

Electrical Engineering

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Foreword

It is with great pleasure that I herewith present this report on the research in Electrical Engineering. It is one of the reports in the second round of quality assessments carried out during the period 1998 - 2003. In this period international committees of independent experts are assessing all university research per discipline.

The Review Committee for the Assessment of Research in Electrical Engineering reviewed 36 programmes of research in Electrical Engineering in three universities: the Delft University of Technology (TUD), Eindhoven University of Technology (TUE), University of Twente (UT). The report gives a description of the research activities in relation to the state-of-the-art in this specific field of Electrical Engineering. Moreover, the Committee gives a number of valuable recommendations and it is my expectation that their judgements and suggestions will be carefully taken into account by the researchers and by the faculties and universities.

As the Chairman of the Association of Universities in the Netherlands (VSNU), I would like to express my thanks to the Chairman and the Committee Members for their kind co-operation in this assessment and for their dedication with which they fulfilled this task. I also thank CWTS (Centre for Science and Technology Studies, Leiden University) for the bibliometric support of the Review Committee. Furthermore, I thank those involved in this assessment within the universities.



Rien Meijerink,
President of the Association of Universities in the Netherlands

Preface

Many of the research programmes in the faculties of Electrical Engineering of the three technical universities in the Netherlands were found to be excellent, with significant contributions to the advancement in the field of Electrical Engineering.

As this was the second review for these three faculties it may be considered as an update of the previous one. Particularly the part describing the aspects and the five points scale of the ratings were gladly adopted from the first review and proved (again) to be very useful.

Notwithstanding the pressure on the funding, the many reorganisations and the overall difficulty of attracting good PhD students, the Review Committee was impressed by the enthusiasm and dedication of the people presenting the programmes.

A general concern is the balance between long-term research and the more applied research, related to the third money stream. Further, the shortage of staff may demand for more focus in the programmes.

The Review Committee appreciated the careful preparation by the faculties before the review, the hospitality and the open discussion during the review and acknowledges the organisational support by Mrs. P.M. van Dijk of the VSNU.

The Review Committee is grateful for the opportunity to participate in this review and enjoyed working together as a team. We hope that our evaluation will be of help maintaining a very strong and viable level programme in Electrical Engineering in the Netherlands.

Chairman of the Committee
Kees Bulthuis

Summary

The Committee is impressed by the high quality in research in Electrical Engineering in the Netherlands. Given the small size of the country, this research constitutes significantly to the advancements in this field, both in knowledge and application.

The Committee sees a slight improvement in quality, compared to the previous review. The average of all assessments is "good" on all four aspects of the assessment (quality, productivity, relevance and viability). This means that generally speaking the international standard is met in their respective fields and the programmes make worthwhile contributions to the international research community.

Relevance, with respect to the advancement of knowledge or expertise, impact and applications in future technologies and positioned in relevant networks, is good in light of the significant contributions made to prominent fields.

Productivity scores were somewhat lower than in the previous review. The main reason for this may be found in the speed in which the area of Electrical Engineering develops and in which the individual programmes have to operate on the one hand and the strong competition of industry on the other hand.

The scores in viability between and within universities had major differences, some programmes having an excellent viability, others below standard.

The field of Electrical Engineering is diverse and so are its players. In some areas university research predominates. However, in other areas, due to ever faster developments, huge investments in (mostly expensive) facilities and large research staff, industry takes the lead.

The Committee is rather pleased with the cooperation of the different groups with industry, although it has the impression that this causes in a number of cases an imbalance between fundamental and applied research, since the latter is responsible for a major part of external funding.

All three faculties underwent changes in their organisation, also due to the conclusions and findings of the previous Review Committee.

- **Information Technology**

The overall scores for the submitted programmes in Information Technology are good. The relevance is good to excellent as this area is very market driven and meets the requirements of the information society. A lot of the research undertaken by the groups are strongly related with industry, telecommunications and computer-engineering, which is also shown by the high number of patents.

- **Micro-electronics**

The programmes in Micro-electronics are good on the average. The quality of the programmes is commendably good in this industry dominated field. There are strong links with industry that help keep the relevance high. The viability is standard to good. Some of the programmes are less viable due to a small number of staff and a vulnerable financing, which could threaten its future prospects. There is activity from circuits down to fabrication procedures.

- **Power Engineering**

The scores given by the Review Committee to the different programmes in the area of Power Engineering differ. There are different reasons for this. Research in Power Engineering is in a transition stage as the 'old fashioned' power support starts to make place for newer ways of producing and distributing electrical power and of newer ways of desinging and maintaining electrical power equipment. This development can be seen worldwide.

- **Sensors and Actuators**

All but for one programme the programmes in Sensors and Actuators have good overall scores.

- **Signals and Systems**

This subdiscipline spans a large number and a wide variety of subjects ranging from circuit design to control engineering over biomedical engineering. Most of the programmes are of high quality, a reflection of the fact that Dutch universities are contributing at an internationally competitive or sometimes leading level in this subdiscipline. The relevance of the programmes is good to excellent, again spanning a wide range from fundamental to very much industrially applied research. This overall variety is good, since it is difficult for a single group to cover the complete range. Beside in this way, both fundamental and industrially applied research are present, which is a necessity in an engineering faculty. In some cases viability and productivity suffer from the external job market forces.

- **Telecommunications**

There is an enormous amount of competition in Telecommunications. Not only between groups, but also with industry and other telecommunication providers. This shows in the scores. All groups are working very hard to strengthen their qualitative standings as well as the means of being very productive. Here too, the viability is strong due to the extensive co-operation with industrial partners.

1 Introduction

1.1 The Dutch System for Quality Assessment of Research

The quality assessment of research of Electrical Engineering is part of the assessment system for all Dutch university research, under the aegis of the Association of Universities in the Netherlands (VSNU). The system started in 1993, with trial-assessments by four international committees in four very different disciplines: biology, historical and archaeological studies, mechanical engineering and psychology. The Dutch universities to enhance the system, whose general principles and procedures were described in the 1994 Protocol for the Quality Assessment of Research, have used the observations of these committees. From 1993 until 1997 all university research, for each discipline or scientific area, was assessed by means of peer review (international committees of experts within a certain discipline) according to this protocol. In 1997, when nearly all areas had been assessed, the VSNU Committee on the Future of Quality Assessment evaluated the system. As a result of this Committee's advice the VSNU Board decided to have the first round of VSNU research quality assessment followed by another round. Again the general principles and procedures, with a number of changes in comparison with the first round, were described in a protocol (*Protocol 1998*).

The assessment of research in Electrical Engineering, which is described in this report, is carried out according to the new protocol. The most important changes are:

- a greater emphasis on the context-specific aspects of research programmes and faculty or institute missions;
- a more precise application of the criteria academic quality, productivity, relevance and viability in the light of the mission of a group, faculty or institute;
- the use of nomenclature and definitions according to the VSNU brochure *Definitie-afspraken wetenschappelijk onderzoek* (VSNU, 1994).

As in the first round, the most important functions still are quality assurance (improvement of university research quality as a result of self-regulation within universities, faculties or research institutes), accountability and the collection of information that can be considered relevant to third parties.

The aims of the assessment system are:

- assessment of the quality of research programmes (groups) on the basis of self-evaluations and appraisal of how the work is related to the group's mission, as well as to the mission of the faculty or the institute of which the group's programme is a part;
- evaluation of the mission of faculties or institutes, as well as the group's own mission;
- appraisal of the state-of-the-art in the discipline or academic area concerned.

This means that the assessment takes place at the aggregate level of research programmes. Faculties or research institutes submit a description of the results that have been achieved in each research programme during the previous five years (including quantitative data about staff input, five key publications and a list of publications), a short outline of the 'mission' statement of every programme, and developments anticipated in the context of the research profile of the faculty or institute. The mission statement has to contain elements such as: the scope of the research, the nature of the research in terms of pure versus applied, the general approach of the research in terms of its uni-disciplinary, multidisciplinary or interdisciplinary character, and the principal source of inspiration (curiosity-driven or society-driven). They also discuss goals and

objectives, give an indication of the local identity (e.g. its place in a research school), and a description of the relevance of the work to the different audiences. Highly valued features of the assessments are the interviews, which the review committee conducts with delegations of the faculty boards, the directors of the research institutes or research schools, the programme directors and a panel of graduate students drawn from the respective programmes. The interviews with the delegation of the faculty boards are specifically directed at a discussion of the faculty's research profile, resulting from the faculty's research policy.

1.2 The Review Committee for Electrical Engineering

The Review Committee was appointed per 17 May 1999 and consisted of:

- dr.K.Bulthuis, Eindhoven, the Netherlands
- prof.dr.W.Redman-White, Department of Electronics and Computer Science, University of Southampton, UK
- prof.dr.-ing. R.W. De Doncker, Institut für Stromrichtertechnik und Elektrische Antriebe, Rheinisch-Westfälische Technische Hochschule, Aachen, Germany
- prof.dr.ir. P.Lagasse, Department of Information Technology, Universiteit Gent, Belgium
- prof.dr. T.S. Durrani, Department of Electronics and Electrical Engineering, University of Strathclyde, UK
- prof.dr.-ing. P.Noll, Institut für Nachrichtentechnik und Theoretische Elektrotechnik, Technische Universität Berlin, Germany
- prof.dr.J.N.Zemel, Department of Electrical Engineering, University of Pennsylvania, Philadelphia, USA
- drs P.M.van Dijk, VSNU, has been appointed as secretary of the Review Committee.

A short curriculum vitae of the members is included in Appendix 5.

1.3 Scope of the Assessment

The Review Committee was asked to operate according to the earlier mentioned *Protocol 1998*. For the assessment of Electrical Engineering, this protocol was elaborated in the *Discipline Protocol Electrical Engineering*, prepared by the Discipline Committee Science and Technology, Subcommittee Electrical Engineering and established by a degree of the Chairman of the VSNU, dated March 1999. In this discipline protocol it is mentioned that the assessment covers the whole field of Electrical Engineering and that a distinction will be made into the following sub-disciplines:

- Information Technology
- Micro-electronics
- Power Engineering
- Sensors and Actuators
- Signals and Systems
- Telecommunications

The discipline protocol also mentions the basic elements of the self-evaluation report and the use of a bibliometric analysis, of which the exact form had to be determined in consultation with the chair of the Committee.

The participating universities in the assessment were:

- Faculty of Electrical Engineering, Delft University of Technology (TUD)
- Faculty of Electrical Engineering, Eindhoven University of Technology (TUE)
- Faculty of Electrical Engineering, University of Twente (UT)

The period of the assessment was taken from 1994-1998 .

