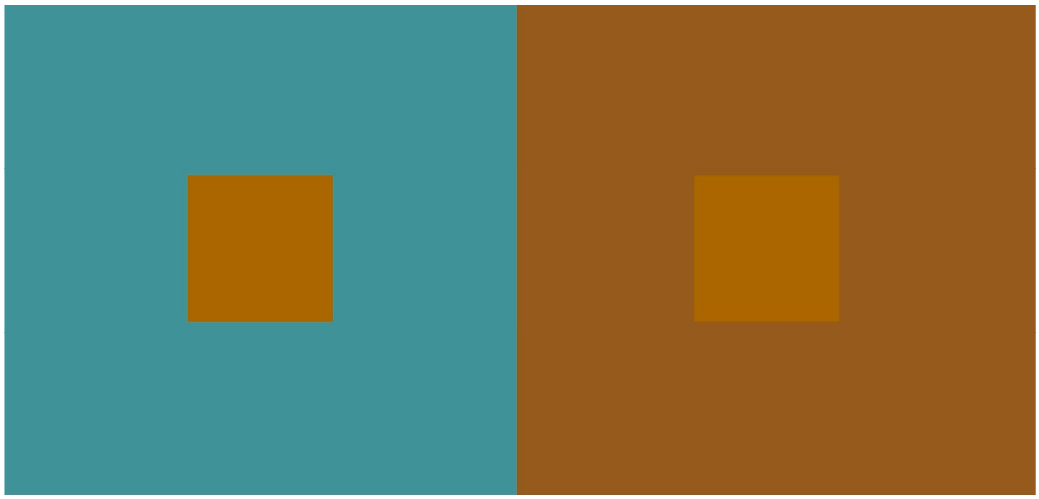
# Research Evaluation
# Mathematics
# 2009 - 2014



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# Report on the research evaluation of Mathematics in the Netherlands

## Content

# Preface

Before you lies the report giving the research evaluation of the mathematics research over the period 2009-2014 of nine Dutch universities according to the Standard Evaluation Protocol 2015-2021 adopted by the KNAW, the VSNU and NWO.

The assessment was performed by an Evaluation Committee consisting of a chairman, a secretary and 7 foreign members. The areas of expertise of the Evaluation Committee covered Algebra and Topology, Analysis, Applied Analysis, Dynamical Systems, Geometry, Numerical Analysis, Computational Science, Discrete Mathematics, Probability Theory and Statistics, Mathematical Physics, Systems and Control, Optimization, and Decision Theory.

The project started in the fall of 2014 with meetings of the prospective chairman with the Research Committee of Platform Wiskunde Nederland. One of the issues considered by this Committee was the issue of bibliometric analysis. It was decided that no bibliometric studies would be performed. It turned out that the members of the Evaluation Committee concurred with this decision, and bibliometric information played a minor role during the evaluation. On the issue of benchmarking, the PWN Research Committee decided to leave this out of the format for the self-evaluation report, with the argument that ample international benchmarking would take place by the seven members of the Evaluation Committee.

Information on the modus operandi of the Committee can be found in Chapter 1 of this report. The committee has been extremely well guided by dr. Meg Van Bogaert, who acted as secretary and project manager. In name of all the Committee members I would like to thank her for her excellent support.

I would like to thank, also in name of the entire Dutch mathematical community, Regina Burachik, Alberto Cattaneo, Hans Künsch, Robert MacKay, Volker Mehrmann, Rolf Möhring, and Don Zagier for their tremendous effort.

Michel Dekking
Chair of the Committee

# 1. The evaluation committee and the review procedures

The Mathematics Evaluation Committee was appointed by the Executive Boards of University of Amsterdam (UvA), Vrije Universiteit Amsterdam (VU), Delft University of Technology (TUD), Eindhoven University of Technology (TU/e), University of Groningen (RUG), Leiden University (LEI), Radboud University Nijmegen (RU), University of Twente (UT) and Utrecht University (UU) to perform an assessment of the research in Mathematics at the aforementioned universities. The assessment covers the research that was conducted in the period 2009-2014, as well as the research strategies that were outlined for the upcoming period. In this sense the assessment was both retrospective and prospective.

In accordance with the Standard Evaluation Protocol 2015-2021 for Research Assessment in the Netherlands (SEP) and the Terms of Reference (ToR) specified by the participating universities, the committee's task was to assess the (1) academic quality, (2) societal relevance and (3) viability of the participating research units in relation to their strategic targets, and to advise on further improvements. Each of the three SEP criteria had to be scored against international standards by using a 4-point scale, ranging from 1 (excellent) to 4 (unsatisfactory). The SEP criteria and rating system are described in more detail in Appendix 2. The research programmes that are underlying the research units are assessed in a qualitative way, but conforming to the SEP 2015-2021 no scores were given to these research programmes.

Furthermore, SEP 2015-2021 instructs review committees to devote special attention to research integrity policies and the quality of PhD programmes, both at the level of the research unit.

**Composition of the committee**

The mathematics committee consisted of the following members:

- Professor R.S. Burachik, associate professor at the University of South Australia, Australia;
- Professor A.S. Cattaneo, professor at University of Zürich, Switzerland;
- Professor F.M. Dekking (chair), emeritus professor at Delft University of Technology;
- Professor H.R. Künsch, professor emeritus at ETH Zürich, Switzerland;
- Professor R.S. MacKay, professor at University of Warwick, United Kingdom;
- Professor V. Mehrmann, professor at TU Berlin, Germany;
- Professor R.H. Möhring, professor at TU Berlin, Germany;
- Professor D. Zagier, professor at Max Planck Institute for Mathematics, Bonn, Germany.

Short curricula vitae of the committee members are included in Appendix 1.

Dr. M.J.V. Van Bogaert of Quality Assurance Netherlands Universities (QANU) was appointed Secretary to the committee.

**Independence**

All members of the committee signed a statement of independence to safeguard that they would assess the quality of mathematics research units in an unbiased and independent way. Any existing personal or professional relationships between committee members and the programme under review were reported. The committee concluded that there were no

unacceptable relations or dependencies and that there was no specific risk in terms of bias or undue influence.

**Data provided to the committee**

The committee has received the self-evaluation reports of the universities under review, including all the information required by the Standard Evaluation Protocol (SEP), with appendices.

**Procedures followed by the committee**

The committee proceeded according to the Standard Evaluation Protocol 2015-2021 (SEP). Prior to the first committee meeting, all committee members independently formulated a preliminary assessment of a number of the units under review. The final assessments are based on the documentation provided by the universities as well as interviews with the management and representatives of each university. The interviews took place on 16-20 November 2015 (see the schedule in Appendix 3) in Amersfoort. Although the committee did not visit any of the nine universities, the meetings and interviews in Amersfoort are referred to as the *site visit* in this report.

Preceding the interviews, the committee was briefed by QANU about research assessment according to SEP, and the committee discussed the preliminary assessments and decided upon a number of comments and questions. The committee also agreed upon procedural matters and aspects of the assessment. After the interviews the committee discussed the assessments and comments. The final version was presented to the universities, for factual corrections and comments. The comments were discussed in the committee.

# 2. General remarks

**Introduction**

In this general chapter the committee provides a number of observations and opinions that are not related to a specific mathematics unit. The first part of this chapter concerns the assignment to the committee, the procedures that were followed and the evaluation protocol that was used. The second part of this chapter describes a number of findings and observations by the committee that cover the mathematics research in the Netherlands.

Some universities have an institute in which mathematics is organised; others have a department of mathematics. In the chapters in which the individual universities are evaluated (chapters 3-11) the committee adopted the organisational structure of the university. In this general chapter the committee uses the words 'institutes' and 'departments' interchangeably to refer to the unit of assessment.

**Standard Evaluation Protocol**

In contrast to the previous evaluations (evaluation report 2010), the present Standard Evaluation Protocol (SEP 2015 -2021) prescribes evaluations at the level of research units of at least 10 research fte excluding PhD students and postdocs. The result is that all universities evaluated in this report have put forward one institute covering the entire research in mathematics. Even when combining all the research in mathematics, more than 50% of the universities did not manage to have a research institute of at least 10 research fte. Furthermore, the various sub-disciplines within each university are diverse in such a way that it is not possible to simply combine them, and give one assessment. This demonstrates the mismatch between SEP 2015-2021 and the mathematical discipline. The committee has decided to first evaluate the separated underlying research programmes before joining them into one integrated quantitative score.

A second important change in comparison to the previous evaluation protocol is that when referring to research quality, the rating scale ('quantitative assessment') has been condensed to a four-point scale, where the highest rating (1) reflects 'world leading/excellent', while the lowest rating (4) denotes 'unsatisfactory'. According to the committee practically all Dutch mathematical research is internationally recognised and therefore the rating 'good' (3) would do no justice to the level at which research is performed. Effectively therefore, the four-point scale is reduced to a two-point scale since .5 scores were explicitly not allowed. The committee mentions yet another consequence of the 2015-2021 protocol. Rating an institute of 25 researchers is not a matter of taking an average score over these 25 individuals. When just a few of these are absolutely world-leading, this could result in the rating (1) for the whole institute. This all leads to a quantitative rating that is too coarse to reflect the differences that exist between the universities or between programmes within an institute. As a result, the narrative descriptions in this report should be seen as considerably more informative than the quantitative scores.

SEP 2015-2021 dictates that the self-evaluation reports should not exceed the total of 15 pages (excluding tables). Almost all universities exceeded the number of pages, or included lengthy appendices. Of course, the committee understands that exceeding the limit easily occurs in order to provide in-depth information on research contributions. Even so, this in-depth information often still provided insufficient information on the actual research that was done at the departments. The committee found very useful, however, the short narratives a

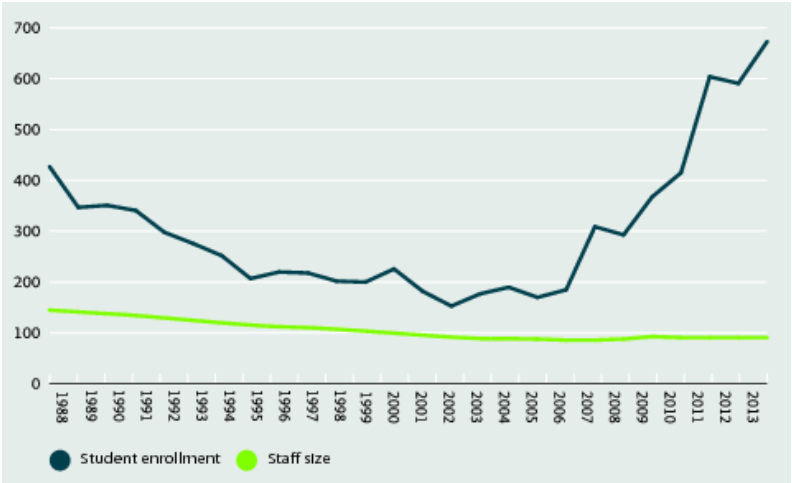
few institutes provided on their 15 highlighted publications or on selected projects of societal relevance.

Despite the best efforts of the universities supplying the information, comparability (specifically of the quantitative information in the tables) turned out to be a major challenge. Universities did not always use the same criteria; for example, not all included scholarship students as an independent group. It also turned out to be impossible to compare percentages of direct funding, grants and contract funding. Some universities have a monopoly in mathematics service teaching for the entire university, which leads to huge amounts of direct funding to compensate the teaching input. However, this leads to a distorted ratio between direct funding and indirect funding. Hence the committee had to rely to a substantial extent on the information collected during the site visits, in particular information reflecting strategies and policies aimed at quality maintenance and improvement.

**Overall assessment of research quality**

The committee believes the research in mathematics in the Netherlands to be of very high quality, and in a number of cases even excellent. In general the research finds its way to top level international journals, with exception of some of the very applied research.

The single most prominent fact about the development of mathematics at Dutch universities during the last 12 years is that there has been a dramatic and most welcome upswing in the numbers of beginning students since the catastrophic decline in the years 1988-2003. However, there has not been a corresponding increase in the number of staff members, which in some cases continued to be cut long after the low enrolment numbers might have justified this. One has to realize that the figure below does not tell the whole story: the student enrolment refers to mathematics students, but since there has also been an increase of students in other disciplines, the service teaching load is also much heavier.




Staff size is measured in research fte.

The result is an increased workload, an undue financial pressure and pressure on getting grants, and as a consequence a less attractive environment for young researchers that in the long run will inevitably decrease the ability of the Netherlands to continue to attract top talent from abroad. This problem is crucial, and despite the still excellent level of Dutch university mathematics as a whole, potentially devastating. It is of course being discussed at many levels, from individual departments to faculties to boards to national initiatives (Deltaplan), but it cannot be emphasised enough how important it is that these efforts continue and are taken seriously at both the university and the national level.

**Societal relevance**

On the whole, Dutch mathematics is making an excellent contribution to society, not just for its intellectual value, the training of students in valuable mathematical methods and public engagement, but also in direct research projects in a diverse range of areas such as water management, medical imaging, electric power distribution, healthcare planning, forensic science, and the development of software. Although a balance is necessary between doing mathematical research for its own sake and for applications, there are more opportunities that Dutch mathematics could take. In particular, some institutions view the shift in funding regime towards application-driven research as a threat, whereas others view it as an opportunity. This is particularly true of the Top-sectors, to which a separate section is devoted below.

On a general level the importance of mathematics as the language of science cannot be overestimated. Furthermore in almost all key technologies the impact of mathematics, in particular mathematical modelling, simulation and optimization is huge, but not sufficiently recognized by society. Mathematics acts as a transversal science, results can be transferred from one field to another once the appropriate abstraction level has been reached and the language barriers are broken. This is prominently visible in the technical universities but also to a large extent in every single department under evaluation.

In previous years large efforts have been made to increase the visibility of mathematics for other sciences and society. But more efforts are needed in this respect to make the societal relevance obvious. Mathematical research needs to be incorporated and funded within funding programs for all technology areas, in particular the Top-sectors.

**Funding**

As mentioned earlier it was impossible for the committee to compare institutes based on the quantitative information that was provided in the self-evaluation reports. Direct funding strongly depends on the amount of service teaching that is done by the departments. Some mathematical departments do all service teaching in mathematics at their university, while others have very limited service teaching. The committee therefore did not use percentages of the funding streams, but did look at absolute grant income and contract research in combination with the size of the staff.

Many of the research institutes that were assessed are (or have been) shifting focus from predominantly national grant applications at NWO to international grant opportunities. These are often larger grants and, similarly to national grants, very difficult to obtain. According to the committee, initiatives like 3TU.AMI can be valuable in the application of these large, international grants.

The committee observed professionalization of the funding acquisition process. All universities have a support office at central university level that supports the grant application procedure. A number of universities also provide support at faculty level. The committee concluded that a better understanding of the specific situation for mathematics of the supporting staff leads to better support and more success in grant applications. The support office that was most specifically targeted at mathematics, PDO in Eindhoven, deserves to be mentioned as best practice. The PDO support staff selects appropriate calls for mathematicians from the large amount of calls that are available. It furthermore supports scientific staff to apply, and executes a lot of the procedural activities. In the evaluation period this support has led to a high success rate in grant applications, and it seems worth the investment.

### Top-sectors

The Dutch Top-sectors programme with its focus on research in themes and on short-term valorisation makes it difficult for mathematics to have a leading role. Some of the institutes engage well already with the Top-sectors, while others have more difficulties to find the right approach. However, mathematics is a fundamental requirement in all Top-sectors, and although it might not be the primary objective of many projects, mathematicians should claim their crucial role in the applications and projects. The committee therefore considers that Dutch mathematicians should try to join forces with other disciplines with whom they cooperate and become involved as partners in Top-sector projects. For instance, Logistics, Life sciences and Health, High Tech Systems and Materials, Energy, and Water offer opportunities to become an active player. At the same time, mathematicians should try together with other areas of fundamental research to lobby against further reduction of funds for basic research. The arguments will become stronger if one can point out that mathematics is involved in some Top-sector projects.

### Hiring strategy: recruiting and retention

At many universities the hiring strategy focuses on excellence in research quality of the individual candidate rather than an exact match of the expertise within a research group. The university that most convincingly takes this approach, and is successful in this, is Leiden University. Other universities are also taking this approach more often and seem successful. The balance between this strategy and coherence of the departmental research topics should always be considered. If this is the case, the strategy could be very successful.

A drawback of the focus on excellence is a retention problem. The committee has observed that during the assessment period quite a few of the top researchers have moved at least once. Institutes that have put an effort to put themselves on the map in a certain area then are often forced to change their strategy.

### Tenure-track policy

As can be read in the assessments for the different universities, all institutes have a tenure-track policy in place. The committee considers tenure-track essential for Dutch mathematics, in order to attract young, talented mathematicians and compete with foreign research institutes and universities. The basis of the tenure-track strategy is similar for all universities; an assistant professor temporary contract is given to the researcher for a certain period (4-6 years) in which the tenure-tracker can develop and display his/her ability in doing high quality research, teaching and grant acquisition. When complying with the criteria that were set at the beginning of the tenure-track, a tenure position is guaranteed. The execution of the tenure-track strategy differs between the universities. The two predominant differences that are observed might affect the attractiveness of tenure-track positions between universities.

The first is the support given to the tenure-tracker at the beginning of the contract. All universities aim to provide the tenure-tracker with a PhD student to supervise. However, not all universities can make use of direct funding to pay for this PhD student. This could lead to either not being able to provide a PhD student to a tenure-tracker, or providing one that is paid for by grant funding. This latter is preferred to not having a PhD student at all, but nevertheless might lead to a PhD student with a research topic that is not closely related to that of the tenure-tracker. The committee highly appreciates the universities that make available direct funding for PhD students.

The second difference that is observed is the way departments are allowed to adapt the criteria for tenure to the specific situation of mathematics. This predominantly is important

for the success in grant applications. In areas like mathematics, chances to obtain grants may be much lower compared to other disciplines within the faculty, owing to less funding being available. Many universities in the Netherlands consider writing a proposal that has received a very good evaluation by the reviewers to be sufficient for the criterion grant applications, even if the grant itself was denied. In some universities this is currently not the case, giving tenure trackers in mathematics a disadvantage compared to other disciplines.

A third difference is the application of the ius promovendi. Most universities only have ius promovendi at full professor level, while some universities grant the ius promovendi at the associate level.

At all Dutch universities a tenure-track position, when complying with the set criteria, guarantees a tenure position. All departments stated that there is no competition for one tenure position between a number of tenure-trackers who satisfy the criteria.

**Diversity**

More proactive efforts should be made to acquire female mathematicians at all levels (tenure track, associate professor, full professor). The record of Dutch mathematics in this respect was dismal, and although some progress has been made, it is not even close to sufficient, nor at all commensurable with the efforts being made and the success being attained in neighbouring countries. The claim that is occasionally still made that there are almost no equally qualified female candidates is simply no longer true, although the numbers are still much smaller than for male candidates and one therefore has to try harder. What is true is that, because of the imbalance on the supply side and the fact that universities everywhere are trying to improve their profile in this respect, it is often difficult to get an excellent female researcher, even if one makes a good offer. Each department should therefore seriously think about ways to make offers that are particularly attractive, especially for young people and with respect to the probability of acquiring tenure. Some departments or faculties (or universities) have set aside funds specifically for hiring female candidates, and although it is to be hoped that such measures will not be necessary in a few years, given the present situation and the necessity of changing the current negative perception of the academic world of female researchers starting their careers, such initiatives should be welcomed and encouraged.

**Research integrity**

Infringement of research integrity and fraud are very uncommon in mathematics. Nevertheless, the committee considers it to be very important that not only there is policy at university level, but also specific policy with respect to mathematics. There are two levels of research integrity, that of general science, and that of the discipline of mathematics. It would make sense according to the committee that all institutes would agree on choosing the same code of conduct at these two levels. For the first level this could be the VSNU "Netherlands Code of Conduct for Scientific Practice", for the second the code of conduct of the European Mathematical Society. At the moment some research units employ other codes of conduct.

Also, the policies should be actively communicated to staff, specifically to PhD students and undergraduate students. This seems to be the case. It was, however, difficult for the committee to assess the effectiveness of any of the policies. All universities stated in their self-evaluation report that no misconduct or infringement of research integrity occurred during the evaluation period.

In some areas of applied mathematics, reproducibility of numerical experiments and statistical analysis is a key aspect of research integrity. This requires a policy for the storage of data and for making computer code publicly available, and it would be desirable to have a common set of rules for this too.

**PhD training**

Without exception the committee was very impressed by the quality of the PhD training and supervision. PhD students are encouraged to visit other researchers (internationally), attend conferences and summer/winter schools. Another positive point is the Dutch custom that there is mostly an international committee assessing and ensuring the quality of the thesis, giving an international accent to the work of the PhD student. The committee compared quality of PhD training with foreign universities for which it knows the situation and considers the Netherlands to have a very high quality of PhD training.

All PhD students have the opportunity to follow courses on topics that help them in their research. Often these are Mastermath courses, and usually the supervisor advises the PhD students on which courses to follow. In addition, many departments offer a number of compulsory courses in general skills, like presenting and scientific writing. There is a tendency to organise the PhD training in graduate schools. These graduate schools allow for a more organised training of general skills, while also providing individual PhD students to follow courses within their own discipline.

Most universities assign the primary responsibility for PhD training to the supervisors. This makes the individual supervision very important, but also allows for a tailor-made training. With projects from different funding bodies, different duration of the projects and different requirements between for example regular and scholarship PhD students, it is very difficult to set up one training for all PhD students at one university. The committee considers the supervision of high quality and is supportive of the individual training programmes as long as it allows PhD students to graduate within time and with high quality research. In case of low graduation rates, high dropout numbers or other problems, the committee noticed that adequate action was taken. This action often resulted in less freedom for individual students, while providing the structure that was required to improve the situation. One example is the way a department makes use of the go/no-go decision. According to the committee, this decision moment should always have a formal character, and provides an excellent tool to enforce structure in a department in need of it. In practice this might of course be handled informally.

A third activity, next to doing research and training, is teaching. Most PhD students are involved in teaching activities in undergraduate courses, mainly exercise classes. All claimed to enjoy teaching and to value the experience. Although the amount of teaching required varied between universities, it was always acceptable and within the limits of the contract.

**Data Science centres**

In view of the huge importance of data driven research for the further development of science and technology, data science centres are being set up at most universities. The committee thinks that this offers many opportunities for mathematics since research in data science raises interesting new questions for statistics and optimization. It is therefore essential that mathematics institutes play an active part in such centres. An especially well advanced activity was observed at TU/e, where the mathematics institute has taken a leading role.

# 3. Research evaluation Korteweg - de Vries Institute for Mathematics, University of Amsterdam

## 3.1. Organisation, leadership, strategy and targets of the research unit

The Korteweg-de Vries Institute for Mathematics (KdVI) is responsible for the research in mathematics at the University of Amsterdam (UvA) and provides lecturers and instructors for mathematics teaching within the Faculty of Science (FNWI). The institute is led by the director, who has full responsibility for the institute, and meets the (vice) Dean of the faculty regularly. The mathematical research at KdVI covers various research areas, grouped in three programmes:

- Algebra, Geometry, Mathematical Physics (AGMP): this programme comprises algebraic groups and representation theory, arithmetic algebraic geometry, algebraic number theory, moduli spaces, integrable systems, discrete mathematics, and combinatorial optimisation.
- Analysis: this programme comprises dynamical systems, complex analysis, and numerical analysis.
- Stochastics: this programme comprises queuing theory, stochastic processes, operations research, financial mathematics, stochastic differential equations, statistics, Bayesian statistics and forensic statistics.

The mission statement is as follows: the Korteweg-de Vries Institute for Mathematics furthers the science of mathematics, both in its theoretical and applied aspects, and aims to stimulate the application and appreciation of mathematics in other academic disciplines and in society as a whole.

According to the self-evaluation report the strategy is divided into three parts:

- **Sustaining a coherent, dynamic research environment.** The hiring policy has an element of expediency and opportunism, giving highest priority to scientific quality rather than a narrow description of the sub-disciplines. Nevertheless, the coherence and continuity of research programmes, as well as their synergy, has been crucial to sustain active groups with sufficient mass and focus and thus is part of the hiring policy.
- **Development in research focus.** An important theme in AGMP is mathematical physics, also providing common ground for collaborations with the physics department in the FNWI focus area programme *Quantum Matter and Quantum Information*. In the stochastics group, a new focus and strong impulse is given by the NETWORKS project.
- **Outlook**. The intended merger between UvA and Vrije Universiteit Amsterdam (VU) was blocked in 2013 and led to a new, bottom-up approach in the science domain. It includes possibilities to intensify and strengthen the collaboration with VU mathematics department and the Institute for Logic, Language and Computation (ILLC).

The high degree of national organisation of mathematical research and education requires KdVI to play an active role at this level; indeed it is active in all four NWO research clusters. Another partnership is with the universities of Eindhoven, Leiden and the CWI (NETWORKS). Formal collaboration with Nijmegen resulted in joint appointments of extraordinary professorships. Also at international level, several collaborations exist, for example with University of Queensland, KU Leuven, University of Gent and Aix Marseille

Université. In addition, much collaboration exists at the level of research projects by individuals.

The committee discussed intensively the consequences of the failed merger with VU, which is clearly a setback for organisation and management of the mathematics departments at both universities. The universities have put both mathematical departments in an unfortunate limbo, unsettling the mathematicians by first proposing a merger and then not continuing with it. Nevertheless, the departments have to find a way to deal with it.

The Dean expressed clearly that currently a bottom-up approach is in place for all disciplines at both Faculties and the onus is on each department to explore ideas for collaboration. Some departments apparently are actively seeking collaboration both in research and in education. In mathematics, however, discussions on collaboration at the departmental level are limited to education, though there are informal interactions in research areas like dynamical systems, and there is even a joint appointment. Although mathematics, unlike for example physics, does not need an expensive infrastructure that could profit from joint initiatives between VU and UvA, the committee was disappointed that not more efforts have been made in the direction of a combined strategy in mathematical research. This could turn out to be dangerous since other departments within the same faculties are actively pursuing joint research activities and the bottom-up strategy may be abandoned at some point if it does not produce results in Mathematics; it may be replaced by a top-down one which might not take into account the views of the mathematicians.

