QANU Research Review
Electrical Engineering 2011

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1. THE REVIEW COMMITTEE AND REVIEW PROCEDURES

Scope of the assessment
The Committee was asked to perform an assessment of the research in Electrical Engineering at Eindhoven University of Technology (TUE), University of Twente (UT) and Delft University of Technology (TUD). This assessment covers the research in the period 2005 - 2010.

In accordance with the Standard Evaluation Protocol 2009-2015 for Research Assessment in the Netherlands (SEP), the Committee's tasks were to assess the quality of the institutes and the research programmes on the basis of the information provided by the institutes and through interviews with the management and the research leaders, and to advise how this quality might be improved.

For the assessment of the societal relevance of the research, the Committee was asked to use the ERiC Guide "Evaluating the societal relevance of academic research" as a complement to the Standard Evaluation Protocol.

Composition of the Committee
The composition of the Committee was as follows:

- Bart de Moor, KU Leuven (chair);
- Kay Hameyer, RWTH Aachen University;
- Lajos Hanzo, University of Southampton;
- Marcel Pelgrom, NXP Semiconductors, Eindhoven;
- Johan Schoukens, VU Brussel;
- Anthony Walton, University of Edinburgh.

A short profile of the committee members is given in Appendix 1.

Roel Bennink of the Bureau of QANU (Quality Assurance Netherlands Universities) was appointed secretary to the Committee.

Independence
All members of the Committee signed a statement of independence to safeguard that they would assess the quality of the Institutes and research programmes in an unbiased and independent way. Any existing personal or professional relationships between Committee members and programmes under review were reported and discussed in the committee meeting. The Committee concluded that there were no unacceptable relations or dependencies and that there was no specific risk in terms of bias or undue influence.

Data provided to the Committee
The Committee has received detailed documentation consisting of the following parts:

- Self-evaluation reports of the units under review, including all the information required by the Standard Evaluation Protocol (SEP), with appendices;
- Five key publications per research programme;
- A joint note about the 3TU cooperation, strategic research directions, chairs.

The joint note also contained information about actions taken after the previous review. The Committee would have appreciated some harmonised information about the impact of the research. Basic information about the organisational structures, the embedding of the

departments in the university, their size in terms of staff and students, would also have been helpful.

Procedures followed by the Committee
The Committee proceeded according to the Standard Evaluation Protocol (SEP). According to the expertise of the committee members, the programmes were assigned to specific reviewers, who independently formulated a preliminary assessment. The final assessments are based on the documentation provided by the Institutes, the key publications and the interviews with the management and with the leaders of the programmes. The interviews took place on 21-25 November 2011 on location at the Institutes.

Preceding the interviews, the Committee was briefed by QANU about research assessment according to SEP, and the Committee discussed the preliminary assessments. The Committee also agreed upon procedural matters and aspects of the assessment. After the interviews the Committee discussed the scores and comments. The texts for the committee report were finalised through email exchanges. The draft report was presented to the faculties for factual corrections and comments. The comments gave rise to several adaptations in the draft, to clarify and expand the text and to adjust some scores. A telephone conference was held on 10 July 2010 to agree upon the direction of the changes. The final report was presented to the boards of the participating universities and was printed after their formal acceptance of the report.

The Committee used the rating system of the Standard Evaluation Protocol (SEP). The meaning of the scores is described in Appendix 2.

2. GENERAL REMARKS

The review of the research in Electrical Engineering at the three TU's in the Netherlands gave insight in an impressive array of activities and results, in many cases with a high degree of interdisciplinary collaboration and very productive interaction with stakeholders in industry and society.

Electrical Engineering can perhaps be regarded as the most wide ranging research area on the scale from theoretical/fundamental science to fully functional applications, and especially in terms of the fruitful connection between these two.

The main general impression of the Committee is that EE in Eindhoven is very strong in collaboration with Industry, Twente is very advanced in a number of fundamental research topics with biomedical orientation, Delft is strong in research with high societal relevance (climate, sustainable energy).

Related to the breadth of the field, it is a complicating factor for this review that the organisational structures in Eindhoven, Delft and Twente differ with respect to the combination of disciplines. Disciplines or subdisciplines in the EE field are sometimes part of other faculties. This makes it more difficult for the Committee to make general/comparative statements at the Institute level.

A common trend is that virtual network structures are being developed for interdisciplinarity and societal relevance, often in line with strategic themes per university.

Societal relevance
The Committee noticed a very high degree of relevance of the research for a wide range of extremely important issues and aspects in society, from climate analysis to energy efficiency, from robotics for medical surgery to sensors and activators for automotive suspension, from early detection of colon cancer to the charting of depression and happiness in social media networks, from high-temperature superconducting cables to crawlers for gas pipe repair and low-cost flexible photovoltaic modules.

Innovation in terms of new applications that result from research findings, is very difficult to steer or predict. It requires broad and fertile feeding grounds, long-term perspectives and opportunities for spin-offs. The road from discovery to market can be long and arduous, and contains many challenges in areas including risk investment, product development, marketing and staffing. Valorisation in terms of the dissemination of knowledge to the professional field and/or to the general public is not dependent on such serendipity and risks, and the Committee has been presented with many good examples of such activities.

Funding
All departments have shown great flexibility in adapting to changes in the funding policy. In most cases a decline in direct funding has been compensated by an increase in external funding. The Committee notes that the importance of fundamental research is still fully recognised, both by the universities and by the industry, but reduction of government funding, such as the loss of 500 M€ of funds from the natural gas revenues, now threatens the knowledge base and the pool of next generation researchers. There is a danger that the PhDs become too expensive for Industry, because the universities can no longer count on sponsorship from public-private-partnerships (which often was 50%).

Government initiatives currently focus on the Top Sectors, innovation contracts and Topconsortia Knowledge & Innovation (TKI). This should lead to agreements between all parties in the knowledge chain (including TNO, STW and NLR), with financial and content-based targets. Information about these important developments could not be fully taken into account in this research review, so the Committee can only make a few general comments:

- The proportion of funding for EE from sources like STW (second category funding) has never been very high. The EE departments should not take this as a given fact; and STW and ERC funds should be actively sought more than ever.
- The vulnerability of large infrastructures (radar, robotics, cleanrooms) deserves special attention, as the Committee understands that government funding to support these facilities has been significantly reduced. The investments in ensuring the availability of up-to-date labs and equipment needs long-term support from structural funds for maintenance, retention of key technical staff and energy supply. In the case of the excellent cleanroom facilities that exist at the three TU's, the Committee was assured by the Faculties that the shortfalls would be covered from other sources. The Committee still has some concern about the longer-term viability of these solutions.
- Innovation cannot be sufficiently stimulated by focussing on applications, but only by maintaining a technology layer with high-quality research capacity.
- Stimulating spin-offs and valorisation remains important. However, commercialisation should not be seen as a priority objective of research groups themselves, but selling IP-rights and know-how may be attractive in some cases, even though the university will probably not able to build up a profitable patent portfolio, because of the overhead costs involved.
- New strategies for systematic technology transfer should not only focus on large companies. There is a great need and potential in the SME sector as well. Links between universities and SME's have been neglected, because the SME's mainly participate in networks with institutions for higher professional education (HBO). This may not be sufficient for bolstering the innovative power of the economically significant SME sector.
- A policy or research question might be to what extent a critical approach is needed towards overstated claims about solving grand challenges with technological solutions. The value of technological knowledge also lies in the rational analysis of its limitations. Inflated expectations can be just as disturbing as an irrational fear for technocratic solutions.

Strategy
We have seen many examples of strong strategic management and a good combination of national complementarity and international collaboration, combined with healthy competition. The NanoLab NL is a particularly striking example. The focus and integration of the research themes has clearly received much attention, and the results are evident. In the area of Photonics and Energy opportunities seem to exist for 3TU coordination, to improve synergy.

The joint note of the three deans contained much information about the research agenda's and 3TU cooperation per field, and presented a future outlook in relation to the major challenges for the next 50 years. This excellent overview inspires full confidence in the strategic positioning of the fields and subfields and can serve as a good starting point for developments in the years ahead.

Quality
On average, the quality of the work in the research programmes is assessed as slightly higher than Very good, with a number of programmes that are regarded as Excellent. This means that the research groups are internationally competitive and make a significant contribution to their scientific field. In some fields we see clear international leadership.

Overall the Committee was very pleased to see a marked improvement compared to the previous assessment period.

3A. INSTITUTE LEVEL - Eindhoven University of Technology

University: Eindhoven University of Technology
Faculty: Faculty of Electrical Engineering[1]

1. The institute

Research at the Department of Electrical Engineering is organised in nine capacity groups, in line with long-term research disciplines. The fundamental research in these groups is complemented with cross-disciplinary mid-term and short-term research that answers to the societal and industrial needs, especially to three societal themes that the Department has chosen. To facilitate this connectivity, "technology centres" were created, in which the capacity groups work together on integrated technological solutions. These centres, only staffed by a director and a limited number of supporting program officers, function as a portal for initiation and presentation of relevant cross-disciplinary research projects carried out by the staff in the groups.

The technology centres are:

- COBRA: Centre for COmmunication technology Basic Research and Applications (1998)
- CWTe: Centre for Wireless Technology Eindhoven (2007)
- C3Te: Centre for Care and Cure Technologies Eindhoven (2010)
- CPEe: Centre for Power and Energy Eindhoven (2010)

The cross-disciplinary research that the groups perform in the context of the centres, and indirectly also the long-term fundamental research within each group, is focused on three long-term societal themes:

- Connected World
- Care and Cure
- Smart and Sustainable Society.

The Departmental Board is responsible for all the decisions on issues of research, education and support. Responsibility for research content, personnel and finances is given to the chairs of the capacity groups. The main task of the Dean and of the Board is to appoint highly qualified professors with a profile which supports the main research focus of the Department. The Board provides a clear focus on the future mission of the Department and manages the realization of the mission. The Dean and the Board of the Department give freedom to the full professors and their staff to realize this mission in their research programmes. Each chair maintains direct links with industry. The groups are being strengthened by the appointment of an extra full-time professor. For most groups this has been achieved.

The Department policy and the research activities within the chairs are summarized in a yearly research report, with a format similar to the self-assessment reports required for external visitations.

Assessment/remarks

The Committee appreciated the well-prepared documentation and presentations in Eindhoven. The dean of the Department showed a clear vision for the future and effective planning processes. The Committee also appreciated that attention had been paid to the recommendations of the previous research review.

[1] In English, the TUE uses the term Departments for what they call Faculties in Dutch.

A special characteristic of Electrical Engineering at the TUE is that the Department does not contain 'other' disciplines, such as at UT and TUD, where EE is part of Electrical Engineering, Mathematics and Computer Science (EWI).

The four Technology Centres are a good idea, but it is too early to assess their effectiveness in the new context. The Centres provide 'shop windows' and clear communication lines with industry and other stakeholders. Some further development of their strategic approach seems to be needed, in connection with the developments in the Top Sectors.

2. Quality and academic reputation
The self-assessment report states that funding obtained by groups and individuals within the groups increasingly depends upon proven and recognized research contributions. Building up the necessary reputation is a process that takes a long time and requires careful monitoring of the progress made by the groups. Generating new knowledge is key to the success of a group, but getting funding for long-term blue-sky research is hard in the field of Electrical Engineering, and application oriented research is becoming increasingly important to acquire the necessary research funds.

The Department distinguishes between funds obtained for **academic research** –both fundamental and application oriented research- and funds obtained for **valorisation of knowledge.** Valorisation of knowledge offers opportunities for generating the money needed for funding long-term blue-sky research for which it is hard to get direct funding.

The research of the Department is exclusively done within the research groups, while the technology centres have the task to initiate and coordinate cross-disciplinary technology and valorisation-oriented research projects. A very significant part of the funding is acquired by these research centres (COBRA, CWTe, C3Te and CPEe).

In the view of the Department, each capacity group needs to have three types of research projects:

- Long-term research on well selected topics that enable the group and its individuals to build up and extend their scientific reputation; this research results in new technologies, improved understanding of specific technologies and extension of available knowledge in the various areas of expertise.
- Medium-term application oriented research required for building engineering skills and acquiring the funding for financing PhD and PostDoc positions; this research results in proof of principle and lab scale proof of concept.
- Short-term application oriented research to bring applications from proof of principle and lab scale proof of concept to industry; this research has to support application development and support the introduction of new technologies and products to the market.

The research is done within the capacity groups, but the Department wishes to enable joint multidisciplinary projects with contributions from academic groups, national research centres and industry. The capacity groups are expected to transfer knowledge to national research centres and industry, in order to improve valorisation and open innovation.

Assessment/remarks
The quality of the research programmes is high, some are world class. The combination of long-term, medium-term and short-term types of research is a very useful principle. Some issues per group may require action, as indicated in the programme assessments.

3. Resources
The TUE has decided to invest 50 M€ in a new building and labs for the Department of Electrical Engineering together with the Department of Applied Physics. This should be ready in 2014.

The ratio of direct funding, research grants and contract research in 2010 was 42:7:44 (with 7% other funding).

Funds available for long-term fundamental academic research in the field of Electrical Engineering have decreased, because the focus shifted to short-term application oriented development rather than long-term research. In three years time it is expected that the basic funding of the Department will diminish 25% due to governmental budget cuts. On top of this in 2013 the NRC/Photonics funding may come to an end.[2] The aim is to compensate these cuts with extra income out of contract research. Still, the Department wants to ensure that all groups combine long-term, medium-term and short-term research.

To earn the money needed for funding the long-term research activities and the required infrastructure, the Department's policy aims at ensuring solid research contributions and a good connection to research areas which are considered relevant by society and industry.

