Research in Mathematics in Norwegian Universities and Colleges

A review

The Research Council of Norway
P.O.Box 2700 St. Hanshaugen
N-0131 OSLO
Telephone: +47 22 03 70 00
Fax: +47 22 03 70 01
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To the Research Council of Norway

The members of the Review Committee for Research in Mathematics at Norwegian Universities and Colleges submit the following report.

The views presented in this report are expressed in consensus among the members of the Review Committee. The members of the Review Committee are further in collective agreement with the assessments, recommendations and conclusions presented.

Professor Elja Arjas
University of Helsinki, Finland

Professor David Cox
University of Oxford, U.K

Professor Joachim Cuntz
University of Münster, Germany

Professor Ivar Ekeland
University of Paris-Dauphine, France
Chairman

Professor Bertil Gustafsson
Uppsala University, Sweden
Vice chairman

Professor Jean-Pierre Kahane
University of Paris-Sud, France

Professor Chiang Mei
MIT, USA

Professor Susan Montgomery
University of Southern California, USA

Professor Jack Morava
John Hopkins University, USA

Hycham Basta, from the University of Paris-Dauphine, acted as scientific secretary of the evaluation committee.

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We thank the committee for their work during the review process and especially for their help in developing the broad conclusions that are the keystone of such a report.

We thank all the staff, professors and students from the University departments and colleges, who prepared the detailed written submissions that provided the basis for this review. We would like to particularly thank those who travelled to Oslo for their valuable oral presentations and for being open and helpful during the discussions that followed. Without this contribution a wide-ranging review of this nature would not have been possible.

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I. Presentation

This report is an evaluation of mathematical research conducted in Norwegian universities at the request of the Research Council of Norway. The mandate was as follows: "[The committee is requested] *to make use of the departments' self-evaluations in its assessment of the overall state of Mathematics and to draw up a report with a set of specific recommendations for the future development of this field. The committee is requested to evaluate scientific activities with respect to their quality, relevance and international and national collaboration, bearing in mind the resources available. The committee is further requested to evaluate the way in which research in Mathematics is organised and managed. The conclusions of the committee should lead to a set of recommendations concerning the future development of research in Mathematics in Norway*."

The members of the committee, including a vice-chairman and a chairman, were appointed by the Research Council. The mathematics departments to be investigated were defined by the Research Council to be those at Bergen (UiB and NHH), Oslo (UiO), Trondheim (NTNU), Tromsø (UiT), Ås (AUN).

This report is based on the following information:

- Self-evaluation reports contributed by each mathematics department and each research group. These reports were collected by the Research Council, and sent to the committee members in January 2002, together with some global quantitative information.
- Selected reprints for each researcher. These reprints were collected by the Research Council and made available to the committee members during their stay in Oslo for the interviews.
- Interviews conducted with representatives of each department and of each research group in Oslo from February 25th to March 1st, 2002.

The committee is well aware that it was afforded only a partial view of mathematical research in Norway. Mathematical research is conducted within other institutions as well, such as teaching colleges and specialized research institutes (SINTEF and Norwegian Computing Center being the most relevant for mathematics), and also within other departments of universities.

This is especially the case in applied mathematics, where research typically lies at the interface of mathematics and other sciences. For example, besides the mathematics department, research in industrial mathematics can also find place at the engineering school, research in fluid mechanics at the oceanography department, and research in numerical analysis at the informatics department. It is even more the case in statistics. Virtually all branches of science use statistical methods. This results in much work in statistics being based in subject-matter departments, for instance in medical schools, and lying outside the terms of reference of the present review. While much of this additional statistical work is strongly focused on the specialized needs of the relevant subjects, this is by no means universally true. The committee is aware, therefore, that this report may appear to somewhat underestimate the general strength of applied mathematics and statistics in Norway.

In pure mathematics as well, it is the case that some individuals who are active members of university research teams fall outside the scope of this report for administrative reasons, for instance because they hold positions in teaching-only colleges.

Within the limitations expressed above, the committee feels that it has had access to all relevant information. Any request of additional information, either from the Research Council or from the individual departments or research teams, has been met readily. The members of the committee would like to take this opportunity to thank the Research Council for the way it organized this evaluation, and their Norwegian colleagues for the thoroughness of their self-evaluations and the quality of the interviews.

This report represents the unanimous view of the committee members.

II. Executive summary

1. There is evidence that Norway is underinvesting in science and technology, of which the mathematical sciences are an essential part.

2. The mathematical sciences in Norway are facing a depletion problem: current trends project into fewer students in mathematics and therefore fewer professors and researchers in the future.

3. Resources should be supplied for new appointments in advance of forthcoming retirements.

4. University and research positions should be made more attractive, in terms of money and prestige, in order to retain the best people in Norway and to attract others from abroad.

5. There should be a joint effort by the Research Council and the universities to create a clear path leading to academic careers, with quick decisions taken at the crucial transitions.

6. Steps should be taken to encourage more women to enter mathematical studies and a research career.

7. Universities and the Research Council should systematically take into account the contribution of mathematicians and statisticians to research in other disciplines.

8. Mathematics libraries are important tools for research, and should be kept up to date, as well as computer facilities.

9. The collaborative system which the Norwegian mathematical community has put in place should be preserved.

10. Academic careers should favour mobility between Norwegian universities and encourage periods of study or research abroad.

Recommendations about individual departments and research groups will be found in the appropriate sections of this report.