Based on the current assessment, the committee concludes that both departments (VU and UvA) do very good research and each has its strengths. A merger might not strengthen the research in mathematics and could lead to counter-productive disruption. However, the two departments should make an effort to emphasize the fact that they are complementary in many respects, which is currently not clear to an outsider. At the same time a search for common research topics in which synergy can be obtained should also be started. The committee has seen some good examples of this and strongly encourages the departments to continue in a more structured way. The committee recommends that the departments do not sit back and wait, but actively participate in the bottom-up approach instigated by the Dean.

**Resources**

In the period of review the number of staff members increased from 29 to 35 (tenured and tenure-track), while the number of PhD candidates increased from 16 to 34. Hiring policy has shifted from offering tenured positions to offering predominantly tenure-track positions at assistant professor level. This tenure-track policy provides clear conditions for promotion, although it also increases pressure on tenure trackers.

KdVI expresses concerns regarding the numbers of PhD candidates and postdocs. Due to decreased direct funding at university levels, hiring of these staff members depends strongly on success in national and European grant competitions. KdVI strives to attract guest PhD candidates from outside academia and offers them supervision and a working place; examples are TNO and NFI.

Direct funding of KdVI is based on the number of PhD defences, diplomas (MSc and BSc), teaching hours and a flat rate. Next to direct funding, KdVI obtained a number of research grants (2 ERC Advance Grants, 2 VICI grants, NETWORKS programme). Staff is actively encouraged and supported to seek external funding. For the near future, the focus lies on exploring the possibilities for funding within the thematic programmes of Top-sectors and

Horizon 2020, instead of being fully dependent on personal grants. KdVI mentions the challenge ahead to maintain a good balance between fundamental and applied research. Total funding has increased by 1M EUR between 2009 and 2014, mainly due to an increase in (inter)national research grants.

The committee verified that while the number of staff members strongly increased, direct funding did not follow this increase. This has led to a significant reduction in the number of PhD students financed by direct funding. The committee agrees that a balance in funding streams is required in order to have a stable situation in number of PhD students and postdocs. While KdVI did very well in obtaining research grants during the assessment period and there are no signs that this will change in the near future, the balance is tending towards too much reliance on external funding.

The committee supports the tenure-track policy in which young, talented researchers get the opportunity to do research and develop a research group within their expertise. If no PhD student is available from (external) grant funding, KdVI should make an effort to provide one on direct funding.

Another recommendation is to adapt criteria for tenure to the specific situation of mathematics. In mathematics it is very difficult to obtain grants from (inter)national research councils. The committee learned that KdVI adapts the criteria of grant acquisition - even down to the level of subprogammes - to deal with this problem. It advices KdVI to stick to this strategy in order not to lose its appeal to tenure trackers.

## 3.2. Assessment of the SEP Criteria

### Introduction

The AGMP research programme consists of three research groups, *Algebra and Geometry*, *Mathematical Physics* and *Discrete Mathematics*. In 2014 the programme consisted of 14 scientific staff members, 7 postdocs and 15 PhD students with a total of 17.6 research fte. A number of scientific achievements covering a wide spectrum of topics in pure mathematics were described in the self-evaluation report.

The analysis programme consists of two groups, *Pure Analysis and dynamical systems* and *Numerical and applied Analysis*. In 2014 the programme consisted of 7 scientific staff members and 6 PhD students with a total of 6.8 research fte. A number of scientific achievements covering a spectrum of topics in dynamical systems, complex analysis and numerical analysis are described in the self-evaluation report.

The third research programme, Stochastics, consists of two groups, *Probability Theory* and *Mathematical Statistics*. In 2014 the programme consisted of 12 scientific staff members, 2 postdocs and 13 PhD students with a total of 11.2 research fte. Central research themes in the group *Probability Theory* are Probability, Stochastic Process Theory, Stochastic Operations Research, and Mathematical Finance, all of them viewed from an applied as well as a foundational angle. New application areas of the programme include the stochastic analysis of road traffic and energy networks. The research in the subprogramme Mathematical Statistics has both fundamental and applied components. The fundamental work focuses mainly on developing mathematical theory for modern, high -dimensional statistical problems. Applied statistical work is carried out in various domains, in collaboration with domain experts.

**Research quality**

The research done by the AGMP group is of superb quality, with a strong interaction between pure mathematics and theoretical physics (helped by the part-time presence of a world-famous mathematical physicist). Among the many research highlights in this direction one can single out the identification of Eynard-Orantin theory for matrix models with Givental's formal Gromov-Witten theory, an index theorem in the context of noncommutative geometry, major contributions to the sensational "Umbral Moonshine conjecture" relating mock modular forms to Niemeier lattices, and a characterization of the partition functions of vertex models, while on the purely mathematical side one can mention the discovery new applications and aspects of the representation theory of Hecke algebras and a number of impressive results in algebraic geometry.

During the assessment period there were many staff changes. Some staff members left for more senior positions (tenured or full professor) elsewhere, and some very prominent mathematicians retired during or at the end of the period in question. In exchange, there were a number of new appointments, based on a very good hiring policy with priority given to scientific quality, at both the professorial and tenure track levels.

The success of the AGMP programme is reflected in the grants that were obtained, which include a VIDI grant, an ERC starting grant and ERC advanced grants. This also led to a doubled PhD population, which helped the flourishing of the programme. The work of this programme has a strong impact on the academic community world-wide.

The Analysis programme has strong and visible researchers and although the programme has lost one scientific well established researcher, the output has been constant over the years. The committee would recommend hiring some tenure-trackers in this programme.

The Stochastics programme published papers on queuing theory and on nonparametric Bayesian statistics in top journals. The committee considers the programme to have a number of very good researchers who are mid-career and have the potential to further develop into world-leading scientists. During the assessment period the programme also hired two younger researchers who are very promising and who strengthen the areas of stochastic analysis and finance. An endowed chair contributes to research in forensic probability in cooperation with the Netherlands Forensic Institute.

The Stochastics programme is very good and although not yet quite world leading, the committee certainly considers that it is going in that direction. The NWO Gravitation programme NETWORKS, which is led by one of the full professors of the stochastics programme, looks very promising. This programme involves several areas of mathematics, and the committee considers it very positive that PhD students in this project have two supervisors from different areas, which encourages cooperation.

**Relevance to society**

Like all universities KdVI stresses the importance of mathematics for modern society. A clear strategy to strengthen the impact of mathematics is difficult to implement because often there is an extremely long time span between the invention of a mathematical concept and its application outside mathematics, and because often there are several intermediate steps within different areas of mathematics until the applicability of an idea is realized. Within this situation, mathematicians have to consider their strategy on impact on society. Training young people to translate their knowledge and skills into novel opportunities for society while working in industry or other areas of research remains presumably the most important

contribution of mathematics to society, but the committee encourages the institute to devote more energy to direct contributions towards societal challenges. The committee learned that at the level of the institute, KdVI is involved in 'Education development' and 'History of Science'.

The AGMP programme is doing theoretically oriented research, making it more difficult to identify the direct connection to societal relevance, which is clearly not one of the main priorities of this programme. The intense interaction with physics is certainly important for society in the long term, but is not directly aimed at any technological advances. A number of the members of the programme are also involved in outreach activities, like giving public lectures and involvement in advisory activities.

Also for the Analysis programme societal relevance is not the main priority; the focus is more strongly on academic research and impact. Nevertheless, from the self-evaluation report it is clear that some efforts in popularization and outreach are taken, and that a recent appointment in multiscale dynamical systems has prospects for impact in the modelling of climate and power grids.

Although the Stochastics programme has its strength originally more on the theoretical side, serious efforts to increase the direct impact of research are clearly visible. Examples are in financial mathematics, forensic science and climate research. The Stochastics programme has a contract with SURFnet to develop methods for the design and management of high speed networks. Also the NETWORKS programme has a lot of possibilities for more direct relevance, and more could be done to exploit this. The committee considers that the stochastics programme is well positioned for a major impact on society and a lot of their work has potentially high relevance. It recommends that the next step is taken to actually interact even more with other disciplines.

**Viability**

The institute is well positioned for the future with its quality of the research staff and a good age balance. It is involved in all four NWO research clusters which is evidence of its breadth. However, the SWOT analysis by KdVI, which was very well thought out, also touches upon a number of uncertainties that are partly outside the scope of the institute. The strong reliance on external funding gives pressure to continue writing applications and with the uncertainty of success makes it more difficult to prepare for the near future.

Furthermore, the situation of the abandoned merger with the VU has its effects on the future of the KdVI. Although KdVI can be proactive in dealing with this situation, it is also dependent on the Boards of the universities.

In the evaluation of the tenure-track system, KdVI is recommended to look into the support for tenure trackers. Giving them a PhD student financed by direct funding at the early stages of their tenure track might prove to be an excellent investment. Chances are that with the support of a PhD student the tenure tracker develops academically more quickly and that this will lead to higher success rates in grant applications. Also, the committee advises KdVI to set up specific mathematics criteria for evaluation of the tenure track, and make sure not to give an exaggerated weight to the obtaining or just missing of a grant.

Finally, a general challenge for the future is the high teaching load. The sharp increase in student numbers is considered to be positive for mathematics as a discipline, but the budget for teaching has not (yet) increased at the same rate. The committee understands that

changing this situation is not in the hands of KdVI, most likely not even in the hands of the Faculty. Nevertheless, it is important that the Board of the University acknowledges the steep rise of student numbers and provides compensation.

The situation in 2015 for AGMP is one with extremely good people and a sound financial basis. During the assessment period there were many staff changes. Some staff members left for more senior positions elsewhere, and some prominent mathematicians retired. In exchange, there were a number of new appointments, based on a good hiring policy with priority given to scientific quality, at both the professional and tenure track levels.

The Analysis programme indicates in its SWOT analysis that they might be rather small for a successful future. In addition the chair will retire in the next assessment period and the success in external grant applications has fallen behind the other two programmes at KdVI. The committee agrees with this statement and recommends that the programme formulates a strategy on the future of this programme. It is clear to the committee that the analysis programme needs strengthening in order to remain viable. In this respect the committee suggests that complementarities and synergy with the VU be explored.

According to the committee, the Stochastics programme has an excellent future potential. The two leaders of the programme are successful and can develop into world leading researchers. They have a clear strategy for the future. The NETWORKS programme will continue for a number of years and in the recent past good hiring choices were made. These aspects provide the programme with a very solid viability.

**Conclusion**

The three underlying programmes of the KdVI each have their own strengths and challenges. Two programmes do very good research at an international level, and one programme stands out as exceptional.

The programmes still seem to be developing a position and strategy regarding the relevance to society. Taking into consideration that part of the KdVI is focussed on pure mathematics, making a direct link to societal relevance more difficult, the institute is doing very well.

The viability differs between the programmes. While the Stochastics programme has an excellent strategy and position for the future, the AGMP programme has some challenges ahead that can easily be dealt with. The Analysis programme has most challenges, predominantly the small size of the programme. In addition, for all programmes there is the uncertain situation of the future collaboration with the VU. The committee is convinced that KdVI should actively look for ways to connect with VU where synergy and strengths can be gained, and at the same time develop its own distinguishing features.

### 3.3. PhD programmes

Over the review period KdVI hosted an average of 14 regular PhD students per year. A total of 40 candidates received a PhD in the review period; this number includes regular and guest PhD candidates. Between 2006 and 2010 a total of 20 regular PhD candidates enrolled and with the exception of two discontinuations, all but one candidate graduated within five years.

Emphasis of the PhD programme lies on training the student to become an independent researcher either inside or outside academia. The programme comprises three elements:

- developing knowledge and research skills on the specific research topic;

- teaching (on average) 2 tutorials per year in the bachelor's- or master's programme, adding up to approximately 15% of the contract;
- training of personal skills in the trajectory 'mastering your PhD', with an emphasis on developing various skills and focussing on career planning.

Like all mathematics PhD programmes in the Netherlands the KdVI is doing very well in training and supervising its PhD students. The PhD students the committee interviewed made a good impression and seemed to be more than satisfied with their project, training and supervision. The committee has no doubt that these PhD students will all graduate within reasonable time and that their theses will be of high quality. Contact with the supervisor is close; all students have at least weekly meetings with their supervisors.

For most Dutch PhD projects, also at KdVI the research topic for a prospective PhD student is defined prior to the start of the project. However, students indicate that they have sufficient freedom in making changes in the research project to fit their own wishes.

At KdVI PhD students seem to graduate within four to five years and drop-out rates are low. A go/no-go decision is made in a meeting with the supervisor after approximately one year, based on an interview with the candidate. This interview was considered to be informal and was valued by the candidates. The size of the PhD programme looks reasonable. Most of the PhD graduates find a job after 3 months of graduation, which is an excellent outcome.

Most PhD students followed a number of courses, often these were Mastermath courses, but no strict requirements on following courses exist. The committee considers this not to be a problem, since supervisors are closely involved in the development of the PhD students and seem to take responsibility to advise PhD students to follow specific courses.

The committee is positive on the fact that PhD students are involved in teaching, most often they supervise exercise classes in undergraduate courses. None of the students indicated that their teaching load was too high. In fact, most students were positive on getting some experience in teaching.

### 3.4. Research integrity policy

The UvA endorses the principles of the Netherlands Code of Conduct for Scientific Practice and has adopted the Academic Integrity Complaints Regulations. To provide guidance and advise to UvA staff, a University Academic Integrity Adviser has been appointed. If this adviser cannot resolve the complaint, the matter is referred to an Academic Integrity Committee, where a formal complaint is lodged. KdVI policy is to further strengthen the policy of the university by making explicit what the policy means for mathematicians. The ethical code of the European Mathematical Society and relevant parts of the American Mathematical Society are adopted. Both in bachelor's and master's programmes scientific integrity is addressed.

As mentioned in the general chapter of this report, infringement of research integrity and fraud are very uncommon in mathematics. Nevertheless, it is very important to have clearly written-out policy and to communicate it actively to staff, specifically to PhD students and undergraduate students, and the committee commends the KdVI for doing a good job on both points.

### 3.5. Recommendations

General recommendations

- The KdVI should strengthen collaboration with mathematics at the VU, make a joint plan on how to continue. This could for example be done by a joint research strategy. This strategy could consist in agreeing to develop in complementary areas, thus requiring very little coordination beyond a non-competition agreement. For Dynamical Systems and Statistics, which are topics of both universities, it would make more sense to plan cooperation agreements. Also, the strategy can build on the collaboration in education, by joint PhD projects and joint degrees. Some incipient signs of research collaboration already exist, such as joint UvA-VU PhD projects mentioned in one of the self-evaluation reports.
- Training young people to translate knowledge is a laudable route to societal relevance, but it is best achieved by example; thus the institute staff is recommended to get more actively involved in interdisciplinary projects that are of high societal relevance.
- KdVI should try to provide each tenure-tracker with a PhD student to direct research in his/her own area.

Recommendations to AGMP:

- In view of the very successful research being done, it is not easy to make useful suggestions for improving the strategy. The synergy between high-level theoretical mathematics and physics is the great strength that should continue to be emphasised;
- The existing cooperation (with CWI, Tsinghua, Berlin, Paderborn, MPI, etc.) should be continued and extended (perhaps to include England and the US more), since the work being done in Amsterdam is of great international interest.

Recommendations to Analysis:

- It would make sense for the dynamical systems group to plan a formal cooperation with that at VU;
- Develop a specific plan for the desired expansion in Analysis, for example, a prioritisation of areas or a head-hunting plan; develop the arguments that justify the desired expansion.

Recommendations to Stochastics:

- Further intensify the ongoing collaborations with researchers from application areas. A good example is the collaboration with researchers from climate sciences. This recommendation does not imply that theoretical work should be reduced. Collaboration with application areas combined with the strength of this programme on theory side could rise the overall level of the programme;
- Use the opportunities that the NETWORKS programme offers to bring different areas of mathematics to interact.

### 3.6. Quantitative assessment

| | |
|---|---|
| Research quality | excellent (1) |
| Relevance to society | very good (2) |
| Viability | very good (2) |

# 4. Research evaluation Department of Mathematics, Vrije Universiteit Amsterdam

## 4.1. Organisation, leadership, strategy and targets of the research unit

The Department of Mathematics is responsible for the research in mathematics at the Vrije Universiteit Amsterdam (VU). It is part of the Faculty of Sciences (FEW), for which it also provides mathematical courses, and is closely linked to the Faculty of Earth and Life Sciences (FALW) and Faculty of Economic Sciences (FEWEB) at the VU. Its research policy is directed towards finding a balance between applications and the fundamentals of mathematics. This policy has led to a department in which dynamical systems and stochastics (statistics, probability theory, and business analytics) are especially well represented. Many of the researchers are active in multiple themes and the themes have overlap with multiple mathematical disciplines. The department distinguishes the following themes and sub-themes:

- Biomathematics: brain imaging, mathematical biology, population dynamics, statistical genomics, statistics for neuroscience, systems biology;
- Business Analytics: call centres, E-health, health care logistics, operations research, optimization of business processes, queuing theory, statistics;
- Determinism and Randomness: dynamical systems, probability theory, random processes, statistical physics, statistics, stochastic differential equations, forensic science, philosophy, partial differential equations (PDE's);
- Geometric Dynamics: Morse-Conley-Floer theory, percolation, spatial probability, symmetries in dynamical systems, symplectic geometry, variational methods;
- Modelling and Statistics: Bayesian inference, control theory, forensic stochastics, industrial mathematics, mathematical physics, partial differential equations, statistical models;
- Patterns in Complex Systems: coupled cell networks, dynamics in biological networks, high-dimensional statistics, large systems of nonlinear differential equations;
- Shape and Structure: algebraic K-theory, arithmetic geometry, convex geometry, homotopy theory, number theory, symplectic topology, toric topology.

The mission statement of the Department of Mathematics is two-tiered: to perform research on the frontier of mathematical knowledge, motivated by scientific and societal questions and needs, yet emphatically including a fundamental component. Where possible, the department aims for research on the crossroads of fundamental mathematical results and practical questions, exploiting the interplay between theory and applications. It has formulated two research objectives:

- Perform high-quality mathematical research resulting in publications in outstanding international journals.
- Carry out applied mathematical research that is highly relevant to other disciplines and/or society.

The department aims at a balance in staff between fundamental and applied mathematics. Staff members have full freedom to choose their research topics. Diversity in research topics is important, while at the same time a certain focus is aimed for, in order not to spread too thinly on specific themes. This has consequences for the type of researchers that are hired.

The department takes part in all four NWO clusters, in the national research schools WONDER and DISC, and in Amsterdam Data Science, an initiative of the UvA, VU, CWI, and Hogeschool van Amsterdam that brings together leading researchers in data science. It participated in the European collaboration programme CAST (Contact and Symplectic Topology) as an associate member. Research partnerships are almost exclusively based on individual contacts, both within the VU, and nationally and internationally. The department has research contacts with essentially all other mathematics departments in the Netherlands, and with numerous institutes around the world.

The intended merger between UvA and VU was blocked in 2013 and led to a new, bottom-up approach in the science domain. It includes possibilities to intensify and strengthen the collaboration with the Korteweg-de Vries Institute (KdVI) and the Institute for Logic, Language and Computation (ILLC) at the UvA. The committee intensively discussed the consequences of this failed merger, which is clearly a setback for organisation and management of the mathematics departments at both universities. The universities have put both mathematical departments in an unfortunate limbo, unsettling the mathematicians by first proposing a merger and then not continuing with it. Nevertheless, the departments have to find a way to deal with it.

Regarding this merger, the same comments the committee made for KdVI are in order, these comments are recalled here for the reader's convenience. The Dean expressed clearly that currently a bottom-up approach is in place for all disciplines at both Faculties and the onus is on departments at each to explore ideas for collaboration. Some departments apparently are actively seeking collaboration both in research and in education. In mathematics, however, discussions on collaboration at the departmental level are limited to education, though there are informal interactions in research areas like dynamical systems and even a joint appointment. Although mathematics, unlike for example physics, does not need an expensive infrastructure that could profit from joint initiatives between VU and UvA, the committee was disappointed that no efforts seem to be being made in the direction of a combined strategy in mathematical research. This could turn out to be dangerous since other departments within the same faculties are actively pursuing joint research activities and the bottom-up strategy may be abandoned at some point if it does not produce results in Mathematics; it may be replaced by a top-down one which might not take into account the views of the mathematicians. On the other hand, there is a strong ongoing collaboration with the department of econometrics and computer science that has a strong influence on the business analytics curriculum and training. Concerning research, there are joint activities in the direction of business analytics.

Based on the current assessment the committee concludes that both departments do very good research and each has its own strengths. A merger might not strengthen the research in mathematics and could lead to counter-productive disruption. However, the two departments should make an effort to emphasize the fact that they are complementary in many respects, which is currently not clear to an outsider. At the same time a search for common research topics in which synergy can be obtained should also be started. The committee has seen some good examples of this and strongly encourages the departments to continue in a more structured way. The committee recommends that the departments do not sit back and wait, but actively participate in the bottom-up approach instigated by the Dean.

**Resources**

In the period of assessment the number of scientific staff members (tenured and tenure track) of the Analysis, Algebra and Geometry programme decreased from 15 to 11, while the

number of PhD students increased from 8 to 11. The number of scientific staff members (tenured and tenure track) in Stochastics decreased from 17 to 15, while the number of PhD candidates decreased from 16 to 11.

The majority of the staff members are tenured. Roughly 10% of the budget is reserved for flexible decisions whenever needed or wanted, such as employing temporary staff members and allowing young staff members, like tenure trackers, to hire (and supervise) a PhD candidate. The department has four tenure-track researchers, for whom the tenure conditions have been clearly formulated.

The committee supports the tenure-track policy in which young, talented researchers get the opportunity to do research and develop a research group within their expertise. The committee is very positive on the flexible budget that the department uses to support tenure trackers and the policy of giving them a PhD student to supervise. Requirements for tenure are on teaching, research and grant acquiring. The committee applauds the fact that VU provides each tenure tracker with a PhD student to supervise within his/her own area of expertise. This displays support by the VU to the tenure tracker, for whom the PhD student provides support in doing research, developing an academic track record and writing grant proposals. The committee is also very positive regarding the way criteria for tenure are adapted to the discipline. In mathematics it is extremely difficult to obtain grants from (inter)national research councils. Even when a proposal is rated as very good by all assessors, obtaining the grant is not a certainty. The committee agrees with the VU department in mathematics that a very good assessment of a grant application should allow for granting tenure, even if the grant itself was denied. Concluding, the committee compliments the department on their policy regarding tenure track.

The department depends predominantly on direct funding. Next to its direct funding, the department obtained a number of grants. A large number of PhD candidates are paid by industry through the Business Analytics programme. In the near future, the department wants to put more emphasis on European grants.

Total funding has decreased 700 k EUR between 2009 and 2014, mainly due to a decrease in direct funding and fluctuating funding in research grants. The decrease in direct funding is a consequence of cuts in national funding and reduced student numbers at university level. This is considered a problem, since student numbers in mathematics are increasing.

## 4.2. Assessment of the SEP Criteria

### Introduction

The Analysis, Algebra and Geometry (AAG) research programme consists of two research groups: Analysis and Dynamics and Algebra, Geometry and Topology. In 2014 the research programme included 11 scientific staff members, 2 postdocs and 11 PhD candidates with a total of 13.7 research capacity in fulltime equivalents.

The Stochastics research programme consists of three research groups, Probability Theory, Statistics and Business Analytics. In 2014 the research programme included 15 scientific staff members, 3 postdocs and 11 PhD students with a total of 15 research fte in fulltime equivalents.

**Research quality**

The VU department in mathematics clearly changed its organisation and focus from mathematical topics towards research themes. The committee tried to focus on both aspects. On the one hand the thematic approach seems to be a very good basis for collaboration across groups and indeed this was observed in the outcomes of research. On the other hand, to be able to assess the quality of the programmes, the committee focussed on mathematical topics.

Six years ago there were three research programmes in mathematics at the VU. The AAG programme is the result of the merger of two of these programmes, namely Analysis & Dynamics and Algebra, Geometry & Topology. This merger makes sense because the Algebra, Geometry & Topology group has shrunk drastically over the period and was probably no longer viable on its own, and a significant part of the research of the dynamical systems team is oriented to geometry (symplectic), topology (braids, homotopy), or algebra (symmetries); furthermore the work in linear algebra is oriented to dynamics. The quality of the research in dynamical systems is excellent. A question remains, however, how well integrated the remaining algebraists and number theorists are. They are doing good work, but appear to be singletons in the department.

The Stochastics programme has lost a world-leading scientist to another university. The programme was able to replace him with a very good successor in a similar area. Moreover, the programme has consolidated its strength in applied areas, namely queuing theory and business analytics on the one hand and statistics in life science, in particular neuroscience and forensic statistics, on the other. The members of the programme are closely collaborating with researchers from these areas. In addition, there is a very good small group in statistical physics with important publications on properties of the Ising model. The committee had some questions about the strategy of the group in view of the diversity of the topics. However, there are members who actively bridge different topics and thus prevent fragmentation. Overall, the research is of very high quality with internationally well recognised senior researchers, a number of tenured junior staff and two tenure-track assistant professors who started recently.

**Relevance to society**

The department made a strong effort in outreach and working with other fields. This is made visible by the change in strategy from mathematical topics towards research themes bridging disciplines. The themes the programme is now focused on (for example business analytics) certainly have high impact in economics and other areas; these activities are justly listed as a strength. Many publications are joint with researchers from other disciplines. In these disciplines it would be difficult for a mathematician to publish on his/her own. One example is the work modelling glycolysis in which a dynamical systems analysis has explained a fundamental bi-stability of cells between the normal state and one in which glucose is consumed continuously but very little ATP is produced. Another example is the large number of publications in medical and bioinformatics journals with co-authors from the Stochastics group.

Both programmes are explicitly focussing on societal relevance in addition to high quality research. The committee has observed a number of excellent efforts that indeed have led to societal impact. Examples are systems biology, forensic statistics, neuroscience, operations research and business analytics. Concerning the latter, the department is co-founder of the Patient flow Improvement Centre Amsterdam (PICA) and of the Amsterdam Centre for Business Analytics.