In 2008 a tenure track system was implemented. New academic staff has to meet several targets in teaching and research to become tenured in 4-6 years. To be able to reach these targets, several courses are available for newly hired staff.

The university programme "Women in Science" stimulates the recruitment of female staff. This is actively implemented in the Department.

Assessment/remarks
The resources and HRM-policies are regarded as excellent. The funding policies are sound and contain a sensible risk assessment.

4. Productivity
In the review period 2005-2010 the Department has produced a total of 157 PhD theses, 927 refereed journal articles, 2606 refereed international conference proceedings, 44 books, 91 book chapters, 160 patents. The total research staff was between 115 and 141 fte per year in that period, with a total of 747 fte in these 6 years.

Assessment
The productivity per fte is very high. The output of journal articles is good, but the impact is not as high as from some groups abroad. This may be a consequence of the applied nature of the medium- and short-term work. Publications about more fundamental research tend to have a higher impact, typically by a factor of at least 10.

[2] The NRC Photonics programme was awarded to COBRA by the Dutch Ministry of Education, Culture, and Science in 1998. It focuses on future optical communication networks. The total initial funding of the program was 35 million euro.

5. Societal Relevance

The Department aims to maintain good connections to research areas which are considered relevant by society and industry. The Department has selected three themes that have long-term societal relevance, that require research contributions from all groups in the Department, and that appeal to a wide range of students interested in engineering sciences:

- *Connected World*, oriented to technology development for wired and wireless data transfer for communication and connectivity, and with a focus on future integrated communication infrastructures.
- *Care and Cure*, oriented towards technology development for remote diagnosis and monitoring of people, early detection of illness, enabling elderly people to stay in their homes reaching high ages with high quality of life, and model based training simulation for medical staff.
- *Smart and Sustainable Society*, oriented to technology developments for enabling high-tech solutions needed for turning our society into a society where a large population lives in harmony with nature without depleting resources and leaving footprints.

The research centres define and maintain the research roadmaps related to these three research themes. The strategic research agendas and the corresponding roadmaps are defined by the research centre directors in close communication with the research group leaders and the main industrial partners of the Department. The research centres are the interface between the research groups of the Department and their external partners.

External communication includes a website, press releases, newsletters, open house, TU/eXperience, brochures, movies and a special game.

Assessment/remarks

The pervasive interaction with Industry is impressive. This is evident in the internships, in the set-up of the PhD training (with 4 days in Industry and 1 day a week at the university), which have an impact on the local economy. There is much innovative industrial activity clustered around Eindhoven and the companies act as sponsors of PhD projects, provide internship places and opportunities for initial work experience.

The cross-disciplinary research is in line with the grand challenges of the EC (develop new and sustainable solutions in areas such as global warming, tightening supplies of energy, water and food, ageing societies, public health, pandemics and security with the objective to contribute to the emergence of an eco-efficient economy in Europe). The presentations showed a focus on energy and environmental issues, also in collaboration with companies.

TUE follows the trends in societal demand, but it might be necessary to reflect more specifically on where the EE research can really make a difference: what unique contribution can they make to these challenges? The Technology Centres are an important step in the right direction, but their strategic direction may require further refinement.

6. Strategy for the future

The faculty groups, the scientific directors of the Centres and the Centre staff members continue working on realization of the roadmaps agreed with the major industrial and societal partners. The roadmaps are the guideline for defining and setting up research programmes and research projects in close collaboration with the partners. The roadmaps are updated regularly on the basis of renewed insight stemming from ongoing research. Money earned with the applied research projects (3rd money stream) is used for financing long term research activities of the capacity groups.

The high workload of critical staff members is a serious point of concern. Actions are planned to re-allocate tasks between staff members to better use people at their strengths and to improve efficiency in the operation. An inventory of tasks and competencies of people has been initiated. On the basis of this analysis and a clear description of group and faculty requirements the re-allocation of tasks to scientific and supporting staff members will be realized.

The recruitment of of BSc and MSc students is another serious point of concern. Actions to increase the present low number of students have been initiated based on closely working together with a selection of schools to stimulate the interest of students for Electrical Engineering. Pilot tests with the Sondervick College have demonstrated the potential success of these actions. Furthermore a serious computer game development has been initiated to create interest for technical studies in general and for Electrical Engineering in particular.

The Centres, as well as the collaborations remaining from the KWR projects (Knowledge Workers Scheme), are used to further cement the collaboration with industry and national labs. As a result the activities related to, and consequently the number of people working on valorisation of knowledge (short-term research projects), will increase. These valorisation projects will to a large extent generate the money required for financing the long term research projects.

The opportunity created by a significant number of people retiring will be used to hire staff members with the talents needed by the organization for realizing the plans.

Assessment/remarks
The strategic outlook of the Department is comprehensive and sound. The coherent structure of procedures, responsibilities and measures inspires confidence.

7. PhD Training
The facilities for PhD students during their research project include:

- education and supervision plan (after 9 months 'go/no go')
- exploration research plan
- contact with supervisor (promoter and co-promoter)
- education (the PROOF programme).

All PhD students at the TU/e can follow the PROOF program (PROviding Opportunities For PhD students) next to their scientific developments. In many cases the courses are given in interdepartmental groups, so that they become familiar with the work of other departments and can build up a personal network with the university. The Department also offers specific facilities and support for further personal development.

Recommended PROOF courses are: planning and communication, cultural awareness, self-awareness, writing scientific articles, presenting your own research, supervising Master's students, scientific integrity, entrepreneurship and career orientation. This programme is not only intended to enable PhD students to complete their PhD project, but also to increase their chances on the labour market.

From the period under review, all PhD-graduates found employment. Most (57%) found a job in industry with about 30% taking academic posts.

Assessment/remarks
The PhD training is well-structured and up-to-date. The PhD students are constructive, positive, enthusiastic, and international.

3A. PROGRAMME LEVEL - Eindhoven University of Technology

Programme TUE 1: **Control Systems (CS)**
Programme director: Prof. P.P.J. van den Bosch
Research staff 2010: 13

Assessments:		
	Quality:	4
	Productivity:	4
	Relevance:	5
	Viability:	5

The research aims at mastering the complexity of dynamical systems using several methods, such as model reduction of spatial-temporal systems, the synthesis of low-complexity controllers for fast real-time implementation and distributed estimation and control. This is applied to electromechanical systems, large power networks, automotive systems and chemical production processes. Focus is on multi-DOF electromechanical actuators, very fast observers and controllers (100 kHz or higher) for power electronics, the control of power systems with less-predictable renewable resources. In the area of modern vehicles, the research contributes to advanced energy and battery management. In the area of Care and Cure, the research theme is data-based modelling. In Wireless Communication the theme is networked control systems, especially the influence of varying network delays and lost messages in real-time control.

Quality
The group delivers high quality results starting from a sound theoretical basis. This is illustrated by the large number of publications in top level conferences and journals. The international visibility of the group members is not fully in line with the publication output and efforts should be made to increase it in the coming years.

Productivity
The number of PhDs is not at the level that would be expected for such a group and this requires attention.

Relevance
The societal relevance of the work is excellent. Most of the work is done in very close collaboration with the Dutch industrial player in the field. This is also reflected in the very large number of industrial grants across a wide range of applications. However, this also creates a double risk. Firstly, the group (and the government) should pay attention that sufficient funding is available for long term high risk fundamental research in order not to compromise the long term perspectives of the group. Secondly, it also important that the work of the group remains sufficiently focused on their own research strategy. The risk is that the activities get too scattered as a result of the budgetary and industrial pressure that is permanently present.

Viability
The team has anticipated well to the future changes in the staff (retiring staff-members) by attracting a young high potential individual as well as an experienced senior researcher. This is a guarantee that the development of the sound fundamental theoretical basis of the group will be continued.

Programme TUE 2: **Electro-Optical Communication Systems (ECO)**
Programme director: Prof. A.M.J. Koonen
Research staff 2010: 19

Assessments:	Quality:	5
	Productivity:	4.5
	Relevance:	5
	Viability:	5

The team specializes in the research of cutting-edge optical communication networks and their interfacing with other networks for the sake of creating high-capacity long-haul transmission systems. This necessitates the conception of high-speed signal processing and signal routing techniques for providing integrated services for the users, as well as for managing and controlling these networks.

Sub-programmes are: High capacity links; Telecommunication nodes; User access networks; Network management and control (started Oct. 2008).

Quality
The team's research is of excellent quality, which manifests itself both in terms of their past achievements, such as a range of awards, citations, grants, people trained, as well as in terms of their future plans. Of particular merit is the holistic approach they adopt in their overall system-optimization efforts. The team also undertaken a future-proof approach in terms of their four sub-programmes, aiming for substantially improving the attainable throughput of fibre links. In the past they have advanced the state-of-the-art in the area of non-coherent multi-level optical transmissions and recently contributed to the research of coherent-detection aided systems. Their holistic optimization efforts also dictated the improvement of optical switching and routing, leading to new time-, frequency- and spatial-domain optical switching. Of particular note is their efforts in the field of low-cost, yet power-efficient plastic-based multimode optical fibre networks as well as their radio-over-fibre activities. They have also investigated a raft of radical machine-learning aided techniques conceived for cross-layer optimization.

Productivity
The team's productivity is hallmarked by an impressive number of journal and conference publications, as well as books and book chapters. The high volume of publications is not at all to the detriment of quality - the key publications put forward by the team are of high quality, hallmarked for example by the prestigious invited paper published by Prof. Koonen in the Proceedings of the IEEE, which has the second-highest impact factor in the realms of the IEEE journals. The impact factor of the IEEE Journal of Lightwave Technology also belongs to the top league.

Relevance
Clearly, the societal relevance of the team's activities is excellent. They fostered an active interaction with a large number of colleagues in the field within the affiliated organisations, such as 3TU, COBRA, NIRICT, eiTT and with a range of ICT innovation platforms, such as Domotica and Smart Living; A substantial list of industrial contacts is also provided in the well-prepared documentation, with the three most important ones being Genexis, IBM and Nokia-Siemens Networks. This close industrial liaison substantially improves the economic impact of their research. A number of public engagement activities, such as radio interviews on 'green' ICT were also listed in the submission.

Viability

The viability of the research carried out by the team remains excellent. They were able to attract funding from a large variety of sources, reaching an impressive level of about 15.1 Million Euros, despite the limited size of the team. Their impressive research momentum is testimony to the future viability of the team. They specialize in diverse novel subjects, such as video transmission over ultra-wideband systems, in new wave-length division multiplexing schemes conceived for low-cost plastic fibre and an array of other hot topics, which are carefully complemented by a whole raft of classic topics.

Programme TUE 3: **Electrical Energy Systems (EES)**
Programme director: Prof. W.L. Kling (from November 1, 2008), Prof. J.H. Blom (until November 1, 2008)
Research staff 2010: 16

Assessments:		
	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	3.5

The research is in the area of the supply and use of electric energy. The aim is to improve electrical infrastructures and develop sustainable technologies for sustainable, renewable energy systems. The main research activities are Intelligent Power Grids, Pulsed Power Technology and Electromagnetic Compatibility (EMC). Sub-themes are: Transition towards new electrical infrastructures; Handling Power Quality issues; Design, control and protection of distribution networks; Performance of components; Pulsed power and transient plasma; Tuned activation of processes by pulsed power; Electromagnetic interference mitigation; sensors and lighting protection modelling.

Quality
The programme is very well focussed on the mainstream topics smart grids, pulsed power and EMC. This long-established group is well-known in the Netherlands and is internationally recognized, although it is suggested that there is room for increasing their international visibility in order to further develop leadership in the relevant research fields. The laboratory equipment is excellent and provides the group with an excellent base for their R&D.

Productivity
The productivity ranks among the groups with a very good output relative to their size. Due to the current relevance of all research topics in the group related to electrical energy, such as intelligent power grids, it is expected that the group will grow in size. Such growth is also expected to increase the productivity, due to synergetic effects within the group.

Relevance
The research portfolio contains a high number of industrial projects on mainstream topics. However, it is suggested to apply for more public funding, national and European, to be able to work on more scientifically fundamental questions. This will increase the national and international visibility of the group and ultimately provide a more stable basis also for the societal relevance..

Viability
The strategic focus of the group is on applications of lower power range. The group has co-operations within TUE, nationally with TU Delft and internationally with Ghent and Energy Hills (Aachen-Heerlen). The intention to focus the efforts on relatively small power applications might restrict the possibilities to develop into a leading group. Most of the currently important societal questions are related to high power. It would probably be good to extend the topics to larger power applications and to increase national and international competition.

The financial structure is stable on the basis of G2 and G3 funds.

Programme TUE 4: **Electromagnetics (EM)**
Programme director: Prof. A.G. Tijhuis
Research staff 2010: 12

Assessments:	Quality:	4
	Productivity:	3.5
	Relevance:	4
	Viability:	4

Prof. Tijhuis' team aims for conceiving novel modelling techniques for facilitating the accurate analysis, design and synthesis of sophisticated three-dimensional antenna structures. They are engaged in the state-of-the art modelling of wireless communications systems, radio astronomy, radar systems, as well as in the study of diverse other radio wave propagation scenarios. The team also considers various bio-electromagnetic applications, optical fibre based systems and their components, RF and microwave technology, imaging and lithography, as well as their Electromagnetic Compatibility (EMC) problems. Furthermore, the team specializes in the design of high-specification antenna systems and then characterize their performance benefits in the context of complete radio communications systems. Indeed, the research of improved radio communications systems constitutes another strength-area of the group in the quest of designing cutting-edge next-generation wireless systems. To this effect, they analyze, model and mitigate the deleterious effects imposed by the hostile communication channel, which leads to novel design and deployment strategies. Of particular note is the team's role in designing enhanced antennas for communications in the 60GHz carrier-frequency range.

