QANU research review of Applied Mathematics

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Foreword

This report follows the Standard Evaluation Protocol 2003-2009 for Public Research Organisations (SEP) that was developed by VSNU, KNAW and NWO. The purpose of this report is to present a reliable picture of the research activities submitted for this review and to give feedback on the research management and quality assurance.

The review committee was supported by QANU (Quality Assurance Netherlands Universities). QANU aims to ensure compliance with the SEP in all aspects and to produce independent assessment reports with peer review committees of international experts in the academic fields involved.

QANU wishes to thank the chairperson and members of the review committee for their participation in this assessment and for the dedication with which they carried out this task.

We also thank the staff of the units under review for their carefully prepared documentation and for their co-operation during the assessment.

Quality Assurance Netherlands Universities

Mr. Chris J. Peels
Director

Dr. Jan G.E. Veldhuis
Chairman of the Board

Preface

This report summarizes the results of the peer review assessment of the research programmes in applied mathematics of the three technical universities in the Netherlands during the period 2003-2008. It also includes the results for the programme *Technische Mechanica en Numerieke Wiskunde* of Groningen University. According to the *Protocol for the 3TU Research Evaluation of Applied Mathematics 2003-2008*, the evaluation was carried out by a committee of 6 members plus the chairman and secretary. The areas of expertise of the committee covered analysis, applied analysis, scientific computing, probability theory, statistics, stochastic decision theory, systems theory, discrete mathematics and optimization. The information in print provided to the committee consisted of a self-evaluation report 2003-2008 from each university, and the Standard Evaluation Protocol 2003-2009. Data for the year 2002 were presented in order to ensure continuity with the previous review.

The committee wants to express its gratitude for the efforts made by all involved parties to prepare the documentation required for this evaluation. This documentation contained valuable information and formed a very useful basis for an objective evaluation procedure.

Preliminary reviews of each institute and programme were prepared independently by two members of the committee in the summer of 2009. These preliminary reviews were not distributed to the committee; they served merely to ensure that each of the documents had been studied in detail by at least two members. These reviews were summarized and defined the basis for the main part of the evaluation process. From September 9 to 12, 2009, the committee met in person and made site visits to all groups involved, with the exception of the Groningen group, which was included in the site visit to the University of Twente. During these site visits, the committee met with directors of the institutes, representatives of each group, and a selection of PhD students. With the exception of Groningen University, the committee also met with representatives of each university and department, usually the Rector, the Dean, and the Onderzoeksdirecteur. The discussions, usually in the order of 45 minutes for each group, took place in a pleasant informal atmosphere, and they proved essential for the convergence of the opinions within the committee to their final state. The committee is very thankful to all representatives for their willingness to share their opinions and concerns with us in a very open manner.

The committee acknowledges the support of QANU, in the person of Mrs. Meg van Bogaert, for all administrative matters and technical guidance for the evaluation procedure. She also made certain that our meeting in the Netherlands was well organized. Travelling and catering were organized much to our satisfaction.

Let me take this opportunity, as chair of the committee, to thank my fellow committee members for their commitment and dedication to this evaluation process. We have worked together as a real team, open-minded and thoughtful. We all realized the formidable challenge of this task, and I am pleased to be able to conclude that this report reflects the consensus opinions of the committee.

Prof. H.A. van der Vorst
Chairman

1. The review committee and the review procedures

1.1. Scope of the assessment

The review committee was asked to perform an assessment of the research at three Departments of Applied Mathematics at Delft University of Technology (TUD), Eindhoven University of Technology (TU/e), University of Twente (UT) and of one programme at the University of Groningen (RUG). The review covers ten research programmes and the research conducted in the period of 2003 – 2008.

In accordance with the *Standard Evaluation Protocol 2003-2009 for Public Research Organisations* (SEP), the committee's tasks were to assess the quality of the institutes and the research programmes on the basis of the information provided by the institutes and through interviews with the management and research leaders, and to advise how this quality might be improved.

1.2. Composition of the committee

The composition of the committee was as follows:

- Prof. H.A. van der Vorst (chairman of the committee)
- Prof. M.A. Kaashoek
- Prof. A. Quarteroni
- Prof. P. Robert
- Prof. A. Schrijver
- Prof. J. Vandewalle
- Prof. E.A. Verbitskiy

A short curriculum vitae of each of the committee members is included in appendix A.

Dr. Van Bogaert of the Bureau of QANU (Quality Assurance Netherlands Universities) was appointed secretary to the committee.

1.3. Independence

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

1.4. Data provided to the committee

The committee received detailed documentation consisting of the following:

- Self-evaluation reports of the institutes under review, including all the information required by the Standard Evaluation Protocol (SEP), with appendices;
- Copies of six key publications per research programme;
- CWTS report

1.5. Remarks about the data provided

The committee received a CWTS bibliometric report of all groups involved, although this was not part of the formal material. The committee did not evaluate this CWTS study. It was used as additional information to support our findings and to help prevent possible wrong conclusions. The CWTS report was used only at a late stage of the evaluation procedure and did not influence our initial findings, nor did it contribute significantly to any of our final conclusions. It was considered useful input, and our findings did not lead to much contradiction.

1.6. Procedures followed by the committee

The committee proceeded according to the SEP. Prior to the first committee meeting, each institute and research programme was assigned to two committee members for review. A preliminary assessment was independently formulated on the basis of the key publications. Preceding the interviews, the committee was briefed by QANU about the research assessment according to SEP. The committee discussed the preliminary assessments. For each research programme a number of comments and questions were decided upon. The committee also agreed upon procedural matters and aspects of the assessment. The final assessments were based on the documentation provided by the institutes, the key publications and the interviews with the management and with the leaders of the programmes. The site visits took place on September 10, 11 and 12, 2009 (see the schedule in appendix B). After the interviews, the committee discussed the scores and comments. The text for the report was finalised through e-mail exchange. The final version was presented to the institutes for factual corrections and comments. The comments were discussed by the committee and led to changes in the report on a number of points. The final report was presented to the boards of the participating universities and was printed after their formal acceptance. The committee used the rating system of the SEP, the meaning of the scores is described in appendix C.

2. General remarks

Mathematics at the three technical universities is characterized as applied mathematics, which suggests that we have to do with possibly less fundamental mathematics. This would be a misconception. The pure mathematics of today may be the applied mathematics of tomorrow. In fact, as the committee views it, the main difference is in its focus. Whereas the pure mathematician aims to stretch the theory without any restriction of possible applicability, the applied mathematician is normally driven by some problem that stems from outside mathematics. That poses high demands on the quality of the applied mathematicians; they should have a very good and active knowledge of mathematics in general and more specifically of the mathematics related to the scope of their problems. In addition to this, they are also required to be able to adapt and expand their knowledge such that it helps to solve specific problems that originate from outside mathematics, and where the mathematics can bring substantial added value. This is the type of mathematics that predominates at the technical universities.

Through progress in computations and technological evolutions, science, engineering and even biomedical methodologies rely more and more on mathematical models and mathematically oriented analysis. That might create expectations to see an increase in the volume of mathematical research over the past decades, but the reverse is true, perhaps more so in the Netherlands than elsewhere. With respect to, say, twenty years ago, mathematical programmes at the Dutch universities have suffered from a very noticeable decrease in funding. This has been confirmed by many studies and forms a major issue of concern. Some steps have been taken to increase the volume of research, we mention the research clusters with additional funding from NWO and OCW, but this has not prevented an overall decline.

This should be taken into account when investigating the scope and level of applied mathematics programmes. In past reviews, these programmes have been evaluated in general as above average and as competitive at the international level. As a result of budget cuts, the relatively weaker groups have often been disbanded, and reorganizations have taken place to maintain the coherence in the smaller sized groups that had to uphold a broad spectrum of expertise, not in the least for the related educational programmes in mathematics. Of necessity, this has forced the universities to make priorities, which often means abandoning important areas of expertise. Departments have to do more with less manpower. It is evident that this cannot go on without negative effects.

We see this reflected in the workloads, a common complaint in the self-evaluation reports. It also poses ethical dilemmas for the committee. In brief: if we conclude that the quality and viability are still very high, then the responsible managers might conclude that the reduction of the research efforts was not a bad step. Yet we are afraid that further reduction will be considered if we conclude that these parameters have gone down. We realize that a critical mass is mandatory in order to be able to compete at the highest international level. You have to be a member of an international network in order to be aware of the newest trends and discoveries and that these new developments may be essential for breakthroughs in the applications at hand.

Another major problem for Dutch mathematics is that it is highly dependent on so-called second stream funding, coming from the granting organizations NWO and STW. This funding is necessary for the hiring of postdocs and PhD students, for which the basic funding is far from sufficient. However, it is well known that this funding stream is far too small for mathematics.

With some 45 research groups in mathematics in the Netherlands, this type of funding leads to the support of about 13-15 PhD students per year, including Vidi and Vici funding. The granting of NWO funds resembles a lottery, where several proposals that are rated excellent both by the referees and by the selection committee are not granted due to shortage of funds.

Our evaluation has been made with the above in mind. It would not be fair to punish hard-working and highly competent researchers for insufficient funding.

We found, much to our surprise, that the applied mathematics groups in general are well composed, with sufficient coherence to absorb and deal with important and highly relevant research challenges. This is often the result of quite recent reorganizations or reshuffling. In that respect, for some groups, this research assessment comes a bit early to see the positive effects in more glory. Fortunately, in most cases the indications point in positive directions and give confidence for the viability of these groups. It is the committee's opinion that it is now time to give stability to the present organizations and to allow for a period of consolidation.

Practically all of the researchers involved in this assessment act in the forefront of international research and are visible there, through publications, presentations at conferences and the like, and participating in international, often informal, networks. Research in mathematics has long been viewed as a highly individual activity, but even if this was not true in the past, this is in any case not the situation in modern research. We have seen that there is not only much research contact within programmes, but also across programmes and on the national scale. This is, in particular, to be expected for the 3TU Applied Mathematics Institute, although it must be said that the perspective on this valuable initiative differs among the involved institutes, ranging from promising possibilities to highly appreciated new opportunities. This 3TU institute could lead to a bundling of forces and might help to provide the critical mass for research at the forefront of science. Together, the three technical universities offer an interesting and almost complete scale of applied mathematical research directions.

Finally, a word on the scores. The committee points out that the scores are a tool, not a goal in themselves. The committee has used the scores in line with current practice in the Netherlands, but remarks that the scoring system should offer enough flexibility to use it as a tool for improvement. It would be undesirable to misuse the system in such a way that only high scores become standard.

ASSESSMENT PER UNIVERSITY AND PROGRAMME

3. Delft Institute of Applied Mathematics, TU Delft

3.1. Assessment at the institutional level – TU Delft

3.1.1. Introduction

The Delft Institute of Applied Mathematics (DIAM) is part of the Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS). The faculty was established in 1998 after the merging of the Faculty of Electrical Engineering with that of Applied Mathematics and Computer Sciences.

3.1.2. Leadership

The dean of the faculty bears overall responsibility for the faculty and reports to the University's executive board. The dean and the heads of departments operate as the management team (MT) of the faculty and meet every two weeks. The MT is involved in all strategic, policy and operational issues, and advises the dean.

The faculty currently has six departments, with mathematical research concentrated in DIAM, with Prof. B. de Pagter as head of the department. DIAM consists of seven discipline-related research groups. DIAM has approximately 65 permanent staff members, of which 40 are members of the research staff, and on average 40 temporary staff members. The head of DIAM is assisted by a departmental MT, consisting of full professors and the two directors of education (one for the applied mathematics programmes and one for service education). This departmental management team meets at least every four weeks.

One of the full professors is appointed as the chairperson of the department on a four-year basis. He is responsible for the quality and number of personnel involved in education and research, for the overall quality of the research and the department's budget. Usually, a research group consists of two to five assistant and/or associate professors, a small number of lecturers (with teaching duties only) and non-tenured staff (postdocs, PhD students). Regular meetings within the research groups take place to discuss relevant issues and to inform group members of the discussions within the management team. There is a general DIAM meeting (twice a year) in which strategic and operational issues are discussed. Once a year a one-day conference is organised during which staff members may present and exchange the latest research developments. A similar conference is held once a year to discuss and exchange ideas on educational issues.

3.1.3. Mission & Goals

The mission statement of DIAM is to make innovative contributions to the mathematical analysis of complex systems occurring within science and technology which are both applied and fundamental in nature. DIAM aims at advancing the state of the art in this field, assimilating the progress and innovation appearing in the international arena, and transferring knowledge, methods and tools to the scientific community and to partners in other disciplines at the university and within industry.

3.1.4. Strategy & Policy

Between 2001 and 2003 all research programmes were assessed and evaluated by an external committee with respect to their strengths and weaknesses. In view of the cooperation with Leiden, it was decided to discontinue research in algebra and geometry at TU Delft. Throughout the assessment period 2003–2008 several major changes in the programme structure were made, directed towards creating new research areas, improving interaction or obtaining greater visibility.

Until a few years ago, mathematical research at TU Delft covered virtually all mathematical disciplines that were relevant to the applied mathematics curriculum. As a result of the portfolio operation, research was geared to be more coherent and have a stronger focus. A number of programmes have been integrated to improve interaction between the different research areas. In the period 2003-2008, a number of full professors at DIAM retired. Over the same period of time, several new professors were appointed.

To comply with its mission, the faculty strategy, and accordingly the DIAM strategy, focuses on:

- A solid link between education and research
- Internationalisation of the graduate programme
- Delft research centres (DRCs) and institutes as organisational forms
- The three programmes – AN, CSE and PRS
- Cooperation with the universities of the 3TU federation
- Continuation of cooperation with Leiden University

These strategic aims suggest that the faculty and DIAM are well prepared to tackle future challenges. The main focus will be on the following future developments:

- More participation in externally funded projects
- Increasing attention paid to valorisation grants
- Further internationalisation of graduate studies
- Increasing the intake of Dutch students in BSc and MSc mathematics programmes
- DIAM investment and new directions in research
- Stronger 3TU cooperation

The cooperation between TU Delft and the other two universities of technology has been excellent for many years. At least twice a year the faculty boards meet to discuss and compare strategies and policies on education and research. The three universities of technology formed a federation in 2007 (3TU), in which they agreed to present themselves internationally as one unit. 3TU furthermore established a joint MSc programme in Applied Mathematics. In March 2009 the 3TUs decided to establish the 3TU Applied Mathematics Institute (3TU-AMI), which aims to coordinate and stimulate research and teaching in applied mathematics at the 3TUs.