In conclusion, the committee was very impressed by the efforts of the department regarding societal relevance and the results that were described in the self-evaluation report.

**Viability**

The SWOT analysis of VU touches upon a number of topics that were also observed by the committee. Some of these topics lie outside the scope of the department to influence, others could and should be dealt with at the level of the department or Faculty. Although difficult to support with clear examples, the committee considers that the department has more strengths than they seem to be making use of. In a way, they are underselling themselves.

Furthermore, the situation of the abandoned merger with the UvA has its effects on the future of the department. Although the department can be proactive in dealing with this situation, it is also dependent on the Boards of the universities.

The committee compliments the department on their tenure-track strategy. They provide tenure trackers with a PhD student as a starting position, putting them in an excellent position to fulfil the tenure criteria. In the long run this approach is expected to give them an advantage and is well worth the investment of a PhD student on direct funding.

Finally, a general challenge for the future is the teaching. According to the discussion during the site visit, teaching is being paid fairly at VU. This is beneficial for the mathematicians that have to teach the strongly increasing number of undergraduate students. This also leads to the fact that other faculties at VU decide not to ask the department of mathematics to do service teaching, they consider it financially more beneficial to do mathematics teaching themselves. The committee agrees with the department that mathematics is best taught by mathematicians, to assure a certain quality. The recommendation to the Board of the University is to investigate in what way the mathematics department can be facilitated to be more involved in the teaching of mathematics at other departments.

Overall the viability is considered to be very good. The AAG programme made a strategy; the plan is to focus on certain areas, discard other areas and look for collaboration in areas where the programme is small.

The viability of the Stochastics programme is considered to be very good. The group has a good size and covers a wide range of topics. With its strength in applied areas it is in an excellent position to play a leading role in the Amsterdam Data Science initiative and to be successful in acquiring research funds. The group has hired a number of young, talented staff to go forward and develop further.

**Conclusion**

The mathematics department at Vrije Universiteit Amsterdam has a number of strengths and challenges. The quality of the research is very good, although for some topics the department is spread rather thinly. The department actively focuses on societal relevance and effects of this policy are clearly visible.

The viability is very good for both programmes. The committee is convinced that the department should actively look for ways to connect with the UvA where synergy and strengths can be gained, and at the same time develop its own distinguishing features.

### 4.3. PhD programmes

Between 2004 and 2010, 54 PhD candidates enrolled in the Department of Mathematics, of whom 48 candidates graduated and 6 are not yet finished. Of the total number of graduates (48), 36 completed their PhD within four years, 11 within five years and 1 within six years.

All PhD candidates work within the national research school WONDER, and they are all connected to one of the national research clusters. According to the VU, the quality of the PhD candidates is foremost guaranteed by the selection procedure. The department allows the best students to proceed in a PhD programme and it solely relies on the knowledge of the individual researchers to select only the best candidates. Most of the candidates publish articles in international refereed journals throughout their PhD period. Candidates initially have a one-year contract, after which they are evaluated. It rarely happens that the contract is terminated after this first year. In most cases, the candidate receives a contract for the remaining three years of the PhD programme.

Like all PhD programmes in the Netherlands the department at the VU is doing very well in training and supervising its PhD students. The fact that none of the PhD students dropped out and completion of the projects is nearly always within the five years, seems to confirm the strategy of hiring the best candidates. When asked their impression on the supervision, students were very positive and all have regular meetings with their supervisors. The committee is positive about the fact the each PhD student has two supervisors.

Although there are no formal courses to be followed, the close supervision of PhD students assures that courses are followed when this is considered useful for the progress of the project. Most PhD students attended a number of conferences.

All PhD students are required to be involved in teaching. Officially this is 15% of their contract, but in reality it is considerably less. They spend approximately one day a week on teaching when they are involved in exercise classes, but they are not involved throughout the entire year.

### 4.4. Research integrity policy

The VU adheres to the principles of the Netherlands Code of Conduct for Scientific Practice as laid down by the VSNU and the Code of Practice of the European Mathematical Society. Furthermore, the VU secures the right to complain if university employees breach academic integrity or are suspected of doing so. This right has been laid down in the VU-VUMC Academic integrity complaints regulation (July 2014). The policy of the department is directed to further strengthen the university's principles and standards by making explicit what research integrity means in the context of mathematics. The most important factors of research integrity are awareness, openness and discussion. Students are being educated in line with the culture and tradition of the department to uphold the standards of ethical behaviour, particularly in relation to the public and dissemination of mathematical research.

As mentioned in the general chapter of this report, infringement of research integrity and fraud are very uncommon in mathematics. Nevertheless, the committee approves that the department has a policy and is actively communicating this policy to its staff, and specifically to PhD students and undergraduate students.

## 4.5. Recommendations

General recommendations

- The department should take a more pro-active approach to the opportunities for research in the Top-sectors, in particular in Life Science and Health where they have already good connections with researchers from these disciplines.
- The department should strengthen collaboration with mathematics at the KdVI, make a joint plan on how to continue. This could for example be done by a joint research strategy. This strategy could consist in agreeing to develop in complementary areas, thus requiring very little coordination beyond a non-competition agreement. However, for dynamical systems and in statistics, that are topics of both universities, it would make more sense to plan cooperation agreements. Also, the strategy can build on the collaboration in education, by joint PhD projects and joint degrees. Some incipient signs of research collaboration already exist, such as joint UvA-VU PhD projects mentioned in one of the self-evaluation reports.
- Business analytics as a mathematical theme is very promising and should be fostered. The already ongoing cooperation with econometrics may give it an additional stimulus with good chances to increase the outreach.

Recommendations to Analysis, Algebra & Geometry:

- This programme needs to assess the viability of its small part in algebra and number theory. Now the programme is predominantly in Dynamical Systems, albeit with strong geometric, topological and algebraic strands. There is a case, however, for strengthening the group in algebra and number theory.
- The programme could take more opportunities in the direction of applications of dynamical systems to societal relevance.
- It would make sense for the dynamical systems group to plan a formal cooperation with that at the University of Amsterdam.

Recommendations to Stochastics

- The programme is recommended to develop a strategy to obtain a leading position in the Amsterdam Data Science initiative.
- The programme has an excellent position to become a partner in an application for a big multidisciplinary research grant in life sciences or management sciences.
- The programme is recommended to strengthen the interactions between more theoretical and more applied research lines in the programme.

## 4.6. Quantitative assessment

| | |
|---|---|
| Research quality | very good (2) |
| Relevance to society | excellent (1) |
| Viability | very good (2) |

# 5. Research evaluation Delft Institute of Applied Mathematics, Delft University of Technology

## 5.1. Organisation, leadership, strategy and targets of the research unit

The Delft Institute of Applied Mathematics (DIAM) is part of the Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS) at Delft University of Technology (TU Delft). The research area of DIAM is mathematics, in particular, applied mathematics. Within DIAM there is a variety of mathematical research, ranging from applied to more fundamental mathematics. DIAM's broad research spectrum is reflected in the following research programmes:

- Computational Science and Engineering (CSE);
- Probability, Risk and Statistics (PRS);
- Analysis (An);

The basis of DIAM's mission statement is that the mathematical sciences are playing an increasingly pervasive role in science and society and that mathematics has become a key enabling technology for innovations that shape modern society. DIAM aims to be a key player in this process by making essential contributions at the forefront of the mathematical research underlying current and future technological innovations. Its objective continues in the same line: to further strengthen DIAM's prominent position as a knowledge institute in a rapidly changing world of education and research.

In 2009, TU Delft began a large-scale, university-wide restructuring operation (the *herijkinsoperatie*) to adjust the financial strategy to the present governmental budget for the university and still be able to invest in new initiatives. DIAM's staff recruitment policy is that 'programme follows people', that is, it tries to find excellent candidates within a broad profile. The new staff, in turn, influences the direction of the research profile. DIAM encourages its researchers to publish regularly in high-quality research journals. Participation in national and international conferences and visits to other universities are encouraged and financially supported. In the past few years, the collaboration between the research programmes has improved substantially.

Over the years, DIAM has succeeded in building up and expanding a strong research network. DIAM has many joint research projects with other departments within the EEMCS faculty and all other faculties at TU Delft. It also leads the Delft Center of Computational Science since 2003. Next to the internal collaborations, TU Delft is also embedded in a national research network. It participates in the J.M. Burgerscentrum, DISC, WONDER and EEMCS graduate schools. In addition, DIAM is involved in 3TU.AMI institute, which is a joint venture of the mathematics departments of the three Dutch technical universities. The research programmes of DIAM are also actively involved in national NWO clusters DIAMANT, NDNS+ and STAR. DIAM maintains much contact with research groups at other Dutch universities. The contacts with Leiden University are particularly extensive. There are more than 50 collaborations with research institutes such as Deltares, KNMI, EURANDOM et cetera. Internationally, DIAM has ample collaboration with renowned universities such as TU Berlin, KTH Stockholm, Oxford University, University of Waterloo, Ecole Polytechniques Paris, ETH Zurich, et cetera.

The committee is positive about the clear focus on applied mathematics, which is combined with a good strategy and is supported, amongst others, by the link with 3TU.AMI. From the self-evaluation report as well as from the site visit, the increasing collaboration between the three research programmes within DIAM was clearly visible.

Focus on hiring excellent researchers and adapting the research programmes according to the expertise that is present, is an effective way of strengthening the quality of DIAM. Nevertheless, the committee recommends to always strive for a balance between hiring an excellent researcher and the coherence of research topics within DIAM.

A specific positive remark is directed at the collaboration with Leiden University; the two universities have complementary strengths and joining forces has benefits for both.

**Resources**

In the period of review (2009-2014), the number of scientific staff members remained stable, and the number of PhD candidates increased from 62 to 70. Since 2013, TU Delft decided to structurally allocate an additional 1.2 million Euros to DIAM for service teaching. This is used to hire additional teaching capacity and to create a little more time for research (and decrease the workload for staff in general). The committee has the impression that it would be beneficial if DIAM could spend more of its resources on research in the future. However, this will only be possible via an increase in the direct funding of the institute.

DIAM receives a substantial amount of direct funding since it provides all service teaching in mathematics for the other faculties at TU Delft. This is considered one of the strong points of the department, but makes DIAM vulnerable to changes in university policy concerning the teaching of mathematics at TU Delft. Next to its direct funding, the department obtained a number of grants (one VENI grant, two VIDI grants, one VICI grant, one NWO Meervoud Subsidy).

The committee applauds the fact that all service teaching at TU Delft is done by DIAM: this strongly shows commitment by the university towards the quality of mathematics teaching. However, financial compensation for this activity has seriously lagged behind the input from DIAM. In the interview with the Dean it was mentioned that the faculty and university promised five fte for educational positions. DIAM would like to have these educational positions matched with four research fte to maintain a viable institute. The committee is of the opinion that 10 new staff members all having both research and educational tasks are indeed needed to provide a stable future, and it encourages the Dean to consider matching the already promised educational positions with research time to hire high quality researchers.

Assistant professors on tenure-track positions are also heavily involved in teaching activities. In general, the committee supports tenure-track policy in which young, talented researchers get the opportunity to do research and develop a research group within their own expertise. Requirements on teaching, research and grant application are part of getting tenure at all universities. However, the way these requirements are assessed is different.

It remained unclear to the committee if all tenure trackers work with a PhD student within their own expertise from the beginning of their appointment, since apparently the department does not provide PhD positions for tenure trackers. According to the committee, DIAM should make an effort to link a PhD candidate to a tenure tracker, as it will help the tenure tracker in doing research, developing an academic track record and writing more successful grant proposals. These aspects are essential in attracting the most talented tenure trackers.

Many other universities offer this support, posing a future threat for DIAM. On top of this, although tenure-trackers have a slightly reduced teaching load, it is still very high in comparison to other universities.

TU Delft has formulated general criteria for tenure; according to DIAM these are not always realistic for mathematics. DIAM has decided to create individual criteria that fit the discipline. The committee is positive about the fact that DIAM can formulate individual criteria for a tenure tracker. For example, the rating of a grant proposal as very good by the assessors does not guarantee that the grant is awarded. The committee believes, as do a number of Dutch mathematics departments, that a very good assessment of a grant application should allow for granting tenure, even if the grant itself was denied.

## 5.2. Assessment of the SEP Criteria

### Introduction

The research programme in Computational Science and Engineering (CSE) covers the mathematical modelling, numerical analysis and optimisation of complex technical and physical systems.

The research programme Probability, Risk and Statistics (PRS) aims at developing fundamental knowledge in the subfields of probability (interacting stochastic systems, financial stochastics & risk) and statistics (nonparametric methods, asymptotics) and enhancing applications of mathematical methods in probability, risk and statistics.

The research programme in Analysis (AN) contributes to the development of novel tools, techniques and methods in the areas of analysis, functional analysis and operator theory, with applications to deterministic and stochastic differential and partial differential equations and other infinite dimensional systems.

### Research quality

The information on the research topics in the self-evaluation report was very limited and apart from the names of the group leaders there was no information about the distribution of the staff between the programmes, making it difficult to assess the quality of the work on the different topics. Actually Delft should be praised for sticking meticulously to the SEP-protocol, but in comparison to other universities the task of the committee has been somewhat harder.

Quality of the output in more general terms can be observed from the 15 highlights, listing publications in top journals in fundamental mathematics, inter-disciplinary journals and research monographs. Many staff members have high quality outputs, but it seems that there is some room for improvement in quantity. Maybe the high teaching load and the resulting restriction in visits to other collaborators harms the productivity. Furthermore, quality can be seen as very high due to marks of recognition such as science awards, best PhD thesis awards, invited key note lectures and international meetings.

DIAM is strong in the production of software and has expertise in a wide range of research topics. The quality of the work is very good, and the strong interdisciplinary and industrial cooperation is an asset, but visibility of some parts of the group could be improved.

In spite of acquiring considerable national grants, the percentage of international grants is reason for concern. The external funding could be improved; it seems that the high teaching

load has significantly tempered the grant application process. DIAM is recommended to professionalise its grant application process, for example with an office that supports the researchers, or in close collaboration with 3TU.AMI.

**Relevance to society**

According to the self-evaluation report, DIAM is primarily a mathematics institute. That is, joint projects with external partners have a significant and non-trivial mathematical component and preferably also lead to contributions of substantial mathematical interest. In addition, there should be room for curiosity-driven research of a more fundamental character supporting and complementing the more application-driven research. Ideally, these strands complement each other in a meaningful way.

The committee unanimously thinks that societal relevance of DIAM is excellent. There are applications to a wide range of areas and a high involvement in relevant projects for society is evidenced from the self-evaluation report, notably to do with water management. Within all of these applications, the quality of the mathematics is preserved. Collaborations with Deltares and Shell and research projects funded by STW are perfectly justified. Furthermore, in the numerical group software products are developed and already used by industry. Courses are provided by DIAM on using the software that was developed.

**Viability**

From the SWOT analysis as well as from the interviews, it becomes clear that the main threat for DIAM is the high teaching load. It clearly results in reduced time for research and grant applications for tenured staff and/or poses a threat to reduced quality of teaching. Both are undesirable. To address this, DIAM makes heavy use of ICT-assisted teaching, which sounds excellent, but it does not completely solve the problem. In addition, the high teaching load is also a burden for the tenure trackers. Although DIAM tries to reduce the teaching load of the tenure trackers, it is still high in comparison to many other universities. The Board of the University acknowledges the high teaching load, which is a very good start to solve this problem. The desired increase in staff with a total of ten new positions that include both an educational and a research component is very important for the viability of DIAM. It will give a strong boost to DIAM.

A minor weakness from the past that will be dealt with by DIAM is the absence of large international grants. DIAM formulated a strategy for getting mathematics into large projects, which includes carefully monitoring which staff members are eligible for grant applications at a certain moment and subsequently supporting them in the application. The committee strongly encourages this and recommends to put even more emphasis on supporting these grant applications by people who understand the specifics of mathematical research and can reduce the workload of the researchers. This support should be provided to both senior staff as well as to tenure trackers.

Like many other universities, TU Delft has a Data Science centre which is situated in the faculty. The committee has the impression that Computer Science is leading in this initiative. For instance, the Data Science and Technology Track is part of the MSc in Computer Science, and the only concrete activity mentioned in the self-evaluation is a master course on 'Mathematical Data Science'. The committee thinks that data science provides excellent opportunities for DIAM and it urges DIAM to be more proactive in taking a leading role in (parts of) this initiative.

DIAM seems in a very good place to continue growing, based on its wide and solid ground of research topics, and its collaborations, which may also bring complementary expertise. The increasing number of students should be seen as a blessing and an opportunity for DIAM to be assertive, being the only teaching source for mathematics in Delft. From the site visit the committee concluded that DIAM is in an excellent position for acquiring funding at an international level and also nationally within, for example, the Top-sectors. The balance between a strong link to applications on the one hand, and fundamental mathematics and curiosity driven research on the other hand should be exploited by DIAM.

**Conclusion**

DIAM has a very good track record in doing high quality research, in particular during the evaluation period. Strategy, activities and results concerning societal relevance are impressive and the committee has no suggestions for further improvement. Regarding grant application, there is a good strategy in place and the committee expects that larger and more internationally oriented grants will be acquired. In order to have an excellent viability, the issue regarding teaching load has to be dealt with in a structural way. Promising steps have already been taken, now the time has come for DIAM to be rewarded for its input.

### 5.3. PhD programmes

A total of 64 PhD students received a PhD during the review period. Most candidates successfully complete their PhD, but not within four years. The Faculty Graduate School aims to monitor and control the PhD duration. PhD students have an initial evaluation meeting after 6 months and a go/no-go review and decision after 12 months. Formal progress reviews are held at the end of the second and third year. At the end of the fourth year, the thesis and propositions need to be submitted for a plagiarism check and then approved by the supervisor(s), co-supervisor(s) and an external committee. At the end of the PhD programme, candidates have an exit interview.

The results on PhD graduation indicate that students take a long time to graduate, and the number of students who began in the period 2006-2010 and who discontinued or have not yet graduated is rather high. In this respect improvement is required. At the same time, from the self-evaluation reports it became clear that TU Delft has the highest number of PhD students per staff of all mathematics units participating in this review. This high number of PhD students requires a more strictly regulated process of supervision and training.

The committee met with enthusiastic PhD students who seemed very content with their position and supervision and all expect to graduate within four to five years after starting. The go/no-go decision is formal, with a presentation by the PhD student, assessment of the portfolio and discussion on future plans. In combination with the graduate school that was introduced in 2011 the committee has full confidence that graduation rates will improve.

Officially the teaching load for PhD students is 15% of their contract, in practice it often takes less time. In addition to the general courses from the graduate school, PhD students have ample opportunity to follow courses within their own expertise.

The one point that could be improved according to the PhD students is the way PhD students from the three underlying research programmes interact with each other. The fact that the PhD students are on different floors of the building is claimed to be a major reason for the limited contact. PhD students suggested that a joint seminar would be welcome. The committee recommends to DIAM to facilitate and stimulate initiatives from PhD students.

## 5.4. Research integrity policy

TU Delft has made significant efforts to raise awareness about plagiarism and the proper reporting of experimental results, conflicts of interests, administrative integrity, security and undesirable behaviour. At the university level, the code of ethics has been actualised (October 2012) with a roadmap to make it practically operational. Furthermore, the following measures are in place:

- All academic staff report part-time assignments/affiliations in order to be transparent with respect to potential conflicts of interest in their research;
- An independent scientific integrity committee/conflict of interest committee was installed;
- The mandatory PhD start-up course includes a half-day module on scientific integrity;
- As of 1 January 2015, a plagiarism check of PhD theses is compulsory;
- Since 2010, the faculty's direct funding is no longer dependent on the quantity of the output of scientific papers (weighed by impact scores of journals).

As mentioned in the general chapter of this report, infringement of research integrity and fraud are very uncommon in mathematics. Nevertheless, the committee approves that TU Delft has a policy, and that this policy is actively communicated to staff members, specifically PhD students and undergraduate students.

PhD students mentioned that the integrity part of the start-up course was very helpful in the awareness on this topic. The committee considers that an institute like DIAM, with many contacts and collaborations with industry, should pay additional attention to the integrity aspects of these interactions. More specifically, all aspects on communication, sharing and publication of 'shared' data with industry are important with respect to integrity.

## 5.5. Recommendations

- DIAM should continue to make efforts to keep the balance between research and teaching and at the same time between fundamental and applied research. The department is recommended to support the researchers in their attempts to acquire more research funding in particular at the international level. The university should support this development by proceeding with its plan to hire a substantial number of staff members (10 new positions) to decrease the individual teaching load.
- The tenure-track programme deserves more support, in particular by reducing the teaching load for starting-tenure trackers and by providing them with better support in writing proposals.
- DIAM is recommended to formulate a strategy on the Top-sectors. DIAM is involved in several of the Top-sector areas (e.g., Water) but there did not seem to be a strategy on this.
- DIAM should increase its involvement in the Delft Data Science centre.

## 5.6. Quantitative assessment

| | |
|---|---|
| Research quality | very good (2) |
| Relevance to society | excellent (1) |
| Viability | very good (2) |

# 6. Research evaluation research unit Mathematics, Eindhoven University of Technology

## 6.1. Organisation, leadership, strategy and targets of the research unit

The research unit Mathematics is a sub-department of the Department of Mathematics and Computer Science (M&CS) at the Eindhoven University of Technology (TU/e). It is inspired by questions of scientific, technological and societal relevance, and driven by curiosity. Throughout the research unit, fundamental and applied research fruitfully feed each other with questions and answers. The research unit Mathematics comprises three research programmes:

- Center for Analysis, Scientific Computing and Applications (CASA);
- Discrete Mathematics (DM);
- Stochastics (STO).

The M&CS department's mission statement is as follows: to advance mathematics and computer science by conducting ground-breaking scientific research, educating first-class students and by transferring results to practice.

In 2014, the M&CS department launched four research themes, free from boundaries between mathematics and computer science and their sub-disciplines, to address great scientific and societal challenges that require an interdisciplinary approach. The four themes are data analytics, algorithmics and stochastics, systems and software, and computational science. The themes yield a strong cohesion and cross-fertilisation between all mathematics and computer-science chairs within the department, and enable a pro-active response to external developments.

Alongside this thematic focus, the department has several other future strategies which aim to further develop cross-disciplinary research. It is very keen on a good balance between fundamental and applied research, it maintains an up-to-date overview of the research talents among its student population, and it actively prepares the cross-disciplinary research themes for strategic research opportunities outside the department and university. The most promising current opportunity is data science. In addition, the department strives not only for growth in quality but in quantity as well.

The department is involved in STAR, DIAMANT, NDNS+ and NETWORKS, and it is part of the 3TU.AMI institute. The latter is a joint venture of three Dutch technical universities. The recent preferred partnership between Utrecht University and TU/e is promising. There is a fruitful cooperation between TU/e and CWI. The EuroTech Universities Alliance is a recent strategic partnership of the Technical University of Denmark, Ecole Polytechnique Fédérale de Lausanne, the Technische Universität München and the TU/e. On a personal level excellent research cooperation exists with many individual researchers abroad, both in academia and industry.

The research unit Mathematics in Eindhoven is one of two sub-departments in M&CS. According to the committee this seems very beneficial in the interaction between the research staff and the management at Eindhoven. Within the department there is continuous attention for the balance between fundamental and applied research. Also, there is an integrated approach of bringing mathematics and computer science together by the introduction of the

four overarching research themes, bridging the two disciplines. One example that was given is the Data Science Centre, which is led by both mathematics and computer science. The committee is very positive about the current collaboration with Tilburg University in mathematics for social science, more specifically the MSc programme in Data Science and Entrepreneurship, for which Tilburg's input on economics and law has been crucial.

**Resources**

In the review period (2009-2014), the number of scientific staff slightly decreased as did the number of postdocs, while the number of PhD candidates increased from 55 to 66. The research unit applies the YEPP, the Young Excellently Performing Professionals programme, to scout, coach and preserve young research talent.

Total funding has decreased by 831 k EUR, between 2009 and 2014. This is the result of less contract research in the latter years, while direct funding as well as funding from both national and international grants increased. The percentage of national and international grants that contribute to the total funding, such as several VENI, VIDI, VICI and three ERC grants, has also increased.

During the site visit it became clear that the high amount of direct funding – more than double the amount of most universities – for universities of technology, like Eindhoven, has to do with the high amount of service teaching. For example, in Eindhoven the Mathematics department is responsible for the Calculus course that is followed by over 2000 first-year bachelors' students. Moreover, over the evaluation period the research unit Mathematics at TU/e obtained the largest amount of national grants of all participating mathematics departments and the second largest amount of international grants.

The research unit Mathematics in Eindhoven is the only one with a project development office (PDO), supporting researchers in grant application, contacts with industries and other potential users. Usually, grant writing support is provided at the university level, or, in the best cases, at the faculty level. PDO, however, has a more targeted approach. It provides direct support to applicants through project managers with experience in mathematics research and deep understanding of the project's details. Thus, it provides tailor-made support to each specific project. The committee considers this an excellent idea despite the required investment of 3 fte for two sub-departments. This investment seems very well justified since it removes a huge administrative workload from the researchers, who can focus on the content of the application rather than the paperwork. Indeed, the proven success of the department in grant applications and contract funding is hard evidence of the fact that PDO has been and will continue to be worth the investment.

According to the committee the department has a very good and formalised hiring strategy. YEPP is a programme for scouting research talent at an early stage and not only at Eindhoven University of Technology. Talented young staff is usually hired on a tenure track assistant professor level.

The committee supports the tenure track policy in which young, talented researchers get the opportunity to do research and develop a research group within their expertise. It welcomes in particular the fact that tenure trackers will obtain the ius promovendi at the associate professor level, thus giving them greater independence and visibility through their own PhD students. The committee learned during the site visit that criteria for tenure differ between universities as well as the support that is given to tenure trackers. The committee is positive about the criteria in Eindhoven.

In Eindhoven tenure trackers are appointed for 4-5 years and criteria on research, teaching and funding are set to be able to get tenure. According to the management interview there is some flexibility on fulfilment of the criteria. For example, grant acquisition is a requirement, but not only personal grants are counted, successful joint applications are also valid. In the interview it was clearly stated that tenure trackers are supported intensively to be able to satisfy the criteria.

