning, learning from small data sets, multi-task and transfer learning. Another future strategic area is security and privacy issues in machine learning based systems. This connects to Secure Control Systems area below. An additional new initiative where the division is engaged is to build up an internationally leading environment is the challenging area of modelling, system identification and control of bioprocesses, where the intention is to build up, together with the School of Engineering Sciences in Chemistry, Biotechnology and Health, among others.

5.1.2 Communication Systems (COS)

Communication systems encompasses teaching and research in all seven layers of the classic ISO/OSI stack, starting from the physical, via the network and transport layers, and all the way to the application layer. Modern communication considers the whole networking stack because achieving the desired performance, reliability, and power consumption goals cannot be achieved in an isolated manner. Traditionally, the division is particularly strong in wired and wireless communication, via its Network Systems and Radio Systems labs. Optical Networking and Mobile Services labs have very good presence in their respective areas as well. Wireless@KTH is winding down as a fully funded research centre, but is still a potentially important vehicle for industrial collaboration and VINNOVA funding.

The division is visible nationally (via its SSF Smart Systems "Time-Critical Clouds" framework project, as well as VR and VINNOVA projects), and especially internationally via its past ERC Starting Grant ("PROPHET", Prof. Kostic) and newly received ERC Consolidator Grant ("ULTRA", Prof. Kostic). ULTRA will provide ultra-low latency network services that are implemented using open source software running on commodity hardware, while being potentially geo-distributed across multiple cloud data centres. The division traditionally also has good showing in the EU Horizon 2020 programmes. This trend continues with the recently granted "PriMO-5G" project on development and demonstration of high data rate mmWave systems with fast mobility. The division had successful recruiting efforts recently, adding competence in the areas of wireless networks design, self-organising networks and experimental research and prototyping. We have also hired two assistant professors with already active research in the EIT Digital "ACTIVE" and "ICARO", and CelticPlus "SooGREEN" projects.

Research action plan in summary

The division is already involved in the definition of the new ICT TNG research centre on digitalization. COS members are participating in the foresight group, are leading a potential 'academic research challenge', and were selected to submit a proposal with 'industrial' backing on low latency services. The division of Communication systems is well-established within the broad communication area and we anticipate moderate growth. This means that we need to hire to replace our retiring professors, as well as to satisfy the division needs based on the strategic outlook for the area described below. We want to hire one assistant professor per year after broad searches, in a way that helps us achieves gender balance.

Networked systems will play a highly important role in our societies' further digitalization efforts. In particular, distributed ledgers (aka block chains) are likely to play a prominent role. Development of high-performance, efficient block chains will require network support. Classic internetworking has evolved into high-speed, low-latency network services provided using open source software on commodity hardware. Classic internetworking problems (such as congestion control and event scheduling) are as important as ever but are becoming much harder to solve due to the increases in the bandwidth delay product and the vast differences in the deployment scenarios (ultra-low latency requirements, latency variance, etc.). Meeting the requirements for timely, high bandwidth communication requires applying evolving AI techniques to solve these long-standing problems. Network security will play a prominent role in digitalization efforts. For example, in the ongoing Internet of Things deployments, it becomes crucial to fundamentally address network security concerns. Several recent exploits have taken advantage of IoT devices (e.g., cameras) to obtain sensitive information. A highly related issue is privacy, which has been recently thrust into the spotlight and is likely to remain a difficult issue to address.

5.1.3 Computational Science and Technology (CST)

The division comprises 5 main research groups all belonging to the leading groups nationally and internationally in their fields as is demonstrated by their publication records and the high success rates in obtaining third party funding including H2020 FET and ERC grants. The *Computational Biology and Machine Learning in Biomedicine* groups' primary methodology is machine learning and where cancer is perhaps the currently dominating application domain. Within machine learning, probabilistic approaches, focused on modelling and inference algorithms are employed, as well as the deep learning methodology, applied particularly to medical image analysis. Another line of research is modelling, and inference in the context of somatic evolution, both in healthy tissue and in cancer. The *Computational Brain Science* groups use mathematical modelling and quantitative analysis to generate understanding of brain functions over different scales of organisation (molecular, cellular, network, functional, systems) and to extract general principles for brain functions. The research in the *Numerical Methods* group is focused on the development of numerical methods for partial differential equations and adaptive algorithms for massively parallel computing systems, with particular focus on computational mechanics and in silico medicine. The group include founders and developers of the widespread open source software project FEniCS. The *Parallel Computing* group focuses on programming environments and tools for exascale computing. We work on extensions to the Message Passing Interface for data intensive applications exploiting novel memory/storage technologies, performance tools, and the convergence of HPC and BigData environments. The *Visualization* research is focused on feature-based methods and application to very large data sets. The areas Visualization and HPC leverage their synergies in this regard and work closely together. The current focus of the visualization group lies on in-situ visualization, the interactive exploration of data using VR/AR technology, and the simulation of crowd behaviour.

Research action plan in summary

Biology and medicine are perhaps the richest application domains for machine learning. The *Computational Biology and Machine Learning in Biomedicine group* will continue to strengthen and build on collaborations with biotechnology developers, physicians, and biomedical researchers in the forefront of applying experimental techniques. Currently the most strategic areas are analysis of single-cell data and biomedical image analysis, but, in the longer-term, there will be a number of opportunities for expansion driven by an urgency for analysis of gigantic biomedical data sets. The long-term vision of the *Computational Brain Science* group is to continue to contribute to deeper understanding of the computational mechanisms underlying biological brain function in addition to working towards a strategic partnership with the Stockholm University Brain Imaging Centre. We play an active role in building Swedish research community at the crossroads of brain science and ICT, including also neuromorphic hardware in collaboration with other EECS groups (like the ESY division). Within *Numerical Methods* engagement in the open source community FEniCS and the H2020 e-infrastructure project MSO4SC for HPC/cloud computing will continue; and further develop the interdisciplinary research collaborations in the H2020 ITN programme ENABLE for advanced manufacturing; the VPH Institute for in-silico medicine; and the OES programme for ocean energy. At the national level, the team collaborates with KI, LiU and UU; and is engaged in SeRC, the Swedish Network for Mathematics in Industry, and the Swedish Biomechanics Society. In *Parallel Computing*, the efforts towards exascale are propelling novel hardware developments, which require appropriate programming and tool support. In addition, an increase focus on data calls for novel approaches and opens collaboration opportunities with other groups in the school. In *Visualization* research, we will explore machine learning and how visualization can help shed light onto automatically generated decisions.

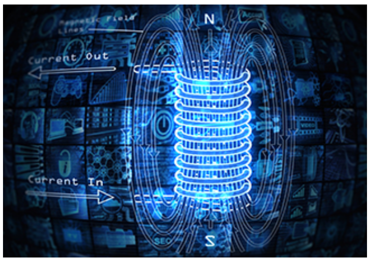
5.1.4 Electric Power and Energy Systems (EPE)

The research and education conducted at the Division of Electric Power and Energy Systems covers areas including electricity markets, facilitating renewable electricity generation and its integration into the system, power system dynamics, operation and control, power electronics and its application in grids, electric drives and machines and their applications in electric transportation, and resilient communication and control systems. Researchers at the division rank high internationally within several of these fields, and as a whole the division is among the best ranked across KTH. A key strength is the tight collaboration with Swedish industry. We participate in international projects, conferences and we have also regularly organised internationally well reputed conferences at KTH. A majority of the research activities involve collaboration with industrial actors, including industrial doctoral students. The main research focus in electric drives and machines is put on targeting further improvement in industrial and automotive applications. Power electronics focuses on two different fields: wide band-gap power semiconductors and high-power electronics for power system applications. Within WBG power semiconductors the focus is on integration, packaging and gate drivers. In high-power electronics the emphasis has been on modular multilevel converter, but is gradually shifting to HVDC grids. The power system operation and planning has a strong focus on efficient methods for balance of increasing volumes of continuously varying electricity generation such as wind and solar. The research is in strong collaboration with Nordic actors and thereby a specific focus on systems with high share of hydro power. An important focus with high share of variable power includes development of models, methods, tools, and control strategies to maintain a secure and reliable operation of power systems. In the area of electricity markets research includes but not limited to: Electricity Market operation, analysis and design, Market power detection and mitigation, Transmission investment and competition analysis, Generation-Transmission investment coordination, Distribution network pricing.

Research action plan in summary

In the area of Electric Machines an important goal is to further increase the engagement within the Swedish Electromobility Center (SEC). This is enabled by SEC increasing its research volume in its coming phase; with an even more active involvement by Scania CV and other industrial actors. In the area of power systems operation and planning including integration of variable renewable power there are well-established cooperation in the field of power system operation and planning with several other universities in Europe. Individual Ph.D. students are also developing contacts in North America and other parts of the world. The division has earlier been involved in cooperation with universities in Africa and we are currently in the final phases of cooperation with Addis Abeba University in Ethiopia. In the area of power system stability we are currently increasing the Nordic research collaboration with national power system operators as well as with universities in the Nordic countries, and also with Chinese universities and European universities via EU-projects. On the faculty side the division has just recruited a new associate professor in the area of electric machines. There is also a plan to announce a new position in the area of Smart-Grids with the focus to closely link the interaction between the instant requirement of balancing a power system and the instant reaction of the components in the system, an area where significant teaching is presently needed. There is a continuous ambition, in all research areas, to increase the international collaboration through, e.g., European projects and we are continuously increasing this effort. The division has historically not had a significant funding share from the Swedish Research Council mainly depending on availability of other funding. However, the research area is certainly on a level which should make it possible for such funding, and the plan is to increase the amount of funding from these sources.