III. Science and mathematics

Over the last two centuries, science and technology have been the backbone of economic growth and social change in the Western world. Underpinning these developments have been the mathematical sciences, providing an essential basis for the physical sciences and the associated technologies. In very recent years, there has been increased interest in the biological sciences, especially but by no means only in genetics, and in issues connected with the economic and financial system, particularly in the light of the computer revolution. The need for statistical support is ubiquitous, calling for a strong mathematical base, and the role of mathematical modelling in biology is growing rapidly. While the traditional areas of mathematical applications retain their importance, even if the emphasis is reduced, new challenges are constantly rising from these current developments. More generally, in a knowledge-based society, the need for critical quantitative thinking supported by solid mathematical work and research into new challenges is, in the committee's view, likely to expand. Pure and applied mathematics, which at this level cannot be dissociated, are essential for the scientific future and technological development of society.

In this context, it is worth mentioning that the National Science Foundation of the US, in addition to its core research and education activities, has identified six priority areas in its 2002 and 2003 budget[1], among which the mathematical sciences, for which 60 M$ of additional funds are allotted from this side of the budget in 2003, a 100% increase from 2002 figure. In a similar move, NSERC, the Canadian Research Council, has just reallocated 27 M$Can to the new priorities for basic research, among which is the funding of three institutes in mathematics. So it does seem that a new concern is emerging about preserving the existing potential in mathematics and strengthening the field so that it can meet new challenges.

For all these reasons, the committee considers it very important that Norway should build on and indeed expand its tradition and current strengths in mathematics.

These findings are supported by other reports[2][3][4][5]. In a sense they are also supported by the situation in Norway, as in many other countries, where students even with limited mathematical training are in great demand by employers. However, the committee wishes to point out that, while these opportunities are a testimony to the effectiveness of a mathematical education, they are also a considerable drain on the stream of highly qualified undergraduates entering research and ultimately having a university career. Allowing this stream to dry up would put the future in jeopardy.

[1] http://www.nsf.gov/bfa/bud/fy2003/goals.htm
[2] "Renewing US mathematics – a plan for the 1990s", David et al., National Academy Press, 1990
[3] "Kunnskap och kompetens", Industriförbundet, 1995, Stockholm
[4] "Reports on the strength and weaknesses of European science", European Science Foundation, 1997
[5] "Science and technology indicators 2002", National Science Foundation,www.nsf.gov/sbe/srs/seind02/start.htm

IV. The special situation of Norway

Norway is a developed country with special geographical features. It has a small population stretched along 2,000 miles of coast. It has made a great effort, including the creation of a university in Tromsø, to keep the northernmost part of the country populated. Its traditional industries are fisheries, hydroelectricity and maritime transport. The discovery of oil beds in the Norwegian continental shelf has turned it into a major oil producer.

This special situation is well known and has been much investigated. Several consequences are relevant to the situation of scientific research in Norway:

- The very long coastline and the maritime tradition of Norway fosters a general interest towards maritime research, and the fact that one-third of the country lies above the Polar Circle fosters a strategic interest towards polar studies. Norway is well situated to develop scientific research connected with these broad themes. One would also believe that the very extension of the country, and the level of education, would foster a special interest in modern technologies of communication, but there is little evidence to that effect: it seems that industry in neighbouring countries has taken a much greater part in the telecommunications boom than in Norway.

- The traditional industries in Norway are not technology- or research-intensive. To be sure, technological obstacles were to be overcome in the initial phases of oil extraction from the seabed, or of salmon farming, but these are basically production industries, and not transformation industries: total factor productivity growth in Norway is among the lowest in the OECD[6]. As a result, the rate of innovation is low[7],

- The existence of substantial oil revenues lowers the price of import goods relative to domestic goods. There is a danger that this may lead to the desindustrialization of the economy[8], as it historically occurred in Holland after the discovery of North Sea gas. The consequences for R&D are far-reaching: in an open economy, like the Norwegian one, the choice between developing your own technology, and paying for it in real terms (basically man-power and education), or buying it ready-made from abroad and paying for it with "free" oil revenues, is distorted in favour of the latter. The danger then is that the country embarks on a vicious circle driven by market prices: the less it invests in R&D, the more costly domestic technologies become relative to imported ones, and the less it will invest in R&D.

One should also bear in mind the special structure of R&D in Norway. Almost all of the R&D is funded by the public sector, and done either in public universities or in research institutes which specialize in applied research. This is in contrast with the US situation, where private funding and institutions play a very important role, and with the French situation, where research institutes are not specialized, but are large, all-purpose institutions, covering also basic research. In addition, much of the Research Council funding come from ministries

[6] OECD STI scoreboard at www.oecd.org; see also "Et verdiskapende Norge", Reve and Jakobsen, Universitetsforlaget, 2001
[7] According to th 1996 community innovation survey, 20% of Norwegian firms had introduced new products within the preceding three years, against an OECD average of 31%.
[8] See the entry "Dutch disease" in the Dictionary of Business, Oxford University Press, 1996

which have a natural tendency to support research with immediate applications. There is a feeling that this system may generate a bias against basic research, such as pure mathematics. It is certainly the case that mathematics benefits less from the research programs of the Research Council, which tend to be focused on industrial priorities such as oil and technology, and more from the so-called free projects, than other disciplines. In 2000, 40% of total support from the Research Council to mathematics came through free projects (11,8 M NOK out of a total of 29,4), which is unique among all disciplines (average figure is 16,5%).