Assessment of the committee on Leadership, Mission & Goals and Strategy & Policy
While the self-evaluation report of DIAM states that there is excellent cooperation with the other two TUs, this seems to exist at the moment mainly at the level of management, education (MSc courses) and tuning of research, but not in an intrinsically scientific cooperation.

The committee is surprised that the TU Delft vision of 3TU-AMI is rather restricted. It seems to have 'just dropped on their plates', and the only observed advantage is money. Is there a strategy, and is Delft enthusiastic about the 3TU-AMI? In our view, they should have a strategy for active participation. According to the committee, 3TU-AMI offers very good opportunities to strengthen the level and visibility of mathematics at the three TUs, also through increased funding possibilities. The committee supports the dean's policy that 3TU-AMI should help to improve the research quality and capacity at DIAM further. It would also help to achieve a critical mass, very much along the same lines as with the Dutch mathematical research clusters. On the other hand, given the current profiles of the three TU's, it is not clear to the commit-

tee whether the scope of mathematics at the three TU's, except for a few directions, would be broadened significantly as a result of the 3TU-AMI initiative. In the past DIAM hardly participated in the national clusters of mathematics. Participation is currently increasing and will strengthen the level and capacity of research at TU Delft.

3.1.5. Resources

The faculty's policy is to attract part-time professors from industry and the CWI (Centre for Mathematics and Computer Science) with the objective of embedding knowledge of industrial development in research, and of exploring new developments in research. Generally, a part-time professor is appointed for a period of four years, with the possibility of extension.

Selection of full professors is done by the executive board of the university. Associate and assistant professors are selected by a committee chaired by the head of the department, but the final decision is made by the dean. Recruitment of PhD students or temporary staff is usually the responsibility of the research group concerned. Additionally, a PhD Screening Committee evaluates the quality of starting PhD students. Table 3.1 provides an overview of the staff at the institute level, table 3.2 provides an indication of the factor of research time, and table 3.3 provides an overview of the staff for the three research programmes of the institute.

The performance of each member of the academic staff is evaluated annually in a results and development interview. This evaluation covers two components: the past year's performance, and the prospects and expectations for the year to come. For young researchers the faculty offers an attractive career prospect, as these assistant professors are increasingly recruited on a tenure-track basis.

The faculty wishes to provide a supportive environment to all its PhD students, with the objective to finish their programme within four years. In their first year they prepare an education and supervision plan with their supervisor. The faculty aims to improve the supervision and mentoring of the PhD students as well as monitoring of their progress. Currently, a go-no-go decision is made at the end of the first year, to which two PhD mentors are assigned. Furthermore, modest funding for the appointment of PhD students is provided by DIAM.

The faculty has approximately 175 fte in support staff, which can be divided into four categories: (i) central faculty support, (ii) departmental administrative support, (iii) departmental technical support, and (iv) lab support. For DIAM the support staff consists of 4.0 fte in technical support and 4.3 fte in administrative support.

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**Average**
Full professors	3.3	3.2	2.9	2.4	2.8	2.9	2.9
Associate professors	6.8	7.1	6.6	5.8	4.9	5.3	6.1
Assistant professors	3.6	3.5	3.8	4.4	4.7	5.5	4.2
Total tenured staff	*13.7*	*13.8*	*13.3*	*12.6*	*12.5*	*13.6*	*13.3*
PhD students	24.4	27.1	31.5	27.1	29.8	37.9	29.6
Other non-tenured staff	1.9	2.2	3.3	3.7	5.5	6.7	3.9
Total non-tenured staff	*26.3*	*29.3*	*34.8*	*30.8*	*35.3*	*44.6*	33.5
Total research staff	**40.0**	**43.1**	**48.1**	**43.4**	**47.8**	**58.2**	**46.8**

Table 3.1: Staff at institute level (in research fte)

	factor of research
Full professors	0.4
Tenured staff	0.4
PhD students	0.8

Table 3.2: Factor for converting fte to research fte.

	2003	2004	2005	2006	2007	2008	Average
Analysis							
Total tenured staff	*3.7*	*3.7*	*3.3*	*3.1*	*3.4*	*3.1*	*3.4*
PhD students	2.8	2.8	2.8	2.4	2.2	4.0	2.8
Other non-tenured staff	0.8	1.1	1.0	0.6	0.1	0.3	0.6
Total non-tenured staff	*3.6*	*3.9*	*3.8*	*3.0*	*2.3*	*4.3*	*3.4*
Computational Science and Engineering							
Total tenured staff	*5.3*	*5.4*	*5.5*	*5.2*	*4.8*	*5.9*	*5.3*
PhD students	18.1	17.7	19.7	17.3	21.1	26.4	20.1
Other non-tenured staff	1.2	1.1	1.6	1.9	2.2	2.1	1.7
Total non-tenured staff	*19.3*	*18.8*	*21.4*	*19.3*	*23.3*	*28.5*	*21.8*
Probability, Risk and Statistics							
Total tenured staff	4.7	4.7	4.5	4.4	4.3	4.6	4.5
PhD students	3.5	6.7	9.0	7.4	7.5	7.7	7.0
Other non-tenured staff	0	0	0.7	1.1	2.2	4.1	1.4
Total non-tenured staff	*3.5*	*6.7*	*9.6*	*8.5*	*9.7*	*11.9*	*8.4*

Table 3.3: Staff at programme level (in research fte)

Assessment of the committee on quality of Resources
Recently, DIAM has appointed a number of new young staff members of excellent quality who should be very good candidates for attracting second stream funding, including the '*Vernieuwingsimpuls*'. It is expected that this will contribute to the quality of the institute. With these recent appointments, the viability of the institute is also ensured at several research groups. The committee was informed that recently two staff members have been granted a Veni and Vidi subsidy from NWO. This information was taken into consideration when assessing the viability of the individual programmes.

The internal organisation and interaction between the groups seem to be very good, with joint seminars and one-day conferences. However, for all groups considered at Delft TU, the strategy for the future (e.g. 3TU-AMI) is not as well prepared as it should be, especially when compared to Twente and Eindhoven.

The committee finds that the number of PhD students is at a good level, both compared with other mathematical departments and given the relative complexity of the area. An increase in the number of freshmen students might result in a further increase in PhD students, through both an increased number of candidates and an increased capacity at the professorial supervision level. Attracting financial support takes time, but should be pursued.

3.1.6. Funding Policies
Table 3.4 provides an overview of the funding and expenditure of the faculty. The faculty's funding consists of (i) direct funding, (ii) research funds, and (iii) contract funding. Direct funding allocation is determined by the education and research budgets of the faculty and is based on output in the execution of the curricula and research output according to the university model.

Research funds are received on a competitive basis from national and international research councils (e.g. NWO, STW, and IOP). Contract funding is received from contracts with third parties for specific research activities, from EU framework programmes, etc. Other funds come from third parties without contracts (e.g. consultancy, software development, editorships, etc).

At this moment the financial situation of the EEMCS faculty is healthy, but the direct funding part is quite high, and the research funds and contracts are low. This can be a vulnerability for DIAM. Extra funds were received to support research over the past few years. In addition, the university's new allocation model implemented in 2004 has tended to be favourable to the faculty. A current major source of funding is BSIK, which was terminated in 2008, making the immediate future uncertain. All research groups are aware of this uncertainty and have put efforts into acquiring future funding.

	2003		2004		2005		2006		2007		2008	
	k€	%	k€	%	k€	%	k€	%	k€	%	k€	%
Funding												
Direct funding	5.531	83%	5.933	83%	6.871	83%	6.388	83%	7.199	83%	7.596	83%
Research funds	278	5%	371	5%	442	5%	627	5%	443	5%	412	5%
Contracts	418	8%	557	8%	479	8%	218	8%	568	8%	496	8%
Other	284	4%	286	4%	339	4%	499	4%	539	4%	626	4%
	6.511	100%	7.147	100%	8.131	100%	7.732	100%	8.749	100%	9.130	100%
Expenditure												
Personnel costs	6.002	92%	5.236	92%	5.993	92%	5.929	92%	5.859	92%	6.739	92%
Other costs	548	8%	1.418	8%	1.941	8%	1.587	8%	1.868	8%	2.245	8%
Total expenditures	6.550	100%	6.654	100%	7.934	100%	7.516	100%	7.727	100%	8.984	100%

Table 3.4: Funding and expenditure of DIAM

Assessment of the committee on quality of Funding Policies and Facilities
The research at this institute is in very good shape. The committee is impressed by the current amount of funding and the relatively small programmes, making the department quite visible internationally.

On the other hand, the faculty and university management should be realistic and should realize that with this amount of funding, the department will not be able to join the international top 10.

3.1.7. Academic Reputation
The faculty provided a list of memberships, editorships (guest or permanent), invited lectureships, appointed professorships, co-organisation of conferences, visiting professorships and other academic achievements of the programme members.

3.1.8. Societal Relevance
Analysis: By further developing mathematical theory and techniques, the programme contributes significantly to the international scientific community. This development is often directly or indirectly inspired by problems of a physical or technical nature. Theoretical support is provided for the other research programmes within DIAM. The programme furthermore plays an important role in the education of future engineers and actively participates in outreach activities. At present there are no contacts with industry. Considering the fundamental nature of the programme, it is not expected that this will change in the near future.

Computational Science and Engineering: The programme provided a list with socially relevant activities, e.g. the operational system for storm surge forecasting that makes use of the data assimilation scheme in the research programme, an inverse modelling system that is currently used by RIVM and TNO, numerical methods to simulate gas flows in high pressure networks that are used by Gasunie, and many others. This programme has many contacts with industry, mainly on joint PhD and MSc-projects.

Risk, Probability and Statistics: Similar to CSE, this programme provided a list with socially relevant activities, e.g. delay propagations in railway networks, exotic option pricing, and risk models for oil spills, corrosion of gas pipelines, air transport. The programme has many contacts with industry.

Assessment of the committee on Academic and Societal Relevance
Concerning academic relevance the committee is of opinion that the department has a solid academic reputation. Since the assessment concerned applied mathematics, the committee focussed mainly on societal relevance of the institutes and programmes. The quality of the research is good to very good, and in some individual cases excellent, while the relevance is mostly excellent. The cooperation of the institute with other departments on the TU Delft campus and with industry is also quite impressive. The productivity is good to very good, again with individual exceptions. The committee supports the institute's policy to go for quality over quantity of publications.

The balance between innovative research and consultancy for other departments is good, but requires constant monitoring, since applied research also needs a fundamental basis. DIAM invests a high amount of research capacity in industrial contacts. This is appreciated by the committee, for both academic and societal relevance the contacts with industry are considered important. The committee wants to stimulate DIAM to assure that in the future the amount of funding from industrial contacts (currently about 0.5 million euros annually) will be proportional to the capacity invested.

3.1.9. Balance of Strengths & Weaknesses
In the self-evaluation report, the following SWOT self-analysis was provided of which a summary is given in this report:

Strengths
- The presence of many researchers/groups with good international reputations;
- A broad research spectrum ranging from application-driven research to top-level fundamental research, with staff active in cutting-edge applications, creating a flexible research potential able to anticipate future research needs and directions;
- Outward looking, in particular with a view to intensive international cooperation and interdisciplinary projects;
- Successful internationalisation of the graduate programme, reflected in increasing numbers of international students in the MSc programme;
- Good cooperation with Leiden University;
- An important and exclusive role in on-campus education services.

Weaknesses
- Low student intake in both the BSc and MSc programmes;
- Understaffing, in particular due to the provision of education services, which may reduce available research time;
- Limited visibility in national research clusters in mathematics.

Opportunities

- The healthy financial state of DIAM allows for the appointment of new staff, which will result in a more balanced age structure and strengthening of small research groups;
- Possibility of filling the positions of full professors and recruiting young academic staff, both of which will sharpen the research focus of DIAM and provide new stimulus;
- Delft Research Initiatives as a basis for externally funded programmes;
- The planned 3TU Applied Mathematics Institute offers opportunities for increasing visibility and strengthening the research and educational programmes.

Threats

- Strong pressure from TU Delft to carry out applied research and to obtain external funding for almost all of the PhD projects puts pressure on more fundamental mathematical research;
- A research financing policy that focuses too much on quantity and too little on content and quality;
- Little recognition of the importance of engineering by Dutch society, together with the low visibility and low popularity of applied mathematics amongst young people, results in a low intake of new students.

Assessment of the committee on Strengths and Weaknesses

The committee would like to provide the following recommendations to the institute:

- The quality of the research at DIAM is good to very good, and some researchers are even excellent, but there is still room for improvement, which should be pursued.
- Increase opportunities and potential for obtaining more funding from national and European agencies (second money stream) by creating conditions that attract such funds, for instance by stimulating, and offering extra time for writing proposals, by attracting top researchers, and by filling vacancies with excellent young researchers who are capable of attracting NWO funding, including the *Vernieuwingsimpuls*, etc. This requires an active attitude and strategic planning.
- The pressure from TU Delft to carry out applied research and to obtain external funding for most of the PhD projects should not be seen as a threat, but as an opportunity by choosing the right topics that are relevant in society and intellectually challenging for mathematics, and match well with the competences and the long term plans
- Continue the constant monitoring of a healthy balance between innovative research and consultancy for other departments, to ensure research renewal and innovation of the mathematical instrumentarium in the long term.
- Increase the participation of DIAM in the mathematical clusters so as to increase the level and capacity of research and the cooperation and interaction nationwide.
- The structure and organisation of the department into three programmes after the reorganization and merging of groups are good, and the committee recommends keeping the present structure and allowing room for consolidation.
- Make the assignment of research capacity less dependent on the quantity of the research output and more on the quality.
- The committee supports the dean's point of view that 3TU-AMI should improve the research quality and capacity at DIAM.
- The scientific cooperation within the 3TU framework must not harm the cooperation and interaction with the other, non-technical universities, which might feed the research with more fundamental components. Do not cooperate within 3TU-AMI just for the sake of 3TU.

3.2. Assessment per programme – TU Delft

The committee assessed the following programmes of the Delft Institute of Applied Mathematics at TU Delft:

	Quality	Productivity	Relevance	Viability
Programmes				
Analysis	5	3	4	4
Computational Science and Engineering	3	5	5	5
Probability, Risk and Statistics	4	4	5	4

The detailed assessment per section follows in the next section of this report.

3.2.1. Analysis

Programme number: TUD1
Programme director: Prof. B. de Pagter
Research staff 2008: 7.38 fte
Assessments:

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

Short description
The aim of the Analysis research programme is to contribute to the development of fundamental tools, techniques and methods in the areas of analysis, functional analysis and operator theory, with applications to deterministic and stochastic (partial) differential equations and other infinite dimensional systems. Within the research programme of DIAM, the role of the Analysis programme is to provide theoretical support to the other research programmes which are directed more towards applications.