5.1.5 Electromagnetic Engineering (ETK)

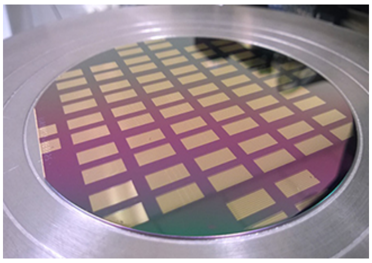


Research at Electromagnetic Engineering deals with the theory, models and methods for design, construction, operation and maintenance of devices intended for generation, transmission and receiving of electromagnetic power at frequencies from a few hertz to several tens of gigahertz, employing a unique combination of methods in Electromagnetics, Physics, and Power Engineering. *High voltage engineering* has renewed importance with the development of ultra-high-voltage AC and DC transmission in emerging markets, and ongoing importance of reliability, cost and efficiency at lower voltage levels. Research includes properties of nanomaterials, streamer development in oil/paper systems, HVDC cable insulation, and optimized characterization of solid dielectrics. Cross-disciplinary research between Material science and Engineering is employed. *Power system protection and safety* increases in importance with changing conditions as variable renewable generation and electric vehicles. The research includes physical modelling, measurements and inference to improve detection and location of faults, and assessment of safety, from extra low voltage microgrids to extra high voltage transmission. Power *System Reliability and Asset Management* include both system and component level. Diagnostics and Monitoring are important for reliable maintenance and efficient operation of power components, in grids, generators, industrial plants. There are new needs due to higher demands on reliability and component loading, and ageing infrastructure; and there are new potentials due to better and cheaper sensors, communications and data processing. Research into *energy storage for smart grids* focuses on modelling, optimization and suitability analysis of different energy storage systems in a smart grid, including hybrid energy storage systems achieving synergy by combining two smaller types of storages. Regarding *Electromagnetic Compatibility* (EMC) the emphasis is on modelling the effects of high power electromagnetic (HPEM) disturbances, both natural and man-made, on complex distributed infrastructure systems and develop cost-effective mitigation strategies. The *antenna research* focuses on the development of new analytic and numerical methods for the design of advanced antennas. These methods include mode matching, circuit models, stored energies and Herglotz functions. The focus is on new techniques aimed to bring one step closer the new generation of millimetre wave antennas. Research on exotic sub-wavelength electromagnetic materials is also ongoing, including materials, which find application in the design of invisibility, illusion and new types of optoelectronic devices.

Research action plan in summary

The division is uniquely qualified in the fundamentals of communications and sustainable energy that enables new robust technical development. The SweGRIDS centre constitutes a substantial part of the power area at KTH, and the development of a continuation of the research activities within the centre is a key challenge. Due to societal interest and importance, a new area of EMC research that will be expanded upon is electrical vehicles for transport of both goods and people. The research on power system reliability and asset management will continue work as a nationally and internationally well recognized group with a large international network for collaboration and exchange, finding solutions for power grid technologies. The energy storage research aims at deepening the cross-disciplinary approach to include e.g. life cycle analysis, long-term losses. The research on Electromagnetic inverse problems aims at diagnosing components and infrastructure for electric power transmission, utilizing guided and/or scattered waves for remote measurements and detection of adverse structural changes. The antenna research aims for innovative front-ends for 5G communications and beyond as well as sensors. Goals include lower energy consumption and better antenna performance. In the area of antenna limitations goals include extension of the limits and realizing antennas and scatters with performance that approach the bounds.

5.1.6 Electronics (ELE)



The division has a profile that covers electronics from a very broad range of basic topics including semiconductor device technology and circuits to systems integration and embedded systems implementation in industrial applications. Within *Device and Circuit Fabrication*: the research ranges from nanometer scaled silicon and germanium MOSFETs to high voltage silicon carbide (SiC) devices and photonic devices like lasers and UV-detectors. We can fabricate and characterize state-of-the art devices and circuits in-house, which is one of the leading university cleanrooms in Europe. High temperature integrated circuits in SiC operating at 600°C have been demonstrated, as well as 15 kV SiC power switches. *Integrated Circuits and Systems:* The research here focuses on bio-medical analogue/mixed signal ASICs covering a wide range of applications such as ultra-low power implantable/wearable biosensors, brain interfaces, and multi-source energy harvesters. The world's smallest bio-impedance spectrometer has been demonstrated. The research has a strong background in VLSI Design and design automation as well as in mixed signal and RF integration. In addition fundamental innovations in VLSI/SoC architecture have been created like network-on-chip, clocking and power management, and high-performance massively parallel architectures. Similar contribution has been made in the area of high-level, system-level synthesis and formal design methods for such systems. Advanced *Embedded Systems* perform an increasing amount of vital functions in areas like transport, communication or health care. Embedded computer systems are integrated into a physical or electrical environment and react continuously with this environment and have to satisfy different requirements, such as real-time, power, size or costs. This design process is inherently complex. Research is on-going on *Emerging Devices* in printed and flexible electronics, integrated photonics and quantum communication, as well as spintronic devices and circuits. On the system level, neural network accelerators and neuromorphic brain-like computing are investigated as techniques for machine-learning with applications in embedded systems, computational neuroscience and bioinformatics.

Research action plan in summary

The research plans couple tightly with the EU ECS-SRA for Electronic Components and Systems. At the national level, we target Swedish industrial innovations in smarter electronic systems and autonomous systems. This includes areas of development such as 3D heterogeneous integration with Ge CMOS, high voltage SiC devices with ABB (planned adjunct professor), high temperature SiC integrated circuits with Sandvik (Vinnova proposal) and high voltage SiC integrated circuits (with Swedish space industry). Further within *Integrated Circuits and Systems*, energy harvesting interfaces low power electronics for self-powered devices, ultra-low power implantable/wearable wireless biomedical sensors, efficient software development methodology rooted in formal methods and multi-core architectures, network-on-chip architecture and design methodology, formal methods for network dimensioning to guarantee quality of service Structured VLSI Design Methodology and massively parallel reconfigurable architectures. Within *Embedded Systems* the plans include formal design of embedded real-time systems with Saab (planned adjunct professor), collaboration within CASTOR center on embedded systems (Saab, Ericsson, EECS), design of heterogeneous safety-critical avionics and automotive systems (Scania, Saab), massively parallel customizable reconfigurable architecture and synthesis framework, sustainable embedded computing for energy efficiency, intelligence and dependability, many-core architectures and systems, hardware security and network-on-chip system generator. Within *Emerging Technologies*, the following topics will be explored: printed supercapacitors for green energy, modelling of variability in spintronic applications, spin torque oscillators (STOs) modelling and STO-based electronic systems, electronic-photonics integration for optical data communication, photonics and quantum information and brain-like computing and neural networks on chip.

5.1.7 Fusion Plasma Physics (FPP)

The ultimate goal of fusion research is to construct and operate a demonstration power-generating system which can be developed as an energy source for future generations. The European contribution to ITER construction is provided by Fusion for Energy (F4E). The programme areas where the Fusion Plasma Physics Division has high activity are: *Magnetohydrodynamics, confinement and diagnostics:* the experimental research programme on magneto-hydrodynamics is mainly carried out on EXTRAP T2R, and in a joint project at ASDEX Upgrade. In the area of confinement studies, the group is actively involved at JET in the area of H-mode pedestal confinement. The theoretical programme aims at understanding of improved confinement and the development of new numerical tools. On the diagnostic development side, work is mainly carried out on JET, in areas of high resolution Thomson scattering and spectroscopy in support of ITER-like wall (ILW). Within *Plasma wall interaction and first wall materials* the research is concentrated on issues relevant for a reactor-class device with the central goal to provide the best data for predictions of material behaviour under reactor conditions. The current research involves a broad characterisation of PFC from present-day tokamaks and testing of materials (beryllium, carbon-based composites and high-Z metals) including also the development of wall materials and diagnostics for JET-ILW. Within *plasma theory, specifically wave-particle interactions, RF heating and current drive* the focus is on modelling and development of RF-heating as a tool to control the plasma. The division is strongly involved in the exploitation of JET, and in the co-ordinated work on Integrated Tokamak Modelling. Codes developed to model RF-heating are validated against JET; three codes for self-consistent modelling of heating and current drive have been developed in collaboration with JET.

Research action plan in summary

The European fusion programme is focused on the international project ITER. Now the device is under construction, and it is expected to come into operation with the first plasma in 2025. After the start of operation, research is expected to be carried out for a period of at least twenty years. Since EU is a leading partner in the international collaboration, it is a great opportunity for Swedish fusion researchers. It has recently been emphasized by the leaders of the European fusion programme that the research carried out in the national fusion laboratories, the so called accompanying programme is crucially important to ensure the continuity of Europe's leadership in the scientific exploitation phase of ITER. Research at the ITER facility will rely on collaboration with national research institutes. It is likely that the Swedish fusion research community will still be based mainly at Swedish universities, and the universities will be the main base for a successful Swedish participation. The preparation for effective exploitation is provided by the coordinated Euratom programme. The activity areas where the Fusion Plasmas Physics Division has high impact are as follows: *Plasma Wall Interaction (PWI).* The selection of materials for the first wall, i.e. plasma-facing components (PFC) is the key issue. The wall is vital for the safe and economic reactor operation. The shift from carbon PFC to an all-metal wall is the topic of Case study. *Operation of ITER* will require advanced modelling in preparation of the pulses as well as in analysing achieved pulses. This requires integrated modelling where the codes are already validated against present experiments, in particular JET. *Active feedback control of MHD stability*; development and implementation advanced control methodology to magnetic confinement. The in-house experiment EXTRAP T2R is used as the test bed for implementation of advanced control techniques in collaboration with the RFX experiment in Italy. Control of instabilities is vital for the safety of the experiment and for economic operation at high power densities and the design of the ITER MHD control system is now underway.