However, the most ominous sign of danger is the scale of the R&D effort across the board, which is substantially lower than in most other developed countries. In 1999 the US was spending 2,7% of GNP on R&D, the mean of OECD countries was 2,2%, and Norway was spending 1,7%[9]. This situation has been stable for a number of years.

[9] OECD sources, see http://www.oecd.org

V. Mathematics in Norway

A. Strengths

There is a strong mathematical tradition in Norway. Historically, the country has shown a remarkable ability to produce world-class mathematicians, Nils Henrik Abel and Sophus Lie being the first ones, and the most famous. From that time on, Norway has been a part of the international research community in mathematics, and Norwegian mathematicians are quite familiar with international standards.

At the present moment, there were 154 tenured persons in mathematics in Norwegian universities, about one for every 30.000 inhabitants. As we mentioned earlier, the boundaries of mathematics are defined somewhat arbitrarily, so that comparisons between different countries are difficult; in France, for instance, mechanics is outside mathematics departments, and so are statistics in many North American universities. However, there is some evidence to the fact that there are relatively fewer professional mathematicians in Norway than in the other OECD countries[10]. On the other hand, some of the Norwegian mathematicians are among the best in the world; in the last International Congress of Mathematicians (Berlin,1998), the landmark event of the profession, which convenes every four years, there were three Norwegian invited speakers out of a total of 180. Bibliometric indicators tell the same story. In terms of total number of publications per capita[11], Norway ranks 10th among 22 OECD countries, but 13th in mathematics. However, the international impact and visibility as indicated by the citations index is higher than OECD average in mathematics: articles with Norwegian authors or co-authors tend to be quoted more frequently. One should note also the high proportion (42%) of articles with Norwegian authors which have co-authors from other countries, showing the strength and importance of international connections.

Another important feature of the Norwegian tradition is that, from the very beginning, universities have sought to strike a balance between pure and applied mathematics. At the University of Christiania, for instance, there were two chairs in mathematics, one pure and one applied, until 1872, when a third one was created for Sophus Lie. In Norwegian universities today, mathematics departments tend to split evenly between pure and applied mathematicians (53,3% to 46,7%), with a strong presence of statistics, in contrast to countries like France, where mathematics departments tend to be overwhelmingly pure or applied. Even the former Norwegian Institute of Technology (NTH), an engineering school which is now absorbed into NTNU, had a strong pure component in its mathematics department. The committee sees this as an excellent tradition, as it helps communication between specialists in various fields, and broadens mathematical research and education in general.

In addition to research activity Norwegian universities have traditionally taken the demands of teaching very seriously. There has been a particular need arising because the teaching of mathematics to students of other departments has largely become the responsibility of mathematics departments. While the committee considers such arrangements wise and much to be encouraged, they do place important demands on the departments, and it is important to ensure that professors have the time and encouragement to pursue and direct research.

[10] The world directory of mathematicians, International Union, 1994
[11] Data from the International Institute for Scientific Information, period 1996-2000

According to the academic survey on academic staff for the year 2000, 33% of working time is spent on teaching, 11% on supervision and 34% on R&D. To the extent that these mean values reflect the true situation, the committee sees this as a reasonable balance.

The dangers facing the future of mathematics in Norway, which will be described in the next section, have led to a remarkable reaction of the Norwegian mathematical community. The problem of mathematical education in high schools has been addressed in different ways by different institutions. On the one hand, UiO has made a major effort in promoting mathematics within the public at large (creation and promotion of the Abel prize), and within high-school students (including visits to schools by university faculty). This effort has undoubtedly led to a renewed interest in mathematics, as witnessed by the appearance of books (biographies of Abel and Lie) and articles (a regular column in Dagbladet) on the subject. On the other, NTNU has obtained the creation of a national center for teacher education in mathematics, which will be located on campus and will presumably increase the level of mathematical proficiency in high schools. One should also remember that the Norwegian Mathematical Society is responsible for NORMAT, a journal specializing in bringing mathematics to scientifically literate readers.

One should also point to the habits and means of cooperation taken up by various research teams in the country. In algebraic geometry and analysis of PDEs, for instance, there is really only one team of researchers, working in close contact although they hold positions in different universities. Several national initiatives take advantage of the facilities at Nordfjordeid, or at the Center for Higher Studies (CHS) at the Norwegian Academy, to capitalize on these cooperations and to create a critical mass which is sorely lacking at the local level. For instance, the CHS organizes research semesters on specific themes, with visiting scholars in residence, and provides Norwegian professors with sabbatical grants to attend them; several such semesters have been on mathematical subjects. The Nordic Summer Schools organized jointly by the algebra groups at Oslo, Bergen and Trondheim for the benefit of PhD students and young researchers, have won international recognition.

All this activity requires a great amount of work from individuals dedicated to the common good. It may be the greatest strength of Norwegian mathematics that there is such a number of them around.

B. Weaknesses

1. The question of teaching

To have a complete idea of the level of mathematics in Norway, one should check it at various levels:

- Basic numeracy throughout the population, such as the ability to compute a simple percentage
- Higher mathematical literacy for people engaged in technological industries, such as engineering, finance, insurance, where mathematical models are commonly used and statistical analysis of data is required
- Research and education in sciences other than mathematics, but making use of mathematical modelling and statistical analysis
- Research in mathematics proper.