Their research is dedicated to four inter-related areas:
- Computational Electromagnetics
- Antennas and Antenna Systems
- Electromagnetic Effects
- Radio Communication.

Quality
Since the team's research and expertise is rather unique in the Netherlands, they bear a high responsibility - they are almost the exclusive source of Radio-Frequency (RF) expertise within the country, even though there is a great industrial demand for their graduates. This manifests itself also in terms of the high level of industrial funding they have received over the assessment period. The committee found the breadth of the team's research beneficial for the entire academic unit/department they are hosted by. Several of the academics have an impressive h-index and the key papers put forward were disseminated in high-impact journals.

Productivity
The team has been quite productive over the assessment period – indeed the committee was informed that this group may be deemed somewhat under-staffed, given the current level of activity and industrial interest in the field. This fact is evidenced by the impressive level of funding they received, which was close to 11 MEuros in total or about 1.1 MEuros per academic staff. The academic staff has a whole raft of outside commitments, including COBRA, TNO, ASML, NXP, etc.

The overall productivity of the team 'just' falls into the upper half of the prestigious 3TU league and the committee had the impression that given the high level of funding per FTE, the team's productivity may be further boosted by involving more part-time or full-time staff in the interest of supervising more PhD students. This hypothesis is supported by the inference that the team's

productivity was at its peak during the middle of the evaluation period, but fell slightly during the last year of the period.

Relevance
As discussed above, the team conducts research into the propagation properties of diverse carrier frequency bands, including hitherto less well explored frequency bands, which are more readily available than the congested bands below 2.5GHz. The thorough understanding of the wireless propagation medium is a fundamental enabler of reliable wireless communications, which in turn is an important source of wealth-creation in business and society as a whole. The team has received about 40 different grants over the past five years, which is an eloquent manifestation of the relevance of their work. The significance of mm-wave and Terra-Hertz communications - which fall into their area of interest - is expected to grow over the next period.

Viability
It is an impressive future-proof feature of the team's research that they are conducting research into the mm-wave and Terra-Hertz spectral region's propagation properties, where a substantial amount of unused spectrum is available. Hence, in this respect the team will retain its momentum and viability into the future.

Programme TUE 5: **Electromechanics and Power Electronics (EPE)**
Programme director: Prof. A.J.A. Vandenput (until 2008), Prof. E.A. Lomonova (from 2009)
Research staff 2010: 11

Assessments:		
	Quality:	4
	Productivity:	3.5
	Relevance:	4
	Viability:	4

The research aims at understanding the fundamental physical properties of electromagnetic actuators, electrical machines, power electronic converters, batteries and storage devices that determine the performance of current and future industrial power conversion and sustainable energy systems. The programme concentrates on performance driven component and systems design by extending the multi-disciplinary theory on advanced methods and tools to enhance the analysis, design and multi-objective optimization of electromagnetic structures and multi-level converters. Theoretical research is combined with ultra-fast numerical tools and supported by dedicated experiments and prototype applications. Application areas are high-performance industrial and medical systems, and electrical vehicle power trains. Introduction of the battery modelling and battery management research in the Department of Electrical Engineering has just commenced; application of this research into automotive, bio-medical, smart grids and wireless sensing applications will be based on the existing battery research experience.

Quality
Research is application driven with a fundamental theoretical background. The group is successful and growing fast. The research involves the scientific study of applications such as magnetically levitated 6 DOF linear motors and actuators with highly accurate positioning. The research is oriented across a diverse range of application areas, such as mechatronics, power electronics, battery & energy storage. The research areas are part of cooperations within the university and/or they are in line with topics of groups at universities that are leading in this field. The quality of the work is good, but the programme might benefit from a more specific focus, which might accelerate the development of their academic reputation and leadership in the community. The performance of the group gives it high potential to gain scientific leadership.

The organisation is excellent, with a high grade of supervision of MSc and BSc students by senior staff members resulting in interesting studies. EPE has the interesting strategy to have a high number of senior staff (former EPE PhD students) by means of part-time contracts with industry employees. This ensures continuity of the work performed and supports knowledge transfer to the next generation of young scientists.

Productivity
The output shows a good mix of conference and peer-reviewed journal publications, resulting in an increase in reputation and high output of valuable publications. The strategy of having part-time TUE and Industry staff members supports the quality of publications of the junior staff. The panel believes there is high potential to further increase the number and quality of the publications.

Relevance
The work performed in the group is technically relevant. There is a good connection to the surrounding industry, which results in a high number of industrial projects. In the opinion of the reviewers, the scientific depth of the work could be increased by adding specific scientific focus. In view of the new leadership, it is expected that within the following years a focus on particular topics will be strengthened.

Viability

The team has consolidated its position after the sudden death in 2008 of their former group leader André Vandenput. Professor Elena Lomonova was appointed as the successor. The group has already achieved very much in this short period of time. The group has a stable basis of G2 and G3 funding and has close collaborations with other groups at TUE. The team has also established close ties with similar groups in France and Germany. The productivity of the group is now in the upper half of the 3TU league and there is a potential to further increase both the number and quality of publications. Under the new leadership the team has been successful in acquiring more funding and in attracting more students, which in time is expected to improve their viability even further. As mentioned above, it is suggested to increase the viability of the group for a specific area by focussing on a theoretically and practically relevant topic.

Programme TUE 6: **Electronic Systems (ES)**
Programme director: Prof. R.H.J.M. Otten
Research staff 2010: 16

Assessments:	Quality:	4
	Productivity:	4
	Relevance:	3
	Viability:	3

The research concentrates on predictable and efficient methodologies for the implementation of complex electronic systems. To identify the key problems, and verify the validity, robustness and completeness of their results, the group develops, implements and maintains consistent and complete mapping flows, and uses them for realizing innovative systems with emphasis on embedded architectures and vision applications. The aim is to provide a scientific basis for design trajectories of electronic circuits and systems from idea to use. Algorithms are developed for synthesis and verification of complex systems, and integrated into complete design environments where they serve as the core of multiprocessor architectures and signal processing, in particular in multimedia, telecommunications and health applications.

Quality
Researching methodologies for the design of complex systems is a difficult task. The important questions in this field often come from problems encountered in very competitive industry groups, while on the other hand the dissemination of results is limited by commercial and legacy issues. Nevertheless the group manages to contribute and even excel in a few chosen topics. In the self-assessment the emphasis is strongly directed towards processor architecture, which seems a new direction. The discussion raises the unanswered question related to closer ties with the informatics department.

Productivity
The listed number of PhD theses is low for the number of staff. On the other hand this ia somewhat balanced by the many publications listed in a very wide diversity of conferences, media etc.

Relevance
Working on the methodology of designing electronic systems bears the danger of inserting another abstraction layer towards visible societal relevance. An extra effort is needed to create awareness of this research within the EE world, but also for non-technical observers.

Viability
The strategy of the group is rather general and operational: the yearly review, aligns to faculty goals and seeks a presence in the popular media. There are no consequences drawn from the various issues and weaknesses that the group reports. In the previous visitation report (2004) the relative isolation of the group was marked as a risk. During the presentation it became clear that this point still applies.

Programme TUE 7: **Mixed-signal Microelectronics (MsM)**
Programme director: Prof. A.H.M. van Roermund
Research staff 2010: 14

Assessments:		
	Quality:	4
	Productivity:	4
	Relevance:	5
	Viability:	4

The research area of the group is advanced purely-analogue and mixed-signal IC design (RF/IF/LF), applied to front-ends, especially for wireless RF transceivers and sensors. In this context, front-ends are defined as the functional blocks that process and translate analogue signals (communication signals, sensor signals) to digital signals (bits), and vice versa. This includes on the one hand system, concept and algorithm level design, and on the other hand circuit block design (antenna-matched low-noise amplifiers, sensor amplifiers, power amplifiers; oscillators, mixers, modulators, detectors; data converters). At all these levels, the group strives to implement smartness (autonomous calibration, adaptivity, error correction, reconfiguration, etc.).

Regarding performance, the group focuses on improvements in high-speed power-efficient, or in ultra-low-power front-ends. Regarding the application domains, the current focus is on communication and medical applications. Regarding technology, the focus is on advanced deep-submicron processing (CMOS, BICMOS) and emerging technologies (organic).

Programme lines are:
- Data converters
- Sensor Interfacing
- RF front-ends
- Terahertz front-ends
- Technology directions.

Quality
The mixed-signal micro electronics group has chosen the concept of smart interfaces as their focus activity. From the publication list it is clear that they progress well in the direction of a world leading team. A stronger presence in the top conferences (as requested in 2004) will be the result. New directions have been defined with new staff members joining the group. The future prospect of the group will depend on the synergy between their disciplines.

The MsM group definitely contributes in the scientific fields they have chosen as their domain.

Productivity
Except for the year 2010 the PhD theses productivity of the group is not exceptionally high. The worry concerning the difficulties of attracting sufficient students is not reflected in a strategic action and the committee suggest this this needs to be addressed. Also there is concern that the rather diverging expertise areas of the new staff could create problems with maintaining (joint) productivity.

Relevance
The relevance of this work in contributing e.g. to the European Grand Challenges programme is certainly present, although the role outside the Dutch scope is less visible.

Viability

Although challenging tasks lie ahead, this group has the staff, the theme and the means to operate at a high level. The set-up of the Centre for Wireless Technology will allow embedding the research in a wider field of expertise and applications, thereby increasing output and impact.

Programme TUE 8: **Opto-Electronic Devices (OED)**
Programme director: Prof. M.K. Smit
Research staff 2010: 11

Assessments:		
	Quality:	5
	Productivity:	4
	Relevance:	4
	Viability:	5

The research focus is on development of the scientific knowledge underlying generic photonic integration technologies that can be applied for fabricating Photonic ICs (PICs) for a wide variety of applications, similar to the role of CMOS in microelectronics. Particular focus is on integration of InP membrane based technology with silicon, and plasmonic nanolasers. This is in addition to continuing work on the development of an elementary set of basic optical building blocks

Sub-programmes or themes are:
- Generic InP-based Photonic Integration
- Nanophotonic Integration.

Quality
The group is performing good research and is recognized as an important technology provider in the area of photonic integrated InP-based circuits. Highlights include the world's smallest optical flip-flop and the first plasmonic DFB laser. The facilities available to the group are internationally leading as are the OED staff.

Productivity
While there is a very healthy rate of conference publications the Committee noted that the journal output was rather low as was the number of graduating PhDs for the size of the group. These are aspects that are key factors in maintaining the group's status and its future development and the committee recommends that plans are actively put in place to address these issues.

Relevance
Among other similar activities, the group plays a leading role in the JePPIX platform (Joint European Platform for InP-based Photonic Integrated Components and Circuits), where partners from universities and companies cooperate to make photonic integration technology accessible by covering the whole value chain from PIC design to application. From the submitted paperwork there have been no spinouts during the period of this review although PhD students have been active in forming photonic design companies.

Viability
The research infrastructure available through the COBRA cleanroom is excellent and the recent acquisition of the 193nm AMSL stepper provides the group with a good opportunity to deliver advanced technology.

There is a concern that the reduction in finance available to sustain the cleanroom could adversely affect the research programme. It is important for the stakeholders (the group, industry and the university management) to develop a realistic and fully costed business plan to address the future funding situation.

Programme TUE 9: **Signal-Processing Systems (SPS)**
Programme director: Prof. J.W.M. Bergmans
Research staff 2010: 19

Assessments:	Quality:	4
	Productivity:	5
	Relevance:	5
	Viability:	5

The research area concerns the development of signal-processing theory, building blocks, algorithms, architectures, and systems.

Sub-programmes or themes are:
- Signal transforms and filter banks
- Media signal processing
- Signal processing for communications
- Medical signal processing.

Quality
The SPS research group is a very successful group. The staff of the group established a very high international visibility. Amongst others, we can mention the large number of IEEE fellowships, keynote addresses and awards. In order to position the group at the absolute top-level of world leaders in their field, the leading 'administrative' positions in many international organizations should be complemented with a number of highly visible and internationally recognized scientific mile-stone publications. At this moment the global impact of the work is lagging behind the excellent visibility of the group.

Productivity
The scientific production (number of PhDs, journal and conference papers) of the group is very high in absolute and relative terms. The papers are published in the best journals and conferences.

Relevance
The societal relevance of the work is excellent. A significant part of the projects is done in direct cooperation with the Dutch industrial strategic partners and is focused on the future needs of the (Dutch) society.

Viabiltiy
The future prospects of the group are very good, due to their balanced mixture of theory and applications, embedded in valuable industrial applications. A significant part of the income is directly related to industrial projects, but there is also a significant fraction of G1 and G2 funding. This should guarantee that the group can continue to follow its own long-term strategic research line in the future. By using the fundamental knowledge of the group in a wide range of applications, the group is not dependant on the temporal success of a specific industrial sector.

4A. INSTITUTE LEVEL - University of Twente

University: University of Twente
Faculty: Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS)
Department: Department of Electrical Engineering (EE)

1. The institute

The Department of Electrical Engineering is one of the three departments in the Faculty of Electrical Engineering, Mathematics and Computer Science at the University of Twente. The Department is responsible for the BSc and MSc programmes for Electrical Engineering and is involved in a number of other study programmes as well. The research takes place in the interdisciplinary research institutes MESA+, CTIT, MIRA and IMPACT. Two groups (DACS and CAES) are shared with Computer Science and were only partly reviewed in earlier assessments. The DACS group does not participate in this review, but the complete CAES group does.