5.1.8 Information Science and Engineering (ISE)

A rough classification of the research activities at the Division is: *Information and coding:* Information-theoretic performance bounds for distributed source and channel coding problems; Information flow in networks and cyber-physical systems; Information theory for learning and AI; Coding for collaborative communication, distributed storage, and secrecy; Network coding. *Multimedia computing and communications*: Analysis of visual data to accomplish search and retrieval of visual information; Decision-making based on compressed local visual data or remotely transmitted visual information; efficient algorithms for telecommunication of visual data beyond video, like dynamic light-fields or holograms (holoportation). *Processing and learning:* Fundamentals of machine learning; Neural networks for image and video understanding and learning; Deep networks; Graph-based signal processing, decision and learning; Reliable decision making and learning based on compressed data; Data analytics; Compressive sensing; Inference and decision over networks; Iterative processing. *Biomedical signal processing:* Optimization, inverse problems, and statistical inference methods, modelling, and machine learning applied to the automation of biomedical data analysis. Applications: Cell tracking, particle source localization, genome sequencing, gait analysis, ovulation detection, seismocardiography. *Privacy and security:* Privacy-by-design and security-by-design; Provable privacy and security guarantees; Secure and private networked inference; Secure and private distributed storage and information retrieval; Security and privacy in learning and AI; Physical-layer methods for authentication, intrusion detection, and secret key agreement; Secure multi-party computation. *Positioning and navigation:* Sensing, processing and utilizing position and navigation capabilities via signal processing, sensor fusion, and artificial intelligence. *Intelligent transportation:* Coordinated platooning and autonomous vehicles; Systems, Industrial Digitalization and Smart and Sustainable Cities: Information science and engineering to enable sustainable, secure and cost-effective future intelligent transportation systems and industry, and smart cities. *Wireless networks:* Modelling and compensation of non-ideal RF hardware, distributed resource optimization, physical layer techniques for industrial and automotive communications; Energy-harvesting communication and wireless energy transfer; Real-time communication; Ultra-reliable and low-latency communication; Performance analysis; Protocols.

Research action plan in summary

The division has ongoing projects funded by VR, H2020 including the ERC, SSF, KAW, WASP, E2DOC excellence grants, MSB and VINNOVA. Our plan is to continue to actively develop the kind of activities and the focus that these organisations represent. To complement the traditional research funding we also plan to interact with Society and Industry via adjunct positions, industrial doctoral students, contract research, instruments like EIT Digital, and support programs such as advisory industrial councils. The Division is at present (2018) part in supervising two SSF and one WASP industrial doctoral students (all with Ericsson). Our active engagement in setting up the new Digital Transformation Centre based in SRA-TNG will be one of the most crucial efforts in the coming years. As part of our long-term strategy to recruit qualified overseas students and to develop research collaborations, our researchers are active in several of the KTH Focus Regions, especially China, India, and Southeast Asia.

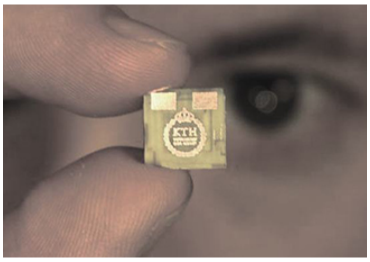
5.1.9 Media Technology and Interaction Design (MID)

Media Technology and Interaction Design (MID) is a cross-disciplinary group focusing on the design and use of digital media in systems for mediated communication. MID is a globally recognised research centre for its long-standing expertise in areas of Human-Computer Interaction, Computer Supported Collaborative Work, and Sound and Music Computing, with a growing standing in fields of sustainability, learning, and immersive technologies. MID is currently organised in six research teams: The *Interaction Design group* approaches digital technologies through design research, with novel design and aesthetic angles, to understand and design for deeply engaging, human needs-driven activities. Topics include arts and crafts, somaesthetic design, aesthetic, smart implicit interaction, and impermanence of interactive technology. *MediaLab* works with interdisciplinary research projects that combine advanced engineering, with philosophy and the humanities. Topics include visual communication, visual computing, ethical aspects of big data computing and phenomenology of interaction. *The Multisensory Interaction* team (MIx) vision is to understand human communication and interaction at the intersections of different perceptual and interaction modalities across sound, music and haptics, to make them a natural part of everyday technology. The *Socio-Technical Practices* group research how stakeholders make sense of and appropriate technology, working closely with users on digitalization of large enterprises and governmental bodies, the design of simulator enhanced training and ethics in AI. The *Sustainability* team (MID4S) research interests span over aspects of environmental, social and economic sustainability, with the aim to decrease the environmental footprint of all sectors in society. *Technology-Enhanced Learning* develops and evaluates socio-technical support for learning. Research includes Learning Analytics, Mobile learning, Integration of formal and informal learning environments, Collaborative and Self-regulated learning. MID's research output is focused on domain-leading venues, particularly conferences and increasingly open access journals.

Research action plan in summary

We foresee that areas such as interaction design for leisure and fun, work practices, sustainability, and learning support technologies will continue to grow and require a great deal of knowledge in the areas of HCI and media technology. We will grow with these advances and advance the design of interactive digital systems that learn how users make use of it through movements, interactions and context-awareness. We will furthermore strengthen our team by recruiting a post doc in media technology, sustainability and communication. For the period 2018-2023, MID is involved in a new Nordic hub for Sound and Music Computing (NordicSMC). Future research will among other things focus on robust interaction between users and humanoid robots by combining competences of social robotics, sound and music computing, affective computing, and body motion analysis. MID has been involved in financing and organising a centre for Arts, Technology and Design - NAVET. The overarching goal for NAVET is to be a meeting place for research and projects, with the purpose of facilitating and creating opportunities for exchange and collaboration among artists, designers, engineers, humanists, natural and social scientists, leading to innovation through collaboration. A central task for the centre will be to support the subject area art, technology and design as a field of research, as well as develop knowledge of cross-cultural management in order to facilitate the inter- and transdisciplinary culture the centre seeks to establish. Research at MID will continue the successful work of our six areas, implementing strategies to increase the production of high-quality journal and conference publications, within- and cross-team grant applications, high quality recruitment, and support for individual researchers. Instigating support for expert evaluation of and support for research and grant writing has shown early success (e.g. VR grants, 7 papers at ACM CHI) and will continue.

5.1.10 Micro and Nanosystems (MST)



The unit is the leading Swedish MEMS research group. The work is centred around six major application areas: *Medical; Bio/Nano Fluidics; Organ-on-Chip; RF, microwave and THz technology; Optics/photonics; and Micro- and Nanosystem Integration*.
The group is involved in many large European research collaborations and several national framework grants, and has a strong tradition of working closely with industry. Several research projects have been the basis for commercial spin-off efforts and contributed to successful company formations. The group is internationally well recognized multidisciplinary team with scientific excellence and good leadership abilities. It is composed of predominately young research leaders exhibiting Complementary competences and different backgrounds and strong internal collaborations. The researchers at the division have a high publication impact by researchers leading their community. The division has stable research funding level during the past years, with the majority of funds coming from the European Commission. In addition an established interdisciplinary collaboration network, national and European, involving key players in the field. The impact through collaboration, dissemination and exploitation is high. There is an emphasis on societal and industrially challenging applications, leading to valuable impact for society and industry. Since 1992, the group has graduated 36 doctoral candidates. Thereof, 22 are now in industry of which 4 are in the position of CEO or partner, and 12 are in academia, of which six professors and three associate professors The research at the division has also led to creating spin-off companies: Silex Microsystems, XValve Company AB (2003), FAUN Data (2004), MyFC AB (2005), Mercene Labs (2012), Capitainer (2016), Mercene Labs (2012).

Research action plan in summary

Our plan is to reinforce and develop KTH-MST's position as one of the leading micro- and nanosystem research groups. To achieve this, we work in multidisciplinary research collaborations with selected partners, with whom we research innovative micro- and nanosystem solutions for improving energy, healthcare and ICT applications by demonstrating smaller, higher performing or lower cost components and systems that address and respond to the grand challenges of industry and society in these areas. We use the novelty and relevance of the solutions as the main research quality criteria. Our current partner network includes world leading experts, whilst continuing collaborations with our existing partner network in existing and novel constellations, we plan to increase collaboration with healthcare professionals, specifically in the Stockholm area, and take a proactive role in major centre formations, such as the new H2020 Flagship EU HEALTH As a multidisciplinary division we are uniquely positioned to leverage on research collaborations with other academic groups and to cross-fertilize into new areas. The division therefor encourages visits from other scholars as well as faculty-initiated research relations with other universities. Currently our faculty has relations with Harvard University and with MIT.

Micro- and nanoelectromechanical systems (MEMS and NEMS) are contributing in various ways to addressing the Grand Challenges of society, including healthcare, energy and resource efficiency, transportation and environmental protection. We will continue our successful research in the six major application areas mentioned above but also expand further in the following new research areas: *Life Science/Medical and sensing technology*, specifically: Biohybrid systems Translational drug delivery and Environmental sensors for sustainable society. *ICT* specifically THz microsystems and *Advanced materials including Nanotechnology* specifically Quantum technologies and Programmable matter.

5.1.11 Network and Systems Engineering (NSE)

The Division of Network and Systems Engineering (NSE) conducts research and provides education and service to society on key aspects of networked systems. The primary research focus is on system design, architecture, and management; system security and privacy; enterprise IT modelling and computing; project and technology management. The core methods for conducting the research are stochastic modelling, queuing theory; game theory, optimization; distributed systems, data analysis and machine learning; software design, prototyping, and experimentation.

Research action plan in summary

On the KTH and national level, NSE faculty will contribute to research centres including CASTOR and SRA-TNG, as well as to the WASP and WASP-AI doctoral programmes. On the European stage, the focus will be on collaborative EU projects and ERC grants. Globally, NSE plans are to strengthen and possibly extend our collaborations with academic groups at MIT, Harvard, Berkeley, UIUC, KAIST, and HKUST, as well as with industry partners, such as Cisco, IBM Research, and KDDI.us.

5.1.12 Robotics, Perception and Learning (RPL)

The research of RPL can be grouped into six overlapping themes: *Active Perception, Computer Vision and Machine Learning, Grasping and Manipulation, Mobile Robotics, Planning and Decision Making and Social Robotics*. We are an internationally competitive division with a uniquely complete research environment in robotics and autonomous systems, computer vision and other types of perception, and machine learning and artificial intelligence. In 2016, we organised the leading robotics conference ICRA in Stockholm. We are part of the research environment at KTH in Automation and Control, which has Shanghai ranking number 12 in the world year. In a recent survey of AI research in Sweden ("Artificiell intelligens is svenskt näringsliv och samhälle", 2018), Vinnova lists us as one of the six central AI environments in Sweden. In the coming years we aim to further strengthen our competence in machine learning and artificial intelligence.