The research funded by other parties than the universities or NWO (The Netherlands Organisation for Scientific Research) should be assessed in so far as it was part of the current research programmes and was supervised by senior academic staff.

1.4 Data provided to the Committee

The Review Committee has received the following documentation:

- a self-evaluation report of the participating universities, containing a research profile and the key-data of the faculty or institute concerned and documentation per programme (a list of the programmes is presented in Appendix 3);
- Five key publications per programme;
- a bibliometric analysis.

1.5 Procedures followed by the Committee

The review of the Committee covered the total of 36 programmes. TUE and TUD submitted thirteen programmes each, UT submitted ten programmes. The three self-evaluations were the main document used by the Committee. The Committee made three site visits, one to each university.

The Committee used the bibliometric analysis as an extra instrument with the self-evaluation of the three faculties. However, the Committee only took use of the analysis in a very superficial way, due to the fact that this analysis was only available at a very late stage of the evaluation procedure, just before the start of the actual site visits. The members of the Review Committee were therefore given very little time to study thoroughly the bibliometric analysis. The Committee decided to judge productivity mainly based on the self-evaluation and make use of the analysis only on the side and occasionally. It is the opinion of the Committee that a bibliometric analysis is very useful if used in a balanced way.

The Committee started its review by reading the self-evaluation reports of the faculties. For each research programme a first and second reviewer were selected. They were asked to read all information in detail and to assess the programmes with the help of a preliminary assessment form (see Appendix 2). The assessment forms were collected as input for the meetings of the Committee with the programme directors during the site visits in October 1999.

During the first meeting, consensus was reached on a first approximation of the scores. The Committee also made a list of questions to be asked by Committee members to programme directors. These questions related to the four criteria considered by the Review Committee: quality (the international comparison of programmes, strengths and weaknesses of the group), productivity (output of papers published, PhD theses, etc), relevance (impact of the research done, societal relevance of the programme) and viability (relation between fundamental and applied research, the ambitions of the group, risks in doing research) .

The Review Committee took into account the publication record of the individual programmes. In the evaluation of publications, the discipline protocol mentions four categories: PhD-theses, scientific publications (split up in international peer-reviewed, national peer-reviewed and others), professional publications, and refereed congress proceedings.

Just before the first meeting, the Review Committee also received the results of the bibliometric analysis by CWTS. However, for "productivity" the Review Committee decided to use the publication lists in the self-evaluation reports.

During the site visits (11 to 14 October and 18 to 20 October 1999), the Committee had its preparatory visit, visited all three faculties, evaluated and planned the writing of the report.

It was very complicated to organise Committee meetings that all Committee members could attend. Because of the various long range commitments of Committee members, arranging a suitable time frame for the review during the required time period was not simple. As described in the discipline protocol, site visits of at least one day for each faculty were organised. In a tight timetable, the Committee spoke to all programme directors, the faculty board and PhD-students.

Some of the programmes submitted were described in the self-evaluation as two independent programmes: TUD3A & TUD3B, UT5A & UT5B, UT6A & UT6B and UT7A & UT7B. During the site visits these programmes were presented separately to the Review Committee. The Review Committee decided to review them as independent programmes. Two programmes (TUE6 and TUE7) were presented to the Review Committee as one programme, although submitted in the self-evaluation as two separate groups. The Review Committee decided to review them as one programme.

The Review Committee was very pleased to be able to speak to a number of PhD-students. It became clear that the faculties put a lot of effort into presenting a good cross section of their PhD-population in Electrical Engineering. At least one PhD-student per programme was present; including both male and female PhD's, Dutch and foreign ones. The Review Committee especially appreciated the dedication and the openness of the students.

The Committee regretted that this tight schedule left no time for visiting laboratories and clean rooms. However, the Committee felt that it got all the information necessary to make an evaluation report that is valuable.

1.6 Aspects and Assessment Scale

The criteria covered by the assessments are stated in the 1998 Protocol of VSNU. The Review Committee was required to give judgements on four aspects: quality, productivity, relevance and viability. A five-point scale was used to give scores on the four criteria and an additional commentary was added for each research programme. These commentaries are an integral part of the assessments.

The 1998 Protocol allows the Review Committee considerable freedom to interpret the four aspects and the assessment scale in such a way that the assessments reflect what they see as important. Consequently the Committee has been taking into account the nature of the research programmes under scrutiny, which range from fundamental scientific research to applied technology.

In the case of this assessment, the criteria were interpreted in the manner as indicated below.

Scientific Quality:

The scientific quality of a research group is based on:

- the contributions made to international scientific developments and the originality of approaches and ideas in attacking scientific problems

-
- the standing of scientific publications and of the journals in which they appeared
 - indicators of international recognition other than publications, like participations in international scientific networks and advisory appointments based on scientific reputation and participation in professional bodies
 - the placement of PhD-students/graduates

The ratings on the five-points scale for quality are defined as follows:

- Excellent (5):** The research group belongs to the international elite within its field of research. It works at the frontiers of international progress in its field and contributes effectively to that progress by means of a substantial number of publications in highly rated scientific journals or, for mainly technology based programmes, contributes on a regular basis to the newest developments in important fields of technology by means of conference papers, designs and international advisory positions.
- Good (4):** The group meets the international standards in its field of research or technology and it makes worthwhile and recognised contributions to the international research community or to the newest technological developments.
- Satisfactory (3):** The group meets the scientific and graduate training meets the international standards in its field of research or technology at an acceptable level.
- Unsatisfactory (2):** The group can meet the scientific and graduate training standards but does not meet the international standards in its field, nor does it contribute significantly to its progress and development.
- Poor (1):** The group is far from meeting international standards of its field and has no influence upon its development and does not meet national needs.

Scientific Productivity:

The scientific productivity of a research group is based on:

- its contribution to the international scientific literature by means of publications in international, refereed journals and scientific books
- the number of Ph.D. theses and contribution to graduate teaching programmes
- for technology based programmes: its contribution to presentations at and proceedings of international conferences
- other scientific output, such as professional publications, designs, design tools and methods, software and patents.

The Committee's assessments are based on the production of each research group with reference to its size and resources. The result therefore is a 'peer review' about productivity, which reflects the Committee's perception of the programme's productivity over the past five-year period.

Taking into account the size and resources of the group, the ratings used for scientific productivity are:

- Excellent (5):** The number and character of scientific publications in highly regarded journals is outstanding, considerable numbers of Ph.D.-theses have been produced per senior fte. Key-note addresses and invited reviews are made regularly at leading international conferences.

Good (4):	The number and character of scientific publications are above average. Clear visibility is achieved through frequent contributions at major international conferences.. Ph.D. theses are produced regularly.
Satisfactory (3):	Productivity is acceptable to maintain the value of the programmes and acceptable for international standards.
Unsatisfactory (2):	There has been some scientific output but as a whole the group's performance is below the standard of other research groups in similar fields.
Poor (1):	The output of the research done is well below international standards.

Relevance

The Review Committee has considered the following aspects as part of its integrated assessment of relevance:

- the significance of the contribution of a research group to the development of its field with special focus on originality of ideas and approaches;
- potential impact and future applications in future technologies and to meet expected needs;
- the contribution of the research group to relevant scientific and professional networks of (future) users (government, agencies, industry and others) based on its specific knowledge and expertise;
- success in obtaining funding from the second and third money source
- the group programme is consistent with the mission statement of the university.

The ratings for relevance are:

Excellent (5):	Notable and influential contributions have been made to prominent fields and strong strategic planning consistent with national needs. Such research groups play important roles in scientific, industrial and/or international communities.
Good (4):	Significant numbers of contributions have been made to prominent fields or else notable and influential contributions have been made to less prominent fields.
Satisfactory (3):	The group has performed acceptable on not very prominent but still useful sub-fields of electrical engineering.
Unsatisfactory (2):	The research only shows few to the actual or potential development or applications of electrical engineering.
Poor (1):	The research appears to have little or no relevance for electrical engineering.

Viability:

The following aspects are taken into account:

- the continued relevance of the research topics, based on the group's visions and plans for the future (scientific prospects);
- prospects of future funding of personnel and facilities;
- continuity of leadership for the programme;
- coherence of the programme
- strength of existing linkages and proposed linkages with appropriate university national and international collaborators.

The group's mission statement and plans are judged against the feasibility of developing or sustaining their research. Guarantees for continuity of leadership at a high academic level is seen as a major aspect of the viability of a programme.

The ratings used for viability are:

- Excellent (5):** Strong in all. The group is judged to have clear and coherent plans on the international frontiers in its field. It has reached and is likely to maintain, its leading role in international networks. Continuity of funding is assured. Highly qualified staff will continue to be available in the future
- Good (4):** Adequate in all. The group is seen as competent to do the proposed research. The scientific issues being researched seem to be fruitful. The research group's position in the field seems to be assured. There are few doubts about the future funding or the availability of the competent staff needed to maintain the programme of research.
- Satisfactory (3):** There are some reservations about one or more of the aspects mentioned above, but if the proper measures are taken in time, there is a good chance that the group will continue to contribute adequately to its scientific field
- Unsatisfactory (2):** Based on the plans presented, the Committee has serious doubts about the continued viability of the research group, and considers that without additional measures or organisational changes, it will not be able to function adequately.
- Poor (1):** Severe weaknesses in one or more criteria for viability are Poor means judged to be non-viable, and should not be continued in its present form.

1.7 General introduction

The Committee is impressed by the high quality in research in Electrical Engineering in the Netherlands. Given the small size of the country, this research constitutes significantly to the advancements in this field, both in knowledge and application.

The Committee sees a slight improvement in quality, although the previous review also remarked the high quality of the programmes. The average of all assessments is "good" on all four aspects of the assessment (quality, productivity, relevance and viability). This means that generally speaking the international standard is met in their respective fields and the programmes make worthwhile contributions to the international research community. Relevance, with respect to the advancement of knowledge or expertise, impact and applications in future technologies and positioned in relevant networks, is good in light of the significant contributions made to prominent fields. Productivity scores were somewhat lower than in the previous review. The main reason for this may be found in the speed in which the area of Electrical Engineering develops and in which the individual programmes have to operate on the one hand and the strong competition of industry on the other hand. The Review Committee noted on several occasions an attitude that publication of papers was irrelevant due to slow processing in journals, so that recent research results would be outdated the moment they are printed. It was held that results are more likely to be communicated at working conferences, and less in written publications as are refereed journals. The scores in viability between and within universities had major differences, some programmes having an excellent viability, others below standard.

The field of Electrical Engineering is diverse and so are its players. In some areas university research predominates. However, in other areas, due to ever faster developments, huge investments in (mostly expensive) facilities and large research staff, industry takes the lead.