Although there are no immediate signals that the successful application of grants is a problem for tenure trackers, the committee recommends that the department should not wait until a problem occurs, but already now consider the consequences. Even when all assessors rate a grant proposal as very good, obtaining the grant is not a certainty. The committee believes, as do several Dutch mathematics departments, that a very good assessment of a grant application should allow for granting tenure, even if the grant itself was denied.

At the moment of evaluation many PhD students were funded on grant and contract funding, but the direct funding of PhD students was terminated. Although the current situation allows for plenty of PhD students on grant and contract funding, having directly funded PhD students will provide stability. Too much reliance on external funding is risky and provisions should be made.

The research unit seems to be one of the few that has a presence in the Top-sectors through Shell-NWO/FOM program Computational Sciences for Energy research. This collaboration with Shell in the Top-sectors is associated with about 70 PhD students and 8 tenure trackers.

EURANDOM, the workshop centre based at the Stochastics Section of the Department, has an extensive workshop and visitor program. Each year around 8 workshops are organized; as well as many seminars and/or lecture days. These bring together a sizeable group of national and international researchers.

Another important resource stems from the NWO Gravitation Program NETWORKS, in which both mathematics and computer science participate, together with partners from the University of Amsterdam, Leiden University and Centrum Wiskunde & Informatica (CWI) in Amsterdam. NETWORKS is a multi-M€ research program with an about 50% budget share of TU/e's Department M&CS.

From the self-evaluation report and the interview during the site visit, it became clear that the teaching load is too high. The strong increase in undergraduate students, both in mathematics and other programmes at Eindhoven University of Technology, has led to a situation that is unacceptable. The committee was pleased that the Board of the University has also come to this conclusion and has provided additional funding to the M&CS department of 10 fte.

## 6.2. Assessment of the SEP Criteria

### Introduction

The aim of the research programme CASA is to develop analytical and numerical methods for a wide range of science and technology applications, with scientific computing, applied analysis and mathematical image analysis as the three main research lines.

The mission of the Stochastics (STO) research programme is to develop and analyse mathematical models and techniques in the areas of probability, statistics and stochastic operations research.

The Discrete Mathematics (DM) research programme aims to develop mathematical techniques and algorithms in the areas of algebra, geometry, cryptography and combinatorial optimisation.

**Research quality**

In the evaluation period CASA has been doing extremely well in combining fundamental research with a clear position towards industry and societal relevance. The research programme has a clear view and strategy on where to go in the wide area of computational science. The focus is on a number of themes, like energy, lighting and biomedical images. The renewal of many positions has led to higher visibility of the research programme while retaining cohesion and keeping a right balance between fundamental and applied research. The strengthening of international and interdisciplinary cooperation as well as the external funding is right on track. CASA is particularly strong on developing numerical methods for medical imaging and reactive flows.

In the STO research programme there are a number of excellent researchers in probability, making the department internationally very well recognised. They work mainly in queuing theory and statistical physics, with a good balance between fundamental and applied research. In statistics, important results have been obtained for compressed sensing problems, and a new chair works on biostatistical applications, with publications mainly in medical and biological journals. Compared to probability, statistics is a small group and an additional hire would be desirable. Cooperation between different members of STO occurs mainly through the NETWORKS programme. This programme allowed to hire assistant professors and to keep a senior staff member after retirement. It offers also opportunities to include and strengthen the research in statistics.

STO is strongly involved in the Data Science Centre. This is a very exciting project and the collaboration with Tilburg University offers interesting possibilities to build bridges to economics and management. Although funding for this project is not at all a problem, the committee recommends STO to carefully consider using their resources, since a lot of work both for teaching and for administration could be generated.

DM is also considered to be a programme that influences research worldwide in discrete mathematics, algorithms and cryptography. The publications by the programme are of very high quality. In the evaluation period a number of very impressive researchers were hired to replace researchers that were leaving. Evidence of this high quality is provided by the five highlights listed for DM, which include internationally awarded papers. DM produces high quality outputs in areas such as algebraic geometry, finite geometry, cryptography and graph theory. More evidence is provided by the fact that DM members have an excellent record in personal grants, scientific awards, invited lectures/plenary talks, and editorships at highly ranked journals.

**Relevance to society**

The committee compliments the research unit on the large number of industry cooperation and the high mathematical quality of work that is done in such cooperation. The committee considers also very positive that mathematics at TU/e has been able to participate in some projects from the Top-sectors. Funding of research by industry often leads to reduced quality of the research. The committee compliments the research programmes on remaining the high quality of work that is done on industry funding.

In CASA many efforts were made to increase relevance and transfer of research outcomes. The programme has been highly successful in this respect and has increased the level of cooperation with other actors in society, in particular industry. Applications and industrial collaboration are excellent. A number of products are already being used, indicating that the strategy to go into this direction and having a technology science park next door, has been very successful. LIME can be given as an example, which is a consultancy group that grew out of the industrial consultancy activities of CASA.

STO focuses on combining fundamental research with applied mathematical problems. The high societal relevance of research by members of STO is reflected in publications in top journals from other fields than the core discipline and in a part time position of a member at Alcatel-Lucent. Another impressive example of an activity with high societal relevance is the fact that Eindhoven is not only participating in the Data Science Centre, but has a leading position in this centre. In addition there are many outreach activities by members of STO, with appearances in the media.

DM collaborates with the Department of Computer Science, as well as with the other research area STO. DM is also active on a variety of topics that lead to societal relevance, like cooperation with industrial companies, spin offs and software products. The programme contributes to the solution of crucial problems in society. For example, spin-offs like Sowiso are clear examples of how the research contributes both in long-term and in short-term to society, facilitating transfer of technology. Examples of relevance include (i) the development of an elliptic-curve-based signature scheme which is currently under consideration for internet-wide deployment, (ii) the optimization of various cryptographic/cryptanalytic algorithms based on advances in computer architecture, and (iii) the discovery of statistical biases in the RC4 stream cipher.

**Viability**

CASA has undertaken many activities in the recent years to allow for an excellent future. Hiring of new staff members at various levels of their career was successful and seems the result of an excellent strategic planning and good view on the strengths and weaknesses of the research programme.

For STO the strategy emphasises very strongly the applied side of mathematics, with a focus on the themes Data Analytics and Algorithmics and Stochastics. At the moment the committee observes an excellent balance of applied and curiosity driven research in probability theory. Keeping this balance will be very important for the long-term success of the programme. There are ambitious plans to expand both research and education in Data Science through the Data Science Centre. It will be a challenge for the staff to manage the additional work involved, but it offers also many opportunities for interesting research projects and recruitment of excellent students.

DM is the smallest of the three research programmes and due to financial setbacks concerning the entire department, one of the retiring full professors was not replaced. However, during the site visit it was mentioned that at present a new senior researcher in pure discrete mathematics is looked for as well as a number of more junior staff. The optimisation vacancy was recently filled and for the entire research programme the situations is rapidly improving. Care should be taken for ensuring that the teaching and supervision load of the DM members is not too high, so that the current level can be maintained.

All three research programmes benefit from the YEPP programme, enabling them to identify and nurture research talent. The only threat for the Eindhoven research programmes, as was mentioned before, is the high teaching load. The commitment of the Board of the University with respect to direct funding for staff to deal with the teaching is crucial for the viability of the mathematics programmes.

The Eindhoven self-evaluation report was one of the few universities that indicated the Top-sectors as an opportunity rather than a threat. The committee appreciates this positive approach towards the Top-sectors, specifically in relation to the Top-sector Energy. It considers that this proactive and optimistic approach will be more successful in the long run compared to complaining that Top-sectors do not fit mathematics.

**Conclusion**

With respect to the quality of research Eindhoven has three programmes that all are doing research at the highest international level. Excellent hiring strategies allowed for continuing research at the same level throughout the evaluation period. With the support of PDO, grant applications and collaborations with industry were successfully applied for, leading to a high number of PhD students and a thriving mathematics department.

The department manages to combine fundamental research questions with a very active approach towards the application of its outcomes. In addition the committee believes that researchers are well equipped to adopt problems that come from society. The PDO strongly improves the connections between the researchers and society / industry.

The future in mathematics at Eindhoven University of Technology looks extremely bright. The only potential worry is the high teaching load that has not yet been completely resolved. However, the Board of the University has acknowledged this issue and has promised to provide more direct funding for hiring staff to reduce the teaching load. Nevertheless, with further growth of student numbers, this aspect should be closely monitored.

### 6.3. PhD programmes

A total of 71 PhD students received a PhD during the review period. Roughly a quarter of the candidates completed their PhD within 4 years, but the majority took at least 4.5 years. PhD candidates may be scouted internally, within the master's or bachelor's programme, or may be internationally recruited. PhD positions are funded by NWO, other national organisations, European organisations, industry and TU/e itself.

PhD candidates first get a one-year contract. Shortly before the end of this contract, a formal evaluation takes place. A negative evaluation leads to a termination of the contract, while a positive evaluation leads to an extension with another three years. During these remaining three years, there are annual evaluations in which the performance is assessed and points for improvement are identified.

In the evaluation period graduating in time was not a priority at the department, more emphasis was on the quality of the work. Although the committee supports focus on high quality thesis work, the department should actively support PhD students to graduate in time. This will be a challenge, specifically with the growing number of PhD students, and the variety of research topics they work on.
During the site visit, the PhD students gave a very good impression. They were positive about the supervision and also active in organizing themselves. Two years ago, they have set up a PhD Council that organizes workshops and represents the Eindhoven PhD students in the

national organization of PhDs. With exception of the go/no-go decision after 12 months, contact with the supervisor is very informal, though frequent. The setting up of a graduate school is considered a positive development, although it was not relevant to the PhD students the committee talked to. The choice of courses that could be followed was done in close consultation with supervisors. Only one course was mandatory, which was on research integrity and was well liked. The students run a mutual help system, where any student can pose a question and others suggest answers. This sounds excellent.

PhD students have teaching obligations of a total of 600 hours. Most choose to do the majority of teaching in the first and second years of their appointment. During these years teaching takes up quite a lot of time, but the experience is valued.

The Impulse Program may be good in the short term for alleviating the need for PhD funding, but it may be counterproductive in the long term, because it may favour applied driven research at the expense of curiosity driven projects. A long-term policy (or a change in the requirements of this program towards fundamental research) needs to be implemented to ensure a good balance between both paradigms. Currently, the performance of the PhD programme, in terms of quality and quantity, seems excellent.

In view of the high quality (and high quantity, a total of 55 PhD students enrolled between 2006 and 2010) of the PhD theses produced in the review period, the organization of the PhD programme, and the policies ensuring the quality of the projects seem adequate, and are working very well. The high quality can be confirmed from the high number of prices received by PhD students between 2009 and 2014, in areas ranging from fundamental to applied mathematics. The review policies regarding PhD students seem adequate.

### 6.4. Research integrity policy

The research unit Mathematics follows TU/e's Executive Board in its pro-active approach of academic integrity. The Executive Board has appointed a TU/e-wide Advisory Committee for Academic Integrity, in which each department is represented by a staff member. Besides this advisory committee, a Central Committee for Academic Integrity has been appointed, as a consultation body in case of actual misconduct. In addition, a TU/e-wide code of conduct has been composed, which is fully in line with the Netherlands Code for Scientific Practice, but specific for TU/e, particularly with respect to industrial research contacts. Currently, plans are being developed for centralised data storage systems. Algorithms might also be stored there.

As mentioned in the general chapter of this report, infringement of research integrity and fraud are very uncommon in mathematics. Nevertheless, the committee considers it important that Eindhoven has a policy and that this policy is actively communicated to staff members, specifically PhD students and undergraduate students.

Having an Advisory Committee in which all disciplines are represented is important, since different disciplines have different needs, approach and requirements in terms of academic integrity. The existence of a Central Committee ensures that the staff members have a body to consult in the situation of need. Paying special attention to the case of industrial contracts seems extremely relevant given the large number of these contracts, in which integrity has to have a clear priority over profit. The goal of making all outputs freely available is commendable and it reflects the current tendency in many internationally respected universities.

### 6.5. Recommendations

- The research unit is doing an excellent job in all aspects. The strategic path with the emphasis on high-tech applications while keeping a strong position in fundamental research should be continued. However, the concerns by the research unit regarding the increase in workload due to teaching and PhD supervision are justified. Hiring of new high-quality staff with some experience both in teaching and in supervision may be needed to ensure the current level of quality and productivity. The issue of teaching load should also be given careful consideration in the involvement in the Data Science project.
- A possible threat in the long term could be the prioritization of applied topics at the expense of fundamental research. This may be avoided by properly expanding the staff so that there is the correct balance between teaching and research, and the quality of the output is maintained.
- Apparently, there have been no PhD students on direct funding since 2011. This should be re-established, at least for new tenure trackers, who should be enabled to have their own PhD student within their own area of expertise.
- Efforts should be made to enlarge the statistics group in STO and to foster interactions of statistics with other projects in the programme.

### 6.6. Quantitative assessment

| | |
|---|---|
| Research quality | excellent (1) |
| Relevance to society | excellent (1) |
| Viability | excellent (1) |

# 7. Research evaluation of the Johann Bernoulli Institute of Mathematics and Computer Science, University of Groningen

## 7.1. Organisation, leadership, strategy and targets of the research unit

The Johann Bernoulli Institute of Mathematics and Computer Science (JBI) is part of the Faculty of Mathematics and Natural Sciences (FMNS) of the University of Groningen (RUG). Head of JBI is the scientific director who reports to the dean and the faculty board.

Unlike other Dutch universities, RUG offers bachelor's and master's programmes in both mathematics and applied mathematics. This educational position is reflected in its two separate research programmes:

Mathematics: this research programme covers two research lines, one in dynamical systems, algebra, geometry & mathematical physics (DAGM) and one in statistics & probability (SP);
Applied Mathematics: this research programme covers two research lines, one in systems, control & optimisation (SCO) and one in computational science & numerical mathematics (CSNM).

JBI's mission is to perform outstanding academic research and teaching in mathematics and to maintain international leadership therein, to foster mathematics as a living body of knowledge, and to make it relevant to society in its broadest sense. As an important part of this mission JBI aims to transfer its results to other areas of science and technology. The symbiosis between pure and applied mathematics, and between mono- and multidisciplinary research and teaching, is described as a distinguishing characteristic.

The strategy for the reporting period, as well as the strategy for the upcoming period (outlined in 'The JBI Faculty Hiring Plan 2015-25'), covers four (partly overlapping) aspects:

- strengthening the overall discipline of mathematics;
- building on JBI's strengths;
- exploring new opportunities;
- tackling current weaknesses.

The current strategy, which will largely be continued in the upcoming period, puts emphasis on increasing cooperation with scientific partners from other disciplines within the FMN and RUG (e.g. ENTEG, UMCG), and outside of Groningen (e.g. IMAU, MARIN, NLR). JBI's hiring policy reflects the strategy of cross-fertilisation, which is thought to help increase research funding for mathematical research. It is stressed that over the review period, JBI was heavily involved in setting up the faculty-wide research theme 'Data Science and Systems Complexity', which provided new opportunities for collaboration with the computer science section of the JBI. During the coming period, existing collaborations will be strengthened, especially within the university focal areas 'Energy' and 'Healthy Ageing'.

RUG is internationally known for its research into dynamical systems and systems & control. The self-evaluation report states that the 'Systems profile' of JBI has been enhanced in various ways during the review period, and will be further strengthened in the coming period, for example by strategic appointments. The systems profile is emphasised in the Faculty hiring plan 2015-2025.

The self-evaluation report indicates that, because of JBI's relatively small size, there is a risk of research lines becoming too attached to individual researchers. During the review period this was countered by strengthening the thematic focus points of the research, as opposed to striving for a more uniform, but necessarily thin coverage of the whole discipline. In the coming period the institute hopes to grow moderately. Also, the institute hopes to remedy the limited success in obtaining personal grants by stimulating collaboration and proactively attracting potential candidates for personal grants. The new financial allocation model will reward teaching efforts more proportionally.

Mathematics in Groningen is a founding member of the NWO cluster NDNS+, and participates in the NWO clusters STAR, Diamant and GQT. RUG also participates in the national research school WONDER, and is an associated partner of AMI (Applied Mathematics Institute of the three technical universities).

The committee concluded that Groningen has one of the smaller mathematics sections in the Netherlands and it was surprised that it nevertheless divided its research activity into more research lines than any other university. Of the four research lines, only one had more than 2 research fte of scientific staff in 2014. The divisions between some of the underlying research lines seemed artificial and are probably the remains of the past. The aforementioned risk of research lines becoming too attached to individual researchers is indeed high with only one or two full professors or even none in a research line. In addition, Groningen is the only university that provides educational programmes both in mathematics and in applied mathematics, leading to another dichotomy in research programmes. The small research lines are considered to be more vulnerable to external changes. The committee does not want to dictate any specific changes, but strongly suggests to the institute to review the current situation and explore possibilities concerning joining groups and/or moving staff members around to create larger groups.

**Resources**

During the review period the number of tenured and tenure-track staff has remained stable at around 17 staff members (which equals 7 research fte's). The number of PhD candidates increased from 32 to 41. This is partly a result of the growing numbers of external scholarship PhD candidates, who made up almost 30% of the PhD population at the end of the review period. The faculty reportedly has an active policy for recruiting scholarship PhDs in China and Latin America.

The annual research budget has remained stable around 3.000 K€. Direct funding remains the most important source of income. The average share of contract research is negligible at 3%. In the coming years, JBI plans to shift the funding targets from national to European funding opportunities, such as Horizon 2020. According to the self-evaluation report, JBI will pursue participation in large consortia to obtain such funding. JBI will also invest in the support system for researchers who write grant proposals. So far, its researchers have had limited success in acquiring NWO VENI/VIDI/VICI grants and ERC grants.

Increasing undergraduate student numbers and a faculty-wide hiring freeze in 2011-2012 have left JBI understaffed for a considerable time. As a result, the teaching load for scientific staff members was high, particularly for thesis supervision. In the coming years, JBI hopes to benefit from a newly introduced, more transparent allocation model (which is among others based on credit points earned by teaching and the annual number of PhD defences), and increased direct funding. As part of its strategic hiring plan 2015-2025, a new position for a tenure-track assistant professor will be opened soon.

During the site visit, the committee also discussed the teaching load with delegations from JBI. It is expected that the new allocation model will lead to hiring new staff, which will subsequently reduce the teaching load. From the interviews it became clear that negotiations on filling four more positions - that are the outcome of this new allocation model - are not yet completed. The committee encourages JBI and urges the Board of the Faculty to come to a swift agreement on these positions in order to hire new staff members on a short time-scale.

A tenure-track policy has been in existence at the FMNS since 2001 and is described as very helpful in 'attracting promising and ambitious young researchers'. However, the faculty-wide tenure criteria for acquiring external funding may be too strict for the field of mathematics. The committee extensively discussed the tenure-track system in Groningen. In principle the committee supports the tenure-track policy in which young, talented researchers get the opportunity to do research and develop a research group within their expertise.

At all universities criteria to get tenure are formulated in three areas "teaching", "research quality" and "grant applications". In Groningen criteria to get tenure are uniform throughout the faculty which comprises many different disciplines, amongst which are funding criteria. The faculty policy is that a tenure tracker should have actually obtained a substantial grant, which is very difficult in mathematics. A number of other universities in the Netherlands consider a proposal that has received a very good evaluation by the reviewers to be sufficient for the criterion "grant applications", even if the grant itself was denied. In Groningen this is currently not the case, which is an undesirable situation and the committee strongly advises the Faculty Board to reconsider the uniform criteria and make them more flexible and fitting to the discipline of the tenure tracker. Otherwise, there is the chance of JBI losing its appeal to candidate tenure trackers to other universities in the Netherlands.

The committee is positive on the fact that, although there is no formal policy according to the interview with staff, all tenure trackers get a PhD student on direct funding. This will help the tenure tracker in doing research, developing an academic track record and writing grant proposals.

## 7.2. Assessment of the SEP Criteria

### Introduction

The research programme in Mathematics consists of two research lines, *Dynamical Systems, Algebra, Geometry & Mathematical Physics* and *Statistics & Probability*. Stochastic systems and networks form a common theme in both research lines. In 2014, the first group (DAGM) consisted of 9 scientific staff members, with a total of 3,7 research fte. The second group (S&P) consisted of just 2 scientific staff members, with a total of 1,1 fte.

The research programme in Applied Mathematics consists of two research lines, *Systems, Control & Optimisation* and *Computational Science & Numerical Mathematics*. In 2014, the first group (SCO) consisted of only 3 scientific staff members, with a total of 1.2 research fte. The second group (CS&NM) consisted of just 4 scientific staff members, with a total of 1.9 fte.

### Research quality

Within the mathematics research programme, DAGM is the larger of two research lines (and the largest in the mathematics section overall) and it seems to be a stable, internationally visible research line. The geometry and topology group works on dynamical systems and bifurcation theory, the mathematical physics group on transport problems and on the geometry of differential equations, the stochastic systems group on statistical mechanics. The

research of this group led to high quality papers and to international recognition. There is only one algebraic expert in DAGM, which is a vulnerable situation. In the interviews it became clear that JBI agrees with this, too limited expertise being present in algebra, geometry and topology. The committee concurs with the priority to hire an additional researcher in this area.

The second research line in the mathematics research programme, SP, is the smaller of the two, with only one full professor and since 2013 one tenure tracker. Both work in the area of high-dimensional statistics with biological applications, and the committee thinks that this group should rather belong to the applied mathematics programme They have published in very good journals and are recognised internationally. The small size of the research line makes it more difficult to excel. Probability theory is represented not in this research line, but in DAGM with the topic of interacting particle systems.

With respect to the applied mathematics research programme, the first research line, CSNM, was led by an internationally well-established researcher in the evaluation period. His activities strongly strengthened the group and led to a number of high quality papers. After his retirement the research line is left without any full professor and has become very small with only three tenured staff members. This makes the group vulnerable.

The second research line of the applied mathematics research programme, SCO, although also very small, is visible world-wide and includes some of the leading figures in the field. The researchers are extremely well cited and have obtained very good funding support. They have made – and still make – major contributions to the field. With two full professors, both very visible at an international level and with a high quality publication on breakthroughs in the area, the research quality of SCO has been excellent.

The quality of the research in optimization theory is very high and has some excellent and very original outputs. Due to the loss of some staff, the current expertise in Mathematical Optimization is on the boundary of Optimization Theory and Control Systems. It may be good to hire staff with expertise in non-smooth optimization, to compensate for the recent loss of a staff member in this area.

**Relevance to society**

The JBI considers relevance to society from three angles: long-term impact of mathematical insights, educating a useful set of professionals, and involvement in applied research. In the self-evaluation report the four programmes are combined in the description, therefore also the committee will assess societal relevance at the level of the JBI.

Because of the fact that the JBI also focuses on applied mathematics, one would expect that the ambitions regarding societal relevance would be somewhat higher. Nevertheless, there are several very good examples of collaboration and applied research that are relevant for society. These include climate modelling, astrophysics, healthy ageing, chronobiology, power networks and simulation of extreme sea waves. Moreover, there is a record of producing software that is used in weather and climate applications and in systems biology. Distinctive is the SCO research line, which has a very good record in working towards societal goals. Many of the ideas and concepts have found their way into society and there is substantial interdisciplinary cooperation and transfer. One outstanding example is the contribution to the energy based modelling which is incorporated in the software M20.

The self-evaluation mentions several times that the department is one of the key players in the faculty theme "Data Science and Complexity" which has high societal relevance and provides opportunities for interdisciplinary research.

**Viability**

Like nearly all universities, JBI started a data science centre. Unlike some others, the focus in Groningen is to actively get the mathematicians involved, by including systems complexity explicitly in the title. They seem to do well in this respect, making mathematics an integral part of the new centre. The Data Science and Systems Complexity Centre appears to be relevant to all research lines, and JBI as a whole. In particular, Systems & Control, Dynamical Systems, Computational Science & Numerical Mathematics, Stochastics, Geometry, and Statistics are expected to play a leading role within the study of Complex Systems and Network Dynamics, whereas in particular Statistics and Computational Science will be key in developing the mathematics underlying Data Science. One of the successes is that the data science and systems complexity centre was one of four themes selected by the faculty to support and received additional funding. The committee is positive about these developments.

The DAGM research line has a good number of tenure trackers as well as more senior researchers, providing the group with a good mixture between senior and junior staff. They are well recognised and have hired a number of very good new staff members. In addition they are further supported to take on the future.

The SP research line, as was mentioned before, is extremely small with only two tenured staff members making it not a comfortable and even vulnerable situation. However, they are both still young and do very good research. Connecting to the probabilists from one of the other research lines might help, but also finding collaborations beyond the JBI might provide opportunities and strengthen their position for the future.

The committee has concerns about the future of the CSNM group. While the number of PhD students is growing the tenured fte staff has decreased, and currently there is no full professor in this research line. Despite the retirement of the group leader, the group has been successful in acquiring external funding and the publications are on an increasing level as well. However, having an engineering degree programme requires JBI to have a strong numerical analysis/scientific computing component. The JBI should consider strengthening this component of their profile.

In sharp contrast with the strategy for the CSNM research line, is the strategy and viability for the SCO research line. The two full professors will continue for the next evaluation period and seem to have a clear strategy. The excellent track record of this research line leaves no doubts for the future. The only minor recommendation is that preparing a strategy for the replacement of two senior researchers who retire after the upcoming review period should not be forgotten.

**Conclusion**

The committee concludes that the small size of JBI and the further division into applied mathematics versus mathematics leads to a scattered approach of mathematics research. The committee wonders if this latter division has to be kept parallel to the two undergraduate degrees. Although the quality itself was good to very good and for one research line even excellent in the evaluation period, the committee fears that not all four research lines are given equal support towards the future. The committee strongly recommends restructuring

the institute. Should JBI decide to do so, the committee considers the viability to be very good because there is a lot of quality within the different research lines. Leaving the structure as it is will make the institute less viable.

### 7.3. PhD programmes

Over the review period a total of 33 candidates received a PhD, this number includes regular and guest PhD candidates. Between 2006 and 2010 a total of 34 regular PhD candidates enrolled. 67% of the candidates graduated within five years and 9% discontinued their projects. JBI hopes to further improve graduation times in the coming period. The university-wide PhD registration system Hora Finita is regarded as a tool that will help to keep track of PhD candidates and their progress.