Research action plan in summary

RPL is, and plans to be continuously, involved in research platforms such as WASP, Wallenberg AI, Autonomous Systems and Software Project, ICT-TNG, Information and Communication Technology – The Next Generation, SeRC, Swedish e-Science Research Centre, and academic networks such as SSBA, Swedish Society for Image Analysis, and IEEE RAS, the IEEE Robotics and Automation Society. We are heavily involved especially in WASP, where Danica Kragic, professor at RPL, leads the activity WASP-AI. We plan to host a number of external guest researchers for shorter or longer stays during the next years, e.g. from University of Hamburg, Germany, from Swedish University of Agricultural Sciences, and a number of shorter visits by researchers from Toshiba Research, Japan. Regarding outgoing affiliations, Hedvig Kjellström, professor at RPL, is an Affiliate Professor at the Max Planck Institute for Intelligent Systems in Germany. No longer outgoing research visits are planned in the near future for the RPL faculty. We have numerous external research collaborations, in the form of EU, SSF, KAW, and VR projects. Most notably, we have substantial funding from KAW. We plan to send two applications for EU projects during the coming year.

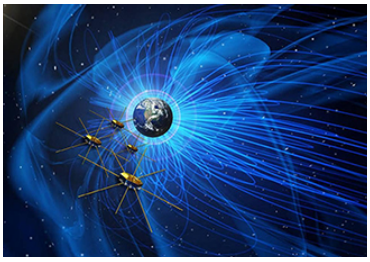
5.1.13 Software and Computer Systems (SCS)

At Division of Software and Computer Systems, the research concerns fundamental principles of engineering and analysis of Systems and Services. The Division contributes with systems that deliver high performance and reliability with cost and resource efficiency. In the area of *Software Engineering* we work with Software technology for DevOps, advanced software testing, with the coordination of the H2020 STAMP project, novel techniques for automatic software diversification, with a WASP chair and the SSF Trustfull project. In *Intelligent Software and Services Analysis and Development Methods* we research new methods and systems for software and services analysis and development. This includes semantics-based and machine learning-based inspired) approaches, new architectures for data analysis systems, autonomous software systems, privacy and trust enabled software and services. In the area of *Model-based Computing Systems* we work with automation of system specific Model-Based Learning, and on Heterogeneous Model Compilers for Uncertain Environments. We focus on generating efficient code, dealing specifically with robust, scalable, and open code generation by combinatorial problem solving. In collaboration with KI, the group currently has projects from VR and the Erling Persson Family Foundation on learning machines for clinical mental health applications. In the area *Distributed and Parallel Systems* we focus on systems research, algorithms and software technologies for distributed and parallel computer systems. The research group has been working on many specific relevant systems where distribution, scalability, autonomy, and fault-tolerance are important including cloud computing, large scale peer-to-peer and edge-computing, block chain technology, and data-intensive computing including systems for scalable advanced analytics. Within *Data science and Applied Artificial Intelligence*, methods and technology for collecting, organising and analysing data for generating new knowledge are developed. We focus on the two latter aspects; systems for large-scale distributed machine learning, algorithms for enabling trust in machine learning models through interpretability and statistical guarantees, and analysis of complex data, such as sequences and graphs. The research is applied in several different domains, including health-care and medicine, drug discovery, climate research, predictive maintenance and social networks. The division has internationally competitive competence in the areas of conformal prediction and interpretable machine learning and extensive presence in editorial boards and programme committees in several of the most prominent venues in the area.

Research action plan in summary

We are actively participating in the recently formed CASTOR centre and the SRA ICT TNG consortium both representing significant research initiatives that is taking place within the EECS area. We have ongoing cooperation agreement with Software Competence Centre Hagenberg (SCCH), Linz, Austria in the area of Computational Models for Data Analysis systems. The cooperation is carried out in the framework of nationally funded COMET project. We continue to work on new challenges in data-intensive computing, most recently on continuous deep analytics systems for real-time decision making in the CDA project supported by SSF. We are also partners in other SSF projects. We collaborate with RISE SICS on BIDAF, a long term project financed by KKS. We have done several projects with EIT-Digital including summer schools of Big data analytics. The researchers within data science and applied artificial intelligence has close, ongoing collaborations with researchers at the national level, both in academia, primarily at KI, SU, and JU, and industry, primarily at AstraZeneca and Scania. The plan is to expand these collaborations through additional joint projects. We are aiming to form a research group in Robotic Process Automation and AI.

5.1.14 Space and Plasma Physics (SPP)



Our research is conducted in extensive national (e.g. Swedish Institute of Space Physics) and international (NASA, ESA, EUROfusion, ITER) collaboration divided into 3 main areas. *Experimental space plasma physics*: exploring various fundamental plasma physical processes associated with the solar wind interaction with Earth´s magnetosphere, and with the space plasma of other planets and solar system bodies. Measurements are done in situ of electromagnetic fields and charged particles by satellites, space probes, and sounding rockets, and remotely by ground-based or space-borne imaging and spectroscopy. Our activity spans the stages from mission initiation and design, instrument hardware development and production, testing, operation and data archiving and processing, leading to data interpretation, assisted by theory and numerical simulations. *Plasma-surface interactions and complex plasmas*: the latest fusion-oriented focus lies on plasma-surface interactions in dense strongly magnetized plasmas of relevance to the ITER fusion reactor. The group is responsible for the physics input and numerical development of two leading numerical simulation codes modelling dust transport and macroscopic melt motion, respectively. We have also initiated theoretical investigations studying the effect of thermionic emission on the fusion plasma boundary. The latest complex plasma focus lies on theoretical efforts to describe structural and dynamic properties of complex plasma liquids as well as model validation by participation in the design and analysis of microgravity experiments on the International Space Station. *Applied Plasma Physics:* the research is focused on the magnetron sputtering discharge, nanoparticle growth in a hollow cathode discharge, and simulations of capacitive coupled discharges of complex chemistry. High power impulse magnetron sputtering, HiPIMS, is studied both experimentally and through modelling, as well as its application to thin film deposition.

Research action plan in summary

In *Experimental space plasma physics* the exploration of fundamental plasma physical processes such as reconnection and acceleration using MMS data will be intensified, The Rosetta data will be further explored to understand cometary plasma interactions. Work will continue on the Jupiter system, looking to further use the capabilities of the Hubble Space Telescope, NASA's Juno mission, the upcoming James Webb Space Telescope, and new ground-based facilities, and preparing for the JUICE (ESA) and Europa Clipper (NASA) spacecraft arrival to the Jupiter system. With the start of operations of EISCAT3D, this powerful new generation incoherent scatter radar will open a new window to space and better the understanding of auroral electrodynamics. We plan to continue our participation in the Swedish sounding rocket and balloon programme. To prepare for the arrival of BepiColombo to Mercury, numerical and in situ data studies of its plasma environment will continue. Our participation in new collaborative missions will continue, with results on ESA's M5 selection due in 2018, where KTH is part of 3 mission proposals. Our plan is to also address outstanding questions in auroral plasma physics by proposing and realizing a small satellite mission within the Swedish smallsat programme. Within *plasma-surface interactions and complex plasmas* we plan to benchmark the two new simulation codes against recent experiments and intensify our predictive work for ITER benefitting from our active involvement in EUROfusion. We shall focus on two relatively unexplored plasma-surface interactions of significance for reactors: (i) emissive sheaths and the transition from space-charge limited to inverted regimes; (ii) vapour shielding phenomena and consequences for ITER and DEMO. In *Applied plasma physics* work on discharge physics and applications will continue. Retaining the focus on HiPIMS, we will also address fundamental issues in the DC magnetron discharge: electron heating, the effect of the magnetic field, and recycling of species. Topics in electric propulsion provide a space technology application of discharge, opening new collaborations within national, EU or ESA funded programmes.

5.1.15 Speech, Music and Hearing (TMH)

The research and teaching at TMH aim at an understanding of how humans communicate through speech, music, and gestures. Rooted in an engineering modelling approach, our research forms a solid base for developing multimodal human-computer interaction systems in which speech, music and gestures are used to create human-like communication. The research field is truly interdisciplinary, and is based on data collection, analysis and generation of human communicative behaviour. Central methods are obtained from signal processing, machine learning, computer animation and robotics, and combined with knowledge from knowledge linguistics, phonetics, cognition and experimental psychology. Our current research areas are: Speech and Language Technologies, Human Speech and Communication, Conversational Systems, Social Robotics, Voice Science and Technical Vocology and Music Informatics and Auditory Perception. TMH is a world renowned research division, evidenced by their participation in more than 25 EU projects and their high ratings in the KTH International Research Assessment Exercises: RAE2008 "This is an outstanding, world leading research group – among the top and most respected (a national asset)", and RAE2012 "Research output is internationally excellent in all fields, with a substantial number of units reaching the level of world-leading quality. Another sign of its international reputation is that it organized Interspeech 2017, one of the largest international speech conferences (800 papers, 2100 participants), as well as six of its satellite workshops.