In the period 2003-2008 the following research themes were distinguished, which partly overlap in terms of interests and researchers involved.

- Operator theory and functional analysis
- Stochastic evolution equations
- Elliptic differential equations
- Quantum groups
- Special functions (classical analysis)

Changes in staff and the merging of the chairs in Functional Analysis and Classical Analysis have resulted in an adjustment of the research themes. The future research themes of the Analysis group will be:

- Operator theory
- Stochastic differential equations
- Functional analysis and PDEs
- Representation theory and special functions

For the TU Delft Analysis group, the present assessment period has been one of transition with a considerable change in staff and programme. Of the ten people constituting the tenured research staff in 2003, only five were still present in 2008. The two chair holders from the previous period retired, and mainly for financial reasons, the two chairs have been merged into one. Three associate professors left the group for a full professorship at other universities. The total fte of tenured research staff went down by approximately 15% from 2003 to 2008. On the other hand, a new experienced programme leader has been appointed, and one of the associate professors, who received a VIDI fellowship in 2002 and a VICI fellowship in 2007, has been appointed to a personal chair. Furthermore, three very active and promising young mathematicians entered the group as tenure track assistant professors. Recently, a young researcher in the group received a Veni grant and one of the analysis PhD students received a Rubicon fellowship.

Quality
The two research leaders of the Analysis programme are internationally highly respected and their work is very well-cited. The research is fundamental in nature and is internationally in the forefront of the areas involved. The Analysis group is considered an international player. The group scores very well in the 'Vernieuwingsimpuls' and in other programmes of NWO, Veni, Vidi and Vici awards have been received. They seem to be too modest in promoting themselves, reflected by the fact that they incidentely chose a lesser quality journal to publish first-class results.

Productivity
The number of PhD theses for the Analysis group is a point of concern. Although higher than the comparable number from the previous assessment period, it is still not adequate. A tighter cooperation within DIAM (and, more generally, on the broader 3TU level) on joint research projects (e.g. on nonlinear PDEs for fluid dynamics, biomathematics and financial applications) could very likely improve the situation in this respect. The number of journal publications is adequate, the number is not uncommon given the academic focus of the group. There are very few publications in conference proceedings, which is also not uncommon in this area of research.

Relevance
The academic relevance is high: they do fundamental rather than applied research. The research themes fit well with the educational role of the Analysis programme within the department, and the Analysis group plays an important role in the mathematical education of engineers in the various departments of TU Delft. The mission of the Analysis programme is also to provide the indispensible theoretical support to other research programmes in DIAM. However, the latter aspect is not yet fully developed. The group could be more pro-active in this matter. In fact, on the research level the outreach activities are limited to the International Internet Seminar. There is a potential for applications outside mathematics.

Viability
DIAM hired new promising researchers, and this has led to sufficient rejuvenation in research. As indicated earlier, several young persons have left the group over the past years for full professorships elsewhere. This indicates a loss of viability. On the other hand, the group managed to attract new staff. One of these new staff members has recently obtained a Veni award, but the full effect of the new staff members on the viability of the programmes has yet to be proven. The heavy teaching load is a threat in this respect.

Conclusion
The research programme of the group deals with modern problems in operator theory, functional analysis and PDEs, stochastic differential equations, and the relation between these topics. The aim is to develop fundamental tools, techniques and methods in the mentioned areas. The coherence between the various research themes of the group is strong. A new and ambitious theme is to unravel further the role of operator theory in the theory of dynamical systems and its applications to combinatorial number theory. Although it is part of the mission statement, the group has no substantial outreach research activity within DIAM or TU Delft in general.

The group benefits from the co-operation of TU Delft with Leiden University through its interaction with the analysis group at that university. On the research level the 3TU's co-operation seems less relevant for the Analysis group. However, in the Master programme and in the education of PhD students, the 3TU's concept is clearly visible. The active participation in the International Internet Seminars, which is research related, is a new and promising development in the international co-operation of the group.

3.2.2. Computational Science and Engineering

Programme number:	TUD2	
Programme director:	Prof. A.W. Heemink	
Research staff 2008:	34.39 fte	
Assessments:	Quality:	3
	Productivity:	5
	Relevance:	5
	Viability:	5

Short description
The Computational Science and Engineering programme covers the mathematical modelling, numerical analysis and optimization of complex technical and physical systems. The programme aims at advancing the state of the art of the key mathematical research themes involved: modelling using partial differential equations, numerical analysis and optimization, including the interfaces between these themes. The research is driven by technical applications and societal/industrial needs, and by opportunities for innovation opened up by advances in mathematics and computing technology.

The programme consists of three sub-programmes:

1. Mathematical Physics
2. Numerical Analysis
3. Optimization and Mathematical Systems Theory

Although the sub-programmes focus on their central research themes Modelling, Numerical Algorithms and Optimization, interdisciplinary research is carried out at the meeting point of the research themes. In its academic practice, the programme concentrates more and more upon technical applications of mathematics in cooperation with technical research institutes. It is the ambition of the programme to publish in high-level interdisciplinary journals.

In the programme, attention is concentrated on a limited number of research topics that are of great scientific importance and fit within the central themes of the programme:

- Asymptotic methods and applications in vibrating systems (sub-programme 1)
- High performance computing and parallel algorithms (sub-programmes 1, 2)
- Computational aspects of stochastic differential equations (sub-programme 1)
- Fast solvers (sub-programme 2)
- Moving boundary problems (sub-programme 2)
- Computational finance (sub-programme 2)
- Filtering, identification and control of large-scale systems (sub-programmes 1, 3)
- Non-standard methods for discrete optimization problems (sub-programme 3)
- Modelling and control of nonlinear networks and systems (sub-programme 3)
- Extensions of methods from finite dimensional linear system theory (sub-programme 3)

Quality
The quality of research is good at a national level. The programme is visible and has a good reputation. Research topics are very useful but not revolutionary. Due to excellent industrial contacts, the CSE programme has a very large number of PhD students: in fact, the highest fraction of research fte filled by PhD students among all of the programmes under review. The programme contributes substantially to the solutions of many engineering problems, occasionally producing new mathematical insight as well. Plans do exist to reduce the number of PhD positions. Focus on a more coherent research programme might help to improve the quality as well (concentration instead of spreading thin). Recent appointments, especialliy in the optimization group, show very good potential for increase of quality and for attracting second money stream funding like the 'Vernieuwingsimpuls'.

Productivity
As already mentioned, the number of PhD theses is excellent. Programme members publish actively in journals and conference proceedings.

Relevance
The research carried out by the programme is highly relevant, which is confirmed by a large number of industrial contracts. Dissemination of knowledge is excellent. The programme aims to extend collaboration with other TU Delft research groups as well. Relevance in a more academic sense is also present, but less pronounced.

Viability
With the appointment of new professors and eight new assistant professors, the future of this programme is quite promising. The programme management clearly recognizes the need to focus on research activities. Moreover, a balance should be established between short-term projects and long-term research. The committee believes that this could be achieved in the forthcoming period.

Conclusion
The scope of current research activities is too wide. More attention should be paid to the development of a coherent research plan and the integration of newly appointed staff. The first steps in this direction are already visible. The committee supports the drive of the programme management to raise the profile of more fundamental long-term research. The programme was rejuvenated in the past period and, in the opinion of the committee, has a good potential to be successful over the next period.

3.2.3. Probability, Risk and Statistics

Programme number:	TUD3	
Programme director:	Prof. F.M. Dekking	
Research staff 2008:	16.45 fte	
Assessments:	Quality:	4
	Productivity:	4
	Relevance:	5
	Viability:	4

Short description
The Probability, Risk and Statistics programme covers large parts of the fields of probability theory, risk analysis and statistics. There are excursions into ergodic theory, dynamical systems and decision theory. The mission of the group is fourfold:

- to develop knowledge in probability, risk and statistics;
- to enhance the application of mathematical methods in probability, risk and statistics;
- to partner with industry and governments in performing innovative applications;
- to develop original and innovative educational programmes to train the next generation of researchers, modellers and engineers in the area of probability, risk and statistics.

The programme consists of three sub-programmes that have the unifying theme 'uncertainty'.

1. Probability

In this sub-programme, several topics have been investigated in the last six years: ergodic theory and dynamical systems, fractals, mathematical finance and models of spatial stochastic processes. Fundamental studies have been carried out as well as the analysis of stochastic models from various applications like the Internet graph or options in mathematical finance. Given the size of the group, the set of topics considered may be seen as quite large. Nevertheless, the quality of the production for the past evaluation period is quite high. It should be noted that the activity on spatial stochastic processes has already been reduced after the departure of one of the members.

2. Risk Analysis

This group is focused on data analysis and reliability/risk problems. Computer software has been produced as a result of the methods developed by this team. The publication output of the group in engineering journals is very good with quite a large number of applications. The computer software activities are developed through a start-up; this is a concrete and interesting output of the research. It is not clear if the strategy in this domain is to produce a tool box with packages or a set of separate software as seems to be the case now.

3. Statistics

This sub-programme has considered problems of non-parametric estimation, evaluation of errors of estimators which are classical problems in statistics, but also volatility models for risk analysis of some portfolios. Two recent arrivals replaced a retiring professor and a departure. For the future, there is some emphasis on applied statistics (like biological models apparently). There is cooperation at many levels, from coffee break discussions to joint publications, joint contract research projects, and the joint Master specialisation in PRS (Probability, Risk and

Statistics). The three sub-programmes strongly support each other, and it is intended to maintain this useful cross-fertilisation in the future.

Quality
Overall the quality is very good, several members of the scientific staff publish regularly in top mathematical journals (probability and statistics in particular) as well as in good journals for specific application domains. The committee noticed some examples of excellent quality, but the quality of the group as a whole could be improved further.

Productivity
This is a small group with a very good production output. In particular, several reference books have been written during the evaluation period. The number of PhD students could be higher. The flow of production is somewhat irregular.

Relevance
The relevance is very high, the members of the group have an open attitude towards applications and are actively looking for collaboration projects. The group selected an attractive focus of research with many opportunities for application and collaboration.

Viability
The overall viability is high. The quality of the research may nevertheless have suffered from several departures in the past period. The hiring of young, talented scientists would bolster this aspect. The committee is nevertheless confident that the programme management is paying sufficient attention to the future of the programme.

Conclusion
The entire programme exhibits a good balance between fundamental and applied research. Applications of the research of this programme are numerous, as revealed in the vitality of the respective domains. The three sub-programmes have a substantial interaction which gives a clear coherence to the programme. As an example, risk analysis for mathematical finance could be a common research topic of these groups; some aspects of it are already being investigated.

4. Division of Mathematics, TU Eindhoven

4.1. Assessment at the institutional level – TU Eindhoven

4.1.1. Introduction

The Department of Mathematics and Computer Science consists of two divisions, viz., the Division of Mathematics and the Division of Computer Science. The Division of Mathematics is organized into seven expertise areas (also called research groups), the MFI school (Mathematics for Industry), and the LIME laboratory (Laboratory for Industrial Mathematics Eindhoven). The seven expertise areas are organized into three research programmes: CASA (Centre for Analysis, Scientific Computing, and Applications), DMA (Discrete Mathematics and Applications), and SPOR (Statistics, Probability, and Operations Research). The department is organized according to the MUB, a system of university administration in which integral management and control are in the hands of the Department Board.

4.1.2. Leadership

During the review period, the board consisted of a dean and a vice-dean, alternately a mathematician and a computer scientist, and the managerial director, who is the head of the department administration. Since April 1, 2009, the heads of the two divisions of the department are both vice-deans on the board. The dean has the decisive vote. The Department Board decides on the research strategy of the divisions and is involved in all staff appointments.

The Division of Mathematics has its own board (with three members) that is in charge of the day-to-day running of the division. The Division Board is in charge of allocating the research and education tasks of the division among the individual staff members. This assignment is made in consultation with the relevant curriculum director.

Important decisions made by the Department Board and/or the Division Board always include a consultation of the council of leaders of the seven research groups in the division. Management decisions are communicated extensively. The Division Board of Mathematics meets monthly with the Council of Group Leaders; the group leaders have informal meetings with their group members to report on these meetings and discuss current affairs.

Motivation of the staff is achieved in several ways. Scientists are intrinsically motivated, mainly from the kind of work they do. The management has a number of means of additional motivation, like bonus awards, pay rises, and promotions to individuals. Incentives also exist on the level of research groups. For tenured staff, career planning is individual, tenured staff members can become associate professors on their own merit. Distribution of research and training tasks is adapted to individual capabilities, with a growing differentiation of available research time.

4.1.3. Mission & Goals

The mathematical research at TU/e is inspired by questions of societal and technological relevance, and it is driven by curiosity. The nature of the studies ranges from fundamental research to applied research, guiding and validating theoretical investigations.

4.1.4. Strategy & Policy

The strategy plan of January 2006 states that the mathematics of the division has an algorithmic profile, with specific expertise in discrete mathematics, stochastics, and computational

engineering. The long-term strategy is to strengthen the expertise in these fields, and to address new and challenging problem areas in which the knowledge and experience can be utilized.

The seven research groups of the Mathematics Division cover the basic principles that are needed for three fields, which correspond to the three programmes:

- Applied Analysis and Scientific Computing (CASA)
- Statistics, Probability and Operations Research (SPOR)
- Discrete Mathematics and Applications (DMA)

The short-term strategy of the Mathematics Division concerns the choice of themes both within mathematics and within society. The strategy is often reflected in collaborations at the departmental level (institutes), the national mathematical research level, and the university or 3TU level.

In terms of societal problem areas, the foci are:

- information and communication technology (ICT)
- biological and biomedical applications (BIO)
- materials (MAT)

In each of these areas, the Mathematics Division matches existing expertise, practical appeal, and concrete possibilities of cooperation with other departments.

In the future, the division's main research directions will continue to be discrete mathematics, stochastics, and computational engineering.

Assessment of the committee on Leadership, Mission & Goals and Strategy & Policy
The mission and goals are thoroughly adequate for a mathematics department at a technical university. The committee is particularly impressed with the hiring policies as well as with policies aimed at stimulating research and personnel development. The division of mathematics has been successful in attracting talented young researchers. The policy to reward researchers based not only on awarded grants, but on nearly awarded grants as well, is commendable. The department has created an ambiance that stimulates research at a high international level and cooperation, both scientifically (worldwide), and industrial and societal.