MESA+ is the institute for nanotechnology. The CTIT institute is the base for all ICT-oriented groups and since 2011 the robotics and mechatronic activities are also part of the CTIT. The new MIRA institute is a merger of the former Biomedical Institute BMTI and the Technical Medicine institute. The IMPACT institute will be discontinued. The research of the groups CE and TST, both of which participated in IMPACT to some degree, will be continued in CTIT and MESA+ respectively.

Electrical engineering at the UT concentrates on the hardware-related aspects of information and communication technology. Research activities range from developing new components and systems for the measuring and processing of physical quantities, to the realisation of electrical and micromechanical systems as well as to applications in robotics and medical systems. All these activities have the measurement and processing of signals in hardware or software as well as their use in a broad range of applications in common.

Assessment/remarks

Six of the eleven research groups were closely linked with biomedical technology, in terms of the research focus and the relationship with the bachelor's and master's programmes. This can be regarded as a clear choice, but there may also be reasons to consider somewhat broadening the scope.

In the area of biomedical technology, the importance of connections with the world of real patients and doctors cannot be overemphasised. In a more general sense, close contact with the actual areas of application is vital for the quality and relevance of the EE research. This is relatively easy in application areas with a technological nature, but it is much more difficult to realise in the clinical environment which is highly idiosyncratic. Collaboration in the cluster RUG-RU-UT-WU may provide good opportunities in this respect.

Environmental sensor systems can probably profit from collaboration with Wageningen.

2. Quality and academic reputation

The Department regards the cooperation with the social science faculties of the UT, and the organisation of the research in multidisciplinary research institutes as important strengths. The contacts with industry and the large number of spin-off companies are also regarded as strong points. The building and lab facilities are new and up-to-date. The new NanoLab is regarded as high-class facility and one of the leading cleanrooms in Europe.

The human resource management in the Department includes annual performance appraisals which can lead to a bonus or to targets being laid down in a personal development plan. Study leave and sabbatical leave is encouraged to support the research dynamics. Most senior staff members have recently attended an Academic Leadership programme. Temporary staff is encouraged to enhance their research skills by following courses in national research schools and in the university.

Vacancies for professorships are advertised internationally. The description of the field of activity is concise and relatively open-ended, in order to attract young, eminent scientists and give them some freedom to further develop their field.

Assessment/remarks
The tenure track system is competitive; there is money reserved for young staff, to support them right from the start. This is very refreshing compared to the old system. The young staff have a target of 30% teaching, 70% research. There is impressive performance in acquisition of 3GS and EU projects. There are 26 spin-offs reported, which is a high number. There is also central support for producing EU project proposals; this seems to be very effective and EE has made good use of these facilities.

3. Resources
The income from contract research plus EU funding has more than doubled in the review period. At the faculty level this has been compensated for the decrease in direct funding that resulted from the decrease in the number of students. Since 2010 a significant part of research funding has been based on long-term research plans and the expected income from externally funded projects, with the objective being to ensure stability and a good balance between short-term and long-term objectives, . Under certain conditions the research groups can also use generated financial reserves for additional temporary staff and investments.

At the end of 2010 48% of the funding was direct funding (mainly spent on the permanent staff and office and lab space), 15% came from research grants and 27% from contract research and 10% from EU projects. The latter three are used to finance PhD's and Postdocs and, as far as possible, equipment and infrastructure.

A substantial budget is allocated to the strategic programmes of the research institutes. Additional funding has been obtained for the 3TU Centres of Excellence for 'Intelligent Mechatronic Systems' and 'Dependable ICT Systems', financing two positions for five years in the groups Control Engineering and Telecommunication Engineering (Short Range Radio).

In 2010 the new Carré building and NanoLab became available. All lab facilities and offices are now first class.

As a result of targeted efforts, some groups have considerably increased their number of PhD students. The total number of PhD students has increased by 24%. The targeted average workload per staff member is considered to be 500 EC (successfully completed by the students) and the supervision of 3 PhD's.

Assessment/remarks
Resources are excellent, but the high level of investment also brings potential financial vulnerability due to the on-going costs of maintenance.

4. Productivity
In the review period 2005-2010 the Department has produced a total of 148 PhD theses, 873 refereed journal articles, 1031 refereed international conference proceedings, 15 books, 93 book

chapters, 61 patents. The total research staff numbers between 130 and 162 fte per year in that period, with a total of 875 fte over the 6 years.

Assessment/remarks
The quantity of the output is good and the impact in terms of citations is relatively high as a result of the scientific orientation. The output per fte is relatively low, especially in the category of refereed international conference proceedings.

5. Societal Relevance
The self-assessment report states that electrical engineering is an essential discipline in a knowledge economy, because modern society increasingly depends on systems designed and realised by electrical engineers. A shift is taking place from single components to complex systems, which means that an EE Department can no longer be the sole 'owner' of the EE field. In several parts of the field there are strong links with e.g. Applied Physics or Mechanical Engineering, which underlines the importance of the discipline.

The UT seeks to stimulate change, renewal and progress in society by combining technical and social sciences. Behavioural and social science research are considered as vital for the technologies of the future, such as information technology, biotechnology and nanotechnology. The most interesting and relevant innovation is seen as taking place at the interface between technology and its implications for mankind and society. The PhD programmes in the Twente Graduate School are to be grouped around strategic issues (see paragraph 7).

The UT has a special programme to help starters setting up a company, the TOP programme. Initially, (former) students and staff members can get facilities in one of the research groups (office space, infrastructure etc.), an interest free loan, a mentor, etc. In a later stage, new spin-offs often move to the Business and Science Park just opposite the University.

Assessment/remarks
The department has a good track record in technology transfer, with 26 spin-offs. The TOP programme is a powerful stimulus for entrepreneurial activities.

The links with the social faculties at UT are potentially important for bridging the gap of misunderstanding in society between technical and social sciences or views. Societal debates about e.g. nuclear energy or genetic manipulation tend to get bogged down in black-and-white positions and technological know-how and scientific knowledge seem to be becoming less effective in resolving such debates, which poses a challenge that seems to require new approaches.

6. Strategy for the future
Partly driven by (expected) budget cuts from the government, the UT strives to refocus research and reduce the number of BSc programmes: Route 14+. The new focus is characterised as "High Tech, Human Touch", i.e. to train engineers that are qualified to develop technology with a sharp eye for the societal context.
The research by the technical faculties is being concentrated in the institutes MIRA, MESA+ and CTIT. Lesser performing groups and groups that do not fit in the new focus will be discontinued. All EE groups will be continued although some will be reduced in size and limited in the diversity of research topics. Some reshuffling of groups within EEMCS or even between faculties may also occur.

The faculty EEMCS has recently started a new BSc programme, Creative Technology. This programme combines elements from electrical engineering, computer science, industrial design

and the arts. Graduates of this study, with streams of 'new media' and 'smart technology', will be system integrators for new creative solutions that make life more pleasant in every sense. There is a high demand from society (industry) to educate engineers who are capable of applying technology in systems needed for a healthier and greener society. EE staff members are involved in teaching in this programme and this will have its impact on the research activities as well.

In the view of the Department, multidisciplinary co-operation is generally required for the development of advanced products. Merging electronics and software will lead to an increased focus on information and communication technology. The future of the Dutch high-tech manufacturing industry will be more in system integration and advanced, complex machinery and systems, rather than in mass-produced components.

Assessment/remarks
The Committee fully agrees with the strategic considerations of the Department. The focus on training engineers that are qualified to develop technology with a sharp eye for the societal context is visionary, valid and valuable.

7. PhD Training
Standard PhD candidates in the Department are temporary employees on a four-year contract. Funding comes mainly from external sources, either from competitive governmental research funding or from contracts with industry. In addition, the Research Institutes fund a few PhD candidates to instigate new developments.

In all cases there is a project plan before the PhD candidate is hired. Based on the background of the PhD candidate, an educational programme is set up consisting of courses necessary for the PhD research. These courses are provided by the university, national research schools and through International Summer Schools. PhD candidates are also offered general courses, such as professional effectiveness, technical writing and presenting, and career orientation. In addition, English and Dutch language courses are offered.

Presently, about 58% of the PhD candidates originate from outside the Netherlands. This creates an international atmosphere that benefits all candidates.

The university has established the Twente Graduate School that offers combined Master's and PhD programmes. This helps facilitate the influx of bachelor students into a PhD programme and improve the visibility of the university to attract excellent (international) students.

The PhD programmes in the Twente Graduate School are being grouped around strategic issues. Approximately 20-25 programmes will be set up university wide, emphasising cohesion between the various research projects. Within the programmes PhD-students follow common courses. EE participates in the programmes Wireless and Sensor Systems, Dependable and Secure Computing, Nano-devices and systems, Advanced Optics, Biomedical Technology and Technical Medicine, Next Generation Energy and Resources. Initiatives are underway for, among others, Robotics and Medical Imaging.

Assessment/remarks
PhD training is well-structured and tailored towards the needs of the students. Finishing on time sometimes seems problematic. The Graduate School can be expected to contribute to improving this aspect

4B. PROGRAMME LEVEL - University of Twente

Programme UT 1: **Biomedical and Environmental Sensorsystems (BIOS)**
Programme director: Prof. A. van den Berg
Research staff 2010: 19

Assessments:		
	Quality:	5
	Productivity:	5
	Relevance:	5
	Viability:	4.5

The research encompasses the study, design, and realisation of micro- and nanofluidic systems and devices, new electrochemical and nanosensing structures for applications in life-sciences, health care and in sustaining the environment. Where needed, new micro- and nano-technologies and fabrication processes are developed with these goals in mind using the MESA+ NanoLab cleanroom facilities. The group aims to investigate new micro/nanofluidic and nanosensing phenomena, integrate them into Lab-on-a-Chip systems and use them for the improvement of the quality of life, i.e. for early diagnosis, development of new drugs and sustainable technologies.

Quality
The BIOS group has an international reputation in delivering innovative Lab-on-Chip systems which is backed up by an excellent set of journal and conference publications. One of their major strengths is their comprehensive coverage of the required multidisciplinary fields of microfabrication, electrical characterisation, medical applications and the culture cells and tissue.

Productivity
The productivity is very high and the publications have high impact. While the output in journal articles was at the top-end of the spectrum, the conference output was low and the committee would encourage the group to use this mechanism to publicise their work and network with their community.

Relevance
The group is to be commended for its knowledge transfer record, which covers spin-off related activities as well as collaboration with industry. Examples include the lithium chip for monitoring the medication of manic depressive patients. This PhD work resulted in the spin-off of Medimate. Blue4Green is another spin-out that uses the same platform for detection of milk fever in cows. Another development of interest is the point-of-care diagnostic instruments, based on amperometric sensors.

Viability
A key aspect is the availability of the MESA+ NanoLab which provides access to the required technology. Adequate steps have been taken to ensure its funding for the coming years, also in the interest of the other NanoLab stakeholders.

Programme UT 2: **Biomedical Signals and Systems (BSS)**
Programme director: Prof. P.H. Veltink
Research staff 2010: 16

Assessments:		
	Quality:	4
	Productivity:	4.5
	Relevance:	4
	Viability:	4.5

The central theme of the group is Neural Engineering. The research focus is on interfacing with the neural system, and (tele)monitoring and influencing body functions through such interfaces. Research is performed across three levels:

- The cellular and network level: neuro-electronic interfacing of live neural tissue on electrode substrates, learning and memory in cultured circuits, neural endcap prosthesis.
- The human function level: neuromodulation and dynamic identification applied to pain, motor control and heart function; diagnosis, functional support and neurofeedback training in rehabilitation.
- The health care level: Telemedicine: remote monitoring and remotely supervised treatment using wearable interfaces and ICT systems.

The group aims to translate knowledge on the cellular and neuronal network level to clinically applied neuromodulation technologies, and knowledge of electrophysiological sensing to tele-monitoring and -treatment.

Quality
This is a successful and fast growing group. The staff members are highly visible in the international scientific community, with a large number of (IEEE) fellows, keynote presentations, and awards. The visibility and impact of the output has been growing fast over the last few years and the group are to be commended for this.

Productivity
The productivity of the group is very good. In particular the number of PhDs and journal publications is very high.

Relevance
The societal relevance is very good, the group has is an intensive interaction with its stakeholders having a long list of industrial collaborators in its projects as well as being involved in patent applications. Clearly the healthcare applications associated with BSS are of societal relevance.

Viability
The transition of the group to the new research topics that were announced at the last evaluation has been accomplished successfully. The group has the potential to become a world leader in the field as they build upon the existing base.

Programme UT 3: **Computer Architecture for Embedded Systems (CAES)**
Programme director: Prof. G.J.M. Smit
Research staff 2010: 15

Assessments:	Quality:	3.5
	Productivity:	3.5
	Relevance:	4
	Viability:	3.5

Energy-efficiency was initially the main research focus of this group. This included energy-efficient processing and communication sub-systems for battery-powered embedded systems, such as mobile phones and wireless sensor networks. This has been extended to dependable embedded systems, i.e. streaming applications in the high-performance high-tech domain (e.g. phased array antenna systems, medical image processing and signal processing on board of satellites) and ICT for energy management of systems such as smart grids.

The three main research themes are:
- Efficient architectures and tools for streaming applications
- Dependable embedded systems
- ICT for energy management of buildings and smart grids.