Research action plan in summary

Speech and language technology has for a long time been driving applications for applied machine learning. The field is rapidly developing, as large cooperation like Microsoft, apple, Google and Amazon are competing in developing the best voice assistants for mobile phones, smart speakers, cars and wearables like watches and glasses. Another emerging area is social robotics, where robots interact with humans through speech, language and gestures. Robots that share space with humans need social and communicative skills that enable them to interact with people and other robots in an intuitive and socially acceptable manner. To maintain the division's leading international research position and to ensure state-of-the-art speech and language resources in Swedish we need to continue to strengthen our faculty in new and emerging research areas. Areas the division needs to strengthen include Machine learning for Natural Language Processing, Machine Learning for Speech Processing, Intelligence Augmentation, Multimodal Social Signal Processing. A long-term strategic area is Acoustic Phonetics, a research field that actually was founded by TMH's Gunnar Fant in the 50s, and that still accounts for a large part of the division's external funds. TMH's international reputation in this field is evidenced by one-year visits from top researchers, such as Professor Julia Hirschberg who received Honorary Doctorate at KTH in 2007 and Professor Petra Wagner got an RJ-Humboldt stipend to come to KTH 2018-2019. Another strategically important area is Voice Science and Technical Vocology. In this area we have received a large number of external grants. In 2018 TMH has a good mix of research funding sources. This leads to a mix of collaborations internationally, nationally and internally at KTH. TMH are applying for more industry- and challenge-driven research funding (EU, Vinnova, PTS, WASP AI, EIT Digital/Health). We have good contacts with international universities, companies and research environments that have offered our doctoral students internships and research visits, e.g. CMU(US), Colombia University(US), Microsoft research(US), Amazon(US), Disney Research(US), ICT-UCS(US), NII(JP), Honda Robotics(JP), Toyota Robotics(JP), Google(UK), QMUL(UK), IDIAP(CH), EPFL(CH), INESC-ID(PT), UniB(DE) and TCD(IE). Our national university collaborations include KI, SU, LU, LiU, KMH and DI.

5.1.16 Theoretical Computer Science (TCS)

The Division performs research on the core topics of computer science, including complexity theory, data- and network security, software construction and analysis, language technology, as well as computer science education. Besides organizing and contributing to top-level international CS theory conferences, the TCS division is developing increasing research collaboration with industry through which we also generate societal impact. In *algorithms and complexity theory* we study the power and limitation of computers and automated computational devices and processes. The twofold goal is to design efficient algorithms for solving different tasks, but also to prove mathematical theorems showing that some computational problems cannot be solved efficiently for inherent reasons. We are particularly interested in understanding different combinatorial optimization problems, and algorithmic and complexity-theoretic techniques for designing efficient graph algorithms with provable guarantees. In *data and network security* we perform research into analysis of networked software, intelligence and security informatics, privacy, provably secure systems, secure networks and systems, and practical and provably secure cryptography. Some practical research has been spun off into a start-up company Verificatum. In *software construction and analysis* we perform research in production of software systems that behave in a reliable and predictable manner, i.e., deliver a trustworthy service in a timely manner without causing injury or significant malfunction. Currently active fields include: programming systems, software evolution, virtualization, formal verification, software testing, automatic programme repair and dependable autonomous systems. In *language technology* we work on questions that involve the analysis and handling of human language. This involves building models that can handle how human language changes over time, between users, topics, channels, and situations, yet make use of the obvious and observable regularities of human language use. In the area of *computer science education*, we conduct interdisciplinary research aiming at improving the understanding of how students learn computer science and how the teaching and assessment of computer science could be improved.

Research action plan in summary

The TCS division has evolved from a research division that was almost entirely mathematically oriented 20 years ago, to a division with a good balance of CS theory and practice. Responding to local industry calls for increased research and student production in software engineering, TCS is heavily engaged in the CASTOR centre, a research centre on software technology at KTH. TCS is also actively in involved in the WASP programme. Machine Learning applications in Software Engineering are one new direction for this research. Another direction is Chaos Engineering. Both of these areas are related to industrial needs such as increased agility and engineering complex distributed systems. TCS faculty are coordinating two new WASP clusters, Security for Autonomous Systems and Software Technology for Autonomous Systems. In parallel activities are building up in software engineering aspects of automotive research with Swedish manufacturers. The security area is one of the strategic areas of growth for TCS. Over the past year a new SSF funded framework grant TrustFull has been awarded to the TCS group, with the aim of developing new methods for full stack security, combining methods from formal methods with techniques based on diversity and automated repair. The area is supported by the WASP programme through several doctoral students, and by the ICT-TNG programme. The group works actively with its industrial contacts, companies, and intends over the coming period to recruit one or more adjunct or affiliate faculty. The computational complexity group has witnessed a healthy growth and is conducting research in many different areas of computational complexity theory, with a focus on hardness of approximation and proof complexity. In the coming years we can expect to see a closer collaboration within the framework of the Wallenberg grant "Approximability and Proof Complexity," and we also plan for more interaction with the mathematics division. In parallel with this, research on applied algorithms for NP-hard problems continues.

5.2 Research centres

The EECS School will during the planning period host four major centres for interaction with industry and the surrounding society. Beside these centres, a number of centres have ceased to receive external funding and do no longer fill a role as being hubs for industrial collaboration. Most of these centres are either being dismantled (e.g. Wireless@KTH) or play only a role for internal collaboration (e.g. ACCESS, CAS).

5.2.1 CASTOR

CASTOR is the research centre on software technology at KTH. Several of the divisions within the EECS School have been instrumental in the creation of the centre, and the activities within CASTOR are augmented by many activities at these divisions. CASTOR has been created by KTH, Ericsson and SAAB to foster collaborations between academia and industry and deliver high-impact, relevant scientific contributions. CASTOR develops novel technology in the areas of DevOps, Data Analytics, Embedded Systems and Cybersecurity.

The key objective of CASTOR is to deliver scientific results that have an academic and industrial impact. The following objectives for CASTOR are all targeted towards high-impact research:

- Perform excellent research. CASTOR is a centre that focuses on scientific research in the area of software technology. It aims at research excellence and leadership, with a clear focus on the lower technology readiness levels (TRL 1-4)

- Foster academia-industry collaborations. Collaborations between KTH and the Swedish software-intensive systems industry are key for CASTOR. These collaborations increase the relevance of the software research performed within the centre. The longevity of the collaboration increases the chances that the result will be of use and have impact. The collaboration leverages bilateral mobility between industry and academia

- Emphasize open science and innovation. CASTOR aims at the highest scientific standards in all its research activities. Reproducible experiments, open data and open publications form the core principles for this objective

- Structure the Software Area at KTH. This last objective aims at strengthening and increasing the visibility of software research at KTH, which is currently scattered over multiple groups, divisions and schools

CASTOR is anchored in the core scientific expertise of EECS. The faculty members of the centre are affiliated with divisions that span the different areas of the school: SCS, TCS, COS, NSE, RPL and CST.

5.2.2 Lab for Digital Transformation (“DigiLAB”)

KTH has been tasked by the government to establish a lab for multi- and inter-disciplinary research in societal opportunities and challenges to sustain Sweden as leading in digitalization based on the current strategic research area “Information and Communication Technology - The Next Generation” (SRA ICT TNG). The ICT TNG consortium consists of KTH, Stockholm University, RISE SICS and RISE Acreo. EECS is taken a leading role in defining and establishing the lab.

The vision is to establish a world-class lab, well-known as the leading European environment in the area, and creating a meeting place for scientists, students, societal functions and industry from all over the world to spearhead development of the future digital society. The goal for the lab is to establish itself as one of the top five research labs in the world. The lab will act as a bridge between academia and society by close cooperation with selected stakeholders from industry and public sector. Societal opportunities and challenges will be natural input and act as inspiration and provide necessary data and other information for research connected to the lab, as the output should facilitate development of society. The lab will promote and implement basic science as well as inter-disciplinary research.

5.2.3 NAVET

In 2016, the School of Computer Science and Communication (CSC) got funding reserved for a mission of establishing a centre for art technology and design at KTH.

The overarching goal for the centre proposed in this application is to be a meeting place for research and projects in the intersection of art, technology and design, with the purpose of facilitating and creating opportunities for exchange and collaboration among artists, designers, engineers, humanists, natural and social scientists, leading to innovation and to the definition of new unforeseen areas of research and collaboration. The proposed centre should both create an environment for already existing projects and collaborations in the area and stimulate the formation of new work, artistic and scientific. A central task for the centre will be to support the subject area Art, Technology and Design as a field of research, as well as develop knowledge of cross-cultural management in order to facilitate the inter- and transdisciplinary culture the centre seeks to establish.

The vision is that Sweden should have a leading position in the intersectional area Art, Technology and Design, with a practical and critical approach that stimulates research, innovation, creativity, and the development of a sustainable society. KTH takes a leading role in this development by creating a platform for future faculty by creating a professorship in the subject area. The centre wants to put the human in the centre, which also implies to question what the human is in an age of technology. The centre would provide a place for soft-networking that can accommodate and initiate new research projects that presently are scattered in various environments and to support them by sharing of resources in terms of laboratories, equipment, courses and teaching programmes.

5.2.4 SweGRIDS

SweGRIDS is the Swedish Centre for Smart Electric Grids and Energy Storage. Started in December 2011, it is a partnership of academia, industry and public utilities, with major funding from Swedish Energy Agency as well as the corporate partners including ABB and Vattenfall who are also strategic partners of KTH. A majority of the activities in SweGRIDS are doctoral and post-doctoral projects. Uppsala University is also a partner in the centre. Uppsala University is also a partner in the Strategic research area STandUp for Energy, funding faculty positions in the same area as SweGRIDS. Uppsala University and KTH are also partners in InnoEnergy, where educational programmes and innovation activities are supported. Together these three initiatives, SweGRIDS, STandUP and InnoEnergy cover different steps of the education, research, development and innovation process, all in the area of Smart electric grids and energy storage.

The overarching purpose of SweGRIDS is to develop new knowledge and technology required to create future electric power grid that will help achieve Sweden’s and the European Union’s ambitious targets for greater use of renewable energy sources and improved energy efficiency. SweGRIDS bring together various disciplinary areas like power systems, electromagnetics, material, physics, and information technology for a common purpose of development of electric power grids that can reliably and economically handle higher proportions of renewable generation and widespread energy trading. There are currently around 40 research projects in SweGRIDS, each involving industrial and academic researchers working with a doctoral student or PostDoc.

5.3 Research infrastructures

The EECS School host two major, national research infrastructures, the Electrum Laboratory (Ellab) and the Parallel Computing Centre (PDC). In addition to these national level infrastructures, the School also host a large number of labs, some of which are at the university level, these are further described below.