4.1.5. Resources

To attract and keep high-level staff members, the personnel strategy is focussed on individual career tracks. Professors and associate professors are appointed by the executive board of the university on the recommendation of the department board. Assistant professors and other staff are appointed by the department board on the recommendation of a hiring committee that always includes the relevant group leader, the curriculum director and the personnel manager. All hired staff members have to be both strong researchers and very good lecturers (or have the potential to become one). The department has an active policy of appointing a part-time professor in each group, who provides a structured link with industrial applications and research institutes. Table 4.1 provides an overview of the staff at the division level, while table 4.2 provides an overview of the staff for the three research programmes of the division.

Every PhD student participates in one research school and follows the educational programme of this research school. PhD students are furthermore offered general courses, e.g. technical writing and presentation courses. Also, specific individual training is provided locally, through participation in seminars run by the research groups, meetings with the daily supervisor, etc. PhD students are encouraged to present their findings at international conferences, and to publish their results in peer-reviewed journals. In the first year a personal training and supervision plan is developed as well as a research plan. At the end of the first year a formal evaluation assesses the progress and development of the PhD student, after which a go-no-go decision is made.

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**Average**
Full professors	2.8	3.4	4.2	4.0	5.0	5.3	4.1
Associate professors	3.2	3.9	3.0	2.9	2.8	2.3	3.0
Assistant professors	10.0	9.6	9.5	8.1	7.2	7.7	8.7
Total tenured staff	*15.6*	*16.5*	*16.7*	*15.1*	*14.6*	*15.2*	*15.8*
PhD students	22.6	26.3	27.6	28.2	29.5	35.5	28.3
Other non-tenured staff	7.9	6.7	11.7	10.5	12.4	14.3	10.6
Total non-tenured staff	*30.5*	*33.0*	*39.3*	*38.7*	*41.9*	*49.8*	*38.9*
Total research staff	**46.1**	**49.5**	**56.0**	**53.8**	**56.5**	**54.5**	**54.7**

Table 4.1: Research staff at the division level

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**Average**
CASA	**24.4**	**24.3**	**24.7**	**23.0**	**21.7**	**23.7**	**23.6**
Total tenured staff	5.1	5.3	5.7	5.1	4.9	5.6	5.3
PhD students	12.8	14.5	13.1	12.2	12.0	13.5	13.0
Other non-tenured staff	6.0	4.1	5.9	5.7	5.0	5.2	5.3
SPOR	**10.0**	**13.0**	**16.4**	**16.8**	**19.8**	**21.9**	**16.3**
Total tenured staff	6.1	6.8	6.6	5.5	5.0	5.1	5.9
PhD students	3.3	4.8	7.5	8.2	9.0	10.4	7.2
Other non-tenured staff	0.6	1.4	2.3	3.0	5.8	6.4	3.3
DMA	**12.3**	**12.6**	**15.0**	**14.0**	**15.0**	**18.8**	**14.6**
Total tenured staff	4.4	4.4	4.4	4.4	4.7	4.5	4.5
PhD students	6.6	7.0	7.0	7.9	8.6	11.6	8.1
Other non-tenured staff	1.3	1.2	3.6	1.7	1.7	2.7	2.0

Table 4.2: Research staff at the research programme level

4.1.6. Funding Policies

Table 4.3 provides an overview of the funding and expenditure of the department. Both funding and expenditure include education as well as research.

	2003		2004		2005		2006		2007		2008	
	k€	%	k€	%	k€	%	k€	%	k€	%	k€	%
Funding												
Direct funding	5,612	78%	5,210	73%	5,637	71%	4,965	66%	6,265	68%	5,329	53%
Research funds	566	8%	610	9%	853	11%	1,162	15%	1,192	13%	1,495	15%
Contracts	1,038	14%	1,340	19%	1,398	18%	1,446	19%	1,777	19%	3,315	33%
Total funding	**7,216**	**100%**	**7,160**	**100%**	**7,888**	**100%**	**7,573**	**100%**	**9,234**	**100%**	**10,139**	**100%**
Expenditure												
Personnel costs	6,191	91%	6,276	91%	6,644	91%	6,944	92%	8,297	90%	9,745	89%
Other costs	577	9%	620	9%	648	9%	598	8%	955	10%	1,172	11%
Total expenditure	**6,768**	**100%**	**6,896**	**100%**	**7,292**	**100%**	**7,542**	**100%**	**9,252**	**100%**	**10,917**	**100%**

Table 4.3: Department's funding and expenditure at the institutional level.

4.1.7. Facilities

In the previous assessment (2003) the TU/e main building was described as 'less than ideal' with regards to the working conditions. The executive board of TU/e has decided to build a new building next to the main building, and the division hopes to move in by January 2012. At that time the library will be integrated in the central library, which will be housed on the lower floors of the same new building.

Assessment of the committee on quality of Resources, Funding Policies and Facilities

The human resources seem adequate for the stated mission and goals. On the other hand, the financial situation of the division deserves attention. The overall budget deficit in recent years, and in particular losses incurred by the division annually from service teaching, are quite worrisome.

The teaching load at the department is rather high, certainly compared with the other two TU's. It may harm the high level of research and the attractivity of the department for young brilliant researchers.

4.1.8. Academic Reputation

For each research programme a list was provided with the academic achievements of the programme members, for example, editorships, memberships (committees, etc.), awards, organisation of conferences, visiting professorships and other academic achievements.

4.1.9. Societal Relevance

CASA: The research of this programme has a unique feature in that it actively tries to solicit problems from industry that it can bring to a satisfactory solution. A dedicated consultancy group was set up, specifically aimed at acquiring projects, and carrying out development and implementation aspects of these projects. This feature helped CASA to become an attractive partner for industry. This led to founding a similar department-wide initiative, called LIME, in 2007. The problems from industry range from metallurgy, via circuit analysis, chip design and manufacturing, to cooling machinery and printing equipment. The benefit is clearly twofold: the problems have led to useful ideas and implementations for industry, but also to relevant and timely research subjects. Moreover, LIME has made special efforts for the branding of applied mathematics in industry and among the pupils and secondary school mathematics teachers with an attractive booklet, that elucidates the important, but mostly hidden role that mathematics play in our modern society.

SPOR: Most of the research is of a theoretical nature, but it is frequently inspired by real-life problems, often originating in computer-communications and in production and logistics. The research activities of SPOR are strongly intertwined with its teaching activities and industrial contacts. The SPOR section has established contacts with several TU/e departments. Collaborations have led to joint publications in e.g. statistical procedures for software release and the stochastic modelling and analysis of digital-to-analogue converters. These projects advance the understanding of the application by resolving the probabilistic part of the problem.

DMA: The research of this programme has attracted the attention of national and international media on several occasions, e.g. the McEliece cryptosystem, finding collisions for the hash standard MD5, and the EIPSI "RIES" report. The work of the programme on interactive documents is widely recognized as highly innovative. The MathDox software was developed within the group and is used to create the mathematical learning environment WortelTU/e, a platform that is in use at several high schools. Strong contacts with industry have always been a characteristic of the group. Names of industry that are mentioned specifically are Philips and NXP. Several patents were obtained, and many contacts exist with high school mathematics teachers.

Assessment of the committee on Academic Reputation and Societal Relevance
Concerning academic relevance the committee is of opinion that the department has a solid academic reputation. Since the assessment concerned applied mathematics, the committee focussed mainly on societal relevance of the institutes and programmes. The societal relevance is excellent. The division contributes to many important problems. LIME is an excellent example of an outreach activity facilitating knowledge transfer to industry. The department has a very good record in attracting second stream funding, in particular the 'Vernieuwingsimpuls'.

LIME is a newly created venture to provide CASA and the other programmes within the department with an effectively operating institute for extramural operations. This represents an interesting paradigm for establishing a link between scientific tasks and consultancy tasks. CASA looks for real-life problems, but its task is not simply to hand out and deliver solutions. The latter is the priority mission of LIME, whose professional agenda is different than (and to some extent complementary to) that of CASA. The functionality of the co-operation between the two institutes is clearly stated and seems to be quite healthy for CASA. It is expected that LIME will help CASA to attract even more projects and enhance the dynamic cooperation between the different mathematical groups (e.g. computer graphics and stochastic groups).

4.1.10. Balance of Strengths & Weaknesses
The institute provided a SWOT analysis which is summarised in this report.

Strengths:
- A substantial rejuvenation in the staff of full professors has been carried through;
- High quality, as reflected in a sizable number of awards and grants;
- Continuing growth in external funding, both from research funds and contracts;
- Broad expertise in industrial mathematics, in areas fitting a technical university;
- The successful role of LIME in knowledge exchange with industry;
- Presence of the research institutes EURANDOM and EIPSI;
- Active participation in the clusters DIAMANT, NDNS+, and STAR;
- Fruitful embedding of mathematics and computer science in one department.

Weaknesses:
- The traditional small scale and individuality of research in mathematics, while research funding is increasingly available only for large consortia;
- Persistently low influx of students in both Bachelor and Master programmes in industrial and applied mathematics.

Opportunities:
- 3TU activities: Collaboration with TUD and UT in the 3TU Applied Mathematics Institute (AMI), and 3TU funding of a few professorship positions;
- Collaboration between the Divisions of Mathematics and Computer Science in the field of security in EIPSI;
- Synergy with LIME and MFI will further strengthen its profile in modelling and technological design.

Threats:
- Lack of external funding of EURANDOM;
- Since an increasing percentage of the total funding is based on project money, the number of scientific staff on temporary contracts has grown. This threatens the consolidation of knowledge within the division. Furthermore, in many cases external funding requires matching from internal funds. These developments threaten to disturb the balance between fundamental and more applied research;
- Demographic developments (minus 15%) point in the direction of a smaller number of potential students in the region;
- High teaching load.

Assessment of the committee on Strengths and Weaknesses
Organisation of research through institutes (EIPSI, EURANDOM, LIME) as well as through the university-wide research initiatives provides maximal visibility and favourable conditions. The personnel policy is clearly working; rejuvenation is successful. The committee shares the concerns about the future of EURANDOM and hopes for rapid resolution. Service teaching is of the utmost importance for the sustainable development of mathematics departments in technical universities. The committee is concerned with the fact that the current financial model employed by the university for remuneration of service teaching does not fully cover the division's costs. Combined with the current budget deficit, this problem has to be addressed quickly in order to prevent damage to the institute's research programme.

All programmes have a heavy teaching load, higher than the other departments, which has strong effects because of the beforementioned financial model for teaching.

4.2. Assessment per programme – TU Eindhoven

The committee assessed the following programmes of the Division of Mathematics at TU Eindhoven.

	Quality	Productivity	Relevance	Viability
Research programmes				
Applied Analysis and Scientific Computing (CASA)	5	4	5	5
Statistics, Probability and Operations Research (SPOR)	5	5	5	5
Discrete Mathematics and Applications (DMA)	5	4	5	5

The detailed assessment per programme follows in the next section of this report.

4.2.1. Applied Analysis and Scientific Computing (CASA)

Programme number:	TUE1	
Programme director:	Prof. R.M.M. Mattheij (coordinator; SC) and Prof. M.A. Peletier (AA)	
Research staff 2008:	24.3 fte	
Assessments:	Quality:	5
	Productivity:	4
	Relevance:	5
	Viability:	5

Short description
The chairs of the research groups for Scientific Computing (SC) and Applied Analysis (AA) have joined their activities in the Centre for Analysis, Scientific computing and Applications (CASA). The major research objective of CASA is to develop new mathematical methods (both analytical and numerical) and improve existing ones for the study of partial differential equations (PDEs) arising from a wide range of application areas.

The groups represented by the chairs of AA and SC each have their specific interest and expertise. The bundling of the two groups in CASA has enabled many cross-boundary connections at the professor, lecturer, and PhD level, thus combining expertise on related problems. The research of the AA group focuses on the qualitative properties of solutions of PDEs. The research of the SC group can be characterised by three major aspects, viz. modelling of problems arising in an industrial context, development and analysis of numerical methods, and design and implementation of numerical algorithms.

The research of CASA spans a continuum from fundamental to applied and covers a wide range of applications. Major research topics include: viscous flow, oscillating gas flow, pattern formation, singular-limit analysis and homogenisation, porous media, mathematical image analysis, micro and macro fluid-dynamics, multiscale numerics, the LCD method and ordinary differential equations, DAE and systems.

Quality
The CASA group has a high international standard and is international leading in its field. The senior programme leader is highly visible in the European community of applied and industrial mathematics, and CASA is a founding member of ECMI, the European Consortium of Mathematics with Industry. Vidi and Vici awards have been received; some of the assistant professors are very visible, too. The group publishes in a nice spectrum of very good journals.

Productivity
The productivity is healthy, the number of PhD students is relatively high. The volume of publications is slightly above average.

Relevance
CASA has set up a research programme that is very attractive for industrial partners, but also for other research groups in mathematics and several institutes operating intramurally with which scientific cooperation is developing very effectively.

The financial support is relevant and sustained: NWO supports the more fundamental research, STW, EU and the industrial partners underwrite the more application-oriented research projects. Even the more applied funded projects, however, are formulated in a way guaranteeing that fundamental mathematical issues will be addressed in the course of the project realization.

Viability
During the assessment period the group strengthened its expertise in the area of pattern formation and variational methods through the appointment of a new full professor in applied analysis in 2004, the present junior programme leader, and in the area of mathematical image analysis through the appointment of a new full professor in 2007. Both these appointments implied a stronger collaboration with the field of bio-chemistry and life sciences.

The group regards the 3TU enterprise as a great opportunity to realize the appointment of a physics/mathematics professor, develop collaborations in the fluid-and-solid mechanics focus area, tune the selection of Master students, guarantee better qualified Master programmes, and provide a broader education for PhD students, among other aspects.

Conclusion
The mission is to develop, analyse and apply mathematical and numerical methods and techniques suitable for solving real-life problems posed by industrial partners. The bundling of the activities of the chairs for Scientific Computing and Applied Analysis in CASA has worked out very well. The team has the capability of selecting challenging problems, devising mathematical and numerical models for their analysis and approximation, writing the relevant software, and delivering benchmark or complete results. In this respect, CASA represents a rare example of integration at the European level between applied analysis, numerical analysis and scientific computing. Its major foci are the analysis and simulation of nonlinear problems in fluid dynamics (for non-Newtonian flows, microfluids, oscillating gas, flow and transport in porous media), singular limit analysis, homogenization and pattern formation, analysis of electric circuits; algorithm developments and analysis for multiscale problems by local defect correction, reduced order models, and preconditioning; mathematical image analysis with applications in advanced MRI techniques.