The Committee is rather pleased with the co-operation of the different groups with industry, although it has the impression that this causes in a number of cases an imbalance between fundamental and applied research, since the latter is responsible for a major part of external funding.

All three faculties underwent changes in their organisation, also due to the conclusions and findings of the previous Review Committee.

Delft Faculty of Electrical Engineering has reorganised its research by bringing back the number of groups and the number of laboratories. The Review Committee encountered a high commitment from the chairs of the different research groups and a good-willing staff to the faculty policy. As to improve PhD-student recruitment, Delft significantly increased their payments. As a result the overall scores of the Delft Faculty of Electrical Engineering are above average.

The Twente faculty of Electrical Engineering continues, as in the previous review, to focus on current trends and to try to be leading in adapting to them. The Review Committee found them quite successful in this effort, while the faculty focuses now on four areas. Their main theme is to contribute to the development of the information technology. The faculty made efforts to overcome the problems with the recruitment of PhD-students by raising their payments. The faculty also installed an internal quality assessment report, which directs research funding by the university. Overall, Twente has a very viable programme that has a clear focus and strategy.

Eindhoven Faculty of Electrical Engineering is in a transition period after a period of re-organisation. Partly, due to the previous review, the faculty has reshuffled its programmes by putting more effort in combining them. A new research policy has been adopted, focusing on financial flexibility. This has led to improvements in a number of programmes. The Eindhoven Faculty of Electrical Engineering has high scores, although their average viability score is somewhat misleading. This is due to the fact that there seems to be quite a difference between groups when it comes to viability: some groups are extremely viable, others lack viability.

> 1.7.1 Sub-disciplines

The discipline protocol, mentioned earlier in this review, distinguishes six sub-disciplines:

- Information Technology
- Micro-electronics
- Power Engineering
- Sensors and Actuators
- Signals and Systems
- Telecommunications

Each of the submitted research programmes had to be classified into one of these sub-disciplines. For some programmes, this was somewhat problematic as they fit into more than one sub-discipline. These programmes were assigned to the sub-discipline that seemed to be the most appropriate.

Information Technology

Programme	Title	q	p	r	v
TUD4	Comp. Architect. and Digital Technique	4	5	5	5
TUD5	Information & Communication Technology	4/5	4	5	5
TUE1	Information Processing Systems and Networks	3	2	4	4
UT8	Tele-informatics and Open Systems	4	4	5	5

The overall scores for the submitted programmes in Information Technology are good. The relevance is good to excellent as this area is very market driven and meets the requirements of the information society. A lot of the research undertaken by the groups are strongly related with industry, telecommunications and computer-engineering, which is also shown by the high number of patents. Especially the programmes in Delft and Twente are strongly oriented towards information technology and both faculties stress the importance of it by putting a lot of efforts in keeping up with industrial developments

Micro-electronics

Programme	Title	q	p	r	v
TUD8	Electronic Research	4	5	5	3
TUD10	Electr. components. technology and Materials	4	4	5	4
TUE4	Electronic Devices	4	4	3	4
TUE5	Electronic Circuit Design	5	5	4	4
UT3	Integrated Circuit Design	4	2	5	5
UT6A	Semicond. comp; ICT, Devices and Reliability	4	4	4	4
UT6B	Semicond. comp; Testable Design and Testing	3	3	3	3

The programmes in Micro-electronics are good on the average. The quality of the programmes is commendably good in this industry dominated field. There are strong links with industry that help keep the relevance high. The viability is standard to good. Some of the programmes are less viable due to a small number of staff and a vulnerable financing., which could threaten its future prospects. There is activity from circuits down to fabrication procedures. Note there is considerable interaction with other programmes for the device level microelectronic work.

Power Engineering

Programme	Title	q	p	r	v
TUD11	Power Systems	4	5	4	5
TUD12	High Voltage Technology	3	5	4	4
TUD13	Electrical Power Engineering	3	2	3	5
TUE6	Electrical Energy Systems	3	3	3	2
TUE7	High Voltage Eng & Electromagn. Compatib.	3	2	3	2
TUE10	Electromechanics and Power Electronics	4	3	5	4

The scores given by the Review Committee to the different programmes in the area of Power Engineering differ. There are different reasons for this. Research in Power Engineering is in a transition stage as the 'old fashioned' power support starts to make place for newer ways of producing and distributing electrical power and of newer ways of designing and maintaining electrical

power equipment. This development can be seen worldwide. Clearly, the faculties which are active in Power Engineering support power electronic research as a key enabling technology in future power decentralised generation systems and distribution networks as well as mechatronic systems and integrated power supplies.

Sensors and Actuators

Programme	title	q	p	r	v
TUD9	Electronic Instrumentation	5	4/5	5	5
UT1	Biosensors	5	4	5	5
UT4	Measurement and Instrumentation	3	3	2	2
UT5A	Mat.Science & Eng; Inform.Storage Technology Group	5	4	4	4
UT5B	Mat.Science & Eng; Lightwaves Devices Group	4	4	4	4
UT9	Transducers Science and Technology	4	4	5	5

All but for one programme the programmes in Sensors and Actuators have good overall scores. UT4 seems to be a programme which is still defining its research targets. On the whole Twente shows to be strong in this area. The programme UT5A and UT5B are reviewed separately on request of the programme director.

Signals and Systems

Programme	Title	q	p	r	v
TUD6	System and Control Engineering	4	5	5	4
TUD7	Circuits and Systems	5	4	5	5
UT2	Control Engineering	4	3	4	4
UT7A	Signals & Systems; Biomedical Engineering	4	5	5	4
UT7B	Signals & Systems; Network Theory	3	3	3	3
TUE9	Medical Electrical Engineering	3	4	3	2
TUE11	Measurement and Control	4	4	4	4
TUE12	Design Technology for Electronics Systems	5	4	5	5
TUE13	Signal Processing	4	4	3	2

This sub-discipline spans a large number and a wide variety of subjects ranging from circuit design to control engineering over biomedical engineering. Most of the programmes are of high quality, a reflection of the fact that Dutch universities are contributing at an internationally competitive or sometimes leading level in this sub-discipline. The relevance of the programmes is good to excellent, again spanning a wide range from fundamental to very much industrially applied research. This overall variety is good, since it is difficult for a single group to cover the complete range. Beside in this way, both fundamental and industrially applied research are present, which is a necessity in an engineering faculty. In some cases viability and productivity suffer from the external job market forces, which makes it difficult to replace staff in a timely fashion and to attract a sufficient number of Ph.D. students.

Telecommunications

Programme	title	q	p	r	v
TUD1	Electromagnetic research	4	5	4	3
TUD2	Telecommunications & Traffic Control Systems & Services	4	4	5	3
TUD3A	Telecomm & Remote Sensing Techn; Microw transm, Radar..	4	3	4	4
TUD3B	Telecomm & Remote Sensing Techn; Phot Integr Circuits Res	5	5	5	5
TUE2	Electro-optical Communication	5	4	5	5
TUE3	Radiocommunication	4	4	4	4
TUE8	Electromagnetics	4	n/a	4	n/a

There is an enormous amount of competition in Telecommunications. Not only between groups, but also with industry and other telecommunication providers. This shows in the scores. All groups are working very hard to strengthen their qualitative standings as well as the means of being very productive. Only one group is laying behind when it comes to productivity: TUD3A is a very young group and the Review Committee observes that prospects for the future are promising. Here too, the viability is strong due to the extensive co-operation with industrial partners.

It is the impression of the Review Committee that this multidisciplinary approach still needs further implementation.

2 Assessment per Faculty and per Programme

2.1 Delft University of Technology, Faculty of Electrical Engineering

The mission statement of the faculty is to educate students for the engineering profession and to carry out research in the fields of Telecommunication, Information Technique, Microelectronics and Electrical Power Engineering, referred to as TIME-themes. The Faculty of Information Technology and Systems has recently been installed. It is the result of a merger of the Faculty of Electrical Engineering and the Faculty of Technical Mathematics and Informatics. From fourteen laboratories and five departments, it restarted with seven departments, some of them mixtures from former departments and/or laboratories. The new departments have several objectives: to maintain the current themes, to look for new education programmes in the future, to try to achieve, where possible, a synergy between the different groups by merging the right group and to be organised in a matrix structure.

The faculty will continue under a new name: Faculty of Information Technology and Systems.

University	TUD
Programme	Electromagnetic Research
Programme director	Prof.Dr.Ir.H.Blok
Assessment	Quality 4
	Productivity 5
	Relevance 4
	Viability 3

Electromagnetic research is increasingly seen as an enabling activity. The programme has a good international standing and well-defined and strong lines of research in Computational modelling of Wave-fields, with associated activities in applications areas established through links with the Centre for Technical Geo-science. Such strategic alliances should be encouraged as it further promotes the relevance of the work. The track record of publications and the output of PhD's is impressive for a group of this size. However, attracting research students to the area is becoming increasingly difficult. This might limit the number of application areas where the group can be contributing.

The relatively small size of the group and the retirement of prominent staff make the future viability of the group somewhat vulnerable.

University	TUD	
Programme	Telecommunications and Traffic-Control Systems and Services	
Programme director	prof.dr.ir.D.van Willigen	
Assessment	Quality	4
	Productivity	4
	Relevance	5
	Viability	3

The research is of high quality in the areas of Radio Transmission and Navigation, Networks, and Quality of Service. The programme is unique in the merging of Telecommunications and Navigation. It keeps a balance between theoretical research and industrial applications. A notable improvement has been made in attracting externally funded research. Much of the strength of the group stems from the fact that it has firm international contacts: almost two thirds of its external funding comes from international sources. The number of academic staff has dropped slightly, two of its professors have only a part-time employment. The number of refereed publications has dropped significantly during the evaluation period, this may be attributed to the competing employment prospects in industry. On the other hand, the number of conference paper contributions is rather high, the research programme is based on a high number of graduation projects. The relevance is excellent, as for viability there is a concern for continuity due to the change of staff, a low number of PhD students, and a significant percentage of part-time staff. The Review Committee had some doubts about the future of Navigation within this programme.

		TUD3A
University	TUD	
Programme	Telecommunication and Remote Sensing Theory: Microwave Transmission, Radar and Tele-Observation Technology	
Programme director	Prof.dr. ir.L.P.Ligthart	
Assessment	Quality	4
	Productivity	3
	Relevance	4
	Viability	4

*Although TUD submitted programs (TUD3A) and (TUD3B) as one programme for the self-evaluation, they were presented to the Review Committee as two separate programmes. Due to the significant differences in technology associated with the subjects, the Review Committee agreed to review the programmes separately.