The training of PhD candidates is embedded in the Graduate School of Science (GSS). In addition to offering general skills courses, GSS cooperates with national research schools WONDER, DISC and the J.M. Burgers Center. The GSS provides an individual training budget for every PhD candidate to follow courses, and attend summer schools and conferences.

PhD students are supervised by full, associate and assistant professors. In line with university regulations there are formal R&D interviews after six and nine months, and at the end of the second and third year of the project.

PhD students are encouraged to take part in career development courses and events organised by the GSS. Half of the graduates pursue a career in academia, the other half obtains employment in industry.

With respect to the size of the staff JBI has a high number of PhD students; mathematical staff members in Groningen have one of the highest number of PhD students per research fte in the Netherlands. Many of the PhD students are doing their research on a scholarship. On the one hand this displays a high success rate in funding of PhD projects, which could be seen as a measure for quality. On the other hand, it will be more difficult for the supervisors to closely follow and supervise the progress of all PhD students. This requires a more formal structure, which is in place in Groningen. In addition, each PhD student formally has to have two supervisors.

After six months the PhD student has a formal interview with his/her supervisor on the progress of the project. At this point concerns should be discussed, giving the PhD student ample opportunity to improve. At nine months a go/no-go meeting is held with members of the graduate school, making this a formal moment. This is assuring both student and supervisor that the PhD student should be capable to finish the PhD.

Like all PhD programmes in the Netherlands the GSS is doing very well in training and supervising its PhD students. Success rates and time to graduation is not bad, but the committee is positive about the activities that are taken to improve them. Students were very positive about the supervision and all stated to have regular meetings with their supervisors.

PhD students which are not on a scholarship have a teaching load of 10%, while those on a scholarship are not allowed to teach. For those students with teaching allocation the actual time spent on teaching fluctuated, sometimes up to a full day per week. This was compensated by periods of no teaching at all. PhD students the committee talked to were

very positive about the experience in teaching; scholarship students indicated regret about not being allowed to teach.

### 7.4. Research integrity policy

RUG adheres to the principles of the VSNU Code of Conduct for Scientific Practice (2012). Familiarity with this code is discussed during annual appraisal interviews. The Faculty of Mathematics and Natural Sciences has appointed a confidentiality advisor for academic integrity. A module on scientific integrity is part of the training of PhD candidates. In JBI there have been no incidents with respect to research integrity.

The faculty is setting up a Research and Data Management Plan that defines the objects of research that need to be stored, the processes to follow for such storage, and a plan for implementation of the storage system. A faculty wide facility for storing images, sensor data and results of simulations is currently being set up.

As mentioned in the general chapter of this report, infringement of research integrity and fraud are very uncommon in mathematics. Nevertheless, the committee approves that JBI has a policy and is actively communicating this policy to its staff, specifically to PhD students and undergraduate students.

### 7.5. Recommendations

- The university is strongly recommended to reformulate the requirements for tenure-trackers, in a way which takes into account the fact that excellent projects in mathematical sciences may not be successful in obtaining grants. At least the departments should be able to adapt criteria to the specifics of the discipline.
- It is suggested that the JBI makes a strategy plan that combines the existing small research lines, and makes sure that staff members have a chance to collaborate with others. The research quality is heterogeneous and strong efforts should be made to improve in this direction. It is recommended to amalgamate the programmes Mathematics and Applied Mathematics, and their subdivisions into research lines. Firstly, dynamical systems runs through both. Secondly, the Mathematics programme is doing a considerable range of applications. Thirdly, the DAGM research line is already an amalgam of a substantial dynamical systems group with various others. The division into Mathematics and Applied Mathematics does not appear to serve any purpose other than to separate responsibility for running the undergraduate degree courses.
- The JBI has a very good chance to have strong societal impact, but should increase its efforts in this direction as a whole.
- JBI should plan carefully what mathematics it wants to achieve in the Centre for data science and systems complexity. The JBI should use the opportunities of this centre for interdisciplinary research and funding.
- The JBI should insist that the new allocation model, that will be beneficial for the financing of mathematics, is implemented without delay.

### 7.6. Quantitative assessment

| | |
|---|---|
| Research quality | very good (2) |
| Relevance to society | very good (2) |
| Viability | good – very good (3-2) |

# 8. Research evaluation Mathematisch Instituut of Leiden University

## 8.1. Organisation, leadership, strategy and targets of the research unit

The Mathematisch Instituut (MI) is currently one of eight institutes that make up the Faculty of Science at Leiden University. MI has one bachelor's and two master's programmes in mathematics and statistics and, in addition, provides courses for the Faculty of Science and Leiden University College in The Hague. The management positions in the institute rotate between staff members and comprise a scientific director, a director of education and a managing director. The full professors of the institute form the scientific board (*Wetenschappelijke Raad*), with monthly informal meetings. Its relatively small size and flat hierarchy allow the institute an informal management style.

The institute operates as one coherent unit and not give undue weight to the subdivision in two programmes, which has been formally present for over the past 15 years:

- Algebra, Geometry and Number Theory (AGN);
- Analysis and Stochastics (AS).

According to the self-evaluation report the mission of MI is to do high quality research at the frontiers of mathematical knowledge, and to educate future generations of mathematicians in a friendly but challenging research environment.

As the result of the mission the hiring policy of the institute puts quality above specialisation, considering that excellent researchers will find ways to establish their specialisation within the institute. As a consequence, various changes of focus in the research directions have taken place over the years. Some specialisations lost prominence; other disappeared, while some have shown growth. Nevertheless, Leiden has concentrated much of its research strength in one direction, namely number theory, rather than attempting to have all fields represented. In trying to create breadth in teaching as well as in research, AGN has exploited several cooperations. For example, in the bachelor's programme there is a connection with TU Delft, and in the master's programme the national Mastermath programme plays a crucial role. Furthermore, a strategic cooperation with the Centrum voor Wiskunde and Informatica (CWI) in Amsterdam brings additional part-time full professors to the institute.

Within Leiden University, MI takes part in a number of research initiatives, for example the Leiden Center for Data Science and the Institute of Biology Leiden. On a national level, MI takes part in three mathematics clusters that play a role in the NWO funding of mathematics, namely DIAMANT, NDNS+, and STAR; it is also a member of the NETWORKS project. More information regarding partnerships with other universities, both national and international, is provided in the self-evaluation report.

The committee concludes that MI is very successful in its strategy to attract top-level mathematicians while putting less emphasis on fields. It also appreciates the positive approach the institute has towards external changes that might not always favour mathematics, for example the focus on Top-sectors. As was mentioned in several interviews during the site visit, the institute management decided not to complain, but rather approach any change as an opportunity.

**Resources**

In the period of review, the number of tenured staff (full professors and associate professors) and assistant professors increased from 23 to 38, while the number of PhD students increased from 27 to 58. Growth was also visible in the number of postdocs.

Total funding has significantly increased between 2009 and 2014. Increase is observed in direct funding, but more specifically in successful applications for national and international research grants. Finally, collaboration with external industrial partners has steadily increased, making up almost 10% of funding in 2014. This strategy of relying not only on national resources makes the institute less dependent on external political decisions.

The committee observed that while the number of staff members strongly increased, even doubled in research fte, the number of tenured staff remained low. The biggest increase was in number of assistant professors, postdocs and PhD students. Increase in direct funding was much more modest than the increase in staff members. This leads to direct funding constituting approximately 50% of the total funding. A balance in funding streams is required in order to have a stable situation in the number of PhD students and postdocs, since research grants end after a number of years and the successful application for other grants is not guaranteed. However, during the site visit the committee learned from the Dean that MI receives its entire budget without restrictions, except for the fact that the institute should be in control of its resources. This provides a lot of flexibility for the institute. Not only does it support the strategy of hiring the best scientists rather than hiring a specific expertise, it also gives freedom to hire PhD students and postdocs on direct funding. In addition, MI is one of the larger mathematical departments in the Netherlands, thus able to spread risks and threats. The committee considers that the situation is successful and robust, specifically as the result of a flexible hiring strategy that is supported by the Faculty Board.

The committee supports the tenure-track policy in which young, talented researchers get the opportunity to do research and develop a research group within their expertise. The committee learned during the site visit that criteria for tenure differ between universities and the support that is given to tenure-trackers. Requirements on "teaching", "research quality" and "grant application" are part of getting tenure at all universities.

Concerning more junior staff, the institute has both tenure-track positions at the assistant professor level as well as assistant professors on a temporary contract. It was explained that the decision on tenure (and therefore on tenure-track positions) is done at the level of the Faculty, restricting the number of tenure-track positions. Once tenure is given, it is expected that the researcher will become full professor within 3-5 years. MI can, however, give a 5-year contract that is not tenure-track. Although the committee is sympathetic to the wishes of the institute to hire more junior staff members as the result of successful grant applications, it is not sure that having two types of contracts at the assistant professor level might not lead to problems.

The committee considers Leiden has a good approach by giving each tenure-tracker a PhD student to supervise within his/her own area of expertise. This will help the tenure tracker in doing research, developing an academic track record and writing grant proposals. If there is no PhD student available from (external) grant funding, MI can provide a PhD position on direct funding.

The committee is positive about the way in which tenure criteria are applied to give tenure to a tenure tracker. Although criteria are set at the level of the Faculty, both institute and Dean indicated that each institute has many degrees of freedom in applying them.

## 8.2. Assessment of the SEP Criteria

### Introduction

The Algebra, Geometry and Number Theory (AGN) research programme focuses on number theory ranging from arithmetic geometry to cryptology. It also hosts the headquarters of the ALGANT Erasmus Mundus consortium in geometry and number theory. In 2014 the programme consisted of 14 scientific staff members, 9 postdocs and 32 PhD students with a total of 26,2 research fte.

The Analysis and Stochastics (AS) research programme covers a broad spectrum ranging from pure and applied analysis and probability theory to mathematical statistics, applied statistics and data science. In 2014 the programme consisted of 24 scientific staff members, 12 postdocs and 26 PhD students with a total of 26 research fte.

### Research quality

The committee assesses MI as an outstanding department; it is clear that the strategy of hiring excellent scientists led to the quality that was aimed for. The consequent reduction in range of research topics did not seem to hinder the quality of the research in any way.

Although the name of the programme AGN suggests a significant amount of algebra and geometry, these topics have been strongly reduced. The strategy of the remaining small group is to be strong in one area in which they can collaborate. The collaborations are indeed multiple, intense and very successful and the group is very cohesive.

The number theory group has certainly been weakened by the retirement of one world-level researcher, although he still is very involved in the research activities and with PhD students. Another world-level researchers is in a 0 appointment but is only sporadically present in Leiden. Although the quality of the group remains excellent, it is crucial that they think seriously about a new full-time appointment at the very senior level.

The programme has a number of excellent researchers who did very high quality research during the period of evaluation. One very talented assistant professor departed to become full professor at another university.

The AS programme covers travelling waves, dynamical systems, linear analysis, statistical physics, mathematical statistics and data analysis. It impressively managed to bring together world leaders in their respective fields. This is reflected not only in the excellent research output, but also confirmed by receiving a Spinoza prize, successful grant applications like the ERC advanced grants, and the invitation to speak at the ICM in 2010. Although number theory and statistics lie at different ends of the spectrum of mathematical topics, there is interaction between these fields within the institute, as evidenced by one of the key publications.

### Relevance to society

Both programmes in the MI predominantly focus on fundamental mathematics. However, over the years more attention is being given to application driven problems in combination with fundamental driven research. There is no specific strategy regarding relevance to society,

efforts and success depends on individual researchers. The self-evaluation report mentions actively communicating the beauty and joy of mathematics, as well as its usefulness. One impressive example of this is the lecture developed by the entire team on 'Escher and the Droste effect' which has been presented approximately 150 times.

During the site visit many examples were given on societal relevant work. These include collaborations with other disciplines, like forensic probability, ecology, systems pharmacology and biology. All interactions aim at being relevant not only for the other discipline, but also for mathematics. Furthermore, a number of projects involve the university medical hospitals and social sciences.

The AGN programme is involved in very theoretical, pure mathematics, making it more difficult to identify the direct connection to societal relevance. Taking this into consideration, the programme did extremely well with tremendous efforts on outreach including books and lectures aimed at the general public. It is worth mentioning, however, that the LLL algorithm, developed at Leiden in 1982 by members of the AGN programme, is the basis for the accurate determination of position by GPS (though it appears that the implementation in GPS is mainly via an equivalent algorithm developed independently by a Dutch researcher at a technical university, so there is a lesson for Leiden to learn here).

Although the AS programme has a strong focus on fundamental research, it is involved in a number of projects that have a direct societal impact, like data mining tools implemented in the SPSS software package CATEGORIES, statistical expertise in legal proceedings, and cooperation with medical centres leading to publications in non-mathematical journals. The programme also uses these applied problems as a source of inspiration for new fundamental research questions.

**Viability**

As mentioned before, the committee concludes that the MI strategy has worked very well in the recent past and it is confident that it will remain an excellent setup for the future. The flexibility to dedicate direct funding for PhD projects when needed is a major asset.

At least one major grant will continue until after the next period of assessment, and there are currently no signs that cause doubts regarding the acquisition of other grants in the future.

In 2013 one of the full professors retired, but he is still active within the institute. Specifically his supervision of PhD students is important, since the number of PhD students has grown explosively over the past years. Early in the upcoming period, another full professor will retire. On the one hand the committee was surprised that a specific plan for a successor is not yet on the table. On the other hand, however, it is consistent with the MI strategy to not fill a position on a certain topic, but rather look for an excellent researcher. It is also likely that some plan exists, but the MI prefers to keep it confidential at this point. With two remaining full professors in the same group there is no immediate threat of becoming too small. Furthermore, since MI is completely flexible in how they spend their direct funding, they can use the vacant budget to hire other staff members.

Finally, the committee would like to mention the Lorentz Center, which is a national research centre located in Leiden. Of course MI cannot (and does not) claim it as part of Leiden University, but it is a major asset and there is some fertile cross-fertilization with the institute. This connection adds to the many other aspects that provide a very promising future for the institute.

**Conclusion**

MI has two underlying research programmes that both have done excellent research in the evaluation period. With some world-leading and many excellent researchers, the institute has built a strong, yet flexible research environment. Despite the absence of an overarching strategy on societal relevance, the committee is impressed by the activities, impact and outreach of the two fundamental mathematics oriented programmes. In the self-evaluation report a robust and solid future is indicated, but even more impressive to the committee was the positive way in which staff and management are collectively embracing the institute's strategy.

The committee commends the institute for the conciseness and relaxed style of its self-evaluation report, but notices that this can lead to omissions (like an incomplete list of scientific staff).

## 8.3. PhD programmes

Over the review period, the MI hosted an average of 40 regular PhD students per year. A total of 45 of these students received a PhD in the review period. Between 2006 and 2010 a total of 33 regular PhD students enrolled and with the exception of one discontinuation, all but one candidate graduated within five years. The committee looked at the average PhD duration, and concluded that there are no problems here.

The PhD programme is formally embedded in the Graduate School of the Faculty of Science, which offers courses for PhD students of non-mathematical nature. In 2007 no student received a PhD, that led to a change in policy. According to the adjusted policy, PhD students are now appointed on direct university funding, while at the same time the institute is applying for grants with money allocated for PhD appointments and the Erasmus Mundus programme Algant-DOC. The committee is positive about the possibility to hire students on direct funding, making the PhD programme as a whole more stable and viable in the long run.

Many ad hoc seminars and working groups are organised and a strong social cohesion among PhD students is described in the self-evaluation report. This was confirmed by the PhD students that the committee interviewed. After defending their PhD, at least half of the graduates continue in an academic career.

As the PhD students explained during the site visit, they all have weekly meetings with their supervisors and are very satisfied with the supervision. On the one hand they feel free to choose their own directions in the research project and at the same time they appreciate the close supervision. According to the committee, it is fruitful for both research programmes that many PhD students and professors interact with each other and share their research experiences.

The committee concludes that having a graduate school at faculty level that provides general courses is not restrictive in any way. Content-wise, PhD students are free to choose their own courses to gain expertise that is required to do their research. Many PhD students choose to follow one or more Mastermath courses, and they have many opportunities to follow winter- and summer schools. The committee is of the opinion that with the close supervision of PhD students there is no need for strong regulation on requirement to take courses.

Regular PhD students are involved in teaching of exercise classes to undergraduate students, correcting homework and sometimes giving lectures. One of the students the committee

spoke with, was doing a joint PhD with a French institute, and had only three years funding. In such cases, students often are not allowed to teach.

### 8.4. Research integrity policy

Leiden University, at the level of the Board, introduced a website outlining the general university policy, and central guidelines on how to deal with integrity issues. According to the self-evaluation report, in proving theorems, the integrity of mathematical proof is seldom contested. Students are taught, more explicitly than before, that providing the right references is important in mathematics.

When research output involves experiments and data, depending on whether or not the data are publicly available, a guideline is available. In case data are produced by a scientist with whom a statistician collaborates, they are often not publicly available, but are maintained by this scientist and additionally also locally. The computer code and algorithms are always made publicly available. The committee welcomes that this situation is addressed explicitly, although the formal status of this policy does not become completely clear from the self-evaluation report.

As mentioned in the general chapter of this report, infringement of research integrity and fraud are very uncommon in mathematics. Nevertheless, the committee is positive on the MI policy and the fact that this policy is actively communicated to staff members, specifically PhD students and undergraduate students.

### 8.5. Recommendations

- The distinction between assistant professors in tenure-track and not in tenure-track is undesirable and could lead to inequality. This issue should be brought up with the Faculty Board;
- The MI should be more pro-active in exploiting the mathematics that it develops. The NETWORKS project offers opportunities in this direction.
- The Analytics and Stochastics research programme is recommended to explore possible cooperation between analysis and stochastics, e.g. in uncertainty quantification.
- It is recommended to use the connections with biologists and medical scientists to become a partner in a project application for the Top-sector Life Sciences and Health.
- It is considered important that another top-level algebraist or number theorist is hired.

### 8.6. Quantitative assessment

| | |
|---|---|
| Research quality | excellent (1) |
| Relevance to society | excellent (1) |
| Viability | excellent (1) |

# 9. Research evaluation Institute for Mathematics and Astrophysics and Particle Physics (IMAPP), Radboud University Nijmegen

## 9.1. Organisation, leadership, strategy and targets of the research unit

The Institute for Mathematics, Astrophysics and Particle Physics (IMAPP) of Radboud University Nijmegen, conducts fundamental research in mathematics, high-energy physics and astrophysics with a special focus on interdisciplinary topics. The topics that involve mathematics are quantum gravity and mathematical physics on the one hand and astrophysics and statistics on the other. IMAPP is actively engaged in outreach. Education in mathematics is part of the core business of IMAPP. The institute arranges activities for high school students, provides service teachings inside the Faculty of Science, designs regular bachelor's and master's courses and facilitates positions for PhD students.

The committee evaluated only mathematics within IMAPP, which consists of three programmes:

- Algebra and Topology (AT). Central themes in this programme with two chairs are algebraic geometry, algebraic topology, computer algebra, differential geometry and logic.
- Mathematical Physics (MP). This programme has three chairs, namely in analysis, geometry, and mathematical physics. The research mainly centres around symmetry, set in a wide variety of different contexts and applications, especially in classical and quantum mechanics and in quantum field theory;
- Applied Stochastics (AS). This is the smallest group with only one chair and two other tenured staff members. Main research areas are probability and statistics, more specifically interacting particle systems, random discrete structures and quantum probability.

The mission statement is as follows: the Institute for Mathematics, Astrophysics and Particle Physics aims to carry out fundamental and applied research in mathematics, at the highest level. According to the institute, research and education are inseparable. The objectives for research in mathematics, as stated in the IMAPP-Strategic Plan 2013-2017 are:

- A balanced research programme with a disciplinary focus in algebra and topology, mathematical physics and applied stochastics;
- Research should be qualified at least as very good according to the SEP;
- An interdisciplinary focus on mathematical tools for particle physics, applications of algebra and logic in computer science, and applications of stochastics in astrophysics and the health domain;
- Expansion of the AS programme to restore the balance between fundamental and applied mathematics in the institute;
- Hiring new staff to ensure that the teaching load is at most 40% for all staff members. The Faculty Board has provided additional money for this purpose.

The research institute strives for a lively research climate, in which creativity and quality can flourish. The general strategic goals for research in mathematics within IMAPP, also formulated in the Radboud University Strategic Plan 2015-2020, are:

- Offering an optimal environment for excellent curiosity-driven research;
- Performing research in mathematics at IMAPP that is internationally prominent;
- Providing a solid training and supervision programme for PhD candidates;
- Participating in national research schools and mathematical clusters.

Mathematicians at Radboud University Nijmegen participate in three national mathematics clusters: DIAMANT, GQT and STAR. These clusters coordinate the organisation of their programmes for the national Mastermath courses, in which mathematicians from IMAPP are actively involved. IMAPP also participates in the national research school WONDER and in national Intercity Seminars, with the aim of learning from important recent developments. In addition, IMAPP meets regularly with colleagues from Belgium or Germany. The Foundation Composition Mathematics plays a positive role in the funding of mathematics conferences.

The committee was asked to evaluate the research in mathematics at nine universities, and despite the generally very high quality of the research it considered the three programmes at Radboud University Nijmegen as the most difficult one to assess individually, partly because the self-evaluation report did not give separate SWOT analyses for them. To the committee it was not always clear why a certain staff member was part of one programme and not of another. In addition, mathematics at Radboud University Nijmegen is one of the smaller mathematics research groups in the Netherlands, and the fact that the focus lies on interdisciplinary research makes the boundaries between the research programmes rather artificial. During the site visit programme leaders confirmed that the division into programmes is not essential for them. These remarks are somewhat moot, however, because IMAPP intends to fuse the three programmes from January 2016. This looks to the committee as a good decision.

At all universities in the Netherlands, mathematics student inflow at an undergraduate level was extremely low ten years ago. It seems that Radboud University Nijmegen suffered even more severely, with a dramatic low of 7 students in 2004. According to the committee, the continuation of mathematics research must have been critical at that point. However, in 2005 mathematics merged into IMAPP and numbers increased to 78 enrolling students in 2015. The department is still small, but it embedded the aim to strengthen by way of internal and external collaboration in its strategy. The committee thinks this is a sound strategy, specifically when taking into account the difficult situation the department has overcome.

The mathematics department's integral position in IMAPP puts it in a unique position to develop mathematical research of relevance to physics, an opportunity that they exploit to the full.

The committee concludes that IMAPP has a clear and realistic view on its present, but still suffers from a somewhat vulnerable position. The committee emphasises the importance of supporting such a small research group by the Faculty as well as the university. During the site visit, it was mentioned that the three programmes will, for organisational purposes, be fused into one programme. The committee strongly supports this decision, since the boundaries are somewhat artificial (in particular between the AT and MP groups) and it will certainly strengthen the viability of the mathematics research group. Furthermore, the Faculty Board confirmed that mathematics at IMAPP requires a substantial reinforcement. New staff for Mathematics can be hired such that the teaching load within the department meets the standard of 40%. According to the committee this will certainly make the position of mathematics in Nijmegen less vulnerable.

**Resources**

In the period of review (2009-2014), the number of permanent staff members of Algebra and Topology (AT) increased from 6 to 7, while the number of PhD candidates increased from 1 to 8. The number of permanent staff members of Applied Stochastics (AS) increased from 0 to 4, while the number of PhD candidates increased from 0 to 2. Mathematical Physics (MP) had 6 permanent staff members in 2009 and 7 in 2014, and in the same period the number of PhD candidates increased from 7 to 8.

The total funding for AT has increased by 370 kEUR between 2010-2014. In the same period, the total funding for AS increased by 99 kEUR, and the total funding for MP increased by 316 kEUR. For the entire department the direct funding fluctuated over the years, but overall increased with 200 kEUR between 2010 and 2014, which indicates that the increase in funding is primarily the result of increased research grants. In the self-evaluation report it is stated that IMAPP actively seeks international (notably ERC) funding as a substitute to direct funding. The committee considers this essential for a balanced financial income.

The committee supports the tenure-track policy in which young, talented researchers get the opportunity to do research and develop a research group within their expertise. The committee learned during the site visit that criteria for tenure differ between universities as well as the support that is given to tenure-trackers. Requirement on "teaching", "research quality" and "grant application" are part of getting tenure at all universities.

Teaching load for tenure trackers at IMAPP is reduced in order to give the tenure tracker more time to do research and apply for grants. The committee is enthusiastic about this policy. However, it is not entirely clear to the committee if all tenure trackers are provided with a PhD student to supervise within his/her own area of expertise. Such a condition will certainly help the tenure tracker in developing an academic track record and writing grant proposals. If there is no PhD student available from external grants, IMAPP should make an effort to provide one via direct funding.

Another topic that was discussed during the site visit and mentioned in the self-evaluation report with respect to tenure-track, is the fact that it is more difficult these days to successfully acquire grants in mathematics. Even when a proposal is rated as very good by the assessors, obtaining the grant is not a certainty. Similar to several Dutch mathematics departments, the committee believes that a very good assessment of a grant application should allow for granting tenure, even if the grant itself was denied. Although IMAPP makes individual agreements with tenure trackers on the criteria for tenure, the actual acquisition of a grant seems a requirement. The committee thinks that this does not do justice to the quality of a tenure-tracker and suggests it might even lead to Radboud University Nijmegen losing its appeal to tenure-trackers in comparison to other universities.

## 9.2. Assessment of the SEP Criteria

**Introduction**

Algebra and Topology (AT) was formerly called Algebra and Logic (AL), but with the appointments of two full professors in 2011 and 2013 the word 'logic' was replaced by 'topology' to do more justice to their expertise.

Mathematical Physics (MP) has three chairs, namely in analysis, geometry, and mathematical physics. Three members of MP started their career as physicists, but switched later to become

mathematicians, and so the group has a nice balance in its expertise between mathematics and physics.