4.2.2. Statistics, Probability and Operations Research (SPOR)

Programme number:	TUE2	
Programme director:	Prof. O.J. Boxma (coordinator; SOR); Prof. G.J. Woeginger (CO); Prof. R.W. van der Hofstad (P&S)	
Research staff 2008:	21.9 fte	
Assessments:	Quality:	5
	Productivity:	5
	Relevance:	5
	Viability:	5

Short description
The mission of SPOR is to develop mathematical models and methods in the areas of probability, statistics, stochastic operations research, and discrete optimization. The SPOR programme aims at performing top-level research in random spatial structures, Bayesian non-parametric statistics and image analysis, queuing theory and performance analysis, matroid theory, logistics and planning. While the research is stimulated by applications, the results are of a fundamental as well as of an applied nature.

The SPOR programme consists of three research groups:

1. Combinatorial Optimization (CO)
   This sub-programme is devoted to the problem of discrete optimization problems and to the design of algorithms in this domain. It aims at understanding the structure and the behaviour of these problems, at developing efficient algorithmic approaches for them, and at applying these insights to practical settings.
2. Probability and Statistics (P&S)
   The general theme is the analysis of spatial random structures occurring in various domains like statistical physics or random networks (associated with the Internet, for example) and the application of statistics (to image analysis, for example). In random spatial structures, the focus has been on random networks, spin systems and self-interacting random processes. In statistics, the main focus has been on applications to industrial statistics, and image analysis and signal extraction.
3. Stochastic Operations Research (SOR)
   This topic investigates stochastic models of various types of networks: production networks and communication networks, for example. There is a strong interaction between applications to computer and communication systems and fundamental results of queueing theory.

Quality
The three research teams within this programme are prominent at the highest international level for their respective research domains. The quality of their publications is impressive: fundamental research is being published regularly in top mathematical journals, and concrete aspects of the research (design/estimation/analysis of algorithms/protocols, for example) are published in more specific journals and at the best conferences. The international recognition is assessed by prizes received by several staff members and by the various international conferences organized. It should be noted that the EURANDOM institute plays a key role in the international visibility of these research teams (and also for other research groups in fact). The

group has a very good record in attracting second stream funding, in particular the 'Vernieuwingsimpuls'.

Productivity
The programme definitely has a very high productivity for publications in both journals and conferences. The number of PhD students, which was somewhat low at one point, has now reached an adequate level. The momentum gained over the last few years is impressive.

Relevance
The research groups in this programme have a significant impact in the application domains related to their expertise. The list of active industrial contacts is very impressive, in length as well as in scope. These contacts have led to significant external funding, proving that their involvement was very much appreciated and effective.

Viability
In the past few years the programme has been highly successful in hiring top young scientists. This is a major success of the programme. Their future plans look very promising, they intend to develop new domains like transport or biological applications. The future lack of national funding of EURANDOM may be seen as a threat, but the group has a strong vision of the future and is currently very active in helping to realize the national cluster STAR.

Conclusion
The scientific leaders of this programme seem to have a clear view of their role in the scientific community from the point of view of fundamental research as well as of the applications that motivate a significant part of their work. Their long-term plans are clearly defined and definitely sound.

4.2.3. Discrete Mathematics and Applications (DMA)

Programme number:	TUE3	
Programme director:	Prof. A.M. Cohen (coordinator; DAG); Prof. H.C.A. van Tilborg (C&C)	
Research staff 2008:	18.8 fte	
Assessments:	Quality:	5
	Productivity:	4
	Relevance:	5
	Viability:	5

Short description
Phenomena throughout mathematics and the natural sciences have discrete algebraic aspects. Describing these aspects involves objects like finite fields, graphs, polynomials, groups, algebras, and symbolic computations. The specific goal of the Discrete Mathematics section at TU/e is to develop the mathematics needed for such a description. This includes:

- Promoting and organizing research in discrete mathematics and its applications by enhancing the collaboration of its participants.
- Organizing and coordinating the education of young researchers in discrete mathematics and its applications (both the pure and the applied parts of the field).
- Providing a natural point of contact for industry when they seek assistance in problems of a discrete mathematical nature.

The research programme is composed of two research sub-programmes:

1. Coding Theory and Cryptology (C&C)
   The group has significantly changed its direction over the last ten years. Coding theory was formerly the main topic, but this has been taken over by cryptology. In the new composition of the group, each member has his/her own distinctive research area, but group members often collaborate to complement one another.

2. Discrete Algebra and Geometry (DAG)
   Several themes have dominated the research in this group throughout the years. Geometries and groups of Lie type, the finite analogs of Lie groups, were the central objects of inspiration. Besides the study of these 'crystalline objects' and related external combinatorics, algorithms in algebra and interactive mathematical documents have been a focus. Two relatively new topics are tropical geometry and algebraic statistics.

Quality
The scientific directors and several staff members have excellent international reputations and citation records, and have achieved prominence with their publications, editorial responsibilities, conference organization, programme committees, invited lectures, awards, and keynotes. Many of their results are published in the best journals and are presented at the best conferences. It has to be observed that typically in cryptography, conferences tend to be held in higher esteem than journals, have a severer review procedure and are more adapted than journals to the fast and dynamic nature of research in cryptology. This international recognition is confirmed by high citation numbers.

Productivity
The production of publications in journals and conference proceedings is very good, the output in terms of open source software for computer algebra is significant and brings international recognition. However, the PhD output is rather low for an average of 4.5 fte of tenured staff (13 PhDs over six years).

Relevance
This group focuses on fundamental and highly relevant questions. The group stresses the importance of combining basic/fundamental research with applications and technological activities. It also has a high societal relevance with computer algebra, software design, even open source as used in secondary schools, and cryptographic designs like a voting scheme that is used in France.

Viability
In view of its clear future plans and its strong position in the Netherlands and on the international scene, the programme has excellent prospects for the future. Moreover, at the strategic level, cryptography is a hot topic. The hiring of a new professor in order to replace a position to be left vacant by an approaching retirement is very good. The succession of the other retiring leader is not so urgent but is being considered, and fits within the 3TU-AMI initiatives. A positive aspect is that the successor is not expected to follow in the exact same area, instead fundamental research in a different area of discrete mathematics may be chosen. Mathematical excellence is the main criterion. There is also some uncertainty about the second layer with the retirement of three more staff members over the next five years, but a strategy is being actively worked out, and a few recently attracted young staff members are very promising.

Their participation in the national cluster DIAMANT was very effective because it allowed them to invest in tenured staff with 5-year funding. Since this funding will be ending soon, it is planned to shift project/staff funding to 3TU funding under AMI.

Conclusion
TU/e has a long tradition in discrete mathematics and coding theory. This programme builds strongly on this tradition but brings in new and important topics as well, like cryptography in the last 10 years and several relevant applications. There are good mutual, formal and informal interactions between the two groups of the programme. Also, since they are physically housed together with computer science (CS), valuable cooperation with CS on computer algebra and information security has been established. The team has a strong position in the 3TU structure since it provides the main focus on discrete mathematics and applications, and it is also prominently present in the Netherlands mathematics research cluster DIAMANT. It has a strong position internationally, with well-organized, attractive PhD courses in EIDMA taught by internationally recognized experts who are invited to come and teach at TU/e.

The overall programme scores are excellent, and the performance is in line with its excellent past record. Moreover, the future plans and successions of the key players are strong and convincing, but must be carried out and need time to mature.

The number of PhDs per year should be increased for the number of tenured staff. This can be realized by creating new PhD positions in new projects. Although several companies discontinued their activities in cryptography, there are still interesting financing opportunities in this field from industry and government agencies in the Netherlands as well as in the EU.

Since the 3TU funding for AMI is needed for staff but is uncertain at this moment, efforts should be made to provide at least some future funding required for continuing the national collaboration, and for an overlapping succession appointment for the approaching retirement of one leader.

5. Department of Applied Mathematics, University of Twente

5.1. Assessment at the institutional level – University of Twente

5.1.1. Introduction

The Department of Applied Mathematics was established in 1968 as the Faculty of Applied Mathematics at the University of Twente. Since 2002, it has been a department in the Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS). The EEMCS consists of three departments: Applied Mathematics, Electrical Engineering and Computer Science.

The Department of Applied Mathematics is organised into chairs, each covering a distinct part of the broad field of applied mathematics. This research in applied mathematics finds a natural clustering in three research programmes: Applied Analysis and Computational Science, Stochastics and Operations Research, and Deterministic and Stochastic Systems Theory. The applied mathematics research programmes are carried out within the framework of multidisciplinary research institutes, which are institutes at the university level, comprising research groups (or parts of them) from different faculties.

5.1.1. Leadership

The EEMCS faculty is led by the dean, and the three departments are each led by the head of the department. The dean and the heads of departments form the management team (MT) of the faculty, assisted by the managing director and the financial controller.

The departments are divided into chairs. The chair holders are responsible for the research focus, quality of teaching, financial matters and management of human resources in their chair. The formal responsibility to the executive board of the university for research activities carried out under the responsibility of the UT research institutes rests with the scientific directors.

The MT meets once every two weeks. In these meetings all issues regarding personnel, budgets, teaching programmes, investments and organizational topics are discussed. Within the Department of Applied Mathematics a monthly meeting is organised, in which all chair holders, the dean, the director of education, the managing director and the head of the department discuss current affairs affecting the department. Twice a year a general information meeting for all staff of the EEMCS is organised.

At the level of the chair, the chair holder is responsible for the teaching and research carried out. A chair holder reports on this research to the scientific director. The chair holder conducts formal annual personnel assessments and job satisfaction meetings.

5.1.2. Mission & Goals

The mission of the Department of Applied Mathematics is to perform high-level academic research and teaching in mathematics and its applications in a multidisciplinary context, motivated by questions of societal and technological relevance.

The research aims at contributing to multidisciplinary research through mathematical reasoning (abstraction, structuring and generalisation) and mathematical methods, either directly in joint research with non-mathematics colleagues, or indirectly by long-term fundamental mathematics research that is associated with the focus of the UT institutes. For this purpose the department pursues an active role in the multidisciplinary UT research institutes.

Assessment of the committee on Leadership, Mission & Goals
Mathematics has been organized (or rather exploited) differently at UT: all researchers fall under the responsibility of at least one of the multidisciplinary institutes of UT regarding their research. While this certainly helps to make mathematics more visible and involved in the UT community, it may raise questions about coherence, long-term research, and visibility outside UT. The applied mathematics institute, as the umbrella for all mathematical research, seems to be well aware of these issues.

From the interview with staff we got the strong impression that the UT setting provides a dynamic and inspiring research environment. Staff appear to be enthusiastic and motivated by the problems arising in this multidisciplinary environment, of course chosen to match their specific field of mathematical expertise as much as possible. In modern terms: a win-win situation. The mathematicians are in a position to influence and help steer the research programmes and can be even leaders of a multidisciplinary institute (as is the case at the moment).

5.1.3. Strategy & Policy
The Department of Applied Mathematics pursues an active and high-quality research programme in the fields of applied analysis and computational science, stochastics and operations research, and deterministic and stochastic systems theory. These objectives require excellent staff with a strong mathematical background, capable of developing close connections with different fields of application. This human capital is the basis for establishing a successful research programme and an inspiring working atmosphere.

A midterm review was conducted in 2007 together with the universities of technology in Eindhoven and Delft. This review covered the period 2003-2005. One of the consequences of this midterm review was the recent decision to establish the 3TU Applied Mathematics Institute (3TU-AMI), which will combine all research and teaching in applied mathematics at the three technical universities in the Netherlands and will provide substantial funding for nine professorial positions.

During the assessment period, the research strategy and policy of the Department of Applied Mathematics were strongly influenced by the decision of UT in 2002 to organise all research into multidisciplinary research institutes. Based on this decision, active participation of applied mathematics chairs in the programmes of UT research institutes was pursued. This move has strengthened the multidisciplinary research and provided additional research funding.

Presently, the research in applied mathematics contributes to the UT research institutes Centre for Telematics and Information Technology (CTIT), the Institute of Mechanics, Processes and Control-Twente (IMPACT), the MESA+ Institute for Nanotechnology, and the Institute for Biomedical Technology (BMTI). Each of these UT research institutes defined a number of strategic research orientations (SROs), which are headed by an SRO officer. The SRO officer is responsible for stimulating the research activities defined in an SRO programme and for initiating activities to obtain funding, by ensuring participation in large national and international research programmes. The institutes also provide the SRO with funds to stimulate new research activities, in particular those enforcing collaboration between different research groups. The SRO programmes are application-oriented and strongly multidisciplinary.

In the future, all three programmes of the Department of Applied Mathematics will share a number of areas of application. One example is health, important aspects of which are present in all three programmes, ranging from improved planning and patient data management, the

design and operation of medical equipment to understanding the fundamental processes in the human body and the treatment of disease.

The department actively anticipates the retirement of several professors in the next few years. The faculty plans to hire new staff for all key positions, to ensure that no gap will occur.

Assessment of the committee on Strategy & Policy
The current UT strategy was implemented only a few years ago, so it may be too early to judge it. However, all signs seem to point in a positive direction, and the involved mathematicians reported being much happier under the new regime. It is up to the management to maintain sufficient coherence in mathematics at UT, as fragmentation of knowledge may be an obvious future threat. It should also be monitored whether the multidisciplinary imbedding puts undesirable restrictions on the hiring of talented young researchers and excellent replacements for the retiring leaders. The department scores not very well in NWO innovation programmes like the 'Vernieuwingsimpuls', and it should increase its focus in attracting researchers that have the potential in obtaining such funds.

5.1.4. Resources

All staff members are employed within the faculty, not in the research institutes. It is faculty policy that all tenured staff contribute to both teaching and research, and this also applies to part-time professors. PhD students and postdocs spend most of their time on research, but some time is dedicated to teaching. The actual tasks of tenured staff are determined by the chair holder. Table 5.1 provides an overview of the staff at the department level. Table 5.2 provides an overview of the staff for the three research programmes within the department.