The programme's central theme is remote sensing with experimental research and fundamental theoretical parts. The quality of this programme is excellent and is at a par with what is being done elsewhere in the world. Having said this, the Review Committee notes that the productivity is just satisfactory over the review period, but the Review Committee also notes that it is important to take into consideration that the group only started a few years ago. The enthusiasm of the staff was quite apparent and the Review Committee has little doubt that their backlog in productivity will be shortly overcome with the fourteen PhD's currently engaged in this area. Consequently, the viability of the programme is good and improving rapidly. It was pointed out to the Review Committee that the group feels the need for input from the methodological community to achieve their objectives because of their more technical orientation. This raises a question concerning their ability to address all fundamental questions in their areas. While they view their status as adequate with respect to capability and expertise, the reliance on co-operation with others based on external funding is a potential source of weakness that may require attention.

		TUD3B
University	TUD	
Programme	Telecommunication and Remote Sensing Theory: Photonic Integrated Circuit Research *	
Programme director	prof.dr.ir. L.P.Ligthart/dr. M.K.Smit	
Assessment	Quality	5
	Productivity	5
	Relevance	5
	Viability	5

*Although TUD submitted programs (TUD3A) and (TUD3B) as one programme for the self-evaluation, they were presented to the Review Committee as two separate programmes. Due to the significant differences in technology associated with the subjects, the Review Committee agreed to review the programmes separately.

The quality of the programme is excellent and the group is world class. They have been developing a wide variety of concepts for the rapid implementation of optical structures including an extremely compact Wavelength Division Multiplication (WDM) cross-contact and an Optical Time-Domain Multiplexer for use in an integrated photonic 16 channel WDM. The productivity in academic publications is very high and although the group came into existence quite recently, it has already produced six PhD's. The relevance of the group is excellent and so is the viability. While the programme is very expensive, the group's excellent work has enabled it to raise funds from the European Union and national sources. Sounding a common complaint, they find it difficult to get good personnel, especially PhD's, to address their increasing needs and growing work load. There are some small problems in maintaining the essential technical equipment for the programme, but they have been able to manage as a result of their close co-operation with major industrial laboratories.

		TUD4
University	TUD	
Programme	Computer Architecture and Digital Technique	
Programme director	prof.dr.S.Vassiliadis	
Assessment	Quality	4
	Productivity	5
	Relevance	5
	Viability	5

This group has a range of programmes centered around computer engineering covering the range from architecture down to transistor level digital hardware testing. The Review Committee believes the group to be one of the leaders in the academic world. The work is of high relevance and there is an impressive level of co-operation with the global leaders in the industry.

The productivity of the group is extremely high, particularly in terms of the number of patents filed (mostly in conjunction with their industrial partner IBM), although the number of qualitative academic papers is not quite so impressive, but appears to be on the increase. The Review Committee had the impression that a lot of this productivity came from only a few of the staff.

There has been some concern about the disproportionately low number of PhD students in the recent past. This level is now increasing, and the group is confident that it can attract more good students, including good Dutch students against the draw of industrial starting salaries.

The viability of the group is seen as excellent; there are more patents in the pipeline and there is a good mix of established areas and more speculative research.

		TUD5
University	TUD	
Programme	Information and Communication Theory - ICT	
Programme director	prof.dr.ir.J.Biemon	
Assessment	Quality	4/5
	Productivity	4
	Relevance	5
	Viability	5

The work of the group covers a broad, multidisciplinary area overlapping computer science, telecommunications and signal processing. Many of the programmes are very relevant to industry, but the intelligent signal processing is presently more academic. The group is internationally highly recognised. There is excellent financial support from a variety of national and European research programmes. The work of the group is very impressive, the prominence of some staff members is excellent. Compared to the last evaluation period a notable improvement has been made in attracting externally funded research.

There is quite an impressive level of achievement, with several members of staff having a high international profile. Direct international comparisons were not made by the Review Committee because of the scope of the work not being mirrored in other groups. However, the Review Committee believes the group to be among the leaders in the world in their specific fields of activity, but not at the very top.

The quality of the work is excellent, and there are many PhD students, but published output is not quite at the same level. The main problem has been a high level of staff turnover in recent years, but this appears to be stable for the foreseeable future. The number of scientific publications was moderate, but must be judged in the context of losing staff to other function within TUD and to industry. The number of academic staff fte's has increased by 50%, most of its professors have a full-time employment. The group has been able to attract a high number of young people.

University	TUD
Programme	System and Control Engineering
Programme director	Prof.dr. ir. H.B.Verbruggen
Assessment	Quality 4
	Productivity 5
	Relevance 5
	Viability 4

The Review Committee was impressed by the quality of the programme, especially the crane project on container loading and unloading. The productivity is excellent, with good PhD production. The relevance is excellent and the impact of the programme compared to others is extremely high. The viability is good, although the Review Committee expressed some concerns whether the group will be able to generate future projects of the same magnitude as the crane project once it is completed. In the discussion, it was pointed out by the group that after the last review, they concluded that they should bundle their research efforts on a smaller number of topics. Presently, this is evident from the emphasis on intelligent transportation and the joint effort with Civil Engineering on the control of traffic flows. At the moment, they have thirteen PhD students. While it is not to hard for the group to get new students, it is hard for them to get students from the European Union. Nevertheless, it has been possible to recruit 80 % of their PhD students from their undergraduates. Due the appointment of a new chair, the Review Committee thinks highly of the viability of the group and in light of this anticipates that there will be significant changes in the coming years.

University	TUD
Programme	Circuits and Systems
Programme director	prof.dr.ir R.H.J.M. Otten

Assessment	Quality	5
	Productivity	4
	Relevance	5
	Viability	5

The research activities of the group cover the complete design trajectory of electronic digital systems from algorithms to realisation. Although the programme covers a relatively wide area, it is based on a well conceived scientific strategy which aims at tackling problems that are at the forefront of academic interest and of strong industrial relevance. The group is also embedded in an extensive network of academic and industrial research partners, belonging to the top players in the field. The scientific programme is carefully conceived, well executed and coherent, and is rooted in the strong theoretical background of the group. The quality and relevance of the scientific results are excellent and are recognized as such by industrial and academic co-operative research partners. The co-operation and integration with DIMES is one of the strengths of the group. The total volume and the mix of the various components of scientific output are good, ensuring a high viability for the group.

		TUD8
University	TUD	
Programme	prof.dr.irA.H.M.van Roermund (Prof.dr.P.M.Dewilde acted as <i>interim director</i> during the Review)	
Programme director	Electronic Research	
Assessment	Quality	4
	Productivity	5
	Relevance	5
	Viability	3

The programme is centered firmly on transistor level circuit design, focusing on design techniques and methodologies for analogue and mixed signal applications, while having good synergy with technology expertise of DIMES. The work is extremely relevant to industry; there is a very high level of industrial co-operation, and several filed patents are the subject of significant exploitation. The productivity, especially with regard to Ph.D. theses and refereed journal papers is also excellent. The Review Committee sees the group as an internationally leading one.

The stated future priorities for the programme into microwave frequencies and very low power show a sound appreciation of where the mainstream research should go, although there are difficulties attracting good students. The nano-electronics is more speculative and is more attractive for new PhD's. The Review Committee agreed that the methodology and CAD work should be scaled down in favour of the other topics.

There is some concern over the viability of this group arising from the recent departure of the chair, who has been the driver for the programme over most of the review period. The Review Committee noted that this programme had very considerable overlap with TUD9 in analogue design and sensor interfacing. The excellent external reputation for analogue integrated circuit design research in TUD is somewhat based on a composite of these two programmes. The Review Committee felt that in seeking a strong replacement for the chair, the university should also consider the options for reorganising the activities of these two large programmes to maintain and enhance the considerable momentum achieved so far.

University	TUD
Programme	Electronic Instrumentation
Programme director	prof.dr.ir.J.H.Huijsing

Assessment	Quality	5
	Productivity	4/5
	Relevance	5
	Viability	5

The quality is excellent. This large and successful group can be considered as one of the top rank groups in the world. Due to its size the productivity is high, although the number of academic publications is average per fte. The Review Committee had expected a somewhat larger number of patents for this group. The strength of the group is the integration of the sensor with the electronic interface. An impressive result is the adaptive mirrors. The perseverance of the group was shown in the successful development of the windmeter over the last ten years.

The relevance is excellent. The programme is heavily linked with the activities in DIMES. The group continues to attract external funding and was successful in attracting high level staff. The number of PhD students is still below target, however.

The viability is excellent. The Review Committee is confident that the current staff can maintain the high standard of the group.

University	TUD
Programme	Electrical Components, Technology and Materials
Programme director	prof.dr.C.I.M.Beenakker
Assessment	Quality 4
	Productivity 4
	Relevance 5
	Viability 4

The integrated programme of the former group Electronic Materials and Silicon Processing has matured in the review period to a well balanced programme with their focus on thin films transitions, solar cells, integrated sensor technology and high frequency devices. The group is well recognized in the international scene. The productivity has increased compared to the prior review period. The Review Committee encourages the group to be a bit more active in patent applications.

A further stimulation of the synergy between the different research programmes is envisaged. The dependence on DIMES is strong. The viability is considered to be good, in the light of the assurance of the management of the TU Delft for the continuation of the funding of DIMES.

The relevance of the programme is considered to be excellent in view of the choice made for the midterm programmes and under the financial constraints. Co-operation with industry leading in these fields is essential and well in place.

University	TUD
Programme	Power Systems
Programme director	prof.ir. L.van der Sluis

Assessment	Quality	4
	Productivity	5
	Relevance	4
	Viability	5

The quality of the programme is good. This group is the largest in the Netherlands in its field. The productivity of the group is excellent. It is a very productive group. It does a lot of conference presentations which puts many transaction and journal papers in the pipe-line. The relevance is good. The programme focuses on the integration of power electronic systems in the power grid and the upcoming decentralised power generation. The viability of the group is excellent due to their choice of topics. Furthermore, the fact that the electrical energy distribution will move to a liberalised system creates a renewed impetus for research. The group is fairly young and dynamic, as witnessed by them starting to explore the possibilities of using newly developed silicon carbide devices.

University	TUD
Programme	High Voltage Technology
Programme director	prof.dr.J.J.Smit
Assessment	Quality 3
	Productivity 5
	Relevance 4
	Viability 4

The quality of the programme during the review period is standard. The group has suffered due to the absence of a programme director during the first half of the time of this review period. The Review Committee observes that the quality of the programme has improved considerably during the second half of the reviewed period. The group anticipates that future work will focus stronger on medium voltage systems and less on high voltage systems. The productivity is excellent. Major projects are under way, e.g. the high voltage transmission (HVDC) line between the Netherlands and Norway. However, a lot of research in high voltage is kept secret by the industrial partners which hampers publication productivity. The relevance is good. The viability of the programme is good. The Review Committee points out that the laboratory infrastructure is rather costly. As a result, the group gives the impression of drifting away from the original fundamental research targets towards applied development and research. On the other hand, there are few university research programmes left in Europe of the same magnitude.