Quality
The group has clearly followed a new track after the present chair took charge. The application strategy aims at energy efficiency in various systems. The scope varies between ICT for energy efficient systems to energy-efficient processing. For the relatively small group this is a rather wide span to be able to maintain an excellent academic quality. A more prominent position in terms of milestone papers for Computer Architecture for Embedded Systems will help to reach a leading position in the academic world.

Productivity
The number of PhD theses is average, but the group is certainly a champion in spin-out companies (4 over the last 5 years). In itself this is a very good achievement, however, it should not lead to diverting its focus. At present 40% of the publications appear on low-acceptance rate conference, the group strives to increase its presence there. An increase in the number PhD students is expected over the coming years.

Relevance
The work of the group finds its application in many companies. It should be noted that this has not yet led to a substantial funding stream.

Viability
The group has some strong points in the field of computer architectures and embedded systems and starts to focus. The attention for the coming period should be on delivering some world-class contributions in this field. Still a number of crucial decisions have to be taken: e.g. the synergy between the three main themes and the scientific fields in which excellence is pursued.

Programme UT 4: **Control Engineering (CE)**
Programme director: Prof. S. Stramigioli
Research staff 2010: 13

Assessments:	Quality:	4
	Productivity:	4
	Relevance:	5
	Viability:	5

The research area of the group is novel technology and scientific methodologies for the design and development of complete robotic systems and similar intelligent devices, i.e. cyber-physical systems. The binding paradigm is the use of port-based methodologies for modelling, control, embedded software and design of mechatronics and robotics systems for real applications. They aim to realise integrated robotic and mechatronic systems interacting with unstructured environments by making use of port-based methodologies.

Quality
This is a young programme with ambitious and enthusiastic new leadership. The quality is not yet fully developed and the specific scientific challenge will have to be further refined. For relevant projects ensuring adequate interaction with a clinical environment, with real patients and doctors, can make an enormous difference.

Productivity
The group is large, and the volume of the output is not very high yet, but is growing fast. Good accessibility of the senior faculty for the PhD students needs to be maintained.

Relevance
The group has made good use of the TTO office (tech transfer). The work has high potential relevance, and societal recognition is not problematic.

Viability
There is a new drive in the group. Hardware and experimental equipment are very good. The medical technology and robotics in the operating room constitute an exceptional infrastructure

Programme UT 5: **Integrated Circuit Design (ICD)**
Programme director: Prof. B. Nauta
Research staff 2010: 15

Assessments:	Quality:	5
	Productivity:	5
	Relevance:	5
	Viability:	5

The research area of the group is the design of analogue, RF and mixed-signal Integrated Circuits (ICs). The group creates and develops new techniques at both circuit level and system level, which are evaluated in fabricated test chips, with industrial IC technology as boundary condition.

Quality
The integrated circuit design group has clearly defined what quality means and how it wants to be measured. Based on a clear vision how to run the research and how to achieve novel results, the group indeed can be ranked amongst the five best university teams in the world in this field. Next to that they show to be able to engage in fertile collaboration with industry partners, feeding them with results without being used for quick fixes. Also the careful selection of what, where and when to publish is a sign of leadership.

Productivity
The productivity of the group in terms of results is excellent. However, the number of completed PhD theses is disappointing and the leadership should put a plan in place to address this situation, which in part is caused by the marketability of the PhD students who are prematurely enticed away by industry..

Relevance
An aspect that certainly needs to be mentioned is their involvement in starting up new business enterprises. Also the good funding position with many industrial contributions is a sign of strength.

Viability
As a leader in the field the group is fuelling the academic debate. Its results are a benchmark for other groups.

The excellent research and excellent researchers provide a solid basis for future growth in a world where there are as many major boundary condition changes as there are seasons in a year.

Programme UT 6: **Integrated Optical MicroSystems (IOMS)**
Programme director: Prof. M. Pollnau
Research staff 2010: 15

Assessments:		
	Quality:	4
	Productivity:	5
	Relevance:	3.5
	Viability:	4

The research focus is on micro-/nano-scale integrated optical devices. This includes novel materials, structures and optical phenomena, device design, realisation and characterisation, as well as applications in optical sensing and communication. Work is on different on-chip integrated optical devices such as amplifiers and lasers, bio-sensors and medical instrumentation and explores phenomena based on opto-mechanical interactions.

Since the new chair took over the IOMS group at the end of 2004, the group has built up the new research areas of Active Photonic Devices (rare-earth-ion-doped integrated amplifiers and lasers, currently extended from the micro to the nano-scale by combination with plasmonic structures) and Photonics Integration Technology (Raman spectroscopy and optical coherence tomography on a microchip) as well as further developed the pre-existing area of Optical Sensors (on-chip trace-gas sensing, DNA and enzyme analysis) and theoretical support by simulations.

The aim is to exploit synergy effects between our individual sub-programmes for the full integration of light generation, manipulation, environmental interaction, and detection on a single microchip. Real-world integrated optical devices will be developed, enabling industrial development by direct collaboration with Dutch and international companies.

Quality
The Integrated Optics Microsystems group at University of Twente has been in existence for a number of years addressing areas of integrated optics for telecommunications and for sensor applications. Professor Pollnau was appointed as the new chair just one year before this reporting period and this summary reports on the R&D programme undertaken during this transition period.

The previous report indicated that the proposed strategy had very interesting prospects, while recognising that the new technology involved a relatively high risk. This has resulted in the group now being one of the leaders in rare-earth-activated integrated devices with optical gain and also demonstrating the highest optical gain per unit length waveguide lasers with the highest slope efficiency, the lowest quantum defect, and the narrowest laser linewidth. They have also been the first group to demonstrate high-resolution Raman spectroscopy and optical coherence tomography on a micro-chip, and DNA separation in an opto-fluidic chip with a high base-pair resolution and an ultra-low detection limit.

Productivity
The publication rate compares favourably with similar groups and the average impact factor is 4.

Relevance
The knowledge transfer activity, in particular that related to industry exploiting the in-house R&D is less prominent and we would encourage the group to explore how their latest developments could be commercialised with industrial partners. The committee believes there is good potential that has yet to be fully realised.
Viability

The group have identified that the future will involve a reduction of 2 scientific staff members and also technician support in the MESA+ cleanrooms, which will involve PhD students in more cleanroom activities. The committee commends the proposal to increase the number of projects and PhD students to about 4 per FTE scientific staff member over the next 3-4 years

Programme UT 7: **Nano Electronics (NE)**
Programme director: Prof. W.G. van der Wiel
Research staff 2010: 8

Assessments:		
	Quality:	4
	Productivity:	3
	Relevance:	4
	Viability:	5

The programme studies the electronic and magnetic properties of systems with critical dimensions in the nanoregime, with a focus on disruptive technology for future generations of electronics and for information storage. Hybrid inorganic-organic electronics, spin electronics and quantum electronics form important subfields of nanoelectronics. The research synergetically combines aspects of Electrical Engineering, Physics, Chemistry, Materials Science and Nanotechnology. They aim to exploit quantum mechanical resources such as spin and quantum coherence in novel material systems and devices.

Quality
This research activity has suffered from a number of upheavals of staff and has only been able to develop a coherent strategy since 2009 when Prof. van der Wiel was appointed as group leader. Since then the strategy has been to focus on hybrid inorganic-organic electronics, and quantum and spin electronics. In particular the overlapping regions have been identified as potentially productive.

Productivity
The journal output rate per FTE member of tenured staff over the 5 years is good especially considering the low number of PhD students graduating. The committee notes with pleasure the quality of the journals and that since 2009 the number of PhD students has increased from 5 to 12 and we would encourage this trend. The committee is surprised that the number of conference publications is one of the lowest for any of the groups evaluated and we would encourage the group to consider focusing some efforts on increasing this number to help increase their external profile.

Relevance
By its nature the topics addressed by the group make it more difficult to engineer a large part of the research into a form that can be exploited by industry. Two examples that can be identified are the XRF/XRD improvements and the on-chip splitting of water into oxygen and hydrogen using visible sunlight. The group should continue to make every effort to identify similar opportunities in their future work.

Viability
The committee realises that this group is very much "work in progress" and it has in place a strategy which in the future should result in a strong and vibrant activity as indicated by the increasing research income over the last two years.

Programme UT 8: **Signals and Systems (SAS)**
Programme director: Prof. C.H. Slump
Research staff 2010: 13

Assessments:	Quality:	3
	Productivity:	3
	Relevance:	3
	Viability:	3

The core expertise and central theme of the group is Image Processing and Pattern Analysis. Application domains are Biometrics Medical Imaging and Image Analysis. The programme has two main themes:

- *Biometrics (*3D and 2D face recognition, forensic face and fingerprint recognition, pattern recognition concepts)
- *Medical Imaging and Image Analysis (*image analysis, reconstruction, visualisation and surgical navigation, 2D and 3D image analysis for minimally invasive diagnostics, fundamental 3D navigation concepts.

Quality
This group is reaching a good quality on the national level but it is lacking visibility at the international scene. Compared with the previous evaluation no real progress is made to remedy the weaknesses reported in the previous research visitation report, although some positive changes become visible in the last two years of the actual report period. The group should focus its efforts on a single topic and aim to excellence within that strategic choice. Realizing that goal will help the group to get a significantly higher international recognition.

Productivity
The productivity of the group gives a mixed picture. On the one hand, the number of finished PhDs increased significantly in the last two years. However, the number of high quality journals and conference papers did not follow, and it is far below the output of similar groups. We strongly encourage the group to translate the increased research activity also in an improved publication output.

Relevance
There is not much sponsorship from industry. Perhaps there are possibilities for application of the biometrics in security systems (iris recognition, person identification).

Viability
The larger number of PhDs, combined with an increasing funding, offers improved prospects on the viability of the group. This should also improve the international visibility and the quantity of a high quality output.

It is necessary to decide on the future of the acoustic research activities. It should be carefully considered if these still belong to the core business of the group.

Programme UT 9: **Semiconductor Components (SC)**
Programme director: Prof. J. Schmitz
Research staff 2010: 16

Assessments:	Quality:	4
	Productivity:	5
	Relevance:	5
	Viability:	4

The group researches silicon technology and integrated electron devices in order to contribute to the development of process technology, device research, characterisation and modelling, and the understanding of the reliability of microelectronic components. The emphasis is on expanding the functionality of pure digital logic circuits, for instance by adding RF, analogue or high-voltage capabilities. The research uses modelling, simulation and characterisation to gain understanding of industrial and new components and their reliability.

Quality
After some major changes in the composition of the group, a stable basis has now been formed. The focus areas have started to become clear and are staffed with a healthy mixture of people from academia and industry. The group has produced some headline research results, but still can grow in a more solid scientific reputation on the main conferences.

Productivity
Given the changes over the last period the productivity is of a high level for this small team. The publications strategy focuses on specific platforms thereby re-enforcing the group's reputation and there is a good balance between journal and conference publications.

Relevance
The group has excellent contacts with the local industry where many PhD students find jobs and act as liaison to the group. Many innovations are followed by industrial implementation and the group is active in patent applications..

Viability
With the new Mesa+ facilities the group has an excellent infrastructure. The continued financing of the facilties is ensured by recent measures. The funding position of the group is good, although the number of sponsors is limited.

Programme UT 10: **Telecommunication Engineering (TE)**
Programme director: Prof. F.B.J. Leferink
Research staff 2010: 10

Assessments:	Quality:	3.5
	Productivity:	3.5
	Relevance:	3
	Viability:	4

The research team is involved in high-integrity, error-resilient wireless communications, with special emphasis on both short range radio (SRR), as well as microwave photonics (MWP) and electromagnetic compatibility (EMC) issues. Their main expertise is in the physical layer aspects of wireless communication systems, which are optimised with the underlying design trade-offs of energy efficiency versus spectral efficiency. Naturally, one can only be improved to the detriment of the other. The group also contributed towards the design of wide-band multi-beamforming relying on antenna arrays, as well as towards their distributed counterparts invoked for co-operative communications. The team discontinued the study of a number of subjects, which is a consequence of retirements.

Quality
The group was acclaimed for the inclusion of two of Prof. Van Etten's papers in the top 50 telecommunications-related paper anthology of the IEEE. The SRR subject is in its infancy in the team, but this topical subject is expected to attract substantial research attention across the entire community. The team phrased their subject prioritization strategy as "pruning makes space for growth".

At the time of the assessment Prof. Leferink is only able to act as a part-time chairman of the team, since he is also working in industry, while Dr. Bentum assists him in the interim.

The team had a range of papers in high-impact journals, albeit they also had to resort to using some compact Letters in their submission, as opposed to their competitors at other universities, where typically full journal papers published in high-impact journals were submitted.

Productivity
Members of the team have listed 28 grants totalling about 4.8 MEuros, which provided them with a rich source of funding. The output of the team was steady but somewhat lower over the past evaluation period than what may have been expected based on their resources. This statement is valid for both the number of PhD theses and for journal papers.

The committee appreciated the substantial changes that took place after the retirement of Prof. Van Etten, which resulted in 'pruning' some of the less well performing fractions of the team in the interest of creating vigorous growth for the next evaluation period. Indeed, these recent strategic measures formulated for rejuvinating the team have begun to bear fruit, and it would be extremely beneficial if Prof. Leferink could afford spending a large part of his time with the team

Relevance
The team listed about 30 different external collaborators and this clearly indicates the relevance of their work. Their lavishly funded activities also provide evidence of quality-research, but the committee felt that a charismatic and hard-working full-time chairman would bring about more substantial growth in the team. The research topics have high societal relevance and wealth-creation capability. There is also great demand for the would-be researchers and practitioners to be trained/educated by the team. Furthermore, the group is well placed to collaborate with other

teams in the academic unit/Department, for example in terms of implementing some of the sophisticated wireless transceiver techniques conceived by the team in form of ASICs or FPGA.