5.3.1 Electrum Laboratory

The Electrum Laboratory is a resource for cleanroom based micro- and nanofabrication of materials and devices, and characterization of materials, structures and devices. The laboratory is organised as a Centre at KTH with EECS as the host school, and is part of the national infrastructure Myfab. The cleanroom is operated by KTH in close collaboration with RISE. Electrum Lab has the responsibility for lab infrastructure and media supply, user information, marketing and business system, coordination of work environment, safety and quality systems, etc., while the user groups are responsible for tools, processes and projects. Electrum Lab is approved as a KTH Infrastructure, and will participate in the development of rules and intentions of that new concept in benefit of all KTH Infrastructures.

The Laboratory, including premises, facility and tooling, is continuously developed in close collaboration with the user groups – academic and commercial – in order to maintain the versatility and state-of-the-art of the infrastructure at an agreed cost level. Especially the move of SCI School groups to Albano will open up for renewed planning of the premises and the next Myfab application (20+19=). Maintaining competence is a key for quality and safety in the laboratory. In the period 2018-22 three out of seven employees are likely to retire and the laboratory will recruit and educate a new generation of personnel, capable to handle the complex laboratory operation, including potentially dangerous chemicals. The Electrum Laboratory builds networks with similar laboratories through Europe. The networks will be strengthened and developed to give KTH and Electrum Lab increased visibility. The networks are also bases to attract new users, and for participation in consortia applying for national and EU based infrastructure related programmes.

There are several divisions within the EECS School that are heavily engaged in the Electrum Laboratory, for example the MST division which represents one of the largest users groups of lab. Within the Electrum lab, the division has equipment which is strategically relevant and of special interest for the division to maintain and develop. It is important that the division, or electrum lab, can maintain the resources both to allow new investments into critical infrastructure both also to maintain and depreciate on existing equipment.

The Electronics division (ELE) is also heavily engaged in the lab, and complete processes for device and circuit manufacturing have been developed over thirty years by researchers at the division, today offering 100 – 200 mm Si CMOS processes 100 mm SiC bipolar process technology, as well as III-V compound semiconductor photonic devices, including an in-house and versatile metal-organic vapor-phase epitaxial growth system. This infrastructure is continuously being updated to the users' needs, recently chemical mechanical polishing (CMP) was added. There is also state-of-the-art instrumentation for precision DC, RF and low noise electrical characterization of devices, and high speed operation of analogue and digital circuits is available at KTH ICT, even up to temperatures of 600 °C.

5.3.2 PDC Centre for High Performance Computing

The PDC Centre for High Performance Computing is a provider of large-scale computing and storage resources as well as advanced application support primarily to Swedish academia. It is part of the Swedish National Infrastructure for Computing (SNIC). PDC operates a variety of HPC systems, including the currently largest academic system in the Nordic countries, Beskow, a 2.5 PFLOPS Cray XC40. Advanced user support and a comprehensive training programme complement the hardware services. PDC provides its services via SNIC or through direct collaborations with research groups and also industry. A prime example of this is the long-term collaboration with Scania that resulted in a major upgrade of Beskow. PDC is also engaged in international collaborations, most importantly PRACE, the European Partnership for Advanced Computing, where it acts as the Swedish node. PDC is financed through VR (SNIC), KTH, academic and industrial user contributions, and national and international (EU) projects. During 2017 a new model for SNIC was developed, which is now being implemented. This model changes the funding structure of SNIC and it will be important to ensure a stable economic situation for PDC under this new model to avoid disruption in PDC's service provisioning.

The current main system, Beskow, will reach its end of life by the end of 2019 and needs to be replaced during 2020. To be able to serve the increasing user demands, a total budget of some 200 MSEK will be required and needs to be confirmed by autumn 2018 so that the procurement process can start in late 2018/early 2019. In this context the support of new services and user groups (e.g. data intensive computing, AI) needs to be discussed.

PDC is critically dependent on having highly qualified staff both on the system and support side to provide its services. A particular focus is laid on advanced expert support and PDC has built up a team of highly qualified experts in several application areas. These experts work closely with PDC's users, most importantly in the context of SeRC, to improve their efficiency on PDC systems. Sustaining and improving this effort is a major aim for the coming years. The HPC landscape is also changing on the European level with the creation of the EuroHPC Joint Undertaking. PDC plays an active role in these developments and it will be important to maintain PDC's capacity to act as national stepping stone towards European resources.

5.3.3 Additional infrastructures

5.3.3.1 EXTRAP T2R

The fusion research activities at the in-house EXTRAP T2R are complemented by activities at other EU devices and computing facilities made available through participation in the EUROfusion consortium. The major facility is the JET tokamak where several staff members and students regularly participate in experimental campaigns and strong support to theory and modelling. The experimental device EXTRAP T2R hosted by the Division of Fusion Plasma Physics is resource available for other research groups at KTH as well as external researchers. The device produces a high energy density ionized gas – plasma – utilizing the method of magnetic confinement. The plasma has multiple uses, such as research on magnetic confinement fusion, materials research, plasma waste treatment, and various plasma applications.

The plasma in EXTRAP T2R device is contained in a ring-shaped chamber with volume of 0.8 m3. The chamber has a number of access ports enabling insertion of material samples or various types of probes. Typical plasmas are produced from hydrogen gas with particle (ion, electron) densities of the order of 1019 particles per m3. Plasma particles have a thermal energy distribution characterised by a temperature in the range 100-500 eV. The particle flux at the plasma boundary is of the order of 1021 ions/m2 s. Plasma electrons produce a heat flux at the plasma boundary of the order 10-100 kW/m2 s.

5.3.3.2 Micro and Nanosystems Laboratory

The Division of Micro and Nano Systems maintain the MST Laser lab, MST advanced cell and molecular biology lab, MST THz lab and MST polymer lab and also participates in the KTH/KI/SLL's MedTechLabs, Physiology and pharmacology lab at KI and the E-beam facility at the SCI school.

5.3.3.3 ITRL and Smart Mobility Lab

The School also, via the Division of Automatic Control, has a leading role in the Integrated Transport Research Lab (ITRL), in particular in the area of connected and automated transport systems. ITRL has a strong involvement in Living Lab and Test Site projects and the list of external collaboration partners is long. ITRL has developed and built research concept vehicles that are available for students and researchers for experimentation, and collaborations within Drive Sweden give access to a the DS Innovation Cloud, which is a platform for sharing data, services and applications among partners. The Division of Automatic Control also runs the Smart Mobility Lab, which hosts projects and activities both in transportation systems (also as an integral part of ITRL), and in robotics.

The Smart Mobility Lab is used in many courses at the School, in particular in project courses and thesis projects, but also by doctoral students and faculty for research and demonstration. Current research on Aerial Robotics is motivated by our participation in several national and EU (eg AEROWORKS) pertaining to research and experimentation for multiple aerial robots. The current infrastructure is limited and more space and base funding will be required in the immediate future should KTH be aiming at being a top hub for aerial robotics within EU and worldwide.

5.3.3.4 Visualization Studio

The Visualization studio, VIC, a facility used across KTH for advanced visualization purposes in research as well as undergraduate education. The studio is a research environment with modern technology for visualization and interaction where students, researchers and industry meet. The technology in the studio is continuously being improved and upgraded, but includes among other things: interfaces for movement and gesture control, eye- tracking and gaze tracking, haptics and stereoscopic viewing systems (passive, active, as well as auto-stereoscopic). It also has computational capabilities for advanced graphics rendering, including a direct connection to PDC (Center for High Performance Computing).

5.3.3.5 PMIL

PMIL is a multi-purpose facility for data collection and experiments in multimodal interaction. It currently features a 17 camera motion capture system, 3 head mounted gaze trackers, VR equipment and sound recording equipment. PMIL is primarily used by researchers and teachers at EECS. There are also several external collaborations e.g. with Stockholm University of the Arts. In recent years, research usage has increased beyond the initial domain of multimodal interaction due to several large externally funded projects in the area of social robotics. The infrastructure is designed to be updated and extended continuously to fill the need at KTH of a state-of-the-art facility for capturing and studying human performance and interaction. To this end we expect the facility to exist and develop for the foreseeable future.

5.3.3.6 “Språkbanken”

The new national infrastructure Språkbanken was in 2018 awarded 210 MSEK over a 7 year period. It consists of three branches: Språkbanken Text (GU), Språkbanken Society (ISOF) and Språkbanken Tal (KTH TMH). Språkbanken Tal becomes Sweden’s first national infrastructure for speech technology, with a programme that includes the upkeep of publicly available speech corpora, synthesis and recognition in Swedish. It is also established internally at KTH as a formal KTH Infrastructure, which adds to the expectation of longevity beyond the 7 years of initial funding granted by the Swedish Science Foundation.

5.3.3.7 Sustainable Power Lab

The Sustainable Power Laboratory (SPL) enables world-class research into technologies needed for the transition to a decarbonized energy system with radically reduced environmental impact. Research is carried on all levels, from materials characterization to power system dynamics. Key research fields are dielectrics, electromagnetics, power electronics and drives, electric machines, EMC issues, embedded control and Hardware in the loop real time simulation. In terms of final applications a very broad field is addressed – grid interfaces for renewable energy sources, hybrid and electric vehicles and HVDC supergrids. The lab is well recognized in industry, large corporations including KTH strategic partners such as ABB and Scania as well as Volvo, Atlas Copco and General Electric participate in experimental projects in the lab. Several projects are carried out in collaboration with industry and the facilities are made available to industry for testing and verification. Facilities in the lab are frequently rented out to SMEs, including start-ups from students and faculty at KTH.