Applied Stochastics (AS) is the smallest of the three research programmes. It has just one chair in applied stochastics. The two other permanent members are an UHD (universitair hoofddocent), who is also adjoint professor in quantum probability at the Korteweg-de Vries Institute for Mathematics (KdVI) in Amsterdam, and a tenure-track assistant professor.

**Research quality**

The committee considers the quality of the research to be very good across the different researchers and programmes. Some members of the committee perceived that the expertise of some staff members does not perfectly fit the research of other group members. This is not an ideal situation for these staff members. The committee advises the institute to put effort into the coherence within and across research programmes.

The committee found it difficult to distinguish between AT and MP, since some researchers from one programme would be an excellent fit in the other. The three chairs in MP all have outstanding international reputations and during the evaluation period promising staff members were hired, which was evidenced by the acquisition of a VIDI grant.

In the evaluation period the AT programme did some impressive hiring with two new full professors, which gave a strong boost to the programme. Unfortunately, one of these researchers will leave in 2016 for a university professorship elsewhere. However, he was not the only high quality researcher in the programme and although it will be difficult to find a replacement of similar calibre, the programme as a whole has been doing excellent research in the period of evaluation.

The AS programme had two interruptions in the past due to retirements and moves of professors. A new start was made in 2012 with the appointment of a chair whose research shows impressive breadth, covering statistical physics, mathematical statistics and also statistical consulting at a very high level. The programme is still in the process of building up. Additional hiring is planned in the near future. The health of the AS programme depends strongly whether the hiring will bring some focusing of research themes without compromising on quality.

The committee concludes that the quality of research on the whole has continuously increased across the evaluation period, up to a very good to excellent in the final year.

**Relevance to society**

In the self-evaluation report it is stated that the small size of the programmes and high teaching load has forced a reduction in focus on societal relevance. The programmes put effort in increasing the number of enrolling students that was catastrophically low and have been spectacularly successful in this. In addition, there are a number of very good initiatives that are relevant to society.

The AT programme is doing pure mathematical research, making it more difficult to identify the direct connection to societal relevance. However, it engages in some very nice outreach activities, such as the annual tournament for 500 high-school students. The MP programme is strongly involved in outreach activities, which led to an RU Award in bronze for outstanding outreach accomplishments in 2011. In addition, the researchers collaborate with geometry, which led to some interesting results and with physicists, notably on the standard model of

particle physics and on quantum computers. The MP programme formulated a number of interesting potential applications for the future to quantum computing and to extensions of the standard model in particle physics in its self-evaluation report.

The AS programme runs a Statistical Helpdesk for other departments at the university which is a most valuable contribution to the research of disciplines like biology and medicine and thus very relevant to society. Several papers in non-mathematical journals with members of the programme as co-authors are evidence of this interdisciplinary activity. In addition, the programme runs a consultancy course for students, which provides statistical advice to institutions outside the university and at the same time gives students a practical training in collaborating with non-mathematicians.

**Viability**

When it comes to viability, the committee felt that the artificial division of the groups and their disparate sizes make the group as a whole more vulnerable than needs to be the case. The fact that a fusion lies in the near future makes their individual viabilities somewhat irrelevant. The committee supports the plan that these three small programmes should combine forces and become one larger, strong programme. The three underlying programmes are well aware of their strengths and weaknesses and were able to convince the committee that they have a clear strategy for the years ahead.

Hiring strategy is shifting from filling a vacant position with the best candidate who applies, towards scouting actively for talent and creating a position when a candidate with the desired expertise is found. This also allows the programme to focus on female candidates, which is an explicit objective. The committee encourages this new strategy. Specifically in a small-sized department it is important that expertise of different staff members is connected, but not completely overlapping.

As mentioned before, the increasing number of enrolling undergraduate students has a positive effect on the viability of the mathematics programmes. Unfortunately, this positive aspect also has a downside. Direct funding for teaching does not follow at the same pace. This adds to the increased workload of tenured staff, since tenure trackers are given a reduced teaching load. The committee considers that in a small mathematics institute the high teaching load might become a problem and is pleased with the promise by the Faculty Board to create two new tenure-track positions in the AS programme. During the site visit it was mentioned that another 4 fte for teaching is needed. The Faculty Board agreed and added that they intend to implement a talent scouting procedure that pays special attention to promising female candidates. However, no concrete promises were made. The committee strongly stimulates the Faculty to invest in this small department, which is doing very good research.

During the site visit, it became apparent that the AS programme wants to have a larger applied component, as despite its name its main current strength lies in theoretical results in probability. The committee thinks this is an excellent idea and considers that (in combination with the two tenure-track positions that were promised by the Faculty) this will give a boost to the programme.

**Conclusion**

The committee concludes that the difficult period for the mathematics department at Radboud University Nijmegen is now a thing of the past. Despite the difficult situation at the start of the period, the track record over the past six years shows that very good research has been done here.

As mentioned in the self-evaluation report, the focus on doing high quality research was at the expense of a focus on societal relevance. Indeed, more could have been done on the latter, though the committee remarks that the efforts that were made led to very good results.

Looking forward, the fusion of three programmes is considered an excellent move by the committee. All signs are in favour of a bright future provided the promises by the faculty board to create additional positions are realised. Some minor issues can be dealt with by the mathematicians themselves, but the high teaching load remains a major threat and dealing with this is also the responsibility of the Faculty Board.

### 9.3. PhD programmes

Between 2006 and 2010 a total of three PhD students enrolled in Algebra and Topology and all graduated within five years. In the same period nine PhD students enrolled in Mathematical Physics, six of which graduated within 5 years and three within 6 years.

Each PhD student signs a teaching and supervision plan. This plan is updated each year during the yearly assessment with the adviser. The adviser has written the research proposal and carries out the daily supervision. After the first year of the PhD candidate, a go/no go decision is taken. During the second year there is a transfer from learning towards working on more specific research problems. Preferably in the third year, the PhD candidate becomes more independent and at a certain point surpasses his supervisor in the topic of research. In the final year, the manuscript for the PhD dissertation is written. If the manuscript of the thesis is written, approved by the adviser and promotor and sent to the manuscript committee within four years, the PhD candidate receives a bonus of 1,500 EUR. This sounds an excellent way of encouraging completion within the expected time frame as long as quality requirements are upheld. The committee was disturbed, however, by a report that an overly rigid application of the regulations led to the withholding of the bonus in one instance.

PhD candidates are encouraged to make several visits abroad. Roughly half of the PhD candidates continue their research as postdocs, while the other half find a job in society outside academia.

Like all mathematics PhD programmes in the Netherlands, Nijmegen is doing very well in training and supervising its PhD students. The PhD students the committee interviewed seemed very pleased with their projects, supervision, and the fact that they were doing their PhD in Nijmegen. Contact with the supervisors is close and the committee has no signals that the high success rates will reduce in the future.

All PhD students the committee interviewed have been involved in teaching, they are expected to teach courses of a total of 30 EC over 4 years' time. On average they spend almost one day a week on teaching. Although this amount is within the contractual limits, it was the highest teaching load of all universities the committee assessed. The PhD students nevertheless indicated that their experience in teaching is considered valuable, specifically if they plan to continue in academia.

PhD students followed a number of Mastermath courses, but none took any of the general courses that were offered by the university. They would appreciate general courses, like presentation skills or academic writing, but would prefer these courses to be more focussed on mathematicians.

## 9.4. Research integrity policy

IMAPP aims to perform research according to the Regulation Scientific Integrity of the Radboud University (*Regeling Wetenschappelijke Integriteit*). This document also includes the following two guidelines:

Include correct citations. Give fair acknowledgement to other people's work, which you used or which inspired you. Preferably cite original work rather than later repetitions. Be careful with heavy self-citations.
Dare to dream, but refrain from bluffing. There is a narrow but clear gap between an open reflection on possible applications of your work on the one hand and bluffing on the other hand.

Since 2011, Radboud University Nijmegen has organised monthly lectures on the "Ethos of Science", taken in a broad sense. Although these lectures are primarily intended for honours students, they are open to anyone. PhD candidates and faculties also attend these lectures.

As mentioned in the general chapter of this report, infringement of research integrity and fraud are very uncommon in mathematics. Nevertheless, the committee approves of the regulations and more specifically the guidelines that are in place.

## 9.5. Recommendations

General Recommendations

- The committee recommends that when executing the intended talent scouting, the institute should focus on strong candidates in applied mathematics;
- It is recommended to actively pursue the planned fusion of the three groups into one. This will strengthen the institute;
- Continue to exploit the strong immersion in a physics environment to lead mathematical developments of relevance to physics. It would be good to have someone in IMAPP who can contribute to the intended collaboration between astrophysics and statistics.

Recommendations to the specific programmes

- It is recommended to expand the AS research programme in the direction of applications. This programme should try to hire someone who can share the responsibility for the Statistical Helpdesk with the current members of the group.
- The committee was pleased to learn that one new hiring in algebraic topology has already been made, but perhaps even more should be done in the direction of topology or pure geometry, since algebra and algebraic geometry are already well represented in both the AT and MP groups. In the MP group, perhaps more of an effort should be made to work with actual physicists, both within the university (a particularly natural idea in view of the acronym IMAPP) and in collaboration with other Dutch or foreign universities.

## 9.6. Quantitative assessment

| | |
|---|---|
| Research quality | very good (2) |
| Relevance to society | very good (2) |
| Viability | very good (2) |

# 10. Research evaluation Department of Applied Mathematics, University of Twente

## 10.1. Organisation, leadership, strategy and targets of the research unit

The Department of Applied Mathematics is one of the three departments of the Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS) at the University of Twente (UT). The Dean of EEMCS and the department heads form the management team of the faculty. Next to the research activities, the management considers the education of highly qualified engineers as one of the core activities of the faculty.

The mathematical research is clustered into two research programmes:

- Operations Research: The research programme operations research (OR) combines the chairs of discrete mathematics and mathematical programming, and stochastic operations research;
- Computational Science: The research programme computational science (CS) combines the chairs applied analysis, hybrid systems, mathematics of computational science and multiscale modelling & simulation.

The mission statement of the department is to advance mathematical sciences through research and teaching, developing state-of-the-art research in computational science and operations research, and making progress in applications of societal and technological relevance. It has formulated the following objective: training of high potentials in mathematical sciences as well as contributing to research in mathematics. In applications the department focuses on systems that are crucial to every-day life. Therefore, it contributes to smart grids that make energy networks more efficient, mathematical models that assist medical doctors, schedules that make hospitals more efficient and numerical schemes to study multiscale fluid problems and wave propagation from nano to kilometre scales.

The University of Twente has a long tradition of cooperation between different disciplines, including the social sciences. It is the strategy of the department to actively engage in collaborative projects in three research institutes: CTIT for all ICT-oriented groups, MESA+ for nanotechnology, and MIRA for biomedical technology and technical medicine. CTIT is the largest academic research institute in the Netherlands – and one of the largest in Europe – in the field of ICT and ICT applications. With over 500 researchers, MESA+ is one of the world's leading nanotechnology research institutes. MIRA is the research centre for Biomedical Technology and Technical Medicine, an internationally leading institute in the field of Biomedical Engineering, with a closely integrated collaboration with the medical community.

Via the institutes CTIT, MESA+ and MIRA the department participates in various multidisciplinary projects. This cooperation includes groups in both technical and non-technical faculties. In the review period, the department has established two multidisciplinary applied research areas: health and energy. In healthcare, the department has taken the lead in establishing the Center for Healthcare Operations Improvement and Research (CHOIR). It is a multidisciplinary collaboration of the research institutes IGS and CTIT. Within MESA+ a close collaboration was started in nanophotonics with the Complex Photonic Systems group on the development on novel techniques to increase the performance of solar cells. This

research obtained funding from the Computational Sciences in Energy Research Programme (Shell/FOM/NWO).

The department participates in the NWO clusters DIAMANT (DMMP), NDNS+ (AA, MACS, MMS), and STAR (SOR), and in national research and graduate schools: Beta (DMMP, SOR), LNMB (DMMP, SOR), DISC (HS), and J.M. Burgers Center (MACS, MMS). It also actively participates in the 3TU.AMI institute, a joint venture of the three Dutch TU's.

The committee is very positive about the strategy to engage in collaborative projects in the three research institutes. The integration in 3TU.AMI is also considered a very good strategy. Despite the competition between the three Dutch universities of technology, it is crucial to combine forces in 3TU.AMI when it comes to major European grant applications.

The research in mathematics at Twente is approached from a very applied perspective. This approach is encouraged by the introduction of multidisciplinary projects, such as on Healthcare, and collaboration within various institutes. According to the committee the intellectual challenge is to formulate applied topics as fundamental mathematical problems. With the collaborations in health problems, energy and high tech systems described in the self-evaluation report, Twente has succeeded in this challenge. Mathematicians in Twente have been successful in participating in STW (Technology Foundation) programmes; during the site visit the committee discussed the opportunities these activities offer to get involved in the Top-sectors. Based on the expertise in Twente, logistics seems an obvious topic, specifically since Twente is chairing a national institute in logistics. The committee thinks that Twente has an excellent position to actively get involved and be successful in the Top-sectors.

**Resources**

In the period of review, 2009-2014, the number of scientific staff members remained stable around 30 people. The number of employed PhD students decreased slightly from 31 to 27, but other PhD students (not employed) were introduced in 2010, with an average of 20 per year. Between 2009 and 2014, the department has invested in 40% new staff in tenure track positions. This impulse offered high-potential career opportunities for the new staff members.

The committee supports the tenure-track policy in which young, talented researchers get the opportunity to do research and develop a research group within their expertise. At all Dutch universities a tenure-track position, when complying with the set criteria on teaching, research and grant application, guarantees a tenured position.

The committee is very positive about the way Twente supports its tenure trackers. Teaching load for tenure trackers is reduced to 30% of their contract. In addition, each tenure tracker works with a PhD student whom he/she supervises within his/her own area of expertise. This strongly supports the tenure tracker in developing an academic track record and writing grant proposals. The committee is also very positive regarding the way criteria for tenure are adapted to the discipline of mathematics. In mathematics it is extremely difficult to obtain grants from (inter)national research councils. Even when a proposal is rated as very good by all assessors, obtaining the grant is not a certainty. In Twente support is given to tenure trackers in the writing of grant applications, but there are no strict requirements on obtaining the actual grant as long as the assessment of the grant application is good. To provide them with guidance in developing the track record, tenure-trackers are coached by a chair and someone from a different department.

The total funding has increased significantly between 2009 and 2014. The Department of Applied Mathematics depends predominantly on direct funding for its earning capacity. This has to do with the high amount of service teaching by the department, as it provides the entire mathematical education to all faculties. More relevant is the fact that the amount of national, international research grants and contract research increased in the evaluation period.

The department is intensively involved in teaching; it has monopoly on service teaching in mathematics for the University of Twente. The committee is very positive about this monopoly; it finds that the Board of the university shows commitment towards the quality of mathematics teaching. However, financial compensation for this activity has seriously lagged behind the input by the department, specifically with the increasing student numbers. From the interview with management during the site visit, the committee learnt that the recent financial difficulties at university level are a major reason for the limited compensation for service teaching. The committee compliments the department that despite the high teaching load, tenure trackers only have to spend 30% of their contract on teaching. However, this leads to some tenured staff members doing more than 50% teaching. The committee thinks that in the long run the high teaching load is a threat to the high quality of the research. This should concern the Board of the University as well as the Faculty Board and the committee strongly recommends that this issue be placed on the agenda.

### 10.2. Assessment of the SEP Criteria

**Introduction**

Research topics of the Operations Research (OR) research programme include:

- Mathematical optimisation. This aims at the development of new techniques that are relevant for the efficient solution of optimisation problems, ranging from combinatorial to nonlinear optimisation. It includes approximation algorithms, probabilistic and smoothed analysis of algorithms, as well as new methods for the design and analysis of mechanisms in distributed information settings. New models and techniques find their way into practice in optimising smart energy grids, health processes, and traffic models.
- Stochastics & probability: This topic targets new methods for systems that are exposed to randomness. The research advances theory and application of queuing systems, polling models, Petri nets, random graphs, Markov chains, rare event simulation as well as mathematical statistics. New stochastic and statistical methods are developed in modelling and optimising health processes, communication systems, large and complex networks, or in dynamic learning and pricing problems.

Research topics of the Computational Science (CS) research programme include:

- Numerical methods. This topic aims at the development and analysis of computational methods, tailored to the mathematical structure of the governing mechanisms found in key areas of science and engineering. Prominent examples are in (multiphase) fluid mechanics, nonlinear waves, neuroscience and electromagnetism.
- Mathematical modelling. Powerful mathematical methods are developed for systematic modelling of problems in multidisciplinary applications. Expertise in variational analysis is adopted for medical imaging. Immersed boundary methods and interface reconstruction and tracking strategies are used in the analysis of aneurysms as well as boiling processes. Abstract delay equations and bifurcation methods are developed for neuroscience.

- Systems and control. High tech systems are becoming increasingly complex, but also require tighter specifications. Simple classical linear controllers can often no longer provide this. This requires better models, often involving a spatial structure described by PDEs or decentralised models with interconnections modelled by graph theory. Estimation also needs to be improved to handle intrinsic nonlinearities as well as increasing the number of sensors. Finally, control theory needs to be able to handle constraints and decentralised structures, while still meeting challenging specifications.

**Research quality**

The strategy to hire 40% of new staff in tenure-track positions is very promising and an appropriate reaction to the previous assessment that commented on the lack of junior staff. With the hiring of six tenure trackers, the department has significantly been reshaped and another three positions will be filled in the near future. Although it might be early to establish the exact quality of the new researchers, the committee thinks the rejuvenation of the department is a very good development. Overall the visibility of the young researchers is very good.

The high quality of the research is attested from the description of the 15 highlights and the highly ranked journals where the publications appear. The quantity of output is also impressive, including the number of dissertations. The research in the Applied Analysis and Computational Science group is very good and well recognized and there are some very strong researchers in the group. The reputation of the department is very good in particular due to its participation in prominent research institutes, mathematics clusters. Academic reputation is also supported by the impressive list of top universities with which the department collaborates.

Establishing the CHOIR seems to have been a recognized success, and currently trains 10 PhD and a number of MSc students, mostly funded by health organisations.

Research on probabilistic and smoothed analysis, choice modelling, and online learning, is world-leading. The department has tried to build up a new statistics group after the retirement of all senior researchers in the area. This has been done by appointing two tenure-track assistant professors and one part-time full professor. The latter is an internationally recognised expert on spatial point processes, but it is not clear what her role should be in the department and how she can support the two assistant professors who are in quite different fields.

**Relevance to society**

The department focuses its applied mathematical research on health, energy and high tech systems. In all three multidisciplinary areas a number of excellent collaborations are in place. The Applied Analysis and Computational Science has made huge efforts to link their research in energy and high tech systems to the needs in other disciplines. A number of strong connections with other departments at the University of Twente have been established. The department aims at doing mathematical research in context and has a very positive and proactive approach in collaboration and finding mathematical challenges in joint research projects.

Already ten years in progress is the focus on health; in this period a network with hospitals was build and a significant number of PhD students were funded by hospitals. In the near future the next step will be taken, building a consortium with hospitals and looking for a European platform.

In conclusion, the department in Twente has a clear view on its ambitions towards societal relevance. It has created itself an excellent position for collaboration in multidisciplinary projects. The small size of the department is well kept in mind, and the number of key themes that is focussed on remains appropriately limited.

**Viability**

The department is still in the phase of rejuvenation of its scientific staff and aims to increase the number of personal grants in the near future. Its hiring strategy suits an applied mathematics department with a focus on external applications, but at the same time also fits a scientific mathematical point of view. The committee is very positive about the conditions on which these tenure trackers are hired. A reduced teaching load and the supervision of a PhD candidate in his/her own expertise in combination with support in writing grant applications provides an excellent basis for success. But this really recommendable reduction should not put a high load on the other researchers, instead it should be compensate by further staff from the university.

The committee is pleased with the fact that statistics is maintained within the department. The research topics of the staff members in statistics seem somewhat scattered, therefore the committee recommends to also look for ways to foster interactions with other members of the department. Since many research projects are related to different kinds of networks, it would be good if the department could take part in the NETWORKS programme.

Although the self-evaluation report presented a pessimistic attitude towards the Top-sectors, the interviews revealed that the department seems to have a clear and realistic plan on dealing with the Top-sectors, by strengthening its position in NWO and STW programmes. The committee is very pleased to observe this proactive approach. The strong connections to other departments, hospitals and industry will prove to be valuable in this endeavour.

The committee concludes that the department has a clear view on its strengths and weaknesses and overall has a very good strategy regarding the future. There is one major issue, however, that threatens the viability according to the committee: the high teaching load. This was already mentioned in the assessment of resources. The fact that tenure trackers are protected from the burden of a high teaching load is highly appreciated, but it also puts an additional load on tenured staff. The university should reward the fact that all service teaching in mathematics is executed by the Department of Applied Mathematics. The current situation is bound to affect the quality of research in the long run.

Conclusion

The Department of Applied Mathematics has gone through a number of changes in the period of evaluation, primarily as the result of retirements and a rejuvenation of staff. It managed to keep the quality of research at a very high level and performs excellently on societal relevance activities. The many collaborations and joint projects have led to a wide network. The weaknesses are recognised and a strategy is in place to deal with most of the issues. The department should be supported in this respect by the university.

## 10.3. PhD programmes

Between 2009 and 2011, the Department of Applied Mathematics hosted 45 PhD students of whom 29 graduated, 11 are currently still employed and 5 discontinued. Nearly half of the PhD candidates (49% to be precise) graduate within 5 years, 64% graduated within 7 years.

Since 1 January 2014, all PhD students are registered in the Twente Graduate School (TGS). Consequently, uniform procedures and rules apply for all PhD students. All PhD students have a go/no-go decision during their first year, including a formal appointment of the promoter. In addition, they all have to follow the Training and Supervision Plan, which contains a summary of the research plan, the supervision plan, and the educational programme to be followed. The plan is defined by the candidate and the supervisor and then approved by the Dean. It is set up within three months after the start of the PhD student and is periodically reviewed and updated.

The beginning of the evaluation period showed high drop-out rates and long graduation times. In the later years this has improved. The start of TGS is welcomed by the committee, PhD students in a department with many collaborations will benefit from a structured graduate programme and the various collaborations of the department, especially now Twente participates in a number of PhD training programmes throughout the Netherlands.

The PhD students the committee interviewed were pleased with the supervision; all had meetings with their supervisor on a weekly basis and felt free to contact their supervisor whenever this was considered necessary. All PhD students were also involved in teaching activities; they stated that it was not only nice to do, but also prepared them for a future in academia. Formally up to 20% of the contract is for teaching time, but only one student did this amount of teaching.

### 10.4. Research integrity policy

The University of Twente subscribes to the guidelines for scientific integrity, as specified in the Netherlands Code of Conduct for Scientific Practice. The European code of conduct and the Singapore statement on research integrity are also relevant, as well as the advice of the KNAW about correct citations. The Executive Board established the Scientific Integrity Complaints Procedure in order to protect and guarantee scientific integrity. This procedure provides a system for reporting and dealing with possible violations of scientific integrity. The Scientific Integrity Complaints Procedure is consistent with the LOWI regulations.

The first point of contact is the university's confidential advisor for scientific integrity. Possible violations of scientific integrity as well as any follow-up steps can be discussed with him in all confidence. He/she decides whether the reported violation of scientific integrity will be dealt with by the appropriate committee. The decision of the committee is send to the Executive Board for further action. This involves sending the advice to the complainant and the accused party. If the complainant and the accused party do not ask for further advice from the National Body for Academic Integrity (LOWI) the Executive Board determines its opinion on the complaint and takes appropriate measures.

Within EEMCS, attention to scientific integrity is given on various levels. In the first modules of the curriculum research integrity and avoiding plagiarism are already taught. Scientific integrity also receives explicit attention during the BSc and MSc projects and in the training of PhD candidates. When writing their theses, all students and candidates are taught how to deal with quotations, citations and references.

As mentioned in the general chapter of this report, infringement of research integrity and fraud are very uncommon in mathematics. Nevertheless, the committee approves Twente's policy and the fact that this policy is actively communicated to staff members, specifically PhD students and undergraduate students. The department has also formulated a policy on data storage and privacy. This is viewed positively by the committee.

### 10.5. Recommendations

- The department is recommended to continue its path of rejuvenation of staff in both programmes and make sure that the hiring of young researchers is consistent with the strategy.
- The pressure on the senior researchers with respect to the high teaching load should be relaxed.
- The strong interdisciplinary cooperation in areas of major societal relevance should be continued. The activities in Smart Grids may be a good start to become involved in the Top-Sector "Energy". This would ensure a strong participation of mathematics on a high national level, which is usually very hard to reach.
- The experience in the health sector is so excellent that one might consider founding further spinoff companies in that direction.
- The university leaders should consider establishing a Project Development Office (PDO) similar to TU Eindhoven, or as a joint activity in 3TU.AMI

### 10.6. Quantitative assessment

| | |
|---|---|
| Research quality | very good (2) |
| Relevance to society | excellent (1) |
| Viability | very good (2) |

# 11. Research evaluation at the Mathematical Institute of Utrecht University

## 11.1. Organisation, leadership, strategy and targets of the research unit

The Mathematical Institute (MI) is one of two almost independent institutes at the Department of Mathematics, the other being the Freudenthal Institute for Science and Mathematics education, which is not under evaluation here. It covers a broad range of active areas of research. For a clear focus, MI is organised in two research groups:

- Fundamental Mathematics (FM);
- Mathematical Modelling (MM).

The mission of MI is to contribute to the success of mathematics by developing mathematics and its applications at the highest level and disseminating it as broadly as possible. Inspiration is obtained either by the autonomous development of mathematics as a discipline, or by challenges in big data, climate change and many other topics in scientific modelling. Although the emphasis of the two research groups differs, mathematics is considered as a unity with proven cross-fertilisation between subfields. To support this cross-fertilisation MI strives for an open and extrovert attitude towards mathematics. To enhance cohesion and interaction, colloquia and seminars are publicly announced, and participation is encouraged for the whole department.

Breadth is counterbalanced by a deliberate choice to have mass and focus in the research areas in which MI is active, and to be underrepresented in other areas of mathematics. However, quality of research is more important than the specific subfield to which it belongs, leading to a continuous but gradual process of shifts and adjustments in the research profile of MI.