Only the last item lies within the committee's mandate, but the previous three interact strongly with research in mathematics, and it is important that this link be fostered. Indeed, it is very difficult to have world-class research in mathematics if the vast majority of students coming out of the high school system are mathematically illiterate (so that few, if any, will be interested in studying mathematics), or if the prevailing industries are not technology-intensive (so that there will be little support for a healthy applied mathematics sector in research). Although the committee did not investigate the situation, it kept cropping up during the interviews, or even in the national media during the committee's stay in Oslo, and did not seem to be particularly encouraging. Both the basic mathematical literacy throughout the population and the interest of industry in developing mathematics-related technology were called into question. We were repeatedly told about the lack of interest in mathematics in high schools, about poor students and unqualified teachers, resulting in fewer students in mathematics at university level, compounded by the fact that the best students choose other fields.

On the other hand, Norway has recently participated in the recent PISA-study testing the mathematical literacy of 15-years old in various OECD countries. Norwegian students scored almost exactly at the OECD average, not as well as in France or the UK, but better than in the US or Germany. So the situation may not be worse than in some other countries, but it does not mean that it is good. The US, in particular, are known to be dissatisfied with their performance, and are taking steps to remedy it: in 2001, the National Science Foundation launched the VIGRE (Vertical Integration of Research and Education) program ”to increase the number of US citizens ... who receive training for and subsequently pursue careers into the mathematical sciences” [12]. In any case, there certainly is a sense of urgency in Norwegian society about the decreasing level of mathematical literacy.

A result, or possibly a cause, of this situation is that mathematics graduates no longer consider teaching mathematics in high schools an attractive proposition. The committee has been told repeatedly how few of them choose such a career. This is of course a vicious circle, since it reduces the number of mathematics graduates among high school teachers who have to teach, among other things, mathematics, which in turn reduces the exposure of pupils to mathematics, with the result that fewer of them will choose this field in university; among those who do, even fewer will aim for a teaching career.

There has been recently an evaluation of the way mathematics is taught in Norwegian institutions of higher education[13] which analyzes these problems and points to important weaknesses in the training of teachers. The committee can do no better than to refer to this report.

[12] http://www.nsf.gov/pubs/2001/nsf01104/nsf01104.html

[13] "Nasjonal evaluering av høyere utdanning. Fagområde: matematikk", KUF-departementet, 1995

2. The problem of renewal

Table 1 : Age distribution of tenured personnel in mathematics per institution and age interval in 1999 in number of persons.

Institution	Total	Age interval								
		25-29	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**
UiO	41	-	3	2	6	6	9	3	9	3
UiB	24	-	1	2	3	2	1	6	9	-
NTNU	42	2	2	9	3	6	7	8	3	2
UiT	14	2	-	1	4	3	2	1	1	-
AUN	13	-	-	-	2	5	3	1	1	1
NHH	20	-	1	4	3	1	5	2	4	-
Total	154	4	7	18	21	23	27	21	27	6

According to this table, there were 148 tenured personnel in mathematics in Norwegian universities below the age of 65, and 48 of them were between the ages of 55 and 65. This means that about one-third of the existing body will have retired by 2009. Just to fill the vacancies, about 50 persons must be recruited in ten years, on the average five per year.

The number of past and projected recruitments has not been available, but we can look at PhDs. There were 18 PhDs in mathematics completed during the year 1999, and 14 in 2000. These statistics do not reflect the fact that many doctoral students leave without submitting a dissertation (about half in certain institutions), and many PhDs in mathematics find jobs in private companies. In addition, they reflect the situation prevailing 4 to 5 years ago (this is the time it takes to complete a PhD) and not future trends; in fact, it seems that during the years 1999 and 2000, the mathematics departments recruited very few new PhD students and post-docs. The general impression of the committee is that the flow into university careers in mathematics has been below the renewal level, and is going further down.

This leads us directly to the main problem facing mathematical research in Norway: although the present situation is generally good, and even excellent in places, the age structure combined with a shortage of doctoral students could lead to a collapse within a few years. This is the issue that Norway has to address if it wants to keep domestic mathematical research at world level ten years from now.

One should also remember that the problem has been around for some time, and has been addressed by the simple device of hiring mathematicians from abroad, in particular from the former Soviet Union. This is a particular case of the general strategy of importing goods instead of producing them domestically, and, if continued, could result in the domestic education system becoming unable to produce mathematicians. If such an outcome is considered undesirable, a way of producing mathematicians domestically has to be created, that is, a continuous chain leading promising high school students to research positions in mathematics.

There is such a chain at the present time, but it is broken at strategic junctures, the main one coming right after the PhD: universities are reluctant (and with good reason) to give tenured positions to students just out of their PhD, and prefer to observe them for a few more years in a non-tenured position, typically post-doc. Such positions are difficult to find in Norway: there are not more than two or three every year for the whole country. Such small numbers clearly discourage applications, so that new PhDs turn to other possibilities outside academia.

The application procedure has a deterrent effect as well; typically the student must have finished the degree and have a paper accepted to apply, and can then wait up to six months before a decision is reached, by which time the candidate has usually found other opportunities outside academia. PhD scholarships seem to be a problem as well: although there are at least two ways to get one, either through a free project funded by the Research Council or through a straightforward PhD application by the student to the Research Council, it seems that neither of them can come up with a decision quickly enough for the student not to be left in limbo after graduating. This creates a feeling of uncertainty which generally tends to discourage students from engaging into mathematical careers, especially the brightest ones, who, as we noted earlier, have plenty of other opportunities.