The vision is of the lab is to, open up this leading experimental facility to local, national and international collaboration. Across KTH, collaborative work is already happening with the SCI and CBH schools and through the national doctoral programme SweGRIDS the facilities are opened up for collaboration also nationally with Uppsala University. Internationally collaboration in EU level networks such as ERIGRID and DERLab the facilities will be made more accessible. An important step in achieving this openness is strengthened governance and management procedures for facility and equipment sharing, personal safety and equipment upkeep. The flexible lab power supply platform spans two levels of the building in Teknikringen 33. Six rotating DC supplies for 15V – 700V can supply up to 75kW. Six rotating AC supplies allow for high power high frequency supply. Four induction regulators providing variable AC supply up to 50kVA, a 200kW static 4-quadrant SAMI STAR converter and coupling matrix, allowing virtually any supply to be patched to any other location in the lab.

5.4 Research impact – activity plan

The following impact actions have been planned. Actions might stop if low success is expected or resources are missing, and other prospective actions might be added.

- Competence development of EECS staff: Improve the skills that create impact by organising and/or giving seminars and the hands-on graduate course “From Research to Impact” (scheduled next Fall 2018). Seminars targeting EECS faculty and researchers on specific impact relevant topics are planned.

- Strategic partners: Explore needs, value and opportunities from collaborations with strategic partners of KTH and the School. Identify valuable (ongoing) activities and initialise and support new prospective activities.

- Impact Cases: Support the school communicators and faculties in the creation of research impact cases that can be used for communication and school assessments. In particular if this is requested in upcoming assessments, this might include a seminar or workshop to support faculties in the preparation of impact cases.

- Alignment: Participate in impact relevant (strategic) meetings and outreach to different school boards to align school activities, create awareness and anchor impact in the school operation and secure necessary support.

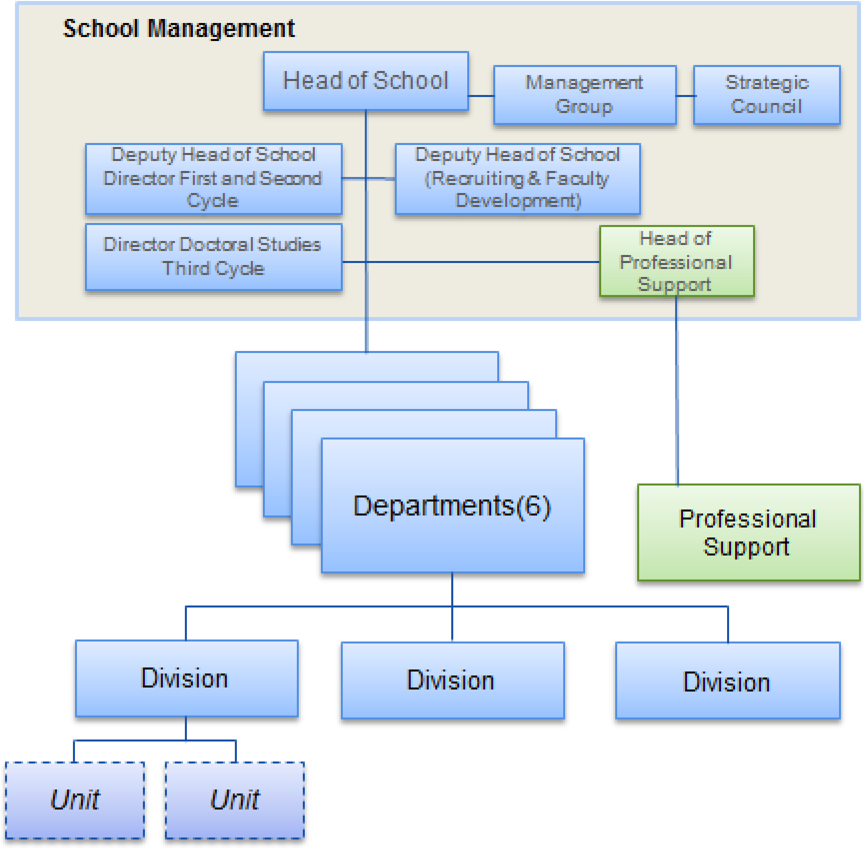
In addition to the above, the School is discussing strategies for alumni relations as well as life-long learning.

[1] https://efecs.eu/publication/download/ecs-sra-2018.pdf
[1] Smarter electronics systems for Sweden, Research and innovation agenda for smart electronic systems, 2013, available from http://www.smartareelektroniksystem.se/insatser/rapporter/

6 Organisational development

6.1 School organisation 2023

The preferred organisational model for the KTH schools is a strictly hierarchical line-organisation model with five to six departments ("institutioner") led by a head of department, each consisting of a number of divisions ("avdelningar"). This organisational model has clear advantages from a management perspective as it provides a clear division of responsibilities. It also allows for the delegation of many decisions to the departmental level (e.g. all temporary employment decisions).



6.2 Organisational development process

Moving from the current, "flat" organisational model with 16 divisions will require several steps in order to avoid large disruptions in the operations of the School. In 2019 a first step is made, by introducing "departments". The "departments" will in this intermediate step focus on the operational aspects of undergraduate and master education and the long-term competence development plan for the area of the "department". The divisions focus on the operational aspects of research. In research matters the division heads still report to the Head of School.

One or several more steps will be taken to reach the final organisation, latest in 2023. The number of departments and divisions may vary during this time as they are reshaped to find their final form.

7 Professional support

On January 1, 2018, the three former schools' administrative units were practically merged into one Professional Support Division at the new School, EECS. This organisational unit consists of some 100 co-workers and is divided into six units (communication, finance, HR, student affairs, infrastructure and service, and the school office). It supports 200 faculties, 500 doctoral student 140 researchers/teaching staff who belongs to 18 different divisions and centres which are located at 10 different addresses.

To assist the School in delivering on the decided performance indicators and contributing to KTH's overarching focus areas (2018-2023), the division aims at providing an efficient, transparent and close-to-operations support. All services offered should be relevant and lead to the development of the School's research, education and collaboration. To deliver on KTH's focus area "An Integrated KTH", EECS will work to provide one common entrance to all services offered. The Service Centres will be a major part of this solution and will both practically and digitally be the natural place to turn to for the School's employees. They will be able to handle a great variety of errands and see to that different processes are made in a lean and professional manner, e.g. practical arrangement surrounding the doctoral thesis defence, low-cost procurements, travel planning, etc. They will also act as a dispatch-centre forwarding errands to the correct destination at the Professional Support Division – always keeping the involved faculty updated about what is happening.

In order to secure closeness to operations and know-how about the specifics about a research environment EECS will further develop the concept of Divisional Teams. They will be the experts on a specific research environment, knowing the faculty and the research projects and be pro-active in making the daily operations run smoothly. They will also be liaison officers to the rest of the Support, and they will in most cases have offices at the division. They consist of resources from the HR and the Finance Unit, and also a contact person within the management of the Professional Support Division.

The balance between keeping local know-how and providing efficient (low-cost) and professional service will be a main focus. A necessity to deliver on this will be a continuous and active dialogue between the Support and the faculty to calibrate the support offered and the design of the processes. The support and the faculty need to cooperate even more closely to make the service offered lean and efficient. Knowledge and understanding of conditions for both parties by both parties will be key.

To keep the level of administrative costs down, and providing similar service to all faculties a common support level for different areas will be established, which will be financed by all divisions. The level will vary between areas and be set by the budget process each year.

To secure delivery on the above, a second important strategy for the Professional Support, is to strive for to becoming one unit – i.e. forming common processes (e.g. budget routines, student services, recruitment processes), cooperating over unit boundaries and creating an inspiring and friendly working environment (see Chapter 8). Developing the staff's competence will be a core part of this ambition as well as using digitalization to reach the set goals.

An additional third strategy is to intensify the cooperation with the other four KTH schools as well as the central administration (KTH UF) in order to benchmark, learn and to form a coherent KTH.

Strategy areas:

- The Professional Support Division will become a role model at KTH known for providing relevant, transparent and integrated support to research, education and collaboration, which always is characterized by pro-activeness.

- The Professional Support Division will become a role model at KTH known for its inspiring and creative working environment in which co-workers are encouraged to develop, take responsibility and challenge themselves.

- The Professional Support Division will become a role model at KTH known for close cooperation with other KTH schools as well as with the central administration (KTH UF).

- The Professional Support Division will have a specific focus on treating all students and all colleagues equally.

Service Centre at Borggården, Lindstedtsvägen 3:

Service Centre in Electrum, Kistagången 14:

Service Centre to be in Q, Malvinas väg 10:

8 Work environment

The EECS School should be an attractive employer with a welcoming and including working environment in which the employees thrive.

Preventive work, systematics and efficiency should permeate the management of the School's work environment issues. Transparency regarding work environment efforts is important and the Head of School has through the School's delegation and rules of procedure delegated responsibility for staff and work environment to the Heads of Divisions.

KTH's intranet, the School's internal pages, workplace meetings (APT) and other informative meetings are the main communication channels regarding work environment issues.

The School will work in line with the President´s priority work environment area "Inequality, Discrimination, Harassment and Sexual Harassment" and ensure that staff will have an opportunity to reflect on KTH's personnel policy, including work environment policies, guidelines and routines in the area and the KTH Code of Conduct.

The school merger has meant major changes, especially for the School's Professional Support Division. The process of creating a uniform Professional Support Division has begun and the goal is a working culture that is characterized by an open dialogue between employees and management.

With regard to the organisational and social work environment, the management of the School strives to ensure that employees experience a high degree of satisfaction at work based on a good working environment, employee ship, healthy workload, good opportunities for continuing professional development and influence.

An important factor for well-being is the physical working environment that should be safe and ergonomic. In order to offer this, the School will ensure that there are preparedness for possible crisis situations, inventory procedures and risk assessment to prevent accidents or occupational diseases, as well as well-trained personnel responsible for the various parts of the physical work environment. A review of the School's premises and local distribution is a priority area.

Strategy areas:

- The EECS management (including Heads of Divisions) and the HR Unit will work on the employee-ship, and making the KTH Code of conduct well known and a natural guide for the employees.

- The EECS management (including Heads of Divisions) and the HR Unit will work to ensure that there is no inequality, discrimination, harassment or sexual harassment.

- The EECS management (including Heads of Divisions) and the HR Unit will work to ensure that the premises are functional, ergonomic and adapted to the organisation's needs.