According to the self-evaluation report, the past five years have shown convergence to a clear research profile. In FM the focus lies on geometry, covering a broad spectrum. In MM an integrative approach is developed to applied mathematics with a focus on climate research, epidemiology, geosciences and scientific computing.

Research output strategy is to stress quality over quantity, high quality textbooks and research monographs are encouraged, while at the same time striving for significant new results in top research journals.

Within Utrecht University MI belongs to the Graduate School of Natural Sciences of the Faculty of Science. At national level, MI coordinates WONDER, the Dutch Research School in Mathematics. Most of Dutch research in Mathematics is organised in four national NWO research clusters: MI coordinates GQT and is closely involved in NDNS+. MI furthermore cooperates with the CWI, resulting in exchange of senior personnel. A similar cooperation exists with the University of Twente. At international level joint workshops are organised with Nijmegen and Bonn and MI participated in two ESF networks. Active collaborations exist with Brazil.

The committee was left with a very positive impression after the interview with the management of MI during the site visit. A clear and convincing strategy was presented on how to move forward and improve the future of the institute. The institute was restructured

after a number of staff members left (either to other universities or retirement), the two research programmes were introduced and a total of four new professors as well as a number of more junior staff members were appointed. In 2016 another two tenure-track positions will be filled, that are specifically dedicated to female researchers.

Hiring strategy shifted towards an increased focus on quality rather than a specific expertise, but still aiming at mass and focus in certain areas. Although it seems a very sound strategy the committee does remark that the institute needs to keep in mind that in fulfilling its goals with the current strategy, there is the risk of imbalance in the institute. From the interview it seems that the MI management is aware of the importance to have balance between FM and MM in the sense of size of the programmes. Letting one outgrow the other will not benefit the institute.

Finally, the committee had the impression that the strategy discussed during the site visit had lost some of its focus and strength at the level of the individual research programmes. The committee recommends to the institute management to make sure the strategy is known and maintained at all levels of the institute.

**Resources**

In the period of review the number of scientific staff members was around 25, while the number of PhD candidates decreased from 23 in 2009 to 20 in 2013 and 15 in 2014. Owing to changes in personnel and a reorganisation of the Faculty of Science, MI changed considerably. However, selective investments led to a better balance between the two research programmes.

Direct funding was cut in half over the review period. However, costs for housing and library etc. also reduced, resulting in a stable funding for research from the university (approximately 40%). National grant income was also reduced by half, whereas international research grants doubled. Total income from research grants did go down; MI believes that the transformation of the institute will have a positive effect on the future earning capacity. The committee agrees with this expectation.

Like the other universities, Utrecht hires junior staff members on a tenure track. The committee supports the tenure-track policy in which young, talented researchers get the opportunity to do research and develop a research group within their expertise. At all Dutch universities a tenure-track position, when complying with the set criteria, guarantees a tenure position.

The committee recommends providing all tenure trackers with a PhD student to supervise within his/her own area of expertise. Such a condition will certainly help the tenure tracker in developing an academic track record and writing grant proposals. If there is no PhD student available from external grants, MI should make an effort to provide one via direct funding.

Another topic that was discussed during the site visit is the fact that it is difficult to successfully acquire grants. Even when a proposal is rated as very good by the assessors, obtaining the grant is not a certainty. From the interview with management it seemed that, similar to several Dutch mathematics departments, a very good assessment of a grant application allows for granting tenure, even if the grant itself was denied. The committee believes that this is fair towards the tenure tracker in the present climate where it is very difficult to obtain a grant, even with a very good application.

MI indicated in the self-evaluation report the wish to do more service teaching, specifically in undergraduate programmes, not only at other faculties of Utrecht University but also within the Faculty of Science. The committee agrees with MI that the quality of mathematics education is best guaranteed when given by staff of MI and not staff hired by other departments for the purpose of lecturing only. The committee recommends that the Faculty Board helps MI to be the preferred partner in teaching mathematics in other departments. The institute should realise that this requires them to subsequently deliver high quality service teaching. This implicates that teaching should be done by all levels of seniority, specifically also by full professors.

## 11.2. Assessment of the SEP Criteria

### Introduction

The tradition in fundamental mathematics lies in algebra, analysis and geometry. The FM programme is organised around three themes: 1) at the interface of algebra and geometry, including algebraic geometry, number theory, (higher) category theory, algebraic topology; 2) at the interface of analysis and geometry, including differential geometry and geometric analysis, symplectic and Poisson geometry, Lie theory, automorphic forms, integrable systems, noncommutative geometry, and mathematical physics; 3) history of mathematics, including cultural and societal aspects.

Geometry is used as the ordering principle for the research and has intricately linked with theoretical physics, but also the recent theoretical study of the structure of data involves geometry.

In MM dynamical systems are used as ordering principle for the research: there is a tradition in dynamical systems, numerical analysis, stochastic processes, and computational science. Strengths are organised around three themes: 1) applied analysis, where applied analysis and dynamical systems meet; 2) numerical analysis, where numerical analysis and dynamical systems meet; 3) stochastics, in which the focus has been on ergodic theory and symbolic dynamics, statistical physics, and random geometry.

The mathematical modelling process seeks to extract structure from empirical data, identify rules in the form of dynamical systems, analyse and compute solutions to the resulting models, and ultimately make predictions, optimise or control the systems. Applications range from the fundamentals of matter and biochemical processes to the geology and climate of the earth, from finance to social media to medicine.

### Research quality

The quality of the research that is done in the FM research programme has a very long tradition and has always been world leading. In the beginning of the evaluation period the research programme lost two of its world-leading senior researchers. One of them was however recovered at the end of the evaluation period as a university professor. In addition, the excellent tradition in high quality research led to impressive hiring at various levels of seniority. The excellent quality of the research is also displayed by a number of high quality research monographs. Also, some prestigious prices were awarded in the evaluation period, like a Spinoza award, Descartes, Huygens and Lichnerowicz awards.

The committee would specifically like to mention the very small, but very good and internationally well recognised group in History of Mathematics. This topic has a strong

tradition in Utrecht and is greatly valued by the committee. It hopes that this topic will keep its position in MI.

The MM research programme has undergone substantial changes in the evaluation period, which also shows in the records. For a certain period, the programme declined due to the loss of a number of internationally recognised researchers as well as financial difficulties. At the same time, student numbers at undergraduate level increased, putting even more strains on the research programme. However, similar to FM the MM programme managed to improve this situation, making several new key appointments, and it is on its way up, strongly supported by the strategy of the management.

The research of the MM research programme ranges widely, from computational methods to stochastic dynamics to analysis of neural field models. The strength of the MM programme lies in deterministic dynamical systems. On the stochastic side, statistical physics and combinatorial probability are represented, but for some years statistics was missing. A recently appointed assistant professor apparently shifted his research interests from statistical physics to applied medical statistics. This offers opportunities for collaborations with the epidemiology group, but the committee thinks that an additional recruitment in the area of stochastic epidemic modelling would greatly enhance the visibility and impact of the programme.

Some of the researchers in MM are visible world-wide and play leading roles at an international level. Although improvements are already visible, there is additional need for funding for PhD students and postdocs. The hiring strategy seems to work very well with respect to the quality of the research. One minor remark by the committee is to pay attention to connecting the areas of the staff members, which vary strongly and do not automatically lead to a coherent group.

**Relevance to society**

The focus of valorisation in MI has shifted over the years from mainly joint research papers with researchers from other disciplines to an emphasis on societal relevance by concentrating more on giving public lectures and being involved as outside experts in truly interdisciplinary projects.

The FM research programme is doing fundamental, theoretically oriented research, making immediate, direct connection to societal relevance more difficult. On the other hand, researchers in the FM programme published several excellent textbooks that are known and used all over the world. In addition, the Utrecht Fundamental Mathematics programme is actively involved in a number of impressive outreach activities. These include the Olympiad high school contest and publications aimed at high school teachers in mathematics. Also the History of Mathematics group deserves a very positive notification in the assessment of this criterion. It plays an important role in making the society aware of the long cultural traditions of mathematics and the contributions from the Islamic world.

The research areas that the MM programme treats are more closely connected to applications. The programme played the key mathematical role in a biological project to understand how to reduce spread of bacteria. It also analysed a simple model to understand the effect shifting climate might have on ecology. Another example of societal relevance is the software tool MATCONT, which is used by many universities, also in other disciplines. The development of open source software is also very impressive. With respect to collaboration with other disciplines, the Utrecht Centre for Infection Dynamics (UCID) is an excellent example, since

the mathematics programme was actively involved in setting up and operating this centre. There is also a fair amount of contract research through master students with an internship in industry. The committee would like to mention the NWO programme on Mathematics of Planet Earth, which could be very interesting for Utrecht. Concerning outreach, the committee is impressed by the excellent organisation of the research programme.

The MM research programme is already involved in the Top-sectors Energy and Chemistry via projects with Shell. It has plans to engage with the Top-sectors in Agriculture and Logistics under the Complexity theme.

**Viability**

FM is considered a young, excellent programme by the committee. Not only at the level of full professors this is high quality, also at the level below (assistant and associate professors) there are some very talented researchers. To crown it all, the world-leading researcher who was lost to another university at the beginning of the evaluation period will return as a university professor. Not only does this rather unique position emphasise the excellence of the individual, but it also displays the support of the Board of the University for mathematics.

In the MM programme the committee also observed the practice of hiring young and excellent researchers, which promises a positive outlook on the future. The SWOT-analysis was clear and to the point.

The committee supports the plans for increasing collaborations with other departments and research centres. One threat that was mentioned is the fact that research funding is changing towards large projects rather than individual grants. The committee confirms that this is a challenge for all universities with a mathematical department. It furthermore considers Utrecht to be very well equipped to deal with this issue. Mathematical modelling requires an integrative approach involving expertise in many branches of mathematics. This is difficult to maintain, but with the excellent researchers and with a continuously fine-tuning of the hiring policy, this should not pose a real problem.

**Conclusion**

In the evaluation period MI has gone through a difficult period with the loss of a number of senior researchers for various reasons. Nevertheless, the remaining staff still managed to do research at an excellent level. This evaluation comes at the right moment, the reorganisation has proven to be effective and in the latter years of the evaluation period the institute was definitely moving upward.

The institute management has a clear vision for the future and seems to be supported by the Dean. The institute should continuously balance the coherence of the two research programmes on the one hand and hiring of the most talented researchers regardless of their expertise on the other hand. If they manage to do so, all signs are directed towards an excellent future.

### 11.3. PhD programmes

Over the review period MI hosted an average of 22 regular PhD candidates per year. A total of 31 candidates received a PhD in the review period. Between 2006 and 2010 a total of 33 PhD candidates enrolled, a total of 6 candidates dropped out and after 5 years only 36% graduated (after 6 years this is 73%). Based on these numbers, the committee considered the PhD programme had serious problems prior to the site visit. However, MI has reacted by introducing a new PhD programme in Mathematical Sciences with stricter control of the

progress of PhD students. Furthermore, in the past evaluation period a number of scholarship students were hired who were not sufficiently qualified. New hiring criteria are in place, in combination with a more strict training and supervision plan. There is a clear go/no-go procedure, with a meeting after one year and the formal decision at 18 months. The scientific director of MI attends these meetings in order to verify the commitment of both PhD student and supervisor. With these measures the committee was reassured that the PhD programme is now on an excellent track.

The PhD programme is part of the Graduate School of Natural Science. The mission is to provide an excellent education for the next generation, including the training of transferable skills related to the dissemination of knowledge both inside and outside academia. Educational activities are required for a total of 20 EC over a four-year PhD programme period. In addition approximately 15% of the workload is done as a teaching assistant. More than 50% of graduates continued in a research career.

Compared to the numbers from the evaluation period, the committee was more impressed by the actual situation. The measures that were taken convince the committee that also in PhD training the institute is strongly improving. At other universities the committee valued the freedom given to the supervisor to provide the best training to his/her PhD students. In this case, however, the committee strongly supports the strict regulations of this PhD programme. Despite the fact that results might not yet be visible in the graduation figures and some struggles might still come up, the committee compliments the institute on the measures taken.

The interview with the PhD students confirmed the assessment that MI has improved. Students were positive about the PhD programme, the supervision they received, and the opportunities to follow relevant courses. PhD students are required to spend approximately 15% of their time on teaching. The PhD students the committee interviewed verified that this is indeed the case; all also stated that the experience gained in teaching was appreciated.

### 11.4. Research integrity policy

In addition to the Netherlands Code of Conduct for Scientific Practice, Utrecht University clarifies the standards for research and education which it upholds. At the level of the faculty there is a faculty integrity coordinator, acting as an impartial, confidential and accessible sparring partner for discussing relevant issues and dilemmas. In addition, there is a Faculty Academic Integrity Advisory Committee, advising the dean on how to guarantee academic integrity.

Policy of MI is directed to further strengthening the university's principles and standards by making explicit what research integrity means in the context of mathematics. Ethical standards are already addressed in the bachelor and master curriculum and at meetings for new PhD candidates.

### 11.5. Recommendations

- Contract research is now mainly done through master students with an internship in industry. The societal relevance and the external funding would even grow more if this could be combined with research on the PhD level;
- MI is recommended to pursue the Top-sector opportunities;
- MI is recommended to maintain the selection and monitoring procedures for PhD students to ensure quality, and completion of the thesis in a reasonable time;
- The MM programme is recommended to increase collaborations both within the MM programme and with other departments and research institutes;

- MI is recommended to continue to support the small group on the history of mathematics, with the goal to secure its future beyond the current decade.

### 11.6. Quantitative assessment

| | |
|---|---|
| Research quality | excellent (1) |
| Relevance to society | excellent (1) |
| Viability | excellent (1) |

# Appendices

## Appendix 1: Curricula Vitae of the committee members

**Regina Burachik** received her BSc and MSc in pure Mathematics in 1987 at the Universidad de Buenos Aires (UBA). In 1995 she obtained her PhD in Mathematics at the Instituto Nacional de Matematics Pura e Aplicada (IMPA) in Brazil. At present she is associate professor at University of South Australia, at the School of Information Technology and Mathematical Sciences. Her research interests are Smooth and Nonsmooth Optimization, Multiobjective Optimization, Convex Analysis and Variational Analysis. She has supervised seven PhD students in nonsmooth optimization as well as co-supervising a joint PhD student with the University of Newcastle. She is member of the Editorial Board of a number of international journals and in addition wrote 55 refereed articles, she published 4 scholarly book chapters and is guest editor of 7 special issues for renowned publishers and international journals. She holds a patent on 'method for performing intensity-modulated ion therapy so as to selection treatment plan satisfying prescribed dose treatment criteria'. She published the Springer research-level book: Set-Valued Analysis and Monotone Mappings.

**Alberto Cattaneo** obtained his degree (1991) and his Ph.D. (1995) in Physics at the University of Milan. He was a postdoc at Harvard University and at Milan University. He was appointed Assistant Professor in Mathematics at the University of Zurich in 1998 and since 2003 he is Full Professor in Mathematics. He is currently director of the Institute of Mathematics. His fields of interest are in mathematical physics, differential geometry and algebraic topology; in particular, his research activity includes deformation quantization, symplectic and Poisson geometry, topological quantum field theories, and the mathematical aspects of perturbative quantization of gauge theories. He has been a long term visitor at the University of Nantes, at Harvard University, at IHES and at UC Berkeley. He was an ICM speaker (Section Mathematical Physics) in 2006 and is a Fellow of the American Mathematical Society.

**F. Michel Dekking** (chair) received his diploma in Mathematics and Mechanics in 1974 at the University of Amsterdam. He was Attachée de Recherche, C.N.R.S. at the Université de Rennes, during 1975-1977. He received his Ph.D. degree at the University of Nijmegen in 1980, with advisors M. S. Keane and W. Vervaat. Since September 1981 he is affiliated to Delft University of Technology, were he is now Professor emeritus. He is active in diverse areas of pure and applied mathematics. In 2013, he was guest editor of the special issue on "Mathematics of Planet Earth" of Statistical Science.

**Hans Rudolf Künsch** obtained his Diploma in 1975 and his PhD in 1980 from ETH Zurich. After a postdoc position at the University of Tokyo he became assistant professor at the department of mathematics at ETH Zurich in 1983. In 1989 he was promoted to associate professor and in 1992 to full professor. His research interests are in the field of statistics and include the modeling and analysis of time series and spatial data, resampling methods, filtering problems and applications in environmental sciences. He was co-editor of the Annals of Statistics 1998-2000. From 2007 to 2009 he has chaired the department of mathematics at ETH, and in 2012/13 he was president of the Institute of Mathematical Statistics (IMS). He is an elected member of the International Statistical Institute and a Fellow of IMS. Since summer 2014 he is retired as professor at ETH, but he continues his scientific activities.

**Robert MacKay** is a professor in the Mathematics Institute of the University of Warwick and Director of the Centre for Complexity Science and of Mathematical Interdisciplinary

Research at Warwick. He was President of the (UK) Institute of Mathematics and its Applications for 2012-13. He has made many contributions to the theory and applications of Nonlinear Dynamics. His research was recognised by the first Stephanos Pnevmatikos International Award for Research in Nonlinear Phenomena (1993), a Junior (1994) and Senior (2015) Whitehead prize of the London Mathematical Society, election to Fellowships of the Royal Society (2000), the (UK) Institute of Physics (2000) and the (UK) Institute for Mathematics and its Applications (2003), entry to the ISI Highly cited list under Mathematics in 2008, a Royal Society Wolfson Research Merit Award (2012-7), and a Renowned Fellowship of EPSRC Recognising Influential Scientists and Engineers (2014). He has published 135 refereed journal articles, 50 articles in conference proceedings, lecture notes and similar, written 1 book and co-edited 1 reprint selection, 2 volumes of lecture notes and 4 conference proceedings. He has experience of evaluation in academia, notably having served on the Applied Maths panel of RAE2001 and 2008, research grant panels in the UK, EC and Netherlands, research evaluations in France, and advisory boards in the UK and France, examination boards in Warwick and Cambridge, and responded to government and other consultations as President of the IMA. He has designed and tested a method for calibrating panel assessments.

**Volker Mehrmann** received his Diploma in mathematics in 1979, his Ph.D. in 1982, and his habilitation in 1987 from the University of Bielefeld, Germany. He spent research years at Kent State University in 1979--1980, at the University of Wisconsin in 1984--1985, and at IBM Research Center in Heidelberg in 1988-1989. After spending the years 1990-1992 as a visiting full professor at the RWTH Aachen, he was a full professor at TU Chemnitz from 1993 to 2000. Since then he has been a full professor for Mathematics at TU Berlin. He is a member of acatech (the German academy of engineering) and vice president of GAMM the (International association of Applied Mathematics and Mechanics), chair of MATHEON, theResearch Center `Mathematics for key technologies´ and vice chair of the Einstein Center ECMath in Berlin. He is Einstein Fellow, holds an ERC Advanced Grant and also was member of the ERC Panel PE1. He is editor of several journals, editor-in-chief of Linear Algebra and its Applications. His research interests are in the areas of numerical mathematics/scientific computing, applied and numerical linear algebra, control theory, and the theory and numerical solution of differential-algebraic equations.

**Rolf H. Möhring** obtained his M.S. (1973) and Ph.D (1975) in Mathematics at the RWTH Aachen and is since 1987 Professor for Applied Mathematics and Computer Science at Berlin University of Technology, where he heads the research group "Combinatorial Optimization and Graph Algorithms" (COGA). He has held earlier positions as associate and assistant professor at the University of Bonn, the University of Hildesheim, and the RWTH Aachen. His research interests center around graph algorithms, combinatorial optimization, scheduling, logistics, and industrial applications. Part of his research has been done in DFG Research Center Matheon, where he was Scientist in Charge of Application Area "Logistics, traffic, and telecommunication networks". He has been chair of the German Operations Research Society and the Mathematical Programming Society and has been awarded the Scientific Award of the German Operations Research Society and the EURO Gold Medal of the European Association of Operational Research Societies. Since 2014 he is a honorary professor at the Beijing University of Technology and in the Board of the Beijing Institute for Scientific and Engineering Computing BISEC.

**Don B. Zagier** has spent most of his professional life in Germany, but is an American. After completing two undergraduate degrees in mathematics and physics at MIT in 1968, he did his doctoral work in Oxford and then Bonn, completing his doctorate in 1972 and obtaining his

Habilitation three years later. After two postdoc years at the ETH in Zürich and the IHES in Bures he returned to Bonn and has been there ever since, but always with another position in another country: from 1979 to 1990 as a Chair Professor at the University of Maryland, from 1990 to 2001 as a professor at the University of Utrecht, from 2001 to 2014 as a professor at the Collège de France in Paris, and since 2014 as an associate of the International Centre for Theoretical Physics in Trieste. In Bonn he worked for the "Sonderforschungsbereich Theoretische Mathematik" from 1971 until the founding of the Max Planck Institute for Mathematics in 1984 and as a scientific member and later director of the MPIM since then. He was also a titular professor of Kyushu University in Fukuoka during 1990–91 and 92–93, as well as having had a number of other long- or short-term visiting positions. He is a member of several academies and has been awarded various prizes. His main area of research is number theory, and in particular the theory of modular forms, but with many interconnections to other disciplines, in particular topology (including knot theory), algebraic K-theory, and mathematical physics (e.g. the applications of Jacobi forms, a theory that he co-invented with Martin Eichler, to string theory and the theory of black holes). He is the author or co-author of some 200 research publications, including 10 books, and has supervised 20 doctoral theses.

## Appendix 2: Explanation of the SEP criteria and categories

The Standard Evaluation Protocol 2015-2021 asks review committees to assess three criteria:

Research quality

- Level of excellence in the international field
- Quality and Scientific relevance of research
- Contribution to body of scientific knowledge
- Academic reputation
- Scale of the unit's research results (scientific publications, instruments and infrastructure developed and other contributions).

Relevance to society

- Quality, scale and relevance of contributions targeting specific economic, social or cultural target groups;
- Advisory reports for policy;
- Contributions to public debates.
- The point is to assess contributions in areas that the research unit has itself designated as target areas.

Viability

- The strategy that the research unit intends to pursue in the years ahead and the extent to which it is capable of meeting its targets in research and society during this period;
- The governance and leadership skills of the research unit's management.

The meaning of the four categories in SEP 2015-2021 is as follows:

| Category | Meaning | Research quality | Relevance to society | Viability |
|---|---|---|---|---|
| 1 | World leading/excellent | The unit has been shown to be one of the most influential research groups in the world in its particular field. | The unit makes an outstanding contribution to society | The unit is excellently equipped for the future |
| 2 | Very good | The unit conducts very good, internationally recognised research | The unit makes a very good contribution to society | The unit is very well equipped for the future |
| 3 | Good | The unit conducts good research | The unit makes a good contribution to society | The unit makes responsible strategic decisions and is therefore well equipped for the future |
| 4 | Unsatisfactory | The unit does not achieve satisfactory results in its field | The unit does not make a satisfactory contribution to society | The unit is not adequately equipped for the future |