3. *Attractiveness of a research career*

The problem is compounded by the fact that, Norway being a small country, there are few students around in the first place. This of course extends well beyond the student level: the question of critical mass is central to mathematical research in Norway. Even the most talented scientists cannot thrive in an environment where they are unable to fruitfully discuss their own work, and get intellectual stimulation from the work of others; if they do not find such an environment in their own country, they seek it elsewhere, as Sophus Lie did, to take a famous example. The problem is even more important in applied mathematics and statistics, which need a constant inflow of data and problems from other sciences. One immediate consequence is that Norway cannot hope to cover all fields of pure and applied mathematics, and has to specialize in certain areas, broad enough to maintain diversity within the corresponding research groups, and central enough to retain a sense of mathematics as a whole.

Wittingly or not, the Norwegian mathematical community has been remarkably successful in implementing this kind of strategy. In important areas, like algebraic geometry, operator algebras or statistics, Norwegian teams are at the foreground of world research. There are of course some weak points: optimization theory and operations research are not part of the regular mathematical curriculum in Norwegian universities (even though they were traditionally very strong in the oil industry), and there are surprisingly few probabilists around. But at the present time, as was stated before, the overall situation is good.

It may, however, deteriorate very fast. Key researchers will retire in the coming years, and one should also bear in mind that mathematics changes quickly, so that not only the teams, but the themes will have to be renewed. This comes precisely at the time when good students in mathematics are so hard to come by, which does not make the problem any easier.

Attracting mathematicians from abroad will be difficult for Norway. On the one hand, the post-tax salaries are not attractive, compared with those of its European neighbours, and there is a language barrier. On the other, countries like France and Germany, and even the United States, will probably face a similar problem at the same time, so that the world market for mathematicians will probably be a tight one. Attracting Norwegian students into mathematics will meet similar difficulties (competition with other occupations, or with a position abroad). It has also been claimed that the recent reforms, which have stripped the title of professor of its rarity and prestige, may also have detracted from the overall appeal of the profession in Norwegian society. They have certainly contributed to the difficulty of finding candidates for positions in the North, and keeping them in place.

The committee met with 45 representatives of Norwegian mathematics departments, among whom there was only one woman. This is a reflection of the general situation, whereby there are 7% of women among tenure personnel in mathematics (some of them, to be sure, in prominent positions) compared to 23% is all fields of science combined. There is considerable scope for persuading many more women to stay for post-graduate work, with the hope that, in the future, the number of women in senior university positions will greatly increase. This process will take time to come to fruition, but the committee considers it very important that steps should be taken now in this direction.

4. Applied mathematics and statistics

One last word about applied mathematics. It faces a structural problem, in the sense that research in applied mathematics can be done either in the mathematics department or in a department or institution which is closer to the problem being modelled. Such separations always have some degree of arbitrariness, different universities make different choices, and sometimes no choice at all, in the sense that the same kind of research is pursued in different departments of the same university. Whatever the structure, the important thing is that interaction between different groups of researchers is not hampered by administrative barriers or difficulties of communicating across campus: numerical analysis, for instance, is needed both by mathematicians and by informaticians. It should not be the case that both the department of mathematics and the department of informatics form their own team of numerical analysts.

The problem is especially acute for statistics. As already noted, all areas of science use statistical methods to some extent and many subject-matter departments undertake appreciable statistical work. It is important that such close links with applications are fostered, but there is some danger of fragmentation of the subject. One possible solution is a strong group of statisticians in the mathematics department maintaining close cooperation with colleagues in applications, and the committee was encouraged to see a number of instances of this.

We note that an appreciable part of the Research Council's budget is tied to the work of particular ministries of government agencies, and is frequently allocated to specialized research institutes associated with them. It would enhance collaboration between these institutes and local universities if in the issuing of research contracts appropriate allowance were routinely made for mathematical and statistical support. The committee believes this would be in the interest of all concerned and would, broadly speaking, enhance the effectiveness of the total research effort.

Generally speaking, applied mathematics and statistics offer more openings for PhD students and research positions than pure mathematics, nevertheless one does find the same shortage of interested (and interesting) candidates, probably for the same basic reasons. Be it an effect or a cause, many interesting opportunities go unexplored. The oil industry was a big supporter of applied mathematics in Norway, and much interesting research was motivated by problems coming from that source, but this support seems to have weakened in recent years, at least the committee did not hear of any new major research project involving Statoil and Norwegian universities. To the committee's surprise, links with industries other than oil appear largely unexplored.

VI. University of Bergen

Department of Mathematics

A. Overall description

The Department of Mathematics at the University of Bergen (UiB) employs 25 permanent faculty, 2 professors II, and 7 permanent staff. There are 6 university funded doctoral students, 12 externally funded doctoral students, and 2 post-docs.

There is a complaint that shortage of funds has led, among other things, to cancelling subscriptions to research journals.

B. Algebraic geometry (4 faculty, 2 PhD students, 1 post-doc)

This is a very good group of 4 permanent members with a good age distribution. The group's interests are similar to those of the algebraic geometry group in Oslo (topics closely connected to string theory, enumerative geometry and non-commutative geometry), with which it has good connections and some coordination.

C. Analysis (1 faculty, 1 PhD student)

This is a strong group, with good international contacts, but very isolated in Bergen.

D. Number theory and discrete geometry (5 faculty, 1 PhD student)

There are 5 permanent members, all approaching retirement, with ages going from 59 to 67. The disappearance of this group may spell the end of the tradition of number theory in Norway. Of the 5 members, 2 are number theorists, 2 work in combinatorics or discrete geometry, and 1 is not active in research. Of those doing research, 2 are very good in their field.