	2003	2004	2005	2006	2007	2008	Average
Full professors	2.4	2.3	2.4	2.3	2.9	3.4	**2.6**
Associate professors	4.0	3.8	3.9	3.6	3.4	3.3	**3.7**
Assistant professors	6.0	6.1	5.7	5.2	4.6	4.5	**5.3**
Total tenured staff	*12.4*	*12.2*	*11.9*	*11.2*	*10.8*	*11.1*	***11.6***
PhD students	29.8	33.5	33.4	30.1	20.0	18.5	**27.6**
Other non-tenured staff	6.5	6.0	5.8	6.1	6.5	5.0	**6.0**
Total non-tenured staff	*36.4*	*39.5*	*39.2*	*36.2*	*26.5*	*23.5*	***33.6***
Total research staff	**48.7**	**51.7**	**51.2**	**47.4**	**37.3**	**34.6**	**45.1**

Table 5.1: Staff at department level (in research fte)

	2003	2004	2005	2006	2007	2008	Average
Applied Analysis and Computational Science (AACS)							**18.3**
Total tenured staff	3.0	3.3	3.6	3.3	3.3	3.2	3.3
PhD students	12.7	14.2	13.9	11.9	8.0	8.4	11.5
Other non-tenured staff	3.3	3.3	3.0	5.0	3.8	2.4	3.5
Deterministic and Stochastic Systems Theory (DSST)							**11.1**
Total tenured staff	2.8	2.7	2.6	2.4	2.4	2.3	2.5
PhD students	9.7	10.8	8.6	6.6	4.3	3.8	7.3
Other non-tenured staff	2.0	0.4	1.7	0.8	1.7	1.4	1.3
Stochastics and Operations Research (STOR)							**15.8**
Total tenured staff	6.7	6.3	5.8	5.5	5.1	5.6	5.8
PhD students	7.4	8.5	10.9	11.7	7.7	6.3	8.7
Other non-tenured staff	1.2	2.3	1.1	0.3	1.0	1.2	1.2

Table 5.2: Staff at programme level (in research fte)

Annual meetings between each staff member and the chair holder provide possibilities for an open discussion on all factors influencing the performance and well-being of the staff member. Parties can agree on steps to enhance the collaboration and performance and to open new fields of interest, whenever appropriate. A second meeting involves an assessment of achieved results; these meetings are part of the steps required to promote a staff member to a higher rank or when serious performance problems occur. Recently, a tenure track programme has been initiated at UT to attract promising young scientists at the assistant professor level.

Part-time professors are appointed if there is a faculty/institutional interest in providing seniority for a specific sub-field for which collaboration with an external partner would be fruitful.

At the start of a four-year PhD project, a clear research plan is prepared, and an educational programme is set up. All PhD students are supervised by a senior staff member and have regular meetings with their promoter and supervisor to discuss progress. At the end of the first year a formal evaluation takes place, in which a go-no-go decision is made. PhD students present their research at international conferences and publish their research in peer-reviewed international journals.

5.1.5. Funding Policies

Chairs are accountable for their finances and are stimulated to obtain external research funding. The participation of groups in research institutes makes them well positioned to obtain research funds in larger research programmes, which is generally not possible for individual chairs. Table 5.3 provides an overview of the department's funding and expenditure.

	2003		2004		2005		2006		2007		2008	
	k€	%	k€	%	k€	%	k€	%	k€	%	k€	%
Funding												
Direct funding	5.765	74%	6.029	78%	6.713	81%	6.603	81%	6.510	82%	7.376	86%
Research fund	1.202	15%	956	12%	927	11%	911	11%	638	8%	608	7%
Contracts	821	11%	779	10%	665	8%	646	8%	839	11%	586	7%
Total funding	7.788	100%	7.764	100%	8.305	100%	8.160	100%	7.987	100%	8.570	100%
Expenditure												
Personnel costs	4.662	62%	5.134	65%	5.313	65%	5.256	66%	4.772	65%	5.729	76%
Other costs	2.901	38%	2.742	35%	2.884	35%	2.730	34%	2.524	35%	1.783	24%
Total	7.563	100%	7.876	100%	8.197	100%	7.986	100%	7.296	100%	7.512	100%

Table 5.3: Funding and expenditure of the department

Assessment of the committee on Resources and Funding

In the past, the mood within the department was rather negative. Money was a big issue, which did not really induce the proper scientific ambiance. Since then the financial system has changed, for instance to long-term agreements on staff funding (not including funding for PhD students). At this moment there are many opportunities for research funding, and the success rate for securing external funding (for hiring of PhD students) is rather good. However, the direct funding part is quite high, and the research funds and contracts are low. This can be a vulnerability. The committee is rather worried about the low score in attracting grants in the 'Vernieuwingsimpuls', the departure in the evaluation period of several excellent researchers because of the UT focus, and the quite aloof attitude of the department and some of its groups towards fundamental mathematics.

5.1.6. Facilities

The Department of Applied Mathematics has no separate lab facilities, and library services are organised at the university level. Funding for personal computers is either obtained from research projects or from funding directly allocated to the chairs.

5.1.7. Academic Reputation

The department provided an overview of memberships, editorships (guest or permanent), invited lectureships, appointed professorships, fellowships, (co)organisation of conferences, visiting professorships and other academic achievements of the programme members.

Assessment of the committee on Academic Reputation

The academic reputation is good to very good, but the department lacks excellent researchers in sufficient critical mass. In breadth the research quality of the group leaders is solid but not outstanding, with on average moderate citation records.

5.1.8. Societal Relevance

AACS: The scientific context is characterised by attention to multidisciplinary research and applications. This stimulates close collaboration with researchers in many different disciplines, in universities, technological research institutes and industry. An example of a direct transfer of knowledge is the close collaboration with the Maritime Research Institute MARIN on the modelling of extreme waves and wave-current interaction on a model basis. The group continues to expand external contacts since they provide challenging research questions, attract additional research funding and stimulate the transfer of knowledge to society.

DSST: Industry requires more automation, higher accuracy and additional flexibility. The research is aimed at obtaining a powerful framework for modelling and control in a wide variety of applications. Examples are aircraft collision avoidance, temperature control of food storage and drinking water purification.

STOR: The group aims to apply mathematical approaches to areas of the utmost societal importance, such as telecommunications, production and logistics, and health care. For the coming period, STOR aims at further regional embedding through close contacts with industrial partners in the Twente region.

Assessment of the committee on Societal Relevance

Concerning academic relevance the committee is of opinion that the department has a solid academic reputation. Since the assessment concerned applied mathematics, the committee focussed mainly on societal relevance of the institutes and programmes. Staff members are hired by the department but actively conduct their research in interdisciplinary institutes. This implies that academic quality and scientific relevance are the most important factors for recruiting. In this sense, Twente institutes have an almost extreme position with respect to relevance: the research staff is almost by definition highly relevant. The societal relevance is high, indeed, which is shown by long lists of joint projects with other disciplines as well as with industry. This might be a threat for academic relevance (their stature in their own field of expertise), but the committee has not seen negative aspects here (except for the departure of some really excellent researchers in the evaluation period). The academic relevance is apparent from their publications in mathematical journals.

5.1.9. Balance of Strengths & Weaknesses

The department provided a SWOT self-analysis of which a summary is given in this report.

Strengths:

- The research of the Department of Applied Mathematics plays a key role in the multi-disciplinary programmes of the UT research institutes, as illustrated, for example, by the intensive collaboration with a large number of chairs in other departments;
- There is a significant second- and third-tier research volume;
- Strong research ties with large technological research institutes, a variety of industries, banks and insurance companies, both nationally and abroad;
- The appointment of three new professors well before the retirement of key professorial staff in the department.

Weaknesses:

- The undergraduate influx is low, implying that the department has to rely on talented students from elsewhere for its graduate programme;
- The presence in national mathematics organisations has been too limited.

Opportunities:

- The new 3TU Applied Mathematics Institute will significantly strengthen the position and visibility of applied mathematics in the Netherlands;
- Programme development within institutes secures critical mass, embedding and greater possibilities for influencing national and international research agendas;.
- The participation of two chairs in the 3TU centres of excellence provides significant additional research funding.

Threats:

- The need to acquire external research funding through projects with a high level of applicability might shift research too far towards short-term issues in lieu of more fundamental research;
- The increased interest of students in multidisciplinary studies deflects talents away from basic disciplines, such as applied mathematics.

Assessment of the committee on Strengths and Weaknesses

A healthy balance between applied interdisciplinary and long-term fundamental research seems to be the main concern. Currently, this seems to be handled in an adequate way, but it is certainly a permanent point of attention for the leaders of the interdisciplinary institutes. It is, therefore, important that mathematicians are in leading positions, too.

5.2. Assessment per programme – University of Twente

The committee assessed the following programmes of the Applied Mathematics Department at the University of Twente.

	Quality	Productivity	Relevance	Viability
Research programmes				
Applied Analysis and Computational Science (AACS)	4	5	5	5
Deterministic and Stochastic Systems Theory (DSST)	4	4	5	4
Stochastics and Operations Research (STOR)	3	4	5	5

The detailed assessment per programme follows in the next section of this report.

5.2.1. Applied Analysis and Computational Science (AACS)

Programme number:	UT1	
Programme director:	Prof. J.J.W. van der Vegt (NACM); Prof. E. van Groesen (AAMP); since May 2009, Prof. S.A. van Gils is director of this sub-programme	
Research staff 2008:	14.3 fte	
Assessments:	Quality:	4
	Productivity:	5
	Relevance:	5
	Viability:	5

Short description
The mission of the Applied Analysis and Computational Science (AACS) programme is the construction of analytical and numerical methods that contribute to the development of mathematics and its application in a multidisciplinary environment. The results of the research are used to devise and analyze computational (multiscale) strategies for the technical, natural and life sciences.

The integration of three areas of expertise is essential to becoming a key partner in multidisciplinary research. The three areas are represented in the three sub-programmes that are integrated into AACS:

- Applied Analysis
- Numerical Analysis
- Computational Science

A binding element in many activities in the AACS programme is the development and analysis of genuine multiscale strategies, in which physical, chemical and biological processes on a wide range of spatial and time scales are consistently integrated, which is crucial for many applications. The main mathematical challenges in multiscale problems that have been addressed are:

- inverse problems and parameter estimation to link models to real-world data;
- asymptotic and reduction techniques to arrive at simpler problems suitable for analysis and numerical simulation;
- fluid mechanics, free-surface flows, electromagnetic wave propagation, direct numerical simulation of turbulent flows, the coupling of models of different types across a physical interface, like the Navier-Stokes equations coupled to lattice Boltzmann models, and the realization of software packages.

Quality
This team addresses complex problems arising from a broad variety of applied fields by sound, rigorous, and detailled analytical and numerical techniques. The size of the group is small compared with the broad ambition of the mathematical problems dealt with. The team is known internationally for their contribution to the theory and application of Galerkin methods (discontinuous), nonlinear biomedical and neuroscience modelling, and nonlinear wave analysis. The research in the group is, on average, of good to very good quality, with low citation records (except for the current group leader).

Productivity
This team is very productive. They systematically publish in excellent journals in the fields of mathematics and engineering, covering a very large spectrum of applications. The number of PhD students is also high; it is a remarkable fact that, since November 2008, 8 new PhD students were enrolled in AACS.

Relevance
AACS members are pursuing a systematic and efficient activity of collaboration within the Applied Mathematics Department with several other UT institutes (like IMPACT, MESA+, and BMTI), as well as several external Dutch academic environments (TU Delft, Nijmegen, and the 3TU consortium at large). While addressing a considerable number of applied projects, the group has selected several subjects to focus on and keeps investigating issues of fundamental mathematical relevance.

Viability
The programme works on very hot topics, and the team leaders are active and have clear views and a broad horizon. The researchers have shown a great deal of flexibility in the past few years: this attitude has allowed the programme to become a valuable and essential scientific partner of several engineering institutes of UT. Their future projects are very ambitious and involve fundamental issues in multiscale physical phenomena and processes.

Conclusion
A very active group, highly productive, strongly embedded in the UT scientific landscape, with a very sound balance between fundamental and applied research. The group has the ambition to cover many diversified and very challenging subjects. The relatively small size of the group will probably require further strengthening of its ties within the 3TU consortium in order to gain mass. The committee has noticed the low score in attracting grants in the 'Vernieuwingsimpuls'.

5.2.2. Deterministic and Stochastic Systems Theory (DSST)

Programme number:	UT2	
Programme director:	Prof. A.J. van der Schaft (2003-2005), Dr. J.W. Polderman (2005-2007), Prof. A.A. Stoorvogel (2007-) for MCST; Prof. A. Bagchi for SST	
Research staff 2008:	7.44 fte	
Assessments:	Quality:	4
	Productivity:	4
	Relevance:	5
	Viability:	4

Short description
The research of the group is focused on systems and control. Mathematical models are studied in order to obtain insight into the properties of a system and its interactions with the environment. In particular, this insight yields controllers which provide prescribed closed-loop behaviour. Stochastic signals play a central role. An important area of application is mathematical finance. The mission of the programme is to be a leader in the field of mathematical systems and control theory and in financial mathematics.

There will be some change in focus in the group in the coming years. This is the result of changes in staff and of new challenges that have arisen because of technological advances. The research programme focuses on two main areas:

Control, Systems and Signals (MCST)
The group addresses the many technological challenges that will be faced in the coming years on the basis of their background in infinite-dimensional systems, hybrid systems, nonlinear systems and signal processing. The group will put more emphasis on controller design in the near future, e.g. in collaboration with their colleagues in numerical analysis.

Financial Mathematics (SST)
In financial mathematics the turmoil of the credit crunch has put the spotlight on modern risk management systems in financial engineering. The group believes that the coming years will lead to an increased, but somewhat different activity in the applications of financial engineering.

Quality
The two sub-programmes have a strong and dynamic leadership, and deal with highly relevant and significant research. Both are visible on the international scene. For the MCST sub-programme, the full deployment of the team has not yet been achieved, but it has the potential to be excellent. Also, the SST sub-programme is very good, but the field of financial mathematics is too vast and scattered for the SST sub-programme to play a dominant role.

Productivity
The number of publications in journals and conference proceedings is very good, often in the best journals and conferences in the field, and brings international recognition. Even though one sub-group experienced exceptional changes in personnel, the overall production of publications in journals and conference proceedings and PhDs is good. A total of 18 PhD over 7 years is rather good for an average of 2.5 fte of tenured staff.

Relevance
The mathematical finance sub-programme SST not only performs theoretical research on stochastic signals but also directly interacts with operators on the financial markets for validation and societal relevance. On the other hand, the MCST group can fully benefit from the embedding in the institutes at the university level. In this way the MCST group can focus more on the mathematics of systems and control, and make novel contributions at that level in wider projects. However, it cannot independently set the agenda for the research items. In this way both programmes operate in a convincing way that combines scientific relevance at the applied mathematics level with societal relevance. Moreover, the societal impact in terms of themes and projects is strong for both sub-programmes.