University	TUD	
Programme	Electrical Power Processing	
Programme director	prof.ir. L.van der Sluis/Prof.dr.J.A.Ferreira	
Assessment	Quality	3
	Productivity	2
	Relevance	3
	Viability	5

During the review period the quality of the programme was standard and the productivity of the group was extremely low. The relevance appeared to be standard. However, the relevance towards power electronic research could have been excellent, but it seems that nobody was interested in the past. Since January 1998, a new programme director took control. It appears to the committee that the viability of the programme has turned for the better, towards excellent. The new programme director is well known in his field and has made some key strategic alliances with other laboratories to co-ordinate research in the Netherlands. This group will have to prove itself within the next review period. The committee is optimistic that Electric Power Processing and Integration offers some real challenges for excellent fundamental research.

2.2 Eindhoven University of Technology, Faculty of Electrical Engineering

The faculty shares the mission of Eindhoven University of Technology: to provide education and research in Electrical Engineering and Information Technology. The faculty's research has four areas: information and communication systems, telecommunication technology and electromagnetics, measurement and control systems and electrical power engineering. "In accordance with an agreement between the Faculties of Electrical Engineering in Delft and Eindhoven, the research effort on electrical energy systems was decreased, while that on III-V technology and opto-electronics and optical fibres was increased". (Self-evaluation page 7)

The faculty has numerous (inter)national co-operations with other universities, research centres and industrial laboratories, five of them being very important: COBRA, EIDMA, DISC, CPS, EESI.

During the review period - 1994 - 1998 - the faculty has been reorganized. As a result of the former review the faculty has put more effort in combining programmes which meant a reduction of chairs from fifteen to eleven.

The faculty has chosen for financial flexibility, which permitted a new research policy. The faculty allocates funds "dynamically" (Self-evaluation page 8) to chairs based on commitments in education. The funding for research was fixed. "The faculty is proud to have achieved - in spite of the reduction in research input - a substantial increase of research output in almost all categories compared to the previous review." (Self-evaluation, page 8).

University	TUE	
Programme	Information Processing Systems and Network	
Programme director	Prof.ir.M.P.J.Stevens	
Assessment	Quality	3
	Productivity	2
	Relevance	4
	Viability	4

The group has a wide range of activities covering computer engineering and telecommunications. The programmes appear to be very relevant to industry, and there are many collaborative arrangements in place. The Review Committee considers the group among the leaders in telecom protocols. Much of the tangible output is presented in terms of software tools, which are taken up by industry, and this output appears to have good acceptance by industry. The group acknowledges that there has been too wide a brief in the past and there is some refocusing in progress, moving towards an emphasis on system level issues and entering into more speculative work in hardware/software design and optimisation processes.

The quality of the work appears satisfactory, although the committee feels that there is room for improvement. The number of PhD students is also satisfactory, but the level of published output is lower than should be expected from such a scale of work. It is noteworthy that two of the key papers cited for the review are PhD theses. The Review Committee was concerned and surprised that the group did not consider it important for researchers to generate journal papers, while the impression of the group is that the publication process is too slow and cumbersome, and therefore the group prefers to maintain visibility solely through conference presentations. The Review Committee felt that since journal papers would be subject to external peer review, this should provide an objective and ongoing feedback mechanism on the quality level. This rather introverted approach could have some impact on the longer term viability despite the sound subject matter.

University	TUE	
Programme	Electro-Optical Communication	
Programme director	Prof.dr. G.D. Khoe	
Assessment	Quality	5
	Productivity	4
	Relevance	5
	Viability	5

Though this programme was initiated in 1994, it has developed rapidly into a very high quality programme. The level of national and international co-operation is exemplary including a COBRA programme developed in co-operation with TUD. The productivity of the group is quite good. Particularly noteworthy is the work on long-haul lines. The division of the programme into three sub-programmes is logical and the relevance of these programmes to the advance of electro-optical communication is excellent. The Review Committee particularly noted the effort on polymer fibers and cross connect elements.

As a consequence, the viability of the programme is viewed as excellent. Of some concern was the relatively small number of PhD's, but, taking into account that the group only started in 1994, the Review Committee believes this situation should be self-correcting in light of the current efforts. Concern was also expressed about the availability of money for experimental work and that the university itself should have more funding, e.g. for the writing of good proposals.

University	TUE
Programme	Radio-communication
Programme director	Prof.dr.ir.G.Brussaard

Assessment	Quality	4
	Productivity	4
	Relevance	4
	Viability	4

This group has a clear focus on antennas, propagation, remote sensing, and digital radio systems. The central activity is the study of radio links. With future applications in mind, the frequency range from 1 to 1000 GHz is under consideration. Within this field the group performs excellently. The radio-communication subgroup has been able to attract significant external support, with an attractive mix of European and industrial money. Recently the information and communication theory group was added to the radio-communication programme. A weakness is that the merger of the two subgroups has not yet led to a development of synergies. The I&C theory group is rather small, it concentrates on lossless source coding and, in the field of channel coding, it has started research in the field of efficient decoding structures for complex channels, such as radio channels. The productivity of the group is good. The relevance is high, especially the radio-communication. The viability is high. The group combines a attractive mix of EU and industrial money.

University	TUE
Programme	Electronic Devices
Programme director	Prof.dr-ing L.M.F. Kaufmann
Assessment	Quality 4
	Productivity 4
	Relevance 3
	Viability 4

This relatively new group in the field is trying to build a reputation by contributing in niches in quite a variety of subjects. The programme is therefore fragmented and it is difficult to compete with the leading groups in the world. The quality is considered to be good but in view of the above not excellent.

The productivity of the group is above average, and in some respects substantial.

The co-operation in COBRA is seen as very important. However, there is an ongoing discussion on the co-operation between the programmes in Delft and Eindhoven.

The Review Committee believes that the relevance of the programme can be improved by more focus. The relatively small group should really select one or two main subjects and try to become excellent.

Two senior staff will retire soon. The viability of the group can be improved by attracting new members with a high profile.

University	TUE
Programme	Electronic circuit design
Programme director	Prof.dr.i.r W.M.G.van Bokhoven

Assessment	Quality	5
	Productivity	5
	Relevance	4
	Viability	4

The group has shown an excellent quality of research in the general area of mixed signal circuit design, addressing A/D conversion, non-linear circuit analysis and 1/f device noise physics. The work in A/D conversion derives from very strong industrial links, and the noise activities resulted from the merger with another group. These two areas in particular are of international repute despite the highly competitive field.

Although the group underwent a number of reorganisations during the review period, the high quality of the research was maintained. The scientific output in the form of papers is excellent. The number of Ph.D. theses is rather low, but shows an increasing trend. Due to its strong collaboration with industrial and academic partners, the relevance of the research is good.

The proposal to extend the research into higher frequency regimes and explore non-silicon circuits is sensible, but there were questions about the suitability of available technology.

The Review Committee perceived the main threat to the further successful development of this group to be in the high attrition rate of its staff members. Several key members have left during and immediately following the review period, with only the appointment of one strong senior staff member at the time of the review. The viability of the group's continued excellence must therefore be lessened.

		TUE6/7	
University	TUE		
Programme	Electrical Energy Systems* High-Voltage Engineering and Electromagnetic Compatibility*		
Programme director	Prof.dr.ir. P.C.T.van der Laan		
Assessment		TUE6	TUE7
	Quality	3	3
	Productivity	3	2
	Relevance	3	3
	Viability	2	2

*The programmes, TUE 6: Electrical Energy Systems and TUE 7: High-Voltage Engineering and Electromagnetic Compatibility, were presented as one programme during the site visit even though they were separately presented in the self-evaluation. The Review Committee decided to treat them as one programme in this report, though giving separate scores.

The past quality and productivity of both groups are average, although they do perform some interesting work. One group performs sound quality research in two subdomains of high voltage engineering, namely: high voltage discharges, and electromagnetic compatibility and monitoring problems in high voltage systems. The other group deals with important national power flow studies and has good co-operation with industry on classical power issues. The work of both groups is oriented towards the needs of the industry and its industrial relevance is attested to by substantial research contracts, mostly with Dutch companies. This has resulted in a large number of professional publications, but the research output in PhD theses and refereed publications has been rather modest. The programme has good facilities.

The Review Committee found it difficult to judge the viability of both programmes since the groups are in the process of merging. While there is little difference in quality, relevance and viability of the individual research programmes, there is a difference in productivity. In considering the situation for TUE 6 and 7, the Review Committee notes that the retirement of the chair in 2000 is one of the factors precipitating the merger of the two groups. However, this merger may prove to be difficult since the people come from such different backgrounds. The Review Committee noted that it has been difficult to obtain a good replacement for the chair, as the requirements are enormous: the group is looking for a "sheep with five legs". So far, the net result has been fewer students in the two programmes though, because of the broad relevance of the issues covered, it has been possible to attract four Ph.D. students in 1999.

In summary, the conclusion of the Review Committee is that the problems of TUE6 are not likely to be solved by simply merging it with TUE7. A comprehensive review of this effort at the national level seems advisable with both TUD and TUE bringing the relevant faculty into the decision making process.

University	TUE	
Programme	Electromagnetics	
Programme director	Prof.dr. A.G.Tijhuis	
Assessment	Quality	4
	Productivity	N/a
	Relevance	4
	Viability	N/a

This programme has undertaken good quality research, but over the review period has been severely hampered by lack of staff and, in particular, the number of senior staff. Despite this, a consistent flow of journal and conference papers has been produced, and a good level of collaboration and funding maintained reinforcing the view of the relevance of the work. The Review Committee believes the groups' work stands comparison with international leaders in specific areas.

For the future, the programme director has sound ideas for how the programme should develop, particularly into biomedical issues, and exploiting strengths in modelling. However, he is evidently struggling against unrealistically low resource levels. A backlog of results to be written up was mentioned. The Review Committee found it difficult to propose a fair assessment of the programme's productivity and viability. Given the rather difficult position of this programme, the Review Committee recommends that the university relieves the director of some administrative burdens, and allows these to be shared with another group.