Although there is a possibility of cooperation between number theory and algebraic geometry via cryptography and elliptic curves, this has not happened here. If the University wishes to maintain the tradition in number theory, it may choose this direction of development and encourage cooperation with the group in algebraic geometry and relevant groups in informatics.

This situation with discrete mathematics is made more difficult by the fact that this subgroup is isolated in Norway, and seems not to have considered the possible applications of convex geometry.

E. Fluid mechanics, ocean modelling (4 faculty, 1 professor II, 1 post-doc, 8 PhD students)

The research interests of the theoretical branch (wave mechanics) are very different from those of the numerical branch (numerical modelling of ocean currents). A very distinguished scientist is about to retire, and the following recruitment will be crucial for the future of the group.

Considering the presence of the large Geophysical Institute, it will be natural for UiB to increase its faculty and graduate program in mathematical geophysical fluid dynamics (GFD) which is a field where Norwegian theoreticians led the world during the early part of the 20th century.

F. Industrial mathematics (4 faculty, 1 professor II, 8 PhD students)

The group has 5 faculty members, with a good age distribution, thanks to 2 recent recruitments, and 8 externally funded PhD students. The research is dominated by problems from the petroleum industry, mainly multiphase flow problems in reservoirs. The group has been successful in attracting external funding, and it has been an important supplier of engineers and scientists for the oil industry for a long time.

The scientific production is very good, with a clear research focus, there are strong connections with industry, and the international cooperation is well developed. With close connection to industry comes the problem of keeping the work on a high scientific level as opposed to the more consulting type work. The group is aware of this problem, and seems to be handling it well.

The numerical analysis group now belongs to a separate department. It is important that the connection to this group be kept up, in particular concerning large scale problems on parallel computers. It is also recommended that the collaboration with the fluid dynamics group be increased.

G. Plasma dynamics (2 faculty, 1 PhD student)

The field of plasma dynamics is dying out at UiB (and also in Norway) as fusion seems as far off as ever and other fields have acquired priority. It will not survive after the retirement of the 2 permanent members of that group. They have laudably switched to other fields and encouraged their students to do so. One of them works on optimal control applied to fisheries management, the other keeps working in plasma physics, but has worked also in physiology with a distinguished medical team on kidney research.

H. Statistics (5 faculty, 3 PhD students)

The statistics group functions as one unit for the purposes of teaching, and has developed joint study programs with the Department of Economics at UiB and with NHH. For the purposes of research, it is divided into 3 subgroups: Biostatistics, Actuarial and Financial mathematics, and Time Series. Academically by far the strongest subgroup, consisting of 2 members, is that in Time Series, with 1 member produces interesting research of a high international profile on non-linear models and non-parametric methods.

It is advisable to coordinate the activities of the 3 subgroups in research, as they are in teaching. Especially the active and successful research on time series analysis at the university would seem to offer possibilities for further expansion and strengthening of the corresponding group, perhaps then forming, in addition to the already existing collaborative links to the Institute of Marine Research, a bridge to the Department of Finance and Management Science and the Department of Economics at the NHH. Another obvious area of research coordination is actuarial and financial mathematics, where the main strength of the statisticians working in this field at the university seems to be on the actuarial side, whereas the financial mathematics aspect could be naturally supported by the expertise offered in this area by NHH.

I. Recommendations

Apart from Industrial mathematics, the number of PhD students per faculty member is low. In addition the number of students engaged in mathematics programs is decreasing. Given the traditional emphasis on teaching within Norwegian universities, this situation does not provide a sound basis for the Department within UiB.

There is a general feeling of fragmentation: some research groups are obviously too small, and there is little interaction between the groups. Applied mathematics has suffered from the separation with computer science: numerical analysis and coding theory went with the newly-founded Department of Informatics, which moved away from the mathematics building, severing long-standing cooperations. In addition, statistics (apart from biostatistics) is not in the same building as pure and applied mathematics.

It is essential that a clear strategy for the future be formulated by the Department of Mathematics. Simply maintaining the existing research groups is not good enough. It does not address the problems above, and it is simply not feasible because of the age distribution. Several retirements are due in the near future, and the opportunity should be seized by the Department to restructure the mathematical research at UiB. Specifically:

- There is a structural problem in analysis. The committee sees three possibilities: (a) phasing out analysis and letting applied mathematics take charge of the subject, (b) creating a structure associating pure and applied mathematicians for the purpose of teaching analysis, or (c) expanding the existing group in analysis, and prepare this expansion right now by an appropriate invitation policy.

- At the present time, there is one main center of scientific distinction within pure mathematics formed by the group in algebraic geometry. The committee recommends that the opportunity offered by the coming retirements in discrete mathematics be used to establish a research group in another field of pure mathematics as a complement to this pole.

- The committee feels that much could be gained if there were closer cooperations between the statistics group and the other groups in applied mathematics.

VII. Agricultural University of Norway

Department of Mathematical Sciences

A. Overall description

The Agricultural University of Norway (AUN) was established in 1859 as an agricultural college, and the first position in mathematics was created in 1898.

The Department of Mathematical Sciences (including informatics) has 10 permanent faculty and 5 vacant positions. Among them mathematics and statistics have 9 permanent positions and 1 vacant one. There are 11 PhD students.

The Department of Mathematical Sciences points to heavy teaching loads and lack of resources for research.