Viability
After an unstable past, the MCST sub-programme has strong future prospects with a commitment to be the focus for the mathematics of systems and control of the 3TU and a stable appointment of the director. A successor for the director of the SST sub-programme is desired, but action must be taken to find one. A greater critical mass of PhD students is needed, and the recruitment of good PhD students seems to be a problem. Hence, more creative approaches and more committed action are needed.

Conclusion
In line with all other research programmes at UT, this programme is integrated into two interdisciplinary institutes at the university level, namely CTIT (Centre of Telematics and Information Technology) and IMPACT (Institute for Mechanics, Processes and Control), in which researchers are more involved with application and validation rather than with more fundamental research driven by curiosity. This is certainly very valuable for the mathematics of control, systems and signals part that is integrated with control engineering. This programme has been selected in the 3TU framework as the focus for the mathematics of systems and control, and is in line with a long and strong tradition at UT. By the same token, the mathematics of systems and control will be de-emphasized at TUD and TU/e.

The overall programme scores are very good, certainly in view of the low average fte of the tenured staff and the changing leadership for one of the sub-programmes. The programme operates at a high international level, and is well known in the international scientific scene. It has a unique role in the 3TU framework as the focus for the mathematics of systems and control. Extra efforts should be made to recruit good PhD students, and for an overlapping succession appointment for a leader who will be retiring soon.

5.2.3. Stochastics and Operations Research (STOR)

Programme number:	UT3	
Programme director:	Prof. G.J. Woeginger (2003 – April 2004), Prof. H.J. Broersma (April 2004 -August 2004), Dr. J.L. Hurink (September 2004 – October 2007), Prof. M. Uetz (from November 2007) for DMMP; Prof. W. Albers for SP; Prof. W.H.M. Zijm (2003 – May 2005), Prof. R.J. Boucherie (from May 2005) for SOR.	
Research staff 2008:	13.14 fte	
Assessments:	Quality:	3
	Productivity:	4
	Relevance:	5
	Viability:	5

Short description
The research programme STOR covers stochastics and mathematics for operations research, with a clear focus on mathematical methods in the multidisciplinary setting of mathematics and its engineering environment. The aim is the development of mathematical models and methods for the design, control and optimisation of complex systems. Research topics are inspired by socially relevant areas of application, such as communications, production & logistics, health care and risk. The mission of STOR is to realise mathematical education and research of an internationally high standard in the areas of stochastics and mathematics for operations research.

The research programme is organised into three research groups:

- Discrete Mathematics & Mathematical Programming (DMMP)
- Statistics & Probability (SP)
- Stochastic Operations Research (SOR)

The programme covers applied probability, statistics, and discrete and stochastic operations research. A substantial part of the research effort is fundamental in nature. Research topics covered by STOR include:

- Mathematical programming, and algorithmic discrete mathematics
- Game theory (algorithmic)
- Queuing theory
- Large deviations and importance sampling
- Stochastic graphs
- Mathematical statistics

Quality
The quality of the research in this group in its current composition is good, sometimes very good to excellent, but there are also lesser individual exceptions. The research output is published in good journals, but too little in top-rank journals. The international visibility of the research is good but modest, and the research output is not cited very much (again with individual exceptions). This may improve when the young researchers in the group develop further. Some very good and highly visible researchers left during the review period. Currently,

the group has a shortage of staff that may successfully apply for programmes like NWO's *Vernieuwingsimpuls*.

The committee notices that the group is aware of the current situation and is planning to act accordingly. They do have the intention to improve, and also the young researchers should be given the space to develop further.

Another positive sign is that the focus has shifted to probability, and thus towards more fundamental science. Statistics is important but more service-related, and therefore continuation would enforce the one-sided orientation of the UT mathematics department. The committee has some concern whether the group will be able to find an excellent probability professor within the limitations of the UT strategy.

The research in the programme would also be enhanced if it participated somehow in one of the recently formed clusters in mathematics.

Productivity
The group is on the right track after a drop in numbers a few years ago. The number of PhD students was relatively low during the review period (probably due to a lack of suitably qualified staff), but this number has increased recently thanks to external funding.

Relevance
The relevance of the group is excellent, and the papers that they publish are highly relevant. The group has many contacts with industry. The group's choice for applied mathematics has both benefits and risks, however. By restricting the field, the focus on specific instead of generic subjects increases. The group should not lose sight of fundamental research, which can also score as highly relevant. The group seems to be aware of this to a certain extent. The committee recommends that there should be space for fundamental research in this group even if it does not fit into the CTIT framework.

Viability
The group consists of relative young and visible people, with a positive attitude towards the future. They have a vision and are optimistic about the future, and the committee also has a very positive impression of their future. Several young research leaders have been appointed, and the programme has a strategy for the replacement of a senior leader (overlapping appointment). In conclusion, the committee considers the programme to be very viable.

Conclusion
The group is very different from three years ago (the midterm review). The group is now less money-driven and much more enthusiastic, and it feels comfortable in the much more relaxed and more research-friendly atmosphere. The perspectives of 3TU seem to be seen very clearly and are supported by this group.

6. Institute of Mathematics and Computing Science, University of Groningen

6.1. Information on the institutional level – University of Groningen

6.1.1. Introduction

The research Institute of Mathematics and Computing Science (IWI) was founded in the early 1990s and consists of the disciplines of mathematics and computing science. IWI is part of the Faculty of Mathematics and Natural Sciences (FWN) of the University of Groningen. The mathematics part of IWI contains four research programmes:

- Computational Science & Numerical Mathematics;
- Dynamical Systems, Algebra, Geometry & Mathematical Physics;
- Systems, Control & Analysis;
- Statistics & Probability.

Only the programme Computational Science & Numerical Mathematics participated in the present research assessment of Applied Mathematics. The information on the research institute IWI in this report serves only as background informationon the embedding of the research group Computational Science & Numerical Mathematics. The committee will not give a formal assessment of the IWI, but will asses the programme Computational Science & Numerical Mathematics.

6.1.2. Leadership

The management of IWI is carried out by a board on which both disciplines (mathematics and computing science) are represented. Day-to-day administration is handled by the director. An advisory council of external experts is currently being formed, with the intention to monitor the quality of IWI from a distance.

Both the board and the advisory council of IWI safeguard the quality of the research, with criteria that enable them to measure the strengths of the researchers against international standards, as these are based on peer review and maintained by the national and international research foundations. Overall targets are to publish in highly ranked journals and conference proceedings and to acquire external funding, mainly for the support of PhD research.

The board also deals with finances, in particular with the annual budget. Monthly meetings take place with representatives of the research programmes of each of the disciplines (mathematics and computing science), chaired by the corresponding board member.

6.1.3. Mission & Goals

The mission of the institute is to perform outstanding academic research and conduct teaching in mathematics, and to maintain international leadership in this field. As an important part of this, the institute aims to transfer scientific results to other areas of science and technology, and to initiate and expand multidisciplinary research collaborations. The symbiosis between mathematics and applied mathematics, between pure and multidisciplinary research, is a distinguishing characteristic of the institute.

6.1.4. Strategy & Policy

There is a general and increasing tendency to focus on more applied research. The mathematics part of IWI has acquired an important position in the modelling of scientific phenomena in the earth and life sciences, medical sciences, information science, physics (mathematical), astronomy, technology and engineering, with direct contributions from the groups in computational mechanics, dynamical systems, systems and control, and statistics, while disciplines like numerics, analysis, geometry and algebra are contributing in an essential way.

Applied mathematics research has focussed on the mathematical aspects of continuum mechanics (fluids and solids). Computational methods formed an important ingredient of the research activities. With the current director's arrival in 1990, the group's research focus changed to emphasising computational modelling aspects even more, thereby concentrating on the design and development of numerical simulation methods for fluid flow. Multidisciplinary contacts with academia and industry are strongly fostered, as they provide inspiration for further mathematical and numerical innovations.

6.1.4. Resources

The tenure track system for scientific personnel was introduced in 2001, in order to attract the best young scientists to the programmes. Formal annual meetings are held with each staff member by his/her immediate superior, to monitor the academic reputation of the staff members.

PhD projects at IWI are partly funded directly by the Faculty, and partly by external sources like NWO, FOM, STW, KNAW, the GTIs and European programmes. An extensive Training and Support Plan exists for all PhD students in which, along with the supervisors, also the PhD coordinator and the IWI director are involved.

	2003	2004	2005	2006	2007	2008	Average
Total tenured staff	4.8	4.6	5.3	5.2	5.4	5.4	5.1
PhD students	14.3	14.3	18.3	18.0	20.9	21.0	2.5
Other non-tenured staff	2.9	2.6	2.3	2.7	3.2	1.4	17.8
Total research staff	**21.9**	**21.5**	**25.8**	**25.9**	**29.4**	**27.8**	**25.4**

Table 6.1: Staff at institute level (in research fte)

Computational Science and Numerical Mathematics							
	2003	2004	2005	2006	2007	2008	Average
Full professors	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Associate professors	0	0	0	0	0.2	0.6	0.1
Assistant professors	0.8	1.0	1.2	1.2	1.0	0.4	0.9
Total tenured staff	*1.2*	*1.4*	*1.6*	*1.6*	*1.6*	*1.4*	*1.5*
PhD students	3.2	3.6	4.7	4.6	3.8	3.5	3.9
Other non-tenured staff	0	0.5	2.0	0.8	0.5	0.5	0.7
Total research staff	**4.4**	**5.5**	**8.3**	**7.0**	**5.9**	**5.4**	**6.1**

Table 6.2: Staff at programme level (in research fte)

6.1.5. Funding Policies

Table 6.3 provides an overview of funding and expenditure concerning mathematics. Direct funding refers to funds provided by the FWN faculty. Research funds refer to funds received from national and international research councils (NWO, STW, DFG, etc). Contracts refer to funds

from third parties for specific research, from EU Framework programmes, etc. Direct funding is decreasing each year, which is compensated by a substantial increase in research funds.

	2003		2004		2005		2006		2007		2008	
	k€	%	k€	%	k€	%	k€	%	k€	%	k€	%
Funding												
Direct	1.759	90%	1.793	86%	1.820	75%	1.617	64%	1.543	59%	1.424	52%
Research funds	102	5%	249	12%	532	22%	827	33%	990	38%	1.206	44%
Contracts	84	4%	53	3%	59	2%	70	3%	90	3%	108	4%
Total funding	**1.945**	**100%**	**2.095**	**100%**	**2.411**	**100%**	**2.514**	**100%**	**2.623**	**100%**	**2.738**	**100%**
Expenditure												
Personnel costs	1.744	90%	1.951	93%	2.241	93%	2313	92%	2.428	93%	2.526	92%
Other costs	201	7%	144	7%	170	8%	201	7%	194	8%	212	8%
Total expenditure	**1.945**	**100%**	**2.095**	**100%**	**2.411**	**100%**	**2.514**	**100%**	**2.622**	**100%**	**2.738**	**100%**

Table 6.3: Funding and expenditures at institute level

6.1.6. Facilities

Apart from some larger desktop PCs, the Computational Science and Numerical Mathematics group does not possess its own computing facilities. However, at the university level the group can make use of shared memory systems, a cluster and a Blue Gene. For larger calculations, sufficient computing resources are provided by NCF (at the national level) and DEISA (at the European level).

Experimental facilities for validation of the simulation methods are available through cooperation with, in particular, NLR and MARIN. The NWO/SRON-funded research on sloshing under microgravity was supported by experiments carried out by the NLR-built satellite Sloshsat FLEVO (funded by ESA and NIVR: the Netherlands Agency for Aerospace Programmes). In the two STW-supported ComFLOW projects, a large budget (over 0.6 million euros) has been awarded to perform experiments at MARIN.

6.1.7. Academic Reputation

The faculty provided a list of memberships, editorships (guest or permanent), invited lectureships, appointed professorships, co-organisation of conferences, visiting professorships and other academic achievements of the programme members.

6.1.8. Societal Relevance

The mission statement mentions that the research programme strives for good contacts with the world outside mathematics. The programme aims to contribute to the next generation of simulation methods, with which new scientific and technological research domains can be explored further. The mathematical innovations thus far are appreciated in various applied research areas:

- contribution to climate research, sustainable energy, safety, healthy aging;
- research on mimetic discretization methods and models is useful in understanding the behaviour of turbulent flow better;
- research on free-surface flow as a design tool by the offshore industry and in the coastal protection arena.

6.1.9. Balance of Strengths & Weaknesses

The institute provided a SWOT self-analysis of which a summary is given in this report.

Strengths

- Broad research team covering a large spectrum of pure and applied mathematics, with many internal collaborations;
- Many collaborations with groups in other scientific and technological disciplines;
- High international visibility due to excellent publication track records, invited and key-note talks and interactions in large-scale networks. Many PhD students.

Weaknesses

- Relatively small size [counteracted by emphasizing collaborations];
- Not many Master students [counteracted by the active involvement in the nationwide Master programme *Mastermath*.].

Opportunities

- Collaborations with colleagues in other disciplines, and possibilities for interdisciplinary research funding.

Threats

- Decreasing funding for fundamental research.

6.2. Assessment per programme – University of Groningen

The committee assessed the following programme of the Institute of Mathematics and Computing Science at the University of Groningen.

	Quality	Productivity	Relevance	Viability
Research programmes				
Computational Science and Numerical Mathematics	3	4	5	3

The detailed assessment of the programme follows in the next section of this report.

6.2.1. Computational Science and Numerical Mathematics

Programme number:	RUG1	
Programme director:	Prof. A.E.P. Veldman	
Research staff 2008:	5.4 fte	
Assessments:	Quality:	3
	Productivity:	4
	Relevance:	5
	Viability:	3

Short description
The research programme wants to contribute to the impact that computer simulation is making on scientific and technological research. Based on a mathematical philosophy, and inspired by external demands, innovative numerical models and methods are being developed. The programme's focus is on simulation methods for flow research: Computational Fluid Dynamics (CFD). The programme strives for a close connection with the applied sciences.

Multidisciplinary cooperation with research groups in academia and industry is strongly fostered. The subsequent submission of joint research proposals is encouraged, while the research programme within the group is kept as coherent as possible.

The focus of the programme's research is on simulation methods for fluid flow. Emphasis lies on the following issues:

- 'mimetic' discretization methods for partial differential equations
- 'mimetic' flow modelling (turbulent flow, free-surface flow)
- interactive methods for sparse matrices and partitioned systems (strongly coupled).

The advance in numerical algorithms and modelling paradigms described above has been quite successful thus far. Many ideas exist for further refinement and progress, e.g. in the area of mimetic flow modelling.