			TUE9
University	TUE		
Programme	Medical electrical engineering		
Programme director	Dr.ir.P.J.M.Cluitmans		
Assessment	Quality	3	
	Productivity	4	
	Relevance	3	
	Viability	2	

The group is small and the chair who retired in 1995 has not been replaced. Nevertheless the group has managed to maintain a reasonably good scientific output. The work, which has monitoring in health care as its central theme, has undoubtedly a very high societal relevance, but is of a very applied nature and therefore not directly comparable to the usual academic standards. It relies heavily on a close interaction with clinical departments. The group has no independent scientific research strategy but works essentially in a responsive mode towards the monitoring problems of patients and clinicians. Although most of the work is in the biomedical domain, rather than in Electrical Engineering, the group plans to merge with TUE13. The viability of the group is considered questionable due to the absence of a chair, the small size of the group and the lack of a clear cut strategy for the future.

University	TUE
Programme	Electromechanics and power electronics
Programme director	Prof.dr.ir. A.J.A. Vandenput

Assessment	Quality	4
	Productivity	3
	Relevance	5
	Viability	4

The quality of the programme is very good. It represents a very specific research area. The group has achieved good results in some specialized areas. The prominence of the programme director is excellent. The productivity is limited because several staff members in this group do not publish at all which hampers their output profile (output per fte). The work of the group has excellent industrial relevance, and its future viability is promising, and very much complementary to their twinned group at TUD. The group has been affected by longstanding manpower problems, academically as well as technically. Finding the right young people at the right place is difficult as most of them are drawn to industry. The group wants to concentrate in the near future on multidimensional actuators, optical mechanical actuators as possible research items. The Review Committee recognizes that these mechatronic systems are increasingly in high demand, and these topics represent promising research areas.

University	TUE
Programme	Measurement and Control
Programme director	Prof. dr.ir.P.P.J.van den Bosch
Assessment	Quality 4
	Productivity 4
	Relevance 4
	Viability 4

The quality of the programme is good with the work on embedded controllers being deemed very good. The group maintains high standards for itself by choosing carefully other groups with which they will co-operate. The studies on non-linear chemical systems illustrates this rather well. The Review Committee noted favorably the growing interaction with the Biomedical Technology group. This is a natural area of co-operation on non-linear and non-stationary processes. The productivity of the group is good. The number of PhD theses generated in the review period is very good. The future effort on the electronically guided bus project in Eindhoven provides a very useful programme that can bridge the gap between fundamental and applied research in this field. The Review Committee agrees that this project would serve as a major application for the rest of the Netherlands. While the chair wants to have eight concurrent PhD-students, this group is experiencing the same difficulties in attracting them as was reported by other groups the Review Committee reviewed.

University	TUE
Programme	Design technology for electronics systems
Programme director	Prof.dr-ing. J.A.G.Jess
Assessment	Quality 5
	Productivity 4
	Relevance 5
	Viability 5

The group has made significant contributions to Logical and Architectural Design of Integrated Circuits. Ties with the COBRA Research School have been beneficial, and contributions to and synergy with the Eindhoven Embedded Systems Institute have led to novel architectural design of processors. The quality of work is excellent and of an international standard and the number of PhD's is good. The transfer of technology through software products and through trained personnel is excellent.

The research work of the group has primarily found exposure through conference presentations and publications, while this is acceptable in the fast moving field of VLSI design, some encouragement should be given to publishing in archival journals to ensure longevity of results. The number of patents is considered to be low. The chair has an excellent international reputation, and it is important that succession is found to maintain the track record of the group.

University	TUE	
Programme	Signal processing	
Programme director	Dr.ir P.C.W.Sommen	
Assessment	Quality	4
	Productivity	4
	Relevance	3
	Viability	2

The group has found an interesting niche in Time-Frequency representation of signals and their applications to Time-Domain and Optical Signal Processing. Its work on Audio-Signal Processing should have widespread applications. New directions in real time signal processing and blind signal separation are rich seems worth exploring. There is a good balance between fundamental and applied research. For the future, the group has an ambition to become established as a leader in audio signal processing for such applications as active control and virtual source generation.

The Review Committee was concerned about the realism of entering the very competitive field of audio without a strong background in acoustics to underpin the signal processing aspects, notwithstanding the close ties with Philips Research.

The productivity in terms of conference papers is satisfactory, journal output should be further encouraged. The output level is also good, although the number of PhD dissertations has been disproportionately low. One of the main strengths and topics with international impact has been the work on mixed descriptions of signals.

At the time of the review the organisation of the signal processing activities in TUE were in transition. For some time there has not been an established professor as programme director and, while the research quality is good, there is an issue of viability of the group and the need for a chair in the area to reinforce its activities. This group is being merged with the Medical Engineering group with one chair leading the composite activity. The effectiveness off this merger will remain to be seen, as they do not seem to be naturally complementary. A strong new professorial appointment has been made which should help the group's viability, but there are still concerns.

2.3 University of Twente, Faculty of Electrical Engineering

The mission of the faculty is: to contribute to the development of the information technology, both in education and research. The nature of research in information technology is mainly application driven.

"Multidisciplinary approaches are explored in order to find the potentials and limitations of new technologies." (Self-evaluation page 6) Research concentrates on four areas all embedded in a research institute: microsystems is embedded in MESA, mechatronics participates in the Drebber Institute, telematics in CTIT and biomedical research in BMTI. The University of Twente concentrates on spearhead institutes, chosen by the university Board of Governors. MESA, CTIT and BMTI are spearhead institutions. More than 90 % of the research of the Faculty of Electrical Engineering is embedded in these three institutes.

During the review period - 1994 - 1998 - the labour market became overstressed. Therefore recruitment of aio's and oio's became very difficult. The UT improved salary conditions for aio's and oio's and decreased the differences in salary between a PhD student and an starting engineer in industry. For the internal quality assessment, the faculty produces an Quality Assessment Report (QAR) every year. "The research budget allocated to the departments is based on a fixed basic amount and a part that is proportional to the research output performance. This performance related budget (59 % of the first budget flow research) creates a strong pressure for quality." (Self-evaluation, page 7)

Compared with the last review, the faculty has embedded his research programmes more strongly into one of the four research institutes. A number of programmes are also more focused towards the development of information technology. In the last review the faculty had focused on more areas.

The embeddedness into one of the four research institutes has implications in the research that is carried out, which turns towards a more multidisciplinary approach. From the point of view of productivity scores, this has consequences. Productivity rates in electrical engineering may be somewhat misleading as, due to a rather interdisciplinary approach, UT publishes a substantial share of its output in not directly Electrical Engineering journals.

University	UT
Programme	Biosensors
Programme director	Prof. dr.ir.P.Bergveld
Assessment	Quality 5
	Productivity 4
	Relevance 5
	Viability 5

The quality of the programme on chemical and physical sensors is excellent and is one of the premier groups in the world. The emphasis on fundamental sensor related studies has enabled the group to maintain extremely high standards as well as attracting substantial funding. The productivity of the group is good. By the nature of the research topics undertaken, the publication venues are quite diverse, ranging from biomedical, to electrical engineering to chemical to sensor journals, as to name but a few. The relevance is excellent and, most importantly, the impact of the programme results on research conducted throughout the world is outstanding. The viability is excellent though funding of the fundamental programmes is dependent on money derived from a continuous stream of more applied industrial projects.

University	UT
Programme	Control Engineering
Programme director	prof.dr.ir.J.van Amerongen
Assessment	Quality 4
	Productivity 3
	Relevance 4
	Viability 4

The strengths of the group are in the area of Modelling, Simulation and Design of

Systems, and links with the Drebber Institute have been effective. The overall quality of the programme is good from the perspective of the areas pursued over the review period.

While several research themes are being addressed, it would be useful for the group to focus on a relatively smaller portfolio of areas, based on current strengths, that would pay off in the long term. In this context software developments in modelling are clearly important for the future.

The productivity of the group over the period of assessment has been is about average; and while the work of the group is industrially relevant, efforts should be made to attract more PhD students.

University	UT
Programme	Integrated Circuit Design
Programme director	Prof.dr.ir.B.Nauta

Assessment	Quality	4
	Productivity	2
	Relevance	5
	Viability	5

This programme is focused on the process of the design of analogue and mixed signal IC's and while staying closely in touch with the fabrication technology, does not involve itself with the manufacturing. It aims to stay with mainly transistor level, and aims to produce work which is directly applicable in industry. The group has ambitions to be compared with the global academic leaders, but this is clearly not yet realistic. The most recent work with a major impact has concerned the behaviour of $1/f$ noise, and there are plans to collaborate with TUE in further investigations. The main weakness is seen as lack of digital expertise, and it is proposed to access this through collaborations.

Whilst the quality of the research of this group has been good, the productivity has not really been satisfactory. This can be mainly attributed to the lack of a full time chair over the review period.

The journal papers produced have been of good quality in highly specialised areas, although low in number. There have also been rather few PhD theses. With the recent appointment of the chair from Philips Research and significant investment from the University, the group is now formulating plans to increase the activity level. Collaborations with industry are being established and a part time Professor in RF techniques is in the process of being appointed. There are presently five PhD students, and it is planned to increase them to twelve. These make the planned expansion of work into communications subsystems very credible, and the Review Committee rates the relevance and viability as excellent.

University	UT	
Programme	Measurement and Instrumentation	
Programme director	Prof.Dr.Ir. P.P.L.Regtien	
Assessment	Quality	3
	Productivity	3
	Relevance	2
	Viability	2

With the departure of staff earlier, the group has attempted to shift the focus of its activities from Computer Vision to Measurements. While useful work has been carried out on the former subject during the review period, impact on the latter has yet to be made, and new themes have yet to emerge. The Review Committee was of the view that the quality of research output was about average. The group needs to develop a clear focus for its research directions. The group has attempted to maintain a balance between pure and applied research, but its main preoccupation at present appears to be the lack of funding, from external sources as well as a perceived decline in support from the university. The lack of success with funding begs questions about the relevance and viability of the programme.

External research support should be sought more widely, and lack of past success in participating in international or EU programmes should be addressed in the future. Collaborative work with the Research Institute on Systems Engineering should be further encouraged. The publication output of the group has been dominated by conference proceedings rather than through refereed journal publications. Some attention should be given to the dissemination of research results in archival journals.

		UT5A
University	UT	
Programme	Material Science and Engineering, Information Storage	
Programme director	dr. J.C.Lodder/prof.dr.Th.J.A.Popma	
Assessment	Quality	5
	Productivity	4
	Relevance	4
	Viability	4

** This group was presented as two sub-programmes, with a limited co-operation or synergy between the programmes. Currently, the chair of UT5 is dean of another UT faculty. The Review Committee learned that in the future there will again be two chairs, one for each sub-programme.