Viability
In a nutshell, the team has talented academics, vibrant research topics and a promise of dynamic growth, but it would benefit from dedicated full-time leadership, whilst retaining the continued support of the current part-time Professors working in industry. This would create a healthy link to industry complemented by readily available full-time academic staff for the undergraduate and PhD students.

The TE-team is part of a well-managed and vibrant academic unit/Department led by Prof. Schmitz. The Department has a future-proof strategy for appointing new academics, aims for publishing 80% of their papers in journals having a high impact factor, supports the formation of spin-offs and even provides seed money. In this environment the TE-team has a bright future.

Programme UT 11: **Transducers Science and Technology (TST)**
Programme director: Prof. M.C. Elwenspoek
Research staff 2010: 25

Assessments:		
	Quality:	4
	Productivity:	5
	Relevance:	5
	Viability:	4

The programme had six sub-programmes but is now in a transition phase to two sub-programmes:

- Integrated microsystems
- 3D micro- and nanosystems.

The group has its roots in microelectromechanical systems (MEMS), which has evolved into a mature technology based on fabrication techniques developed for the integrated circuit industry. The research in this area is strongly driven by questions from spin-off companies.
Meanwhile, the development of fabrication strategies for three-dimensional structures is gaining importance in the programme. Top-down lithography techniques are used to manufacture 3D structures. The research in this area is directed to new materials and increasing complexity, making use of programmed self-assembly.

Quality
The quality of the work is good and internationally competitive with the RIE etch record being a fine example. The programme leader is well respected in the technology and is backed up by a team with significant expertise and this makes it possible for the group to address the range of topics areas researched.

Productivity
As in the previous report the publications rates for tenured staff are lower than other groups. The publication rate per graduated PhD student is much closer to the norm and suggests the need for the group to increase PhD student numbers as was recommended by the previous report. Other outputs of note are those associated with knowledge transfer with the group scoring well in this area.

Relevance
Clearly, transducers are a fundemantal component of many systems and hence contributions in this area have high societal impact. The associated knowledge transfer from this group is good, which is illustrated by the high number of spin-offs being an indication of the relevance of the research.

Viability
TST is one of the larger groups and a major user of the MESA+ NanoLab. Clearly, the effects of any reduction in funding to support this facility will have an impact on TST and a strategy to deal with this needs to be formulated.

5A. INSTITUTE LEVEL - Delft University of Technology

University: Delft University of Technology
Faculty: Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS)
Department: Department of Electrical Engineering (EE)

1. The institute

Electrical Engineering (EE) at TU Delft is located in the Faculty of Electrical Engineering, Mathematics and Computer Sciences (EEMCS). The three departments of Electrical Engineering at TU Delft aim to make leading international contributions to the fields of science, design and engineering, in particular in the areas of telecommunications, computer engineering, microelectronics and electrical sustainable energy. The ambition is to develop innovative solutions to both fundamental and applied electrical engineering problems that arise across a wide range of multidisciplinary settings and to address challenges in society and for humanity. The applicability of the results of the research, in particular to technical settings, is considered an important leading principle.

In 2010, the Executive Board of TU Delft started a process of reorienting and renewing its research and education activities, motivated by reducing funds from the government. EEMCS will focus its research and education activities more strongly on information communication science and technology (ICST), thus creating a clearer profile and further strengthening its national, European and global visibility. The ICT domain exhibits an enormous drive for growth and change, for which a fundamental understanding of complex systems and an integrated strategy are needed. The new focus is currently being implemented by increasing the synergy between the three disciplines of the Faculty, gearing research groups to address complex problems and systems related to the current and future challenges of society and mankind.

Department of Telecommunications

Research in the Telecommunications department focuses on network architecture and systems, radar and remote sensing, electronic navigation systems, electromagnetism, wireless and mobile communications. For a number of reasons, it was felt that reorientation of the TC groups was essential, also taking into account the signal processing activities within the Faculty. The current strengths of the TC department will be maintained and increased. They will be embedded in the Microelectronics department with the objective of increasing the synergy between physically oriented communication technology and microelectronics on the one hand, and network oriented communication technology and computer science on the other.

Department of Microelectronics (& Computer Engineering)

The research in this department combines expertise in nanoelectronics, microsystems and system integration. The Faculty decided to locate the Computer Engineering section within the Computer Science department of Software Technology, in order to create more synergy in the field of embedded systems. The ME&CE department has therefore been renamed the Microelectronics (ME) department.

Department of Electrical Sustainable Energy

The research in this department focuses on sustainable development, with emphasis on renewable energy (generation, conversion and grid integration), smart grids, and efficient converters and components. The Faculty has decided to combine the research in electrical power systems and high-voltage technology into the theme of electrical sustainable energy.

Assessment/remarks
The Rector of the TU Delft demonstrated clear views on collaboration with Erasmus University Rotterdam and with Leiden University, and within the 3TU Federation. The 3TU has a technical focus, while the links with EUR and Leiden aim at a comprehensive structure.

The proactive vision of the Dean, with a differentiated approach towards hardware, software and components, was reflected in the groups. The measures taken to integrate parts of the Department in other areas of the university, can be regarded as well-suited to the circumstances. This concerns telecom, computer science, and radar. The field of EE has become very diverse (computer engineering, biomedical applications, antenna technology). This has stimulated successful growth in the past years, but now requires a certain amount of reshuffling. In the opinion of the Committee, the current situation presents opportunities for refocusing the EE research.

2. Quality and academic reputation
The Faculty of EEMCS wishes to be recognized as an international leader in terms of both its research activities and the quality of its educational programmes. The symbiosis between the disciplines both physically (within one building) and institutionally (within the Faculty) is regarded as an advantage that creates ample opportunities for cross-disciplinary research.

Faculty members participate widely in the European research arena through international consortia, or as experts in or reviewers of European programmes and projects. The Faculty has established formal cooperation with leading universities outside Europe, such as Tsinghua University Beijing, and Fudan University Shanghai in China, and IT Bandung in Indonesia. On the initiative of EEMCS, in May 2011 TU Delft opened a research branch in Beijing. This TU Delft – Beijing Research Centre, which is based at the Institute of Semiconductors of the Chinese Academy of Sciences, will initially be engaged in research on LED lightning. Some of the research will be done by Chinese PhD students, who upon completing their studies will receive their diplomas from TU Delft.

The Faculty focuses on improving the quality and the visibility of its research activities and researchers, by embedding the individual researchers in focused research groups that have sufficient quality, cohesion, size and momentum to maintain a leading international position over the longer term.

EEMCS encourages researchers to participate in large national and international consortia and networks. The Faculty offers administrative and management support to groups that play leading roles in the management of major projects within national or European programmes or within Networks of Excellence. Since 2009, EEMCS has been participating in two Knowledge and Innovation Communities (KIC) established under the common governance of the European Institute of Innovation and Technology (EIT). The purpose of the EIT is to establish and support several of such stakeholder operated communities, which bring together the best European higher education, research and innovation environments to create world-class leadership in their specific fields. EEMCS researchers participate in the Climate KIC and in EIT ICT Labs – an EIT KIC for the future information and communication society that aims at the radical transformation of Europe into a knowledge-based society.

Assessment/remarks
The quality policies and academic reputation of the Department are solid. A point of attention might be that the research groups cover closely related fields (instruments, components, circuits & systems), but they do not show a high degree of interaction. Power grids and energy conversion are even in separate groups. The Faculty objective to gear the groups to research

complex problems and systems related to the challenges of society and mankind, can be expected to increase the internal coherence and interactions.

3. Resources

The Faculty of EEMCS is faced with a decline in direct funding from the university (G1 funding). The present the financial situation of the Faculty is relatively healthy, due to a repositioning of the research programmes (portfolio operation 2002–2003), the reorganisation of support staff (2005) and the new Review process that was started in 2009 and implemented in 2011. The Faculty's good financial health is also a result of the fact that it receives ample income from research projects funded by the Dutch government (FES, Bsik, Agentschap NL), industry and the EU (FP). In the forthcoming period the Faculty will need to adapt flexibly to changes in funding. All groups are very aware of the importance of acquiring future G2 and G3 funding.

For EEMCS the reorientation of the governmental funding has an impact not only on personnel, but also on the maintenance of its relatively expensive infrastructure, such as the radar facilities, the High Voltage Laboratory and the Dimes Microsystems and Nanoelectronics laboratory. Part of the High Voltage Laboratory will be dismantled; the testing facilities will be limited to a system voltage of 420 kV. The main facilities for Electrical Sustainable Energy will be revised, combined and transferred into a Combilab, which will also include facilities for the new research area intelligent electrical power grids. The new Combilab will have both a research and an educational purpose, and will offer general lab facilities for valorisation activities related to the department's research portfolio. It is expected that the Combilab will be operational at the end of 2013.

The radar facilities of the Faculty include full-polarimetric research radars and antenna facilities for electromagnetic research, a flight simulator, microwave system design and measurement facilities, spectrum analysers, etc. The most recently developed facility is the Polarimetric Agile Radar in S- and X-bands (PARSAX), located on the roof of the EECMS building. This software defined radar is an advanced instrument on waveform agility. PARSAX is used as a research platform for radar and environmental studies by scientists and students. It is a key instrument for atmospheric research within the new "Climate City Campus" project.

The DIMES Technology Centre (Delft Institute of Microelectronics and Submicron Technology) offers a laboratory environment for research, development and fabrication in the field of micro- and nanotechnology devices and systems. The facilities comprise:

- Class 100 cleanrooms, which provide a fully equipped processing environment for a wide assortment of structures, devices and complete ICs.
- MEMS Laboratory, which complements the processing line and contains areas for lithography, dry processing, laser processing, wet chemical processing, measurement & inspection, a Solar Cell Laboratory, and a Bonding & Packaging Laboratory.
- Electrical Characterisation Laboratories, which include the IC-Process Monitoring Lab and the RF/ Microwave Lab. The latter is equipped for device and system characterisation up to and above 110 GHz.
- Design Lab, which was set up in the context of the 3TU Centre of Excellence for Dependable ICT Systems (CeDICT). The Design Lab provides a platform to allow PhD students, MSc students and small and medium-sized enterprises to make designs for heterogeneous systems (e.g. sensors, intelligent signal processing components, low-power radio).

In 2010, the Board of TU Delft decided as part of the university's Review programme to reduce the annual allocation for the Dimes infrastructure by 800 K€, and to make an intermediate

evaluation in 2014. As a result, the Dimes infrastructure will profile itself as a national facility for making total systems and subsystems with an advanced electrical function.

Assessment/remarks
The labs, buildings and facilities are of the highest quality. The decisions regarding DIMES are an example of the financial vulnerability due to the costs of maintenance.

4. Productivity
In the review period 2005-2010 the Department has produced a total of 173 PhD theses, 948 refereed journal articles, 3416 refereed international conference proceedings, 32 books, 126 book chapters, 66 patents. The total research staff was between 168 and 250 fte per year in that period, with a total of 1294 fte in these 6 years.

Assessment/remarks
The productivity is generally assessed as very good. The total output per fte is about 4 publications. The impact is reasonably high.

5. Societal Relevance
In order to create a distinct societal profile as a strategic research partner, TU Delft has established four new Delft Research Initiatives (DRIs) in the fields of health, energy, environment and infrastructure. EEMCS participates strongly in all four themes, with a special focus on the health and energy themes, as they are the Faculty's two most important application fields and fields of research.

Since 2007, the appraisal criteria for professors include an assessment of their input and output in terms of knowledge valorisation and the degree to which they encourage knowledge valorisation within their respective research groups. The Faculty also aims at attracting an appropriate number of part-time professors from industry, at encouraging active participation in national and European research programmes, and at maintaining a good relationship with small and medium-sized ICT companies in the Netherlands.

The Faculty also provides support to starters in terms of facilities, knowledge and other forms of assistance in the EE and ICT fields, and is closely connected to Delft's Young Entrepreneurs Society, which supports students, professionals and researchers who are interested in starting high-tech companies or further developing an early-stage high-tech company. The number of start-ups from EEMCS has grown steadily in recent years. During the review period, 15 start-ups officially started business under the auspices of YES!Delft.

Assessment/remarks
The Faculty has made significant efforts in the area of valorisation. In several programmes the societal relevance is an important driver, for instance in the programme Remote Sensing.

The relatively low concentration of larger industrial companies around Delft, has resulted in close collaboration with TNO on topics of societal relevance.

6. Strategy for the future
A number of measures have been taken to increase the synergy between the disciplines in the Faculty and to focus the research on complex problems and systems that are related to current and future challenges in society.

The sections of the Telecommunication department are being repositioned in the Microelectronics department, but communication technology remains an important theme in the

Faculty. The new focus of the Faculty is on information communication science and technology, aiming at a fundamental understanding of complex systems that requires an integrated strategy.

The Computer Engineering section of the former Microelectronics and Computer Engineering department has been repositioned in the Computer Science department of Software Technology, in order to create more synergy in the field of embedded systems. The main focus of the Microelectronics Department is now on small functional microsystems, which require contributions from nanoelectronics, MEMS and system integration and reliability. As the Netherlands is the third most important player in the field of equipment, the ME department will also extend its research relationships with ASML and ASMI. ME researchers also participate in the Advanced Packaging Centre (APC), set up for developing, prototyping and first production of advanced electronic packages that connect components into functional microsystems, such as sensors.

The Faculty has combined the research in electrical power systems and high-voltage technology, in order to create capacity for the challenges in electricity generation and consumption (smart grids). Within the theme of Electrical Sustainable Energy, the three new sub-themes are: Intelligent Grids, Power Electronics and Renewable Energy Sources.