Quality
The modelling of turbulence, based on paradigms and strong vision of the programme leader gives very good results. At this moment it seems to rely largely on craftsmanship and computational skills. Skills are essential in practising good science, but eventually the aim of science is to build a strong theoretical basis with solid proofs. Paradigms may help to give focus in research, but they also carry the risk to block insights from other approaches. Turbulence is a very difficult and tricky subject and for a small group it is not easy to make strong theoretical advancements. The committee advises the group to invest more in collaboration with the other mathematical programmes in Groningen.

Productivity
The productivity in terms of publications is modest, but the output in terms of PhD students is above average. The publications are well-cited by, mainly, the turbulence community. The group also produces software, both public software for its own research and non-public software for contractors. They are successful in this approach.

Relevance
The relevance of the group is excellent. They have a circle around them of interested technological institutes, companies, and research institutes, which is certainly impressive for such a small group.

Viability
This is the smallest group by size in the assessment of the committee on Applied Mathematics. The current programme depends heavily on the views and skills of the leader, who is approaching retirement. There are no clear plans yet for his succession. Recently, the group has been expanded with new young talent. This is promising, but new leadership is not visible at this stage. This poses some concern, but as a whole the programme seems to have a good viability.

Conclusion
The committee believes that a group of this type is certainly of great value for Groningen University. However, especially given the approaching retirement of the current (dominant) leader, it would be wise to develop plans for the future research strategy. This research strategy should be more flexible and more connected to mathematical expertise outside the group in the institute in Groningen. The dedication of the group leader to the research and the researchers in his group (including the PhD students) is exemplary.

The achievements of the group in the modeling of fluid dynamics can provide an excellent basis for attaining significant mathematical insights if the group invests in developing an open and scientifically critical approach towards its own methods and results. There is a wealth of computational evidence and expertise that can be capitalized upon by adding proper mathematical analysis and by establishing more differentiated interactions with the scientific community, while maintaining the valuable industrial relations that they built up over the years.

APPENDICES

Appendix A: Curriculum vitae of the committee members

Professor H.A. (Henk) van der Vorst is retired professor in applied mathematics at the Mathematical Institute of Utrecht University (1990-2006). He obtained his MSc in mathematics at Utrecht University and received his PhD in 1982 at the same university on numerical solutions of very large linear systems of equations. Earlier he held a position at the Delft University of Technology (1984-1990). In 2006-2007 he was international Francqui professor at the K.U. Leuven. He has made some well-known contributions to algorithms for the solution of very large linear systems of equations: ILU, ICCG, Bi-CGSTAB, GMRESR, as special cases of so-called Krylov methods, and Jacobi-Davidson algorithms for eigenproblems. He studied the convergence behaviour of the Conjugate Gradients method and the convergence of eigenvalue approximations in the Lanczos method. He also contributed to new parallel algorithms: truncated Neumann series preconditioning, incomplete twisted factorizations, and the so-called 'vdv' ordering. He was involved in the Templates projects for linear problems and eigenproblems. He is a member of the Royal Netherlands Academy of Arts and Sciences (KNAW), member of AcTi-nl (Netherlands Academy of Technology and Innovation), Ridder in de Orde van de Nederlandse Leeuw and holder of the Holst Memorial Lecture Award (November 2007). In 2009 he was elected SIAM fellow.

Professor M.A. (Rien) Kaashoek is retired professor of analysis and operator theory at the VU University in Amsterdam, where he has been emeritus since December 2002. He received his PhD in 1964 at Leiden University. His primary research interests are analysis and operator theory, including applications to singular integral equations, canonical differential systems and problems arising from Mathematical System Theory. He is vice-president of the steering committee of the series of international workshops on Operator Theory and Applications (IWOTA), and has been chairman and member of the steering committee of the International Symposia on Mathematical Theory of Networks and Systems (MTNS). He coordinated a number of INTAS projects. He has held visiting positions at universities in Canada, Great Britain, Israel, and the USA. He is a member of the honorary editorial board of the *Journal of Integral Equations and Operator Theory* and has been appointed Ridder in de Orde van de Nederlandse Leeuw.

Professor A. (Alfio) Quarteroni is professor of numerical analysis at the Politecnico di Milano, director of the Chair of Modelling and Scientific Computing at the EPFL in Lausanne and scientific director of MOX, Politecnico di Milano. He was previously professor of mathematics at the University of Minnesota, Minneapolis, professor of numerical analysis at the Catholic University of Brescia, researcher at the Instituto di Analisi Numerica of the CNR, Pavia, and head of the Scientific Research Division of the Center for Research and Advanced Studies in Sardinia. Quarteroni is author of 19 books and editor of 5 books, he is author of more than 150 refereed papers and invited speaker at more than 200 conferences and academic departments. He is member of the editorial board of 20 journals. His research interests are Mathematical Modelling, Numerical Analysis and Scientific Computing, Numerical Approximation of Partial Differential Equations, and Applications to fluid mechanics, aerospace engineering, geophysics, and others. Quarteroni has received many awards, among which a SIAM fellow in 2009, the Galileian Chair in 2001, a Laurea *honoris causa* in Naval Engineering. He is a member of the Italian Academy of Science since 2004. He gave a plenary lecture to the ICM 2006 in Madrid.

Professor P. (Philippe) Robert is research director at INRIA, and professor at the Ecole Polytechnique. Robert received his PhD from the Pierre et Marie Curie University in Paris. He is research director at INRIA and professor at the Ecole Polytechnique. He is responsible for the research team 'Communication Networks, Algorithms and Probability' at INRIA. His research interests include theoretical aspects of stochastic networks, random algorithms and scaling methods of Markov processes. Algorithmic aspects of communication protocols and mathematical representations of the Internet traffic are currently the main applications of his research. He is also teaching at the Pierre et Marie Curie University. He wrote a book *Stochastic Networks and Queues* in 2003 published by Springer-Verlag, New York.

Professor A. (Lex) Schrijver is professor of discrete mathematics and optimization at the University of Amsterdam, and researcher at the Centre for Mathematics and Computer Science (CWI) in Amsterdam. Schrijver received his PhD in mathematics at the Free University in Amsterdam in 1977. From 1983 till 1989 he was professor of mathematics at Tilburg University. Schrijver has received many awards, among which the Spinoza Prize in 2005. He is a member of the KNAW, since 1995, and of three foreign academies. Schrijver has held several visiting positions, e.g. at the Department of Computer Science at Yale University and as consultant at Bell Communications Research, and at Microsoft Research. He is editor of several journals (including Combinatorica, Journal of Combinational Theory, Series B, and Journal of Combinatorial Optimization). He is Ridder in de Orde van de Nederlandse Leeuw, honorary doctor of the Univeristy of Waterloo (Canada), and SIAM fellow.

Professor J.P. (Joos) Vandewalle obtained the degree of MSc in Electrical Engineering, a doctoral degree and a special doctoral degree in 1971, 1976 and 1984, respectively, at KU Leuven. He was a postdoctoral researcher during 1976-78 and visiting assistant professor during 1978-79 at the Electrical Engineering and Computer Science Department of the University of California, Berkeley. In 1979 he was appointed to the Electrical Engineering Department of the K.U.Leuven, where he has been full professor since 1986. He has been an academic consultant since 1984 at IMEC (Interuniversity Microelectronics Center). He was twice chairman of the Department of Electrical Engineering and has been the vice-dean of the Faculty of Engineering at KU Leuven. In 2003 he was on sabbatical leave at the I3S laboratory of CNRS Sophia Antipolis, France. His main research interests are in mathematical system theory and its applications in circuit theory, control, signal processing, cryptography and neural networks. He has authored or co-authored more than 300 international journal papers in these areas. He is the co-author of 4 books and co-editor of 5 books. He is a member of the editorial board of several journals. He was chairman of several international conferences (ISCAS 2000, Geneva, IJCNN 2004, Budapest, NOLTA 2005, Bruges). He was elected fellow of IEEE in 1992 for contributions to nonlinear circuits and systems and in 2005 as Vice-President of Technical Activities of the IEEE CAS Society. In 1991-1992 he held the Francqui chair on Artificial Neural Networks at the University of Liège and in 2001-2002 he held this chair on Advanced Data Processing techniques at the Free University of Brussels. He is also a fellow of the IEE (UK). He has received several best paper awards and research awards. He is a member of the Academia Europaea and of the Belgian Academy of Sciences and of a committee of the Research Foundation Flanders (Fonds voor Wetenschappelijk Onderzoek Vlaanderen).He has been on the panels of various research funds (e.g. FWO, ERC, DFG) and international research and teaching evaluations (e.g. Electrical Engineering in the Netherlands in 2005).

Professor E.A. (Evgeny) Verbitskiy is professor of mathematics of life sciences at the University of Groningen, advisor to the Applied Analysis Group of Eindhoven University of Technology and senior scientist at Philips Research Laboratories, Eindhoven. He obtained a doctorandus degree in mathematics at the University of Groningen and an MSc in (Applied) Mathematics at Moscow State University. He obtained his PhD at the University of Groningen (2000, cum laude) on Generalized Entropies in Dynamical Systems. He has been a research assistant at the Department of Mathematics of the University of Groningen and postdoctoral researcher at EURANDOM. He was a member of the workgroup for Mathematics of the KNAW in 2007-2008 and a member of the workgroup 'Masterplan Toekomst Wiskunde' of NWO in 2008.

Appendix B: Schedule of the meetings

Programme Schedule
Research Review Applied Mathematics
3TU; 10-12 September 2009

9 Sept 09				
	19:00	22:00	Arrival committee members in Delft	
			Museumhotel Delft	

10 Sept 09			**Delft University of Technology (TUD)**	
		8:45	Arrival of the committee at TUD	
	9:00	10:45	Committee meeting	
	10:45	10:55	Welcome	Fokkema (rector)
	10:45	12:00	Meeting with institute management TUD	Lenstra (dean), de Pagter
TUD1	12:00	12:45	Analysis	De Pagter, van Neerven
	12:45	13:30	Lunch	
TUD2	13:30	14:15	Computational Science and Engineering	Heemink, Aardal, Vuik
TUD3	14:15	15:00	Probability, Risk and Statistics	Dekking, Jongbloed
	15:00	15:30	Break	
	15:30	16:30	Interview with PhD students	
	16:30	17:00	Committee meeting	Conclusions TUD
	17:00	18:00	Presentation of preliminary results and drinks with hosts & PhD students	
	18:30	20:45	Committee dinner	
		20:45	Travel to Enschede (200 km)	
			Hotel de Broeierd, Hengelosestraat 725, Enschede	

Programme Schedule
Research Review Applied Mathematics
3TU; 10-12 September 2009

11 Sept 09			**University Twente (UT)**	
		8:45	Arrival of the committee at UT	Welcome by Brinksma (rector)
	9:00	10:00	Committee meeting	
	10:00	11:00	Faculty and department/institute	Mouthaan (dean), van der Vegt
UT 2	11:00	11:45	Stochatics and Operations Research	Boucherie, Uetz, Albers
UT 1	11:45	12:30	Applied Analysis & Computational Science	van Gils, van der Vegt
	12:30	13:15	Lunch	
UT 3	13:15	14:00	Deterministic and Stochastic Systems Theory	Bagchi, Stoorvogel
	14:00	15:00	Interview with PhD students	
	15:00	15:15	Break	
	15:15	16:15	Computational Science & Scientific Computing	Veldman, Broer (RU Groningen)

	16:15	16:45	Interview with PhD students (RUG)	
	16:45	17:30	Committee meeting	Conclusions UT and RUG
	17:30	18:30	Presentation of preliminary results and drinks with hosts & PhD students	
	18:30	20:45	Committee dinner	
		20:45	Travel to Eindhoven	
			Hotel Sofitel Cocagne, Vestdijk 47, Eindhoven	

Programme Schedule
Research Review Applied Mathematics
3TU; 10-12 September 2009

12 Sept 09			**Eindhoven University of Technology (TU/e)**	
		9:15	Arrival of the committee at TU/e	Welcome by van Duijn (rector)
	9:30	10:00	Committee meeting	
	10:00	11:00	Faculty and department/institute	Cohen (dean), Boxma (vice-dean), Baeten (vice-dean), Woeginger
TUE 1	11:00	11:45	Applied Analysis & Scientific Computing	Mattheij, Peletier
TUE 2	11:45	12:30	Statistics, Probability and Operations Research	Woeginger, Van der Hofstad, Boxma
	12:30	13:15	Lunch	
	13:15	13:45	Break	
TUE 3	13:45	14:30	Discrete Mathematics and Applications	van Tilborg, Cohen
	14:30	15:30	Interview with PhD students	
	15:30	16:45	Committee meeting	Conclusions TU/e and general conclusions
	16:45	17:45	Presentation of preliminary results and drinks with hosts & PhD students	
			Optional dinner and overnight stay for committee	

Appendix C: Explanation of the SEP scores

Excellent (5)	Work is at the forefront internationally and will most likely have an important and substantial impact in the field. Group is considered an international leader.
Very Good (4)	Work is internationally competitive and is expected to make a significant contribution; nationally speaking at the forefront in the field. Group is considered international player, national leader.
Good (3)	Work is competitive at the national level and will probably make a valuable contribution in the international field. Group is considered internationally visible and a national player.
Satisfactory (2)	Work that is solid but not exciting, will add to our understanding and is in principle worthy of support. It is considered of less priority than work in the above categories. Group is nationally visible.
Unsatisfactory (1)	Work that is neither solid nor exciting, flawed in the scientific and or technical approach, repetitions of other work, etc. Work not worthy of pursuing.

Quality is to be seen as a measure of excellence and excitement. It refers to the eminence of a group's research activities, its abilities to perform at the highest level and its achievements in the international scientific community. It rests on the proficiency and rigour of research concepts and conduct; it shows in the success of the group at the forefront of scientific development.

Productivity refers to the total output of the group; that is, the variegated ways in which results of research and knowledge development are publicised. The output needs to be reviewed in relation to the input in terms of human resources.

Relevance is a criterion that covers both the scientific and the technical and socio-economic impact of the work. Here in particular research choices are assessed in relation to developments in the international scientific community or, in the case of technical and socio-economic impact, in relation to important developments or questions in society at large.

Vitality and feasibility: This dual criterion refers to the internal and external dynamics of the group in relation to the choices made and the success rate of projects. On the one hand, this criterion measures the flexibility of a group, which appears in its ability to close research lines that have no future and to initiate new venture projects. On the other hand, it measures the capacity of the management to run projects in a professional way. Assessment of policy decisions is at stake, as well as assessment of project management, including cost-benefit analysis.