The Information Technology Group is co-operating closely with the Applied Physics Faculty. Because of the nature of the topic and the industrial interest worldwide in this subject, there is a continuous struggle for focus in the group. The "spinvalve" transistor, a term coined here, has put this group on the map. Co-operation with industrial partners is successful and results in a high percentage of second and third stream money. It is the Review Committee's recommendation that care should be taken to maintain an appropriate balance between long and short-term programmes in this group. The quality of the work is deemed to be excellent and the productivity, relevance and viability are rated by the committee as good.

		UT5B
University	UT	
Programme	Material Science and Engineering, Lightwaves Devices	
Programme director	dr. P.V.Lambeck/ prof.dr.Th.J.A.Popma	
Assessment	Quality	4
	Productivity	4
	Relevance	4
	Viability	4

** This group was presented as two sub-programmes, with a limited co-operation or synergy between the programmes. Currently, the chair of UT5 is dean of another UT faculty. The Review Committee learned that in the future there will again be two chairs, one for each sub-programme.

The Lightwave Devices group also operates in a multidisciplinary setting in close co-operation with Applied Physics. As a relatively small group (in Electrical Engineering) focussed on integrated multipurpose sensor-array systems, there are activities on computer simulations, materials, technology and novel photonic structures. Again, the balance between long and short term research and the need for focus needs continuous attention. The quality of the work is considered to be good to excellent and the productivity, the relevance and the viability are seen by the committee as good.

University	UT
Programme	Semiconductors, IC-Technology, Devices and Reliability
Programme director	prof.dr.H.Wallinga
Assessment	Quality 4
	Productivity 4
	Relevance 4
	Viability 4

** This group was presented as two sub-programmes.

The IC-technology research is dominated by the large industrial players. To compete in advanced processes is therefore hardly possible for a university. This programme therefore focuses on a few advanced process steps. In particular the dielectric thin films and the interconnected layers are subject to research in strong co-operation with industry. The devices are processed in the industrial facilities. Device modelling and device reliability research is performed within the group. Within the existing financial constraints and considering the size of the group, the Review Committee considers the above an intelligent approach to stay in the mainstream of the field. The quality of the programme is considered to be good, the productivity is nearly good but could be improved. The relevance of the programme is (very) good. The viability is good, assuming that funding continues to be available and that a well qualified successor of the chair can be attracted. The success of the programme is heavily dependant upon MESA facilities.

		UT6B
University	UT	
Programme	Semiconductors, Testable Design and Testing of Microsystems	
Programme director	dr.ir.H.G.Kerkhoff/prof.dr.H.Wallinga	
Assessment	Quality	3
	Productivity	3
	Relevance	3
	Viability	3

** This group was presented as two sub-programmes.

This part of the group is small (3,4 fte). The group has gradually shifted from chip design into testing of microsystems and testable design during the reviewed period. Again a close co-operation with industry is pursued. Still the funding originates mainly from the university.

The results of the group in the period under review are to be considered as standard for all four aspects. The quality of the programme is standard, although some of the papers are good. The productivity is standard, and is low in refereed journals, which may be explained by the difficulty of publishing papers on testing and measurement equipment. The activities of Testing are relevant, but the Review Committee had some doubts about its impact

University	UT	
Programme	Signal and Systems, Biomedical Engineering	
Programme director	prof.dr.-ing.O.E.Hermann/prof.dr.ir.H.B.K.Boom	
Assessment	Quality	4
	Productivity	5
	Relevance	5
	Viability	4

** This group was presented as two sub-programmes.

The group has a clear research strategy and its programme is well focused on the interaction between technical systems and the neuromuscular system. Within this area it is comprehensive since it covers the complete range of interactions from the cellular/molecular, over the nerve/muscle, to the neuromusculo-skeletal level. The quality of this research has enabled the group to achieve international recognition and to embed its research activities into a valuable network of international co-operation. The significant participation of the group in European research programmes is another indication of the quality of the research. The scientific productivity was excellent, being marked by an increase in the number of refereed publications in the last years of the review period. The research work of the group is highly relevant in general, but special mention should be made of the rehabilitation aspects, which obviously have a special societal relevance. This is also due to the good contacts and co-operation, which the group has established with medical and clinical units. In view of its well-conceived and carefully implemented research strategy, this group has a good viability.

University	UT	
Programme	Signal and Systems, Network Theory	
Programme director	prof.dr.-ing.O.E.Hermann	
Assessment	Quality	3
	Productivity	3
	Relevance	3
	Viability	3

** This group was presented as two sub-programmes.

This research programme covers a very wide variety of topics covering the full design trajectory of digital signal processing systems. This wide scattering of research efforts makes it difficult for the group to participate in prominent European research networks. The policy of pursuing research down to hardware implementations and demonstrators has led to results and designs with significant industrial relevance. This has enabled the group to develop a substantial collaboration with the industry. The recent merger of this subgroup with the Biomedical Engineering group does not seem to be supported by a new and clearly defined research strategy for the group. The lack of clear objectives for the merger may well endanger the development of synergies between the two subgroups. The overall scientific productivity is certainly adequate but the output of refereed papers is somewhat limited.

University	UT	
Programme	Tele-Informatics and Open Systems	
Programme director	Prof.dr.ir.W.C.van Etten/prof.dr.ir.I.G.M.M.Niemegers	
Assessment	Quality	4
	Productivity	4
	Relevance	5
	Viability	5

The Tele-Informatics and Open Systems group is an interfaculty department of the Faculties of Computer Science and Electrical Engineering. Its research is carried out in the Centre for Telematics and Information Technology.

Recently, the group was split into three new groups.

The research group under review is small (6 fte's in Electrical Engineering), but together with computer science the number of staff is around 50. The research programme of the group covers a wide variety of topics addressing all relevant aspects of telematics system development. The programme is very ambitious, perhaps over-ambitious for the size of the group; its strength comes from the interdisciplinary of the research. The quality of research is good, the group participates in European research programmes, and has achieved international recognition.

The productivity of the group is good, the research work is highly relevant. The group is involved in some new projects with industry, e.g. on telecommunications which may place more emphasis on applications. The relevance and the viability are seen by the Review Committee as excellent.

University	UT	
Programme	Transducers Science and Technology	
Programme director	Prof. dr.M.C.Elwenspoek	
Assessment	Quality	4
	Productivity	4
	Relevance	5
	Viability	5

The key strength of this group lies in its expertise in micromachining (MEMS) methods, implemented in the MESA laboratory. Whilst these are broadly available both in academe and industry, this together with the work on sensors and actuators definitely rates a good assessment. The group's work is comparable with programmes at a number of leading institutions around the world. The productivity is (very) good. The issue of relevance requires some clarification. The research activity of the group is quite relevant to its stated field. Hence the rating of excellent. However, just as there is a growing trend to systems on a chip (SoC) in electronics, where the Review Committee notes with concern the relatively limited discussion of broader system considerations, although the group does acknowledge a lack of system level pull as a shortcoming.

In defence of the programme, it is fair to say this is true of the field in general. The field and the group have a future though the research area was more promising five years ago. Over the review period, MEMS based elements have become commodities as industry has taken a more central role. Because of its current position in the field, the group will have excellent viability for the short term. The Review Committee expressed concern that the group may not be keeping up with the latest developments, particularly at the systems level, as this area continues to change rapidly

University	UT
Programme	MESA
Programme director	prof.dr.i.r.A.van den Berg
Assessment	Quality -
	Productivity -
	Relevance -
	Viability -

The committee is convinced that the MESA-institute as an interfaculty activity is of great value for the programmes of the UT in different disciplines and that through MESA a successful way of integrating these programmes is operational.

However, the presentation of a minute part of the MESA-institute (1.65 fte) as part of the Faculty of Electrical Engineering made the Review Committee decide not to review this part of the MESA-institute.

Appendix 1 **Discipline Protocol Electrical Engineering**

1. Introduction

This research assessment covers the discipline of Electrical Engineering. The aim of research and education in the field of Electrical Engineering is to educate academic engineers and designers, to perform fundamental and application-oriented scientific research at an international level and to transfer knowledge; for the latter a good co-operation with industry is of great importance.

The main aims of the assessment are, in concordance with the Protocol 1998, the improvement of the quality of the individual research programmes and the provision of information for the accountability of the research carried out. The assessment will be placed in the context of the activities of the faculty and it will give an appraisal of the general features of the scientific area covered in this assessment.

2. Required expertise of committee members

Besides a positive attitude towards fundamental and applied aspects of research and the multidisciplinary character of the discipline of Electrical Engineering, the following expertise is required for the members of the review committee:

- Information technology
- Micro-electronics
- Power engineering
- Sensors and actuators
- Signals and systems
- Telecommunications

This list is alphabetically arranged and does not show priorities.

One of the application areas of electrical engineering is biomedical engineering. Therefore it would be appreciated if one of the committee members has also expertise in biomedical engineering.

The committee will consist of seven members, the chair included.

3. Procedural plan of the committee

The committee is independent and will determine its own method of working, within the framework of Protocol 1998 and this Discipline protocol. In this respect, the following points are of importance:

The committee will hold site visits. Sufficient time has to be spent on this part of the procedure (at least one-day for each separate faculty).

Separate research groups should be visited by as many (if not all) committee members as possible. The committee members will be able to meet the responsible boards for research management and policy within the faculty, programme directors and other participants in the research programmes (e.g. PhD students).

In preparation of the meetings the committee will give subjects and the goal of the discussions that will be held with the faculty board and the separate groups during the site visits.

4. Assessment standard

According to the types of publications which are mentioned in "Assessment of Research Quality: Protocol 1998, Utrecht, VSNU, 1998, Appendix 4 (pp. 41-44) the following categories are taken into account:

- PhD theses
- Academic publications divided in journal articles and other academic publications. For the journal articles a distinction is made in refereed and non-refereed articles. For other academic publications, a distinction is made in books, book chapters and conference-proceedings & important abstracts.
- Twaio-reports can be added as a category.
- Professional publications
- Patents

The category '*realised designs*' will be mentioned in Section C (Documentation per programme) under paragraph 12: 'other indicators of quality and reputation'.

In accordance to these categories the table concerning research output (see *Assessment of Research Quality: Protocol 1998, Utrecht, VSNU, 1998, appendix 3, Section C, 6. Research output, p.38*) should read:

number PhD theses			1994	1995	1996	1997	1998	total
academic publications	journal articles	refereed						
		non refereed						
	other academic publications	books						
		book-chapters						
		conference proceedings & important abstracts						
Twaio-reports								
Professional publications								
Patents								

A list will be added of PhD theses, academic publications, twaio reports and patents. For the output category 'professional publications' the number of the publications will suffice, however, if desired, three professional 'key' publications may be added.