B. Mathematics (5 faculty, 2 PhD students)

There is little common research interest within the group, which is really a collection of individuals, and insists in maintaining diversity in research. There is also diversity in output, which ranges from topics with no obvious relevance to AUN to applied work in collaboration with groups in biology. Overall, the research output is fair, with some interesting initiatives, such as CEREBAND, an informal exchange group with physicists and regulatory biologists, and CIGENE, a Center of Excellence proposal in integrative genetics, where 3 mathematicians are involved.

The committee was presented with plans to expand into bioinformatics and functional genomics, but finds it is not a realistic target, in the present situation of the group.

C. Statistics (4 faculty, 9 PhD students)

4 statisticians are working in this section, all almost exactly of the same age. There has been an unsuccessful recent attempt to hire one more at full professor level.
There is a heavy teaching load of introductory level statistical courses, apparently quite successful.

It is important that the contribution of the statistics section in supporting empirical research in other departments of the university be properly recognized. Apart from that, research output is modest.

The statisticians are covering a number of fields which are of relevance for AUN, and are starting a large-scale research project with industry on biostatistics (IBION). Such developments are much to be encouraged. On the other hand, interest was expressed in the ”hot” area of bioinformatics (functional genomics, analysis of gene expression data), but it is not clear what the demand of other AUN departments, and what university support there would be for such a study or what distinctive emphasis would be involved.

D. Informatics (4 faculty positions, all vacant)

The committee expresses no opinion on this section, which submitted a research program on data analysis, and which had no representative for the interview.

E. Recommendations

There is a lack of scientific leadership, and the present situation is not satisfactory. Whether it will change or not will depend on a strategic decision on the part of the AUN administration: should the institution develop quantitative methods which it finds relevant to its purposes, such as mathematical modelling in biology or biostatistics, and allocate resources to that purpose? We believe they should; it seems from available information that the decision has already been made to expand informatics. The Department of Mathematical Sciences is encouraged to develop joint research between its members and other research groups at AUN.

VIII. University of Tromsø

Department of Mathematics and Statistics

A. Overall description

The University of Tromsø (UiT) was founded in 1969 and the first positions in mathematics were created in 1972.

There are 14,5 faculty members, and 7 PhD students. From past experience about one-half of PhD students leave without completing their degree. The Department has had severe hiring problems for a long period, and points to increasing administrative and teaching loads.

B. Algebra (4 faculty, 2 PhD students)

There is little research output in past years and research in recent years has been out of the mainstream. A total of 20 MSc degree students have been trained in the algebra group.

C. Analysis (3 faculty, 2 PhD students)

This is a well functioning group of 3 permanent members with a good research output, extending from the geometry of differential equations to differential and almost complex geometry. There have been 5 MSc and no PhDs produced since its creation. There is collaboration within the group (the Sophus Lie seminar) and with other groups in the university, and good international connections.

D. Applied Mathematics (3 faculty, 1 PhD student)

The group has 3 faculty members, and the age distribution is not alarming. Most of the work has been on problems in plasma physics, electromagnetics and optics. The group is small, but has produced very good work: 17 students have completed their master's degree in applied mathematics; a total of 3 doctoral students have completed their dissertation in applied mathematics and 3 doctoral students have completed their degree in physics under the supervision of faculty members from the applied mathematics group. However, currently there is only 1 PhD student, and recruitment seems to be a major concern, as for many other groups in UiT. To remedy the situation, there is now an initiative to start a new master's program in industrial mathematics together with the statistics group. In order for the program to be successful, the applied mathematics group must be actively involved in the planning and implementation.

Work in wavelet analysis has been going at UiT for some years. The leading researcher in this field has left, but some work of this type continues in the applied mathematics group. Considering the many interesting wavelet applications of relevance for industrial mathematics, it would be of importance that this work continues, preferably in collaboration with the analysis group, and also with KTH in Stockholm.

E. Statistics (4,5 faculty, 2 PhD students)

In terms of completed degrees, the statistics group has during its nearly thirty years of existence produced 11 MSc and 2 PhDs (in 1996 and 1999). The trend in master's level students seems to be further declining, whereas for PhD study the situation is now somewhat better (currently 2 students).

The current staff in statistics consists of 1 professor, 2 associate professors, and 1,5 amanuensis positions. All members of this group are still below the age of fifty.

The committee was favourably impressed by the research performance of the senior member of the group. The main thrust in the work is in medical imaging, notably in magnetic resonance (MR) imaging, both conventional and functional. In addition to these, there has been research in non-parametric and semi-parametric smoothing and estimation, including recent attempts to apply simulation based Markov Chain Monte Carlo (MCMC) algorithms in such work. Apart from medical imaging, this work has found applications in environmental research and marine technology.

According to the self-evaluation report, statistics was originally introduced at UiT to support research and education in medicine, biology and fisheries. Marine biology and marine resource estimation would indeed offer a wealth of challenging problems for statisticians.

The Department is planning to a new master's program in industrial mathematics next fall, as a joint effort of the applied mathematics and statistics groups. It is not entirely clear what it would involve on the part of the statisticians, but presumably this program would cover the main activities of the group. Alternatively, given the very limited success which the statisticians at UiT have had in training statisticians at master's level, one might consider another development strategy, by putting a high priority on challenging collaborative research projects in applied disciplines, and training graduate students within such a framework.

F. Recommendations

The Department is below the critical mass, and too isolated for outstanding research to be easily achieved. There are severe problems in getting students to enrol in mathematical programs, and in recruiting faculty.