8.1 Working environment group

A working environment group consisting of operational representatives has been appointed to work with the School's systematic work environment and to be a preparatory body for the Head of School in the field of work environment. The working environment group reports to the school management and supports the Heads of Divisions in work environment issues.

It is also important that there is good cooperation with the central university administration (KTH UF) regarding the working environment law, KTH's guidelines and instructions. In addition, coordination of processes, processing and collaboration with the other KTH schools will be required.

9 Sustainability

The sustainability work at the EECS School is aimed primarily at environmental, economic and social sustainability. It is defined by continuous progression and high ambitions, focused on contributing, in the best ways possible, to the sustainability goals of KTH (A KTH for a more sustainable world).

One long-term goal is that the sustainability work should influence all parts of the School. It should be well integrated, meaning it is applied to all parts and levels. It should also be carried out in close collaboration between groups/divisions/units within EECS, as well as in collaboration with the other KTH schools and the central KTH administration (KTH UF). External partners will be essential contributors, too.

Maintaining the high level of integration, the high quality and ambition, needs continuous work and monitoring. This is driven by the Head of the School, coordinated by the environmental representatives and involving academy, staff and students.

The sustainability work at EECS is carried out within the framework of the environmental management system. KTH holds the certification ISO 14001:2015 for environmental sustainability.

Strategy areas:

- The sustainability work will influence all processes and routines as well as steering documents at EECS.
- The sustainability work will focus on delivering on the projects in the School's local Sustainability Plan.
- The sustainability work will see to that the School's campus environments are characterized by sustainable solutions.
- The sustainability work will be conducted in close cooperation with both other KTH units (schools and KTH UF) and external actors.
- The sustainability work at EECS will deliver on the key performance indicators set by KTH centrally.

10 Attachments

10.1 Attachment 1 - EECS Competence Development Plan

10.1.1 Background

One of the objectives for forming the EECS School was to establish an organization based on engineering subjects and to facilitate efficient undergraduate education well adapted to the requirements of society. The former organization in three schools, divided into two campuses, has in some cases led to sub-optimal solutions for these two important aspects. Not least, this has been clear in the field of faculty development. For historical reasons, today, some subjects are represented on more than one, sometimes up to three, different departments. This applies, for example, to employment profiles in areas such as communication systems, software systems and machine learning. Similar overlap can be seen in undergraduate programmes and courses.

In order to address the shortcomings of the former organization with regard to faculty development, the EECS school will be organized in six departments which will gather the 16 divisions with regards to undergraduate education and faculty development. In terms of research and in terms of third cycle studies, the present departments still have their own discretion over research funds and recruitment of post-docs and postgraduate students. The continued development of the faculty will however be coordinated within the future institution. This means that the competence development plans developed by the departments provides the basis for coordination work within the institutions, which will then develop final competence development plans for their respective subject areas.

This competence development plan contains the facts about the present EECS faculty as contained in the present 16 departments. In addition to this, the plan outlines the process going forward on how the faculty development – specifically recruitment of new faculty shall be organised.

10.1.2 Present EECS academic staff

The total academic staff at EECS including faculty in tenure track, lecturers (*adjunkt*), researchers (*tillsvidareanställda forskare*) as well as affiliated faculty and adjunct professors from industry sum up to above 267 individuals. The allocation across categories is illustrated in table 1 below.

	2018		
	Tot	M	W
Professors	**99**	87	12
Associate professors	**82**	71	11
Assistant Professor	**18**	13	5
Lecturer	**19**	15	4
Researcher	**27**	24	3
Adjunct Professor	**9**	9	0
Affiliated Faculty	**13**	12	1

Table 1: Total academic staff at EECS

In addition to the above numbers, the two large research infrastructures at the School, PDC – *Parallelldatorcentrum* and Electrum Laboratory employ a further 33 researchers and specialists in various roles. This competence development plan does not include these organisations unless specifically mentioned.

A further study of the employed faculty broken down in to categories regarding Docent degree and gender balance provides some insights such as: out of the 85 associate professors, 23 do not have a docent-degree, and of these 4 are women. The other 62 associate professors have a docent degree, and of these 7 are women. Hence, women are over-represented among the category of associate professors who do not have a docent degree. Of the associate professors who do not have a docent degree, 14 have worked at KTH for over 5 years and of these only one is a woman. Although the data is limited, it appears that women are over-represented in the category of associate professors who do not have a docent title, but not so among those who work for a long time as associate professors without earning a docent degree. Of the full-time researchers, 8 of the total 27 have a docent degree, and of these one is a woman. Since the total numbers are too small, it is not possible to draw any further conclusions regarding this employment category.

Overall, the EECS tenure track faculty is composed of 14% women. Of the assistant professors 26% are women, indicating a positive development trend at the junior faculty level. As can be seen from the total faculty development in *Table 2* which includes forecasted promotions the increase in professors from 2018 to 2022 is estimated to be 27 individuals, of which 5 are women. This equals 18% to be compared with the government target for KTH at large which is set at 32% of the new professors being women. From 2022 and on, the numbers are less reliable and at that stage the number of retirements increases.

	2018			2019			2020			2021			2022			2025			2027		
	Tot	M	K	Tot	M	K	Tot	M	K	Tot	M	K	Tot	M	K	Tot	M	K	Tot	M	K
Professor	**99**	87	12	**106**	93	14	**118**	104	14	**119**	103	16	**126**	109	17	**118**	100	18	**112**	96	16
Associate Professor	**82**	71	11	**76**	67	9	**71**	60	11	**70**	59	11	**65**	55	10	**58**	50	8	**55**	47	8
Assitant Professor	**18**	13	5	**14**	10	4	**8**	6	2	**2**	2	0	**0**	0	0	**0**	0	0	**0**	0	0
Lecturer	**19**	15	4	**19**	15	4	**19**	15	4	**18**	14	4	**18**	14	4	**15**	12	3	**15**	12	3
Researcher	**26**	23	3	**26**	23	3	**26**	23	3	**25**	22	3	**25**	22	3	**24**	21	3	**22**	19	3
Professor, adjunct	**9**	9	0																		
Affiliated faculty	**13**	12	1																		

Table 2: Development plan excluding recruitments

It is important to note that the Development plan in *Table 2* does not include recruitment, it only considers the retirement of employed faculty (estimated at age 67) and the promotion of existing faculty as estimated by the heads of the present departments.

10.1.3 Specific challenges

This section lists some specific challenges identified during the development of this competence development plan, which will be considered going forward.

10.1.3.1 Gender balance

Although some positive trends can be noted in present EECS academic staff – specifically with regards to tenure track faculty, there still remains a significant gender imbalance. Assuming that the total number of faculty is fixed, i.e. for each retired professor one new faculty is hired, and further that every new hire is a woman. In this case, at steady state in 2025, the total faculty would be 190 (as for is presently the case in 2018), the new recruits – a total of 14 new individuals – all being women - would change the balance to 21% from today's 14%. The conclusion is that the School must continue to put large focus on gender balance in recruitment, but that quantitative goals must be set in relation to what is possible to achieve.

10.1.3.2 Recruitment in competitive sectors

The EECS School is active in several sectors critical to society in which there is an overall shortage of skilled and experienced staff at all levels of expertise leading to fierce competition for top talents. This is specifically apparent in the software and computer systems domain. To be successful in recruiting top talents for teaching and research at the EECS School specifically in areas where the teacher shortage is significant, the School will provide additional start-up-funding for junior faculty to support the institutions.

10.1.3.3 Academic staff not in tenure track

During development of the competence development plan, a number of cases have been identified were individuals presently in the academic staff of EECS contribute as if they were part of the tenure track faculty. This includes cases of researchers with fixed employments working significantly within education and vice versa lecturers who are contributing to research. During the coming years, the school intends to work actively together with KTH centrally in order to identify possible career paths for such individuals to allow for recognition of their contributions.

10.1.4 Faculty development going forward

Faculty recruitment should be driven by the teaching needs of the school's institutions. This includes in particular opening of new positions and recruitment but also to some extent the promotion of already employed faculty.

10.1.4.1 Process for promotion

The School's processes for promotion within the tenure track system are published on the School's Intranet. It is the responsibility of the department head, together with the FFA at the school to make sure the individual faculty member can develop towards promotion according to the KTH regulation.

Promotion to associate professor is encouraged for all assistant professors and they are coached in this process. Promotion to "docent" is encouraged for all full-time faculties, with focus on those research areas with a shortage of main advisors for doctoral students. The School endorses promotion to full-professor only for candidates that effectively drive their own independent research agenda, including those who already manage research groups of several researchers, post-docs and doctoral students. Such individuals or groups should have demonstrated that they are able to sustain themselves over several years – beyond isolated project funding. There should be a clear need for promotion, e.g. that the candidate is opening a new research area that is sufficiently distinct from the area of the "parent group". The candidates should also have taken an active part in management, development and/or operation of education in the first cycle, second cycle and third cycle.

To make sure that the support letter from the School reflects the contribution both within teaching, research and management it shall be signed by all three of heads of department, head of institution and the deputy head of school with responsibility for faculty development (FFA).

10.1.4.2 Process for recruitment

The School targets to recruit top-talent. The question that needs to be answered in every faculty hiring instance is "can this person add to our competence and improve the position of KTH?". If the answer is negative, we should refrain from hiring. The School needs to employ active search committees to find the best possible candidates on an international "market". The target is to have at least 10 candidates for each faculty position, of which the majority should be international candidates. Proactive measures to attract more female candidates are to be taken. Pedagogic experience that is related to our educational programmes is seen as required.

Recruitment is initiated by the Institution according to the recruitment process in place at the EECS School. The needs in first and second cycle education that the position shall address should be specified.

The head of the institution must also make sure to consult all departments associated with the institution before proposing the position to the School. This consultation includes making sure that the departments do not have teachers available that could fill the teaching needs identified. Second, the consultations should include the question whether the department can consider hosting the new recruit in the research group of the department.