The distinction between refereed and non-refereed journal articles will be made on the basis of a list prepared by the three faculties. This list is added in an appendix.

Further relevant information for this assessment .

In order to evaluate the impact of the research output a bibliometrical analysis will be performed. This analysis will be performed by CWTS, Leiden University and will take into account the publications of those persons participating in the

research programmes present at 31/12/98. A list of names will be compiled by the faculties and needs to be available as soon as the study will be commissioned to CWTS. In principle, the list will contain the smallest number of senior researchers as possible that guarantees the largest coverage of academic publications. To allow for the possibility that others than senior researchers publish independently, programme directors may add such publications produced in their group. An analysis will be made of the publication and citation behaviour for the area in The Netherlands, Europe and worldwide.

In a recent document (ST-1995 09 06-6/2) the Dutch Technology Foundation ST has stated that for technical sciences the results of a bibliometric analysis should never be the sole instrument for evaluation of scientific research, and that such results should only be carefully used by experts in the field. The faculties of Electrical Engineering support this view and they trust that, if the Review Committee (which will use the bibliometric analysis as one of its instruments for assessment) wishes to present bibliometric results in its final Report in one way or another, it will do so with great care.

Level of aggregation

A research programme is defined as “a coherent set of research activities having a common mission and being the work of a group of people who generally work together on a daily basis”. For the purpose of this evaluation this will normally be the activity of a group directed by a chair (leerstoel).

Programme members

The academic staff is subdivided into the following ranks:

professors (hgl)

associate professors (uhd)

assistant professors (ud)

fellows and others who have attained a PhD

Research input of academic staff

In the table concerning research input all junior researchers in any stadium of promotion are concerned as AIO/OIOs; the programme members as mentioned above are concerned as others. In this assessment the input of AIOs etc, as well as postdocs will be standardised to 0.8 fte, UDs and UHDs to a maximum of 0.6 fte and professors to a maximum of 0.4 fte.

Procedures and (tentative) time schedule

Time (1999)	action	responsibility
January	Procedure for chairperson appointment	VSNU, KNAW
February/March	Proposals for Committee chairperson and members Preparation of discipline protocol Approval of Discipline protocol	Universities
March	Procedure for Committee members appointment	VSNU, KNAW and chairman
15 April	Submission of information to VSNU	Universities
June, August	Committee meetings	Committee, VSNU
August/September	Site Visits	Committee, VSNU, universities
September/October	Preparation of report	Committee
November	Publication of report	VSNU

Appendix 2 Preliminary Assessment Form

REVIEW COMMITTEE ELECTRICAL ENGINEERING: PRELIMINARY ASSESSMENT FORM

(Please return to the Secretary of the Review Committee before 1999)

Title programme:
First Reviewer:
Second Reviewer:

Code:
Filled in by:

1. Preliminary assessment of the programme

Please give your ratings on a 5-point scale, in which:

5 = excellent; 4 = good; 3 = satisfactory; 2 = unsatisfactory; 1 = poor

Note: Start from the assumption that all university research should normally conform to a certain standard. Consider whether each aspect of this programme is above/on/below this standard. The Committee report must specify why deviation of the standard is perceived. Your preliminary assessment is only for use in the Committee meetings and will not be published in the Committee report.

	1	2	3	4	5
A. QUALITATIVE LEVEL					
How do you evaluate the quality of the programme with respect to the:					
1. originality of the ideas and the approach					
2. quality of the published output in a foreign language					
3. quality of the published output in the Dutch language; for Dutch understanding reviewers only					
4. prominence of the programme director (including the ability to attract research assistants)					
5. prominence of other members of the research group					
6. coherence of the programme					
Overall assessment of quality level					
B. PRODUCTIVITY/OUTPUT					
Considering number of staff, how do you evaluate the productivity of the programme with respect to the:					
1. total number of publications					
2. number of publications in a foreign language					
3. number of Ph.D. theses					
4. number of publications in the Dutch language					
Overall assessment of productivity:					

	1	2	3	4	5
C. RELEVANCE					
Considering the stated mission of this programme, how do you evaluate the relevance of the research with respect to the:					
1. relevance for the theoretical advancement of the science concerned					
2. relevance for the understanding of major developments in society					
3. relevance for policy					
Overall assessment of relevance					
D. LONG-TERM VIABILITY					
Considering its personnel and facilities, how do you evaluate the long-term viability of the programme					
1. with regard what has been achieved so far					
2. with regard to plans and ideas for the future					
3. in terms of research policy of the programme unit					
Overall assessment of long-term viability:					

2. Points of attention/remarks

3. Questions (to the Programme Director, Board of Faculty)

Code:
Filled in by:

Appendix 3 List of overview of scores per programme

Legenda: 5 = excellent; 4 = good; 3 = satisfactory; 2 = unsatisfactory; 1 = poor
n/a: Not applicable

Code	Research Programme	Q	P	R	V
TUD 1	Electromagnetic research	4	5	4	3
TUD 2	Telecommunications & traffic control syst. & services	4	4	5	3
TUD 3A	Telecommunication and remote sensing theory microwave transmission, radar and tele-observation technology	4	3	4	4
TUD 3B	Telecommunication and remote sensing theory: photonic integrated	5	5	5	5
TUD 4	Computer architecture and digital technique	4	5	5	5
TUD 5	Information and communication theory-ICT	4-5	4	5	5
TUD 6	System and control engineering	4	5	5	4
TUD 7	Circuit and systems	5	4	5	5
TUD 8	Electronic research	4	5	5	3
TUD 9	Electronic instrumentation	5	4-5	5	5
TUD 10	Electrical components, technology and materials	4	4	5	4
TUD 11	Power systems	4	5	4	5
TUD 12	High voltage technology	3	5	4	4
TUD 13	Electrical power processing	3	2	3	5
TUE 1	Information processing systems and network	3	2	4	4
TUE 2	Electro-Optical communication	5	4	5	5
TUE 3	Radio-communication	4	4	4	4
TUE 4	Electronic devices	4	4	3	4
TUE 5	Electronic circuit design	5	5	4	4
TUE 6/7	Electrical energy systems High-voltage engineering and electromagnetic compatability	3/3	3/2	3/3	2/2
TUE 8	Electro magnetics	4	n/a	4	n/a
TUE 9	Medical electrical engineering	3	4	3	2
TUE 10	Electromechanics and power electronics	4	3	5	4
TUE 11	Measurement and control	4	4	4	4
TUE 12	Design technology for electronic systems	5	4	5	5
TUE 13	Signal processing	4	4	3	2
UT 1	Biosensors	5	4	5	5
UT 2	Control engineering	4	3	4	4
UT 3	Integrated circuit design	4	2	5	5
UT 4	Measurement and in Instrumentation	3	3	2	2
UT 5A	Material science and engineering, information storage technology group	5	4	4	4
UT 5B	Material science and engineering, lightwaves devices group	4	4	4	4
UT 6A	Semi -conductors, IC-technology, devices and Reliability	4	4	4	4

Code	Research Programme	Q	P	R	V
UT 6B	Semiconductors, testable design and testing of microsystems	3	3	3	3
UT 7A	Signals and systems, biomedical engineering	4	5	5	4
UT 7B	Signals and systems, network theory	3	3	3	3
UT 8	Tele-Informatics and open systems	4	4	5	5
UT 9	Transducers science technology	4	4	5	5
UT 10	MESA				

Appendix 4 Curricula Vitae

Kees Bulthuis: received his PhD degree in Physics in 1968 at the Technische Universiteit Eindhoven. Since 1964 he worked on the laser for video disc and on high density optical recording. Until 1999 he was senior manager director of Philips Research. He received a honorary doctorate from Trinity College in Dublin, Ireland. He is Chairman of the Board of Silicon and Software Systems, Dublin, Ireland, member of the Dutch FORUM for Science and Technology (1991), member of the President's Advisory Committee on Future Technology (PACT) (1994), Genève and member of the AWT (Advisory Council for Science and Technology Policy) (1997), The Hague.

Rik W.A.A. De Doncker: received his PhD degree in electrical engineering at the Katholieke Universiteit Leuven, Belgium in 1986. He left for the US where he was appointed successively a visiting associate professor (University of Wisconsin, Madison) and research leader at the General Electric Company (Corporate Research and Development Center, Schenectady, New York). In 1994 he joined Silicon Power Corporation as Vice-president Technology. Since 1996, professor De Doncker is director and professor of the Institute für Stromrichtertechnik and Elektrische Antriebe of the Rheinisch-Westfälische Technische Hochschule Aachen, Germany. Professor De Doncker is senior member of the IEEE. He is an active member of the Drives Committee and is chairman of the IEEE-IAS Industrial Power Converter Committee and a founding chairman of the German Joint IEEE IAS/PELS Chapter, In 1999, he became Member-at-Large of the IAS Executive Board.

Tariq S. Durrani: received a degree in Electronics in 1967 and the PhD degree in 1970. Since 1982, he is professor of Signal Processing at the University of Strathclyde, Glasgow, UK. He is head of the Signal Processing Division. Professor Durrani's research interests are in the area of Adaptive and Non-linear Signal Processing, Image Processing and Novel Architectures. He has published over 280 papers, and six books. He has been President of the IEEE Signal Processing Society (1994-1995), Chairman, IEEE Periodicals Council (1996-1997) with oversight responsibility for all IEEE Transactions, Journals, Magazines and Newsletters, and Chairman IEEE Periodicals Review Committee (1998-1999) responsible for the quality and timeliness of all IEEE periodicals. Professor Durrani is a Fellow of the IEE (UK), the IEEE, The Royal Society of Edinburgh, The Royal Academy of Engineering.

Paul Lagasse: received the degree in electrical engineering in 1969 and the Ph. D. degree in 1972, both from the University of Ghent, Belgium. In 1981 he became professor of electrical engineering at the University of Ghent where he is now head of the department of Information Technology. In 1985 he became also director of the INTEC division of the Inter University Micro Electronics Centre in Leuven and since 1993 he is Secretary General of the International Union of Radio Science. After originally working in the area of surface acoustic waves, he is now mainly active in the fields of optoelectronics, high frequency technology and broadband telecommunications. He is member of the board of the Flemish Institute for Science and Technology, Corresponding member of the Belgian Royal Academy of Science and since 1997 member of the board of governors of IEEE LEOS.

Peter Noll: is a Professor of Telecommunications at the Technical University of Berlin, Germany and an Advisory Professor of the Beijing Institute of Technology, Beijing, China. Currently he is Executive Director of the Institute of Telecommunications and Theoretical Electrical Engineering. His

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