Assessment/remarks
The Committee notes that significant measures have been taken to reduce costs, while preserving a good coverage of all major areas of EE, and EE participates strongly in the Delft research initiatives on Energy and Health. Performance indicators have been selected to create focus in the improvement efforts and in the strategy process. These measures seem to ensure an effective alignment of the strategy of the Department and the strategy of the University.

7. PhD Training
There has been a very significant increase in the number of PhD students (see table below), and the Faculty intends to maintain this development, in spite of the uncertainty about the financial budgets and the number of Dutch and foreign students.

Number of PhD students	2005	2010
EE departments	135	215
EEMCS in total	248	432

The Faculty concentrates on improving the quality of postgraduate research and on the coaching and monitoring of PhD students. The graduate school of EEMCS that is currently being established will be instrumental in these efforts. The School will address the issue of low PhD yield: PhD projects are taking too long; too few PhD students succeed within 4 to 4.5 years. Each PhD student will follow formal education courses and attend training sessions, also aimed at career development skills, worth 45 EC. The progress of the PhD student will be monitored and supervised in a more professional manner. A formal graduate office, which will be in place in EEMCS at the beginning of 2012, will provide the necessary support to PhD students, their supervisors and members of the Graduate school.

Assessment/remarks
The PhD students appreciate the academic environment and the excellent facilities. The Committee applauds the plans to improve the coaching and monitoring. The Graduate School is not fully developed yet. Information about the mission and implementation were not yet available.

5B. PROGRAMME LEVEL - Delft University of Technology

Programme TUD 1: **Network Architectures & Services (NAS)**
Programme director: Prof. P.F.A. Van Mieghem
Research staff 2010: 12.2

Assessments:		
	Quality:	4
	Productivity:	3.5
	Relevance:	4
	Viability:	4

The NAS team deals with diverse aspects of networks, which is defined in their manifesto in the most broad and abstract sense possible. More specifically, their interests encompass artificial man-made infrastructures, such as road-traffic networks and the Internet, as well as biological, brain, social, and financial networks. This abstraction is reflected by Prof. Van Mieghem's related book. His team endeavours to train and educate researchers as well as students in the art of modelling complex networks, with special emphasis on their design and performance evaluation.

Quality
The research team conceives new solutions for analyzing data communications networks with the aid of network/graph theory, stochastic processes, algorithms and, ultimately, network measurements. A particularly novel subject in their portfolio is the evaluation of the mood of the participants in networks as a function of their geographic location, which is extracted with the aid of geo-tagging. The papers submitted for evaluation appeared in high-impact journals and cover a fairly broad area of research. The team is young and dynamic, with the promise of a growing h-index and expanding scientific influence. Prof. Van Mieghem has the highest Scopus-based h-index of 16 in the team. He also holds prestigious editorial positions and had an impressive number of seven best paper awards over the past eight years.

Productivity
A comprehensive list of the team's esteem indicators was submitted to the committee, including a good number of invited papers, best paper nominations and awards. The team's PhD intake is quite healthy, which is in line with other teams at Delft, despite the fact that their per capita research income was lower than that of the other teams in Delft. This is partly explained by the fact that their research requires less equipment than that of the more hardware-oriented teams.

The productivity of the team was not among the highest of the TUD programmes, but there was a gradually improving productivity trend throughout the review period, especially in terms of an increased publication output. Though the committee values the increased output of journal articles, conference papers and PhD theses, the Committee supports the policy of the group to concentrate on a higher quality of the papers rather than increasing the output even further.

Relevance
Owing to the fact that the team interprets the abstract concept of networking so broadly, their work has beneficial societal relevance across the diverse fields of telecommunications, transport and energy distribution as well as social networks. They investigate, how bio-inspired techniques, which were inherited from nature might become applicable in classic networks. They are also pursuing the radically new biological networking topic of exchanging information within living organisms in conjunction with Prof. Reinders' bio-informatics group and with Prof. Stam's brain-network team. Indeed, this exciting unorthodox subject might lead to unexpected break-throughs and analogies in classic networks. KPN and CBS are interested in the team's results relevant to financial networks, whilst the linkage to Facebook, Twitter, Hyvese and Digg are fairly direct in

the area of social networking. A whole range of national and international collaborators were listed in the submission right across the industrial and academic communities.

Viability

Given that the team has had almost 20 different contracts throughout the evaluation period, they are clearly well integrated with the research community. As stated in their strategy for the next period, NAS will move to computer science, but in the committee's view it would be beneficial to retain links with the telecommunications and other related engineering communities. This would allow the NAS team to maintain the highest possible grade of practicability for the team's research in the field of holistic cross-disciplinary, rather than limited-scope optimization. The amalgam of the NAS expertise and that of the rest of the Department as a whole is more likely to lead to breakthroughs than the isolated efforts of disjunct teams.

Programme TUD 2: **Radar & Remote Sensing (RRS)**
Programme director: Prof. O. Yarovyi & Prof. H.W.J. Russchenberg
Research staff 2010: 24.2

Assessments:		
	Quality:	4
	Productivity:	4
	Relevance:	5
	Viability:	4

The team aims for advancing both the theoretical and experimental concepts of radar, remote sensing and electronic navigation systems. This ambitious objective requires the in-depth treatment of electromagnetic theory, radio-frequency technology, the signal processing techniques of radar, remote sensing and positioning. A three-pronged approach is used:

- Microwave Technology and Systems for Radar;
- Remote Sensing of the Environment, which relies on multi-sensor techniques conceived for the observation of the atmosphere and for the characterization of the effects of climate-change on the earth-surface;
- Electronic Navigation Systems, a research area which necessitates the integration of sensors and their data flow, especially when designed for mission- and/or safety-critical navigation applications both in the air and on the ground.

Quality
The academics of the team have a strong practical and academic background. Their research is quite well cited and the leading members of the team have a commensurate h-index. Prof. Ligthart's contributions were broadly recognized, for example by the award of three honorary doctorates. He is a Fellow of both the IEEE and of the IET. Prof. Russchenberg and Prof. Yarovoy also have an impressive track-record, which is hallmarked by diverse committee memberships, invited lectures and other professional honours. They listed five important journal papers in their submission without having to resort to conference papers, albeit some of the journals listed are not in the top league of the impact-factor lists.

Productivity
The team has in excess of 40 diverse industrial contacts and a high level of research income, approaching 15 MEuros, which was awarded from about 40 sources. Their per capita funding is around 1.5 MEuros. In recent years the number of PhD students has substantially increased after a dip during 2007 and 2008. The total number of journals published during the past two years was particularly impressive, which were also complemented by a large number of conference papers and book chapters.

Relevance
The societal relevance of this team's research is excellent, since climate change and the mission-critical aspects investigated by the team affect each individual's life and society as a whole. The team is extremely well equipped and the superb resolution of their PARSAX radar results in improved object identification in numerous applications, which have a high potential economic impact, such as the prediction of rain for example. The benefits of the improved rain forecast resolution facilitated by the sophisticated combination of their high-precision equipment and signal processing as well as data fusion techniques are quite explicit.

Viability
Given the impressive level of funding, which the group has benefitted from over the past assessment period, as well as their high-value equipment, their broad expertise and a solid future strategy, the programme may be deemed vibrant, showing long-term vitality and beneficial

societal relevance. Their topics may be expected to attract continued funding. There is also a pressing need for training the next generation of scientists in this important area. The committee was informed that a new climate institute might be formed in the near-future. Due care is recommended for the sake of avoiding any potential damage to the rest of the team's activities after the divestiture, since the current partnership appears to work well.

Programme TUD 3: **Telecommunications**
Programme director: Prof. I.G.M.M. Niemegeers
Research staff 2010: 12.25

Assessments:
Quality: -
Productivity: -
Relevance: -
Viability: -

This programme was withdrawn from the review because the TU Delft had decided with a view to the imminent retirement of Prof. Niemegeers to relocate the research of this programme into the programme Embedded Systems of the Computer Science department.

The research is focussed on ubiquitous wireless communication, in particular on the creation of cuttign-edge technology for addressing pressing societal issues such as health, well-being, energy-saving and personal as well as public safety. The teams work concentrates on the capillaries of the Internet, exemplified by personal networks, sensor networks, in-home networks and on the Internet-of-Things. A cross-layer approach is used to cover all layers spanning from the physical layer (radio) to the upper OSI layers that provide generic services to applications, including the control and management planes of the OSI architecture. The group cooperated with various domain experts, but research on wireless and mobile applications themselves is beyond their currect research remit.

Quality
Whilst this team did not present their profile and achievements to the committee, their contributions to the Department as a whole were much valued by members of the visiting committee. The team received funding from almost 30 different sources, totalling about 8 MEuros, which is an eloquent manifestation of their professional stature, as viewed by the outside world. They also published two outstanding papers in top-ranking IEEE journals, namely in the Journal on Selected Areas in Communications and in the Transactions on Information Theory.

Productivity
The above-mentioned funding stimulated a rich range of activities in the team and despite the modest size of the group, they graduated 13 PhD students in 2009 and 2010. Their overall journal output was also high, with a total of 50 journal papers over the past evaluation period, which were complemented by 43 conference papers and four books.

Relevance
The societal relevance of their research cannot be over-emphasized -after all, telecommunications is one of the vital arteries of society as a whole and of businesses in particular. Hence their research in telecommunications has a large wealth-creation contribution, which was routinely measured by economists by estimating, how much the economy as a whole would stand to lose in the absence of telecommunications, especially without wireless communications on the move.

Viability
Based on the above facts, this team may be expected to act as the 'glue' across the various teams/groups of the Department as a whole, since telecommunications provides the richest applications for applied signal processing across dozens of application scenarios/fields, of mathematics, VLSI/FPGA design, embedded systems, circuit design, as well as of networking, multimedia applications, the wireless Internet, etc. Without a telecommunications group the Department might be crippled, because it loses her ability to design and investigate holistically

optimized systems, which might lead to locally, rather than globally optimized results under idealized, but impractical simplifying assumptions, such as using a perfectly error-free, zero-delay physical layer for networking studies, or the likes. To elaborate a little further, wireless Internet-based networking no longer can be investigated by assuming a perfect physical layer in the seven-layer Open Systems Interconnection (OSI) architecture, since power-control, hand-overs from one cell to another already invoke several OSI layers and these operations are imperfect, because they are subject to finite quantization accuracy, finite processing delays, etc. Synchronization, channel estimation, error correction and all other operations are also prone to practical impairments, which results in a physical layer typically operating about 10 dB away from the theoretical channel capacity. Similarly, improved VLSI/FPGA embedded solutions emerge, when the signal processing algorithms are designed with the specific VLSI implementation in mind, especially, when future VLSI implementations might have to rely on sub-1Volt power supply voltages and hence are subject to electromagnetic compatibility problems, etc.

Again, the lack of a supportive telecommunications group would jeopardize the vitality of many of the above-mentioned teams within the Department. This was well recognized by the other Departments of the 3TU consortium, which have in fact several telecommunications-related teams.

Programme TUD 4: **Circuits & Systems (CAS)**
Programme director: Prof. A.J. van der Veen
Research staff 2010: 17

Assessments:		
	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	4

The CAS-team deals with the theory and the many applications of circuits, systems, signal processing, as well as VLSI circuit and system design. Their main goal is to conceive sophisticated signal processing algorithms and to implement them in form of embedded systems. This innovative process requires an interdisciplinary amalgam of physical device modelling, mathematical methods, signal processing algorithms and digital electronic circuit design. The team is well equipped for carrying out these challenging tasks.

Quality
Indeed, they consider signal processing algorithms as diverse as those conceived both for operational and future wireless communications standards, including smart-antenna techniques, short-range ultra-wideband systems, sensor networks, cognitive radio systems, as well as radar, astronomy and biomedical signal processing. The team also maintains an interest in under-water acoustic signal processing. They implement their algorithms using both Field Programmable Gate Arrays (FPGA) and Application Specific Integrated Circuits (ASICs). Indeed, it is of high interest to the industry at large as to whether FPGA or ASIC implementations are more beneficial for a particular application.

The team has been well known under Prof. Dewilde's Chairmanship and Prof. Van der Veen further enhanced the group's esteem. Prof. van der Veen has been involved in diverse IEEE activities, such as EIC of the highly acclaimed IEEE Transactions on Signal Processing, as TPC cochair of ICASSP 2011 in Prague and will also deliver a keynote lecture at EUSIPCO in Bucharest during the Fall of 2012. Other members of the team, especially Dr. Leus also enjoy a growing esteem across the community. Three of the submitted journal papers were published in prestigious IEEE journals.

Productivity
Despite the modest size of the team, their journal and conference paper output was high. The Committee appreciates this, especially because the high number of papers was not at all to the detriment of quality. The number of PhD students trained was relatively modest. The level of external funding was impressive, totalling at about 10 MEuros from more than 30 sources, which funded a rich range of activities. The overall productivity of the team is very good, but not yet at the level of the best groups in this review.

Relevance
A whole plethora of external contacts was listed, which underlines the broad societal relevance of the group's activities, especially, when complemented by the above-mentioned 30+ research grants awarded to the team. The committee acknowledged the societal importance of the team's signal processing-related radio-astronomy results, their medical imaging and other signal processing contributions to both 3D vision and health-care in general. The impact of their under-water acoustic signal processing innovations was alos appreciated. Furthermore, in excess of 40 companies use the SPACE software package licensed via EDA adn OptEM.