**Appendix 3: Programme of the site visit**

| | | | |
|---|---|---|---|
| Sunday | | 15-nov-15 | |
| 17:00 | 20:00 | Preparatory meeting | PRC, secretay |
| 20:00 | 21:30 | Dinner in hotel | PRC, secretay |

| | | | |
|---|---|---|---|
| Monday | | 16-nov-15 | |
| 8:30 | 9:15 | General preparation | PRC, secretary |
| 9:15 | 10:00 | Preparing Vrije Universiteit Amsterdam (VU) | PRC, secretary |
| 10:00 | 10:45 | Preparing Amsterdam (UvA) | PRC, secretary |
| 10:45 | 11:15 | Interview management VU (dean/institute director) | Prof.dr. Karen Maex –Dean<br>Prof.dr. Mathisca de Gunst - Chair Department of Mathematics |
| 11:15 | 11:30 | break | |
| 11:30 | 12:00 | Interview management UvA (dean/institute director) | Prof.dr. K.I.J. Maex – Dean<br>Prof.dr. E.M. Opdam - Institute director<br>Dr.ing. M. Kranenburg - Institute manager |
| 12:00 | 12:45 | Lunch | PRC, secretary |
| 12:45 | 13:45 | Interview programme leaders VU (content) | Prof.dr. Jan Bouwe van den Berg<br>Prof.dr. Mathisca de Gunst<br>Prof.dr. Rob de Jeu<br>Prof.dr. Ger Koole<br>Prof.dr. Ronald Meester<br>Prof.dr. Rob van der Vorst |
| 13:45 | 14:30 | PhD students (VU) | Berry Bakker<br>Ruben van der Geer<br>Patrick Hafkenscheid<br>Timber Kerkvliet<br>Nurzhan Nurushev |
| 14:30 | 14:45 | break | |
| 14:45 | 15:45 | Interview programme leaders UvA (content) | Prof.dr. E.M. Opdam – AGMP<br>Prof.dr. L.D.J. Taelman - AGMP<br>Prof.dr. J.J.O.O. Wiegerinck - Analysis<br>Prof.dr. R. P. Stevenson - Analysis<br>Prof.dr. J.H. van Zanten - Stochastics<br>Prof.dr. M.R.H. Mandjes - Stochastics |
| 15:45 | 16:30 | PhD students (UvA) | K.J.L. Wang<br>B.L. Sevenster<br>M. Goncalves de Martino<br>D. Broersen<br>J. Hartog<br>N.J. Starreveld |
| 16:30 | 17:15 | Evaluation VU | PRC, secretary |
| 17:15 | 18:00 | Evaluation UvA | PRC, secretary |
| | | | |
| 18:30 | 21:00 | Dinner in Amersfoort | PRC, secretary |

| Tuesday | | 17-nov-15 | |
|---|---|---|---|
| 9:00 | 9:45 | Preparing Utrecht (UU) | PRC, secretary |
| 9:45 | 10:15 | Interview management (dean/institute director) | Prof.dr. Gunther Cornelissen – Head MI<br>Prof.dr. Gerrit van Meer – Dean<br>Prof.dr. Sjoerd Verduyn Lunel – Scientific<br>Director MI |
| 10:15 | 11:15 | Interview programme leaders (content) | Prof.dr. Frits Beukers - MI general<br>Prof.dr. Marius Crainic - Fundamental Mathematics<br>Prof.dr. Jason Frank - Mathematical Modelling |
| 11:15 | 11:30 | break | |
| 11:30 | 12:15 | PhD students (UU) | Felix Beckebanze<br>Hüseyin Sen<br>Kan Jiang<br>Ori Yudilevich<br>Valentijn Karemaker |
| 12:15 | 13:00 | lunch | PRC, secretary |
| 13:00 | 13:45 | Evaluation UU | PRC, secretary |
| 13:45 | 14:30 | Preparing Leiden (UL) | PRC, secretary |
| 14:30 | 15:00 | Interview management (dean/institute director) | Prof. Geert de Snoo Dean<br>Prof. Peter Stevenhagen – scientific director MI until 15/9/2015<br>Prof. Aad van der Vaart – scientific directeur MI<br>Dr. Bart de Smit – director of education MI |
| 15:00 | 16:00 | Interview programme leaders (content) | Analysis and Stochastics:<br>Prof. Frank den Hollander<br>Prof. Arjen Doelman<br>Prof. Aad van der Vaart<br><br>Algebra, Geometry, Number Theory:<br>Prof. Peter Stevenhagen<br>Dr. Bart de Smit |
| 16:00 | 16:15 | break | |
| 16:15 | 17:00 | PhD students (UL) | Björn de Rijk<br>Andrea Roccaverde<br>Mima Stanojkowski<br>Djordjo Milovic |
| 17:00 | 17:45 | Evaluation UL | PRC, secretary |
| | | | |
| 18:30 | 21:00 | Dinner in hotel | |

| Wednesday | | 18-nov-15 | |
|---|---|---|---|
| 9:00 | 9:45 | Preparing Nijmegen (RU) | PRC, secretary |
| 9:45 | 10:15 | Interview management (dean/institute director) | Prof. Dr. F. Vaandrager<br>Prof. Dr. E. Koelink<br>Prof. Dr. B. Moonen |
| 10:15 | 11:15 | Interview programme leaders (content) | Prof. Dr. N. Landsman<br>Prof. dr. G. Heckman<br>Prof. Dr. E. Cator<br>Prof. Dr. B. Moonen |
| 11:15 | 11:30 | break | |
| 11:30 | 12:15 | PhD students (RU) | Johan Crommelin<br>Bert Lindenhovius<br>Norbert Mikolajewski<br>Joshua Moerman<br>Joost Nuiten |
| 12:15 | 12:45 | lunch | PRC, secretary |
| 12:45 | 13:30 | Preparing Groningen (RuG) | PRC, secretary |
| 13:30 | 14:00 | Interview management (dean/institute director) | prof.dr. K. Poelstra (Vice Dean FWN)<br>prof.dr. Roerdink (director JBI)<br>prof.dr. Wit (chair JBI Board) |
| 14:00 | 15:00 | Interview programme leaders (content) | prof.dr. G. Vegter<br>prof.dr. A.J. van der Schaft<br>prof.dr. R.W.C.P. Verstappen<br>prof.dr. E.C. Wit |
| 15:00 | 15:15 | break | |
| 15:15 | 16:00 | PhD students (RuG) | M.H. Silvis<br>H. Jardon Kojakhmetov<br>M. Signorelli<br>A.R.F. Everts |
| 16:00 | 16:45 | Evaluation RuG | PRC, secretary |
| 16:45 | 17:00 | break | |
| 17:00 | 17:45 | Evaluation RU | PRC, secretary |
| | | | |
| 18:30 | 21:00 | Dinner in Amersfoort | PRC, secretary |

| Thursday | | 19-nov-15 | |
|---|---|---|---|
| 9:00 | 9:45 | Preparing Eindhoven (TU/e) | PRC, secretary |
| 9:45 | 10:15 | Interview management (dean/institute director) | prof.dr. Jakob de Vlieg (dean)<br>prof.dr.ir. Barry Koren (vice-dean research) prof.dr. Johan van Leeuwaarden (director Graduate Program Mathematics) prof.dr. Wil Schilders (director Project Development Office) |
| 10:15 | 11:15 | Interview programme leaders (content) | dr.ir. Remco Duits (CASA)<br>prof.dr. Mark Peletier (CASA)<br>prof.dr.ir. Jan Draisma (DM)<br>prof.dr. Tanja Lange (DM)<br>prof.dr. Edwin van den Heuvel (STO)<br>prof.dr. Remco van der Hofstad (STO) |
| 11:15 | 11:30 | break | |
| 11:30 | 12:15 | PhD students (TU/e) | Sarah Gaaf (CASA)<br>Sangye Lungten (CASA)<br>Jorn van der Pol (DM)<br>Christine van Vredendaal (DM)<br>Britte Mathijsen (STO)<br>Jaron Sanderse (STO) |
| 12:15 | 13:00 | lunch | PRC, secretary |
| 13:00 | 13:45 | Evaluation TU/e | PRC, secretary |
| 13:45 | 14:00 | break | |
| 14:00 | 14:45 | PhD students (TUD) | Mohit Kumar<br>Pieter van den Berg<br>Richard Kraaij<br>Menel Rahrah<br>Nick Lindemulder |
| 14:45 | 15:45 | Interview programme leaders (content) | Arnold Heemink<br>Geurt Jongbloed<br>Jan van Neerven<br>Dion Gijswijt |
| 15:45 | 16:00 | break | |
| 16:00 | 16:30 | Interview management | Rob Fastenau (dean EWI)<br>Ben de Pagter (chair DIAM) |
| 16:30 | 17:15 | Evaluation TUD | |
| 18:30 | 21:00 | Dinner in hotel | |

| Friday | | 20-nov-15 | |
|---|---|---|---|
| 9:00 | 9:45 | Preparing Twente (UT) | PRC, secretary |
| 9:45 | 10:15 | Interview management (dean/institute director) | Prof. dr. P.M.G. Apers – Dean<br>prof. dr. ir. M.R. van Steen - Scientific director CTIT<br>prof. dr. S.A. van Gils -replacing Head of Department |
| 10:15 | 11:15 | Interview programme leaders (content) | prof. dr. M.J. Uetz – Operations Research<br>prof dr. R.J. Boucherie – Operations Research<br>prof. dr. ir. B.J. Geurts – Scientific Computing<br>prof dr. S.A. van Gils – Scientific Computing |
| 11:15 | 11:30 | break | |
| 11:30 | 12:15 | PhD students (UT) | Gijs Kooij<br>Pim van der Hoorn<br>Maartje van de Vrugt<br>Koen Dijkstra<br>Sjoerd Gevers |
| 12:15 | 13:00 | lunch | PRC, secretary |
| 13:00 | 13:45 | Evaluation UT | PRC, secretary |
| 13:45 | 15:30 | General evaluation (part I) | PRC, secretary |
| 15:30 | 16:00 | Presentation preliminary results by chair | all participants |
| 16:00 | 17:30 | General evaluation (part II) | PRC, secretary |

## Appendix 4: Quantitative data

According to SEP 2015-2021 quantitative data on the research unit's composition and financing are compulsory. However, the committee concluded that the quantitative data on financing are provided in a way that makes it impossible to use them in a similar way for all nine universities. Direct funding strongly depends on the amount of service teaching in mathematics. Since the amount of service teaching in mathematics varies strongly between universities, the quantitative information on financing provides no useful information on the amount of direct funding that is dedicated to research purposes. The committee therefore decided not to take direct funding into consideration, nor the percentages of second and third stream funding.

**University of Amsterdam**

*Research staff*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | fte | # | fte | # | fte | # | fte | # | fte | # | fte |
| scientific staff | 28 | 7,9 | 28 | 8,3 | 30 | 9,0 | 30 | 9,1 | 31 | 9,4 | 33 | 9,5 |
| full professor | 14 | 3,6 | 14 | 3,6 | 13 | 3,6 | 13 | 3,5 | 14 | 3,7 | 16 | 3,9 |
| associate professor | 10 | 3,1 | 10 | 3,1 | 10 | 3,1 | 10 | 3,3 | 9 | 3,2 | 8 | 2,8 |
| assistant professor | 4 | 2,1 | 4 | 1,6 | 7 | 2,3 | 7 | 2,4 | 8 | 2,7 | 9 | 2,7 |
| postdoc | 9 | 3,9 | 6 | 4,2 | 4 | 2,2 | 5 | 3,5 | 8 | 4,5 | 9 | 6,0 |
| PhD student | 16 | 9,2 | 15 | 8,0 | 20 | 8,2 | 25 | 13,8 | 30 | 16,7 | 34 | 20,5 |
| external PhD student | 5 | 0,0 | 9 | 0,0 | 11 | 0,0 | 11 | 0,0 | 11 | 0,0 | 9 | 0,0 |
| **total** | **53** | **21,9** | **49** | **20,5** | **54** | **19,4** | **60** | **26,4** | **69** | **30,8** | **76** | **35,9** |

*Funding*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % |
| Direct funding | 2.356 | 59 | 2.122 | 63 | 2.346 | 67 | 2.651 | 63 | 2.501 | 57 | 2.929 | 52 |
| National grants | 557 | 14 | 682 | 20 | 711 | 20 | 996 | 24 | 1.280 | 29 | 1.749 | 34 |
| International grants | 177 | 4 | 166 | 5 | 176 | 5 | 383 | 9 | 384 | 9 | 493 | 10 |
| other | 931 | 23 | 396 | 12 | 243 | 7 | 157 | 4 | 202 | 5 | 181 | 4 |
| **total funding** | **4.021** | **100** | **3.366** | **100** | **3.476** | **99** | **4.187** | **100** | **4.367** | **100** | **5.352** | **100** |

**Vrije Universiteit Amsterdam**

*Research staff*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | fte | # | fte | # | fte | # | fte | # | fte | # | fte |
| scientific staff | 32 | 10,4 | 30 | 10,3 | 30 | 10,3 | 27 | 7,6 | 23 | 7,6 | 25 | 8,8 |
| full professor | 15 | 4,7 | 15 | 4,9 | 15 | 5,0 | 13 | 2,7 | 10 | 3,2 | 10 | 3,2 |
| associate professor | 3 | 0,9 | 3 | 1,0 | 3 | 0,9 | 4 | 1,1 | 4 | 1,3 | 5 | 2,0 |
| assistant professor | 14 | 4,9 | 12 | 4,4 | 12 | 4,4 | 10 | 3,8 | 9 | 3,1 | 10 | 3,6 |
| postdoc | 8 | 5,5 | 6 | 3,2 | 5 | 3,1 | 3 | 1,6 | 5 | 2,6 | 5 | 3,6 |
| PhD student | 24 | 17,7 | 21 | 15,5 | 20 | 14,9 | 15 | 11,1 | 18 | 13,4 | 22 | 16,4 |
| **total** | **64** | **33,7** | **57** | **29,0** | **55** | **28,2** | **45** | **20,3** | **46** | **23,5** | **52** | **28,8** |

*Funding*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % |
| Direct funding | 3.238 | 76 | 2.798 | 58 | 2.912 | 70 | 2.448 | 55 | 2.257 | 58 | 2.466 | 69 |
| National grants | 728 | 17 | 1.507 | 32 | 774 | 19 | 1.525 | 34 | 1.207 | 31 | 611 | 17 |
| Contract research | 202 | 5 | 273 | 6 | 272 | 7 | 172 | 4 | 72 | 2 | 219 | 6 |
| other | 113 | 3 | 205 | 4 | 200 | 5 | 292 | 7 | 337 | 9 | 275 | 8 |
| **total funding** | **4.281** | **100** | **4.783** | **100** | **4.158** | **100** | **4.437** | **100** | **3.873** | **100** | **3.571** | **100** |

**TU Delft**

*Research staff*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | fte | # | fte | # | fte | # | fte | # | fte | # | fte |
| scientific staff | 47 | 15,8 | 45 | 15,5 | 46 | 15,0 | 46 | 15,5 | 46 | 15,7 | 49 | 16,4 |
| full professor | 10 | 3,0 | 10 | 3,1 | 11 | 2,9 | 9 | 2,9 | 8 | 2,9 | 9 | 3,0 |
| associate professor | 15 | 5,5 | 14 | 5,2 | 13 | 5,0 | 14 | 5,2 | 13 | 4,6 | 13 | 4,5 |
| assistant professor | 22 | 7,3 | 21 | 7,2 | 22 | 7,1 | 23 | 7,3 | 25 | 8,2 | 27 | 9,0 |
| postdoc | 5 | 3,9 | 3 | 2,1 | 4 | 2,5 | 3 | 1,1 | 3 | 2,0 | 3 | 1,7 |
| PhD student | 62 | 35,5 | 60 | 36,4 | 65 | 38,8 | 74 | 38,5 | 68 | 43,5 | 70 | 41,8 |
| **total** | **114** | **55,2** | **108** | **53,9** | **115** | **56,2** | **123** | **55,1** | **117** | **61,2** | **122** | **60,0** |

*Funding*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % |
| Direct funding | 5.952 | 76 | 5.217 | 67 | 5.467 | 73 | 5.440 | 74 | 6.166 | 69 | 6.425 | 79 |
| National grants | 333 | 4 | 267 | 3 | 509 | 7 | 360 | 5 | 324 | 4 | 582 | 7 |
| Contract research | 712 | 9 | 1.167 | 15 | 620 | 8 | 666 | 9 | 932 | 10 | 1.132 | 14 |
| other | 830 | 11 | 1.086 | 14 | 915 | 12 | 932 | 13 | 1.479 | 17 | 36 | 0,440 |
| **total funding** | **7.827** | **100** | **7.737** | **100** | **7.511** | **100** | **7.398** | **100** | **8.901** | **100** | **8.175** | **100** |

**TU Eindhoven**

*Research staff*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | fte | # | fte | # | fte | # | fte | # | fte | # | fte |
| scientific staff | 55 | 16,6 | 55 | 15,8 | 50 | 15,7 | 50 | 15,2 | 46 | 14,3 | 49 | 14,7 |
| full professor | 13 | 4,3 | 13 | 4,4 | 13 | 4,2 | 14 | 3,7 | 13 | 3,7 | 15 | 4,2 |
| associate professor | 8 | 1,9 | 11 | 2,2 | 12 | 3,0 | 10 | 3,1 | 10 | 3,2 | 9 | 3,0 |
| assistant professor | 32 | 10,4 | 30 | 9,1 | 24 | 8,5 | 24 | 8,3 | 22 | 7,3 | 24 | 7,4 |
| extraordinary prof. | 2 | 0,1 | 1 | 0,0 | 1 | 0,0 | 2 | 0,1 | 1 | 0,1 | 1 | 0,1 |
| postdoc | 20 | 8,8 | 21 | 13,6 | 18 | 9,2 | 19 | 9,6 | 18 | 11,3 | 18 | 9,2 |
| PhD student | 55 | 33,8 | 49 | 29,5 | 53 | 28,8 | 52 | 25,4 | 49 | 26,2 | 66 | 36,5 |
| external PhD student | 4 | 1,3 | 4 | 1,9 | 1 | 0,2 | 3 | 0,3 | 4 | 2,6 | 2 | 0,2 |
| **total** | **134** | **59,2** | **125** | **58,9** | **121** | **53,7** | **121** | **50,2** | **113** | **51,8** | **133** | **60,4** |

*Funding*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % |
| Direct funding | 5.641 | 52 | 6.247 | 56 | 6.053 | 59 | 5.734 | 62 | 6.325 | 65 | 6.167 | 61 |
| National grants | 1.664 | 15 | 1.195 | 11 | 1.561 | 15 | 1.756 | 19 | 1.877 | 19 | 2.414 | 24 |
| International grants | 754 | 7 | 551 | 5 | 541 | 5 | 503 | 5 | 840 | 9 | 999 | 10 |
| Contract research | 2.750 | 25 | 3.132 | 28 | 1.691 | 17 | 1.026 | 11 | 410 | 4 | 369 | 4 |
| other | 100 | 1 | 70 | 1 | 373 | 4 | 246 | 3 | 296 | 3 | 127 | 1 |
| **total funding** | **10.909** | **100** | **11.195** | **100** | **10.219** | **100** | **9.265** | **100** | **9.748** | **100** | **10.076** | **100** |

**University of Groningen**

*Research staff*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | fte | # | fte | # | fte | # | fte | # | fte | # | fte |
| scientific staff | 18 | 7,2 | 16 | 6,6 | 16 | 6,4 | 15 | 6,3 | 16 | 5,9 | 18 | 7,8 |
| full professor | 11 | 3,8 | 10 | 3,4 | 9 | 3,3 | 9 | 3,1 | 8 | 2,9 | 9 | 3,1 |
| associate professor | 4 | 1,5 | 3 | 1,2 | 3 | 1,2 | 3 | 1,2 | 4 | 1,6 | 4 | 1,6 |
| assistant professor | 3 | 2,0 | 3 | 2,0 | 4 | 1,9 | 3 | 2,0 | 4 | 1,4 | 5 | 3,1 |
| postdoc | 2 | 1,2 | 5 | 2,2 | 9 | 6,3 | 7 | 5,2 | 9 | 3,0 | 5 | 4,9 |
| PhD student | 32 | 16,9 | 39 | 28,2 | 40 | 28,3 | 42 | 30,5 | 46 | 32,2 | 47 | 32,3 |
| **total** | **52** | **25,3** | **60** | **37,0** | **65** | **41,0** | **64** | **42,0** | **71** | **41,1** | **70** | **45,0** |

*Funding*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % |
| Direct funding | 1.856 | 68 | 1.788 | 65 | 2.128 | 65 | 2.105 | 67 | 2.390 | 81 | 2.645 | 82 |
| National grants | 809 | 30 | 850 | 31 | 952 | 29 | 848 | 27 | 415 | 15 | 484 | 15 |
| International grants | 0 | 0 | 8 | 0 | 116 | 4 | 84 | 3 | 69 | 2 | 41 | 1 |
| contract research | 57 | 2 | 100 | 4 | 88 | 2 | 109 | 3 | 60 | 2 | 65 | 2 |
| **total funding** | **2.722** | **100** | **2.746** | **100** | **3.284** | **100** | **3.146** | **100** | **2.934** | **100** | **3.235** | **100** |

**Leiden University**

*Research staff*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | fte | # | fte | # | fte | # | fte | # | fte | # | fte |
| scientific staff | 23 | 7,3 | 23 | 7,7 | 24 | 8,4 | 29 | 8,7 | 29 | 9,4 | 38 | 10,7 |
| full professor | 9 | 2,3 | 8 | 2,4 | 9 | 2,4 | 11 | 2,7 | 10 | 3,2 | 10 | 2,9 |
| associate professor | 5 | 1,8 | 4 | 1,5 | 4 | 1,5 | 5 | 1,6 | 5 | 1,6 | 6 | 1,9 |
| assistant professor | 9 | 3,2 | 11 | 3,8 | 11 | 4,4 | 13 | 4,4 | 14 | 4,6 | 22 | 5,9 |
| postdoc | 7 | 2,8 | 8 | 3,5 | 8 | 3,7 | 12 | 5,2 | 13 | 6,5 | 21 | 8,3 |
| PhD student | 27 | 15,9 | 29 | 15,8 | 33 | 17,3 | 46 | 23,5 | 51 | 30,4 | 58 | 33,7 |
| **total** | **57** | **26,0** | **60** | **27,0** | **65** | **29,4** | **87** | **37,4** | **93** | **46,4** | **117** | **52,7** |

*Funding*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % |
| Direct funding | 2.626 | 70 | 2.849 | 70 | 2.702 | 54 | 3.011 | 51 | 3.021 | 44 | 3.341 | 54 |
| National grants | 984 | 26 | 1.003 | 25 | 929 | 19 | 1.397 | 24 | 1.593 | 23 | 1.340 | 22 |
| International grants | 72 | 2 | 93 | 2 | 1.311 | 26 | 1.110 | 19 | 1.794 | 26 | 914 | 15 |
| other | 49 | 1 | 148 | 4 | 61 | 1 | 406 | 7 | 449 | 7 | 588 | 10 |
| **total funding** | **3.731** | **100** | **4.093** | **100** | **5.003** | **100** | **5.924** | **100** | **6.857** | **100** | **6.183** | **100** |

**Radboud University Nijmegen**

*Research staff*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | fte | # | fte | # | fte | # | fte | # | fte | # | fte |
| scientific staff | | | 3 | 1,1 | 4 | 1,1 | 4 | 1,0 | 4 | 1,2 | 5 | 1,3 |
| full professor | | | 1 | 0,4 | 1 | 0,3 | 1 | 0,1 | 1 | 0,4 | 1 | 0,4 |
| associate professor | | | 1 | 0,4 | 1 | 0,4 | 1 | 0,4 | 1 | 0,4 | 1 | 0,4 |
| assistant professor | | | 1 | 0,3 | 1 | 0,3 | 1 | 0,3 | 1 | 0,3 | 2 | 0,5 |
| extraordinary prof. | | | 0 | 0,0 | 1 | 0,1 | 1 | 0,1 | 1 | 0,1 | 1 | 0,1 |
| postdoc | | | 2 | 0,2 | 2 | 0,5 | 2 | 0,5 | 2 | 0,6 | 2 | 0,9 |
| PhD student | | | 1 | 0,5 | 1 | 0,9 | 1 | 0,9 | 1 | 0,8 | 2 | 1,8 |
| **total** | | | **6** | **1,8** | **7** | **2,5** | **7** | **2,3** | **7** | **2,6** | **9** | **4,1** |

*Funding*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % |
| Direct funding | 1.281 | 69 | 1.514 | 69 | 1.570 | 70 | 1.720 | 74 | 1.700 | 64 | 1.701 | 57 |
| National grants | 571 | 31 | 678 | 31 | 669 | 30 | 604 | 26 | 864 | 32 | 1.120 | 38 |
| International grants | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 102 | 4 | 156 | 5 |
| **total funding** | **1.852** | **100** | **2.192** | **100** | **2.239** | **100** | **2.334** | **100** | **2.666** | **100** | **2.977** | **100** |

**University of Twente**

*Research staff*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | fte | # | fte | # | fte | # | fte | # | fte | # | fte |
| scientific staff | 38 | 11,2 | 34 | 11,6 | 35 | 11,7 | 29 | 9,9 | 31 | 10,1 | 32 | 10,3 |
| full professor | 12 | 3,7 | 12 | 3,9 | 11 | 4,1 | 8 | 2,8 | 9 | 3,0 | 8 | 3,2 |
| associate professor | 9 | 2,3 | 6 | 1,9 | 7 | 1,9 | 5 | 1,8 | 5 | 1,3 | 4 | 1,0 |
| assistant professor | 15 | 5,0 | 14 | 5,4 | 14 | 5,3 | 12 | 4,2 | 12 | 4,4 | 16 | 5,3 |
| | 2 | 0,2 | 2 | 0,4 | 3 | 0,5 | 4 | 1,1 | 5 | 1,4 | 4 | 0,8 |
| postdoc | 9 | 4,7 | 11 | 5,0 | 10 | 4,0 | 9 | 4,3 | 8 | 2,6 | 7 | 4,3 |
| PhD student | 31 | 17,5 | 28 | 15,4 | 28 | 16,2 | 33 | 17,3 | 32 | 18,0 | 27 | 15,8 |
| **total** | **78** | **33,3** | **73** | **32,0** | **73** | **31,9** | **71** | **31,5** | **71** | **30,8** | **66** | **30,4** |

*Funding*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % |
| Direct funding | 6.316 | 85,6 | 6.455 | 83,1 | 6.142 | 84,8 | 5.044 | 77,6 | 5.047 | 78,8 | 6.367 | 80,2 |
| National grants | 620 | 8,4 | 707 | 9,1 | 556 | 7,7 | 811 | 12,5 | 776 | 12,1 | 810 | 10,2 |
| International grants | 105 | 1,4 | 36 | 0,5 | 58 | 0,8 | 88 | 1,4 | 96 | 1,5 | 222 | 2,8 |
| Contract research | 338 | 4,6 | 571 | 7,3 | 484 | 6,7 | 555 | 8,5 | 484 | 7,6 | 541 | 6,8 |
| **total funding** | **7.379** | **100,0** | **7.769** | **100,0** | **7.240** | **100,0** | **6.498** | **100,0** | **6.403** | **100,0** | **7.940** | **100,0** |

**Utrecht University**

*Research staff*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | fte | # | fte | # | fte | # | fte | # | fte | # | fte |
| scientific staff | 27 | 9,3 | 24 | 8,7 | 24 | 8,6 | 25 | 17,8 | 27 | 7,6 | 25 | 8,7 |
| full professor | 11 | 3,9 | 11 | 3,8 | 10 | 3,6 | 10 | 13,2 | 12 | 2,9 | 10 | 3,5 |
| associate professor | 6 | 2,2 | 4 | 1,6 | 5 | 2,0 | 6 | 2,0 | 5 | 2,0 | 5 | 2,0 |
| assistant professor | 10 | 3,3 | 9 | 3,3 | 9 | 3,0 | 9 | 2,7 | 10 | 2,7 | 10 | 3,2 |
| postdoc | 9 | 5,8 | 10 | 7,9 | 13 | 8,5 | 11 | 8,3 | 11 | 7,4 | 7 | 3,6 |
| PhD student | 23 | 15,3 | 26 | 16,2 | 27 | 16,9 | 24 | 14,7 | 20 | 12,7 | 15 | 10,9 |
| **total** | **59** | **30,5** | **60** | **32,8** | **64** | **34,0** | **60** | **40,8** | **58** | **27,7** | **47** | **23,2** |

*Funding*

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % | k€ | % |
| Direct funding | 1.402 | 42 | 1.406 | 43 | 1.247 | 44 | 1.030 | 40 | 919 | 39 | 779 | 38 |
| National grants | 1.746 | 53 | 1.574 | 48 | 1.357 | 48 | 1.202 | 46 | 1.000 | 42 | 850 | 41 |
| International grants | 164 | 5 | 273 | 8 | 248 | 9 | 355 | 14 | 437 | 19 | 359 | 17 |
| Contract funding | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 67 | 3 |
| **total funding** | **3.312** | **100** | **3.253** | **100** | **2.852** | **100** | **2.587** | **100** | **2.356** | **100** | **2.055** | **100** |