Viability

Given the recent advances in signal processing, the associated industry substantially benefitted from the academic community's achievements. The team has both signal processing and VLSI skills and hence it is well-positioned for tackling the relevant challenges, provided that sufficient interaction may be stimulated between the two halves of the team, namely between the VLSI and signal processing experts. The group has extensive industrial links both nationally as well as internationally and has enjoyed a lavish level of funding. With the commencement of the new MSc course the team is well placed for the future.

Programme TUD 5: **Computer Engineering (CE)**
Programme director: Prof. K.L.M. Bertels
Research staff 2010: 50

Assessments:	Quality:	4
	Productivity:	5
	Relevance:	4
	Viability:	4

The programme focuses on the hardware/software co-design of computing systems, ranging from embedded systems to supercomputing and from digital design to system tools. The research addresses fundamental challenges as well as more applied topics. The programme has three main research themes: Dependable Nano-Computing, Multi/Many-Core Architectures, and Electronic System Level Design. In 2011, the CE group was integrated into the department of Software & Computer Technology.

Quality
The number of invited papers at conferences and workshops, the leading role in many international meetings and the eight best-paper awards clearly show that the group is well-respected and successful. The domain in which the CE group wants to play a role, stretches from fundamentally new device concepts to the highest layers of hierarchy in compute architecture. Although the group has defined three research foci that are in line with their expertise, the Committee still has some concern about the overall focus of the research. This will need to be addressed in the new situation.

Productivity
The large number of PhD students and the large number of contributions to many conferences are impressive. In the year 2011 (after the review period), about 20 PhD's finished their work, which also meant that the size of the group was somewhat reduced.

Relevance
The group is well positioned to contribute to the progress in this field and has a long list of industrial and academic collaborators. The activities of the group are relevant to many industrial fields in informatics as well as in electronics. The relatively low level of industrial sponsorship may have been due to a lack of visibility and focus.

Viability
The transfer of the group to the department of Software & Computer Technology presents an opportunity to further increase the overall coherence. Care should be taken that the move does not affect the good relations in the field of advanced devices and testing.

Programme TUD 6: **Electronic Components, Technology & Materials (ECTM)**
Programme director: Prof. P.M. Sarro
Research staff 2010: 29.1

Assessments:		
	Quality:	5
	Productivity:	5
	Relevance:	4
	Viability:	4

The research agenda of the ECTM group is to deliver leading edge advanced silicon based devices and microsystems by investigating innovative device and device integration concepts based on in-depth knowledge of device physics, silicon technology and electrical-material characterisation.

The group performs multi-disciplinary research on advanced silicon based devices, microsystems and technology for MEMS/MST, TFT devices and silicon device integration. In the area of advanced silicon based devices and microsystems, they investigate innovative device and device integration concepts based on in-depth knowledge of device physics, silicon technology and electrical-material characterization.

Quality
It was noted that the group fully leveraged the platform technologies available through the excellent cleanroom facilities and addressed a wide range of applications associated with silicon device integration, silicon microsystems/MEMS technology and thin film transistor devices. The committee was initially concerned about the breadth of the topics being addressed, but were persuaded that the strong interactions within the group produced an environment that helps to develop innovation amongst the research staff.

Productivity
The group has made excellent progress since the last review and in the last 5 years the group profile has rapidly developed with invitations for keynote presentations at the major relevant conferences, 13 best paper awards and a very healthy project portfolio (29).

Relevance
The group have noted interactions with 16 companies, which is to be commended. These efforts towards productive relationships with industry and other stakeholders are expected to become more and more important.

Viability
The uncertainty related to financing of the Dimes Technology Centre is of concern and the university needs to resolve this situation in consultation with all the stakeholders as discussed above.

Programme TUD 7: **Electronic Instrumentation (EI)**
Programme director: Prof. P.J. French
Research staff 2010: 29

Assessments:		
	Quality:	5
	Productivity:	4
	Relevance:	5
	Viability:	4

Research in the Electronic Instrumentation group is focused on measurement and instrumentation to create smart sensor microsystems. Areas addressed include microsystems based medical and (bio)chemical instrumentation, precision industrial measurement, photonics, and environmental and food monitoring

Quality
The quality of the research is internationally competitive especially in the area of temperature and magnetic sensors. The group is well networked being in league with the leading players in this area (i.e. universities, hospitals and industry). Staff are clearly well respected in the international community having received a number of awards as well as having been invited to present keynote papers.

Productivity
Over the review period the group has a reasonably strong journal publication record (140) coupled with significant number of conference contributions (480) at meetings such as ISSCC and Transducers.

Relevance
The group has most impressive knowledge transfer metrics with a significant patent portfolio and temperature, magnetic and blood sensing devices being commercially exploited by industry. They have an impressive number of interactions with a broad range of industries, which can potentially be translated into new income streams.

Viability
The group is a key user of the Dimes Technology Centre and again the uncertainty surrounding the funding of the cleanrooms needs to be positively resolved to enable the group to plan for the future. With much of the focus being on sensor development there are many opportunities to interact with both the other microsystems groups as well as other IC design activities.

It was noted that IE has during the course of the review period increased its G3 income to 30% and this puts them in a better position to deal with expected reduction of income from the other two streams. The future strategy as described, while solid, did not appear to be particularly adventurous and could be more innovative by including some more innovative / high risk initiatives.

Programme TUD 8: **Electronics (ELCA)**
Programme director: J.R. Long
Research staff 2010: 23.5

Assessments:		
	Quality:	5
	Productivity:	4
	Relevance:	5
	Viability:	4

The research covers analogue, digital-RF, and mixed-signal electronic circuit realizations that link systems to microelectronics technology. The performance boundaries of electronic circuits are explored, e.g. in power consumption, operating frequency and dynamic behaviour. This includes wireless and wireline communications, biomedical electronics, space-born electronics and intelligent systems applications.

Quality
The group has clearly improved its level over the last six years. A clear strategy is in place: the necessary industrial contacts and academic connections have been established. The impressive track record on top conferences and in top journals is a sign of that. Also the personal engagement of the staff in hands-on education of the PhD students is exemplary and appreciated. The alignment with the other RF research groups in Eindhoven en Twente is visible, although alignment is not yet collaboration.

Productivity
The number of PhD theses over the last period is somewhat low, but the pipeline of the group suggests that a healthy average level of 5-6 per year is feasible.

Relevance
The ideas generated by the group clearly influence the academic debate and find their way in products.

Viability
The group has a huge potential, the field in which it operates has many challenges ahead, yet the access to technology in all its forms could become a limiting factor. Some strategic anticipation is needed and might be organized within the 3TU collaboration.

Programme TUD 9: **Energy Conversion (EC)**
Programme director: Prof. J.A. Ferreira & Prof. M. Zeman
Research staff 2010: 30.9

Assessments:		
	Quality:	4
	Productivity:	3
	Relevance:	4
	Viability:	3.5

The research deals with the conversion and generation of electrical energy using electronics engineering. This includes power electronics, solar cells and electromechanics. The fundamental part of the research programme is driven by new materials, technologies and component integration of these materials, pushing the theoretical and technological limits of energy conversion efficiency and power and force densities at viable cost. In the application part of the programme, the research group aims to accelerate the implementation of renewable/sustainable energy systems with improved energy conversion efficiency in the power grid and mobile platforms, with electrical energy conversion knowledge, solutions and technologies.

Quality
The research in the Photovoltaic area (Prof. Zeman) is strongly technology-driven and of a high quality. The programme has a very interesting approach to energy conversion questions via the material aspects. The group is very well focused. Their academic reputation is high, which is proven in technically and physically relevant projects. The work on Electrical Power Processing (Prof. Ferreira) has received highly prestigious transaction best paper awards from IEEE. The international visibility of this group should perhaps be enhanced by increasing the number of conference contributions. The participation in relevant conferences enables the expansion of the scientific network. There is a high number of PhD students and recently 5M€ was invested in the infrastructure. This indicates excellent future conditions for the undergraduate and post-graduate / PhD education of quality scientific engineers.

Productivity
The number of valuable journal publications is increasing, which is excellent, but the number of conference contributions is decreasing. This might affect the scientific network and international visibility of the group.

Relevance
The group has a large number of industry contracts; all energy topics are of actual and particular interest. The work in basic scientific questions should be strengthened by applying and focussing on fundamental scientific research projects.

The research is focussed on components which are connected to the utility grid, such as solar panels, electrical machines and battery systems. Such components are also relevant for automotive, naval and aerospace systems.

Viability
There is a good strategy to have structured contacts with India and the Far East to attract young scientific co-workers, who are important for a further growth of the group. A well-structured selection and assessment of the foreign future co-workers ensures the required continuity of quality of the work. It has been noticed that the funding of the current programme is mainly from contracts and not from competitive funds. Competitive funds can increase visibility and growth of the group towards high-quality research.

Programme TUD 10: **Power Grids (PG)**
Programme director: Prof. L. van der Sluis & Prof. J.J. Smit
Research staff 2010: 22.9

Assessments:	Quality:	4
	Productivity:	3
	Relevance:	4
	Viability:	4

The research covers the generation, transmission and distribution of electrical energy, and studies the behaviour of power systems in transient, dynamic and steady state. Main concern is the technical, economical and societal performance of the electricity supply system. Theoretical and technological limits of current and future power systems and components are investigated taking into account the changing operating environment, e.g. the large-scale introduction of renewable and distributed energy sources and the application of new and sustainable technologies. The aim is to define the theoretical and technological limits of future electrical power systems in a changing world, influenced by the liberalization of the electricity market, the uncoupling of generation and transmission and the large scale introduction of renewable and dispersed energy sources, by the application of future technologies.

Quality
The programme performs high-quality focussed research on relevant smart grid topics for the large power range. The research topics are complementary to other institutes, e.g. on material issues. The programme concentrates on monitoring rather than diagnosis, and on methodology development, algorithmic protection, grid stability and control in real time.

The leadership could be more internationally visible, though their participation in EU programmes and in CIGRE and IEC is noted. They are relevant and excellently networked in the Netherlands. They have a good academic reputation, the PhD's find employment in internationally well recognized companies such as SIEMENS, ABB, etc. The programme is well-funded by industry and has a well-equipped laboratory.

Productivity
The programme has a very low number of journal publications, but a high number of conference contributions. The committee would encourage the group to focus more efforts on journal publications. Seeking more non-industry funding may help to facilitate producing more journal publications.

Relevance
In line with their focus on innovative materials and smart grids, the programme receives funds from industry and electrical companies, but also from competitive funds from NWO, EU and the Dutch Ministry of Economic affairs.

Viability
The real-time applications and fast simulation are important topics for the coming years.

APPENDIX 1: Short profile of the committee members

Bart De Moor, KU Leuven, chairman (numerical linear algebra and optimization, system theory and system identification, quantum information theory, control theory, data-mining, information retrieval and bio-informatics).

Kay Hameyer, RWTH Aachen University (numerical field computation, the design and control of electrical machines, in particular permanent magnet excited machines, induction machines and numerical optimisation strategies, magnetic levitation for drive systems).

Lajos Hanzo, University of Southampton (mobile radio communications, wireless multimedia communications aiming for flawless telepresence, supported by rich three-dimensional audio/video communications).

Marcel Pelgrom, NXP Semiconductors, Eindhoven, Chair of NXP Research Scientific Steering Board. (research experience in Charge Coupled Devices, MOS matching properties, analog-to-digital conversion, digital image correlation, various analog building block techniques mixed-signal electronics).

Johan Schoukens, VU Brussel (instrumentation and measurement, signal processing, sound and vibration).

Anthony Walton, University of Edinburgh, (IC technology and microsystem/MEMS, microelectronic test structures, MEMS (Micro Electro Mechanical Systems), yield improvement, Design for Manufacturability (DFM) and Technology Computer Aided Design (TCAD), applications of micro and nanotechnology to biotechnology, organometallic materials for semiconductor applications, sensors and interconnect technology, integrating new technologies and materials with foundry CMOS to create smart microsystems).

APPENDIX 2: Explanation of the SEP criteria and scores

The four main criteria for assessment are: Quality, Productivity, Relevance, and Vitality & feasibility. The assessment at the institute level primarily focuses on strategy and organisation, whereas the assessment at the level of the research group or programme primarily focuses on performance and activities of researchers and the results of their work (output and outcome).

Quality	The level or degree of excellence of the research, compared to accepted (international) standards in that field. The scope of the term 'research' is not limited to the research results. Research management, research policy, research facilities, PhD training and the societal relevance of research are considered integral parts of the quality of work in an institute and its programmes.
Productivity	The relationship between input and output, judged in relation to the mission and resources of the institute.
Relevance	Social, economic and cultural relevance. Aspects to be considered are: ▪ *Social quality*: efforts of the institute or group to interact in a productive way with stakeholders in society ▪ *Social impact*: how research affects specific stakeholders or procedures in society ▪ *Valorisation*: activities aimed at making research results available and suitable for application in product, processes and services. Committee members can also remark on relevance for the academic community, but the assessment should be on societal relevance.
Vitality & feasibility	The ability to react adequately to important changes in the environment. Also vision for the future.

The scores on a five-point scale are:

5 Excellent	Research is world leading. Researchers are working at the forefront of their field internationally and their research has an important and substantial impact in the field.
4 Very Good	Research is considered nationally leading. Research is internationally competitive and makes a significant contribution to the field.
3 Good	Research is considered internationally visible. Work is competitive at the national level and makes a valuable contribution in the international field.
2 Satisfactory	Research is nationally visible. Work adds to our understanding and is solid, but not exciting.
1 Unsatisfactory	Work is neither solid nor exciting, flawed in the scientific and/or technical approach, repetitions of other work, etc.