These are major problems, but the Department also suffers from a rigid segmentation into groups, and seems to confront these problems at the group level only: there does not seem to be an overall perspective of the Department as a whole, or a global strategy for mathematics.
To face the problem of student enrolment, two new programs have been started, one in computer security and one in industrial mathematics; it is not clear to what extent these programs will cannibalize the two existing ones. On the other hand, the program in computer security paves the way for a fruitful collaboration with informatics.

The committee recommends that other possibilities should be explored as well. Taking the responsibility of mathematical training for high school teachers in Northern Norway is one of them. There are plans for merging the UiT with an existing college training teachers. While such a merger causes the general fear that UiT might turn into a purely teaching, no-research institution, it could also open new opportunities for mathematicians, especially if there is a policy of improving the training of teachers in mathematics.

The committee also recommends that PhD programs be more focused on local opportunities, such as marine biology or polar research; the projected creation of a research group on the physics of the atmosphere might also bring a new opening. Future recruitments should take these possibilities into account.

IX. Norwegian School of Economics and Business Administration

Section of Mathematics and Statistics

A. Overall description

There is no department of mathematics at the Norwegian School of Economics and Business Administration (NHH). There was one until 1997, when an internal reorganization put the subject under the formal supervision of the Department of Finance and Management Science. There is, however, an informal Section of Mathematics and Statistics.

There are 5 permanent faculty in the Section, and 1 professor II elsewhere in the Department. The number of PhD students is 2.

B. Mathematics (4 faculty, 1 PhD student)

This is a very diverse group, consisting of four permanent members, with basically no common research interest. One of them works in stochastic analysis and finance, an area in which there could be much further expansion in research and teaching. Another member works in control theory applied to economics of renewable resources, which is a natural theme for an institution such as NHH. Overall research output is fair.

C. Statistics (1 faculty, 1 PhD student)

The statistics group, because of difficulties of recruitment, is reduced to a single member. The overwhelming demands of teaching, which have been very conscientiously met, have largely precluded an effective research contribution.

D. Recommendations

The committee feels that NHH could offer great opportunities to develop a strongly distinctive department of mathematics in an environment permeated by economics and management. Within such a department, statistics and econometrics, operations research, mathematical finance, economic modelling and game theory would be important fields. It seems that up to now NHH has not used these opportunities. To do so would require a strategic decision on the part of NHH administration, namely to develop relevant quantitative methods within the institution, perhaps in a joint effort with UiB, thereby developing at the institutional level collaborations which exist on an individual basis. The committee encourages NHH to do so.

X. Norwegian University of Science and Technology

Department of Mathematical Sciences

A. Overall description

The Norwegian University of Science and Technology (NTNU) was established in 1996 after a major restructuring of the academic institutions in Trondheim. The present Department of Mathematical Sciences of NTNU is the result of a merger between the mathematics department of the former University of Trondheim (UNIT) and the former Norwegian Institute of Technology (NTH).

Since 2002, the Department of Mathematical Sciences and the Department of Computer and Information Science will join the faculty of electrical engineering, breaking a traditional link with the Department of Physics. This restructuring is accompanied by a major reorganization of the administration and decision structure (the ORGUT program), with the objective of empowering the Department board to make strategic decisions, and giving operative leadership to the head of the Department.

There are 41,5 permanent faculty, 2 professor II, 35 PhD students, 2 temporary appointments and 5 post-docs. The temporary appointments (typically for one year) are offered to fresh PhDs, with roughly 35% teaching duties, functioning effectively as post-doctoral scholarships. In the sequel they will be registered as post-docs.

B. Algebra (4 faculty, 1 post-doc, 3 PhD students)

There are 4 permanent members with an acceptable age distribution for the moment. Note, however, that within five years, the Department should hire a younger person.

It is the main group in Norway in noncommutative algebra. They emphasize representation theory of algebras and Lie algebras, and their connections to derived categories, noncommutative algebraic geometry and quantum groups.

It is a very good group, some of them truly excellent, with top international visibility. The group has organized three international conferences since 1996, and attracts first-class visitors. The group is developing an interest in applications of algebra to coding theory and cryptography, which is a field that should thrive in a technical university.

C. Complex and harmonic analysis (6 faculty, 3 PhDs, 2 post-docs)

This is a very good group with an excellent leader. However, there is an age problem: 5 out of 6 professors are above 59.

The elder members are working on analytic continued fractions and related matters, which is a strong tradition in Norway. One should take care that their knowledge is not lost: it should be completely recorded in publications, a task that may not be finished by the time they retire.

The younger members, including post-docs, work in active areas of Fourier analysis, but only one member has a full-time permanent position. Though international connections and impact are more than satisfactory; the future is not guaranteed if the group is not stabilized and reinforced very soon by new positions.

The relation with the PDE group could be stimulated if both groups had a common project with the engineering school.

D. Differential equations (5 faculty, 6 PhD students)

The group has five permanent members, very good research output, and excellent international connections. The activities are extremely varied (although they operate as a team), a hallmark being theoretical quality coupled with industrial relevance. The list is as follows:

- Degenerate parabolic and HJB equations, with applications to finance (with interesting problems, such as the pricing of forward energy contracts) and flows in porous media;
- Systems of conservation laws: the front-tracking method, which led recently to major theoretical advances, thanks to the work of Bressan, originated in Norway as a tool for computer simulations of flows in porous media and is currently supported by the Research Council project "Non-linear PDEs of evolution type – theory and numerics";
- Stochastic PDEs and white noise analysis, where again there is a Norwegian school (use of Wick products to model nonlinearities) as another way to model flows in porous media;
- Completely integrable Hamiltonian systems, using algebraic geometry and/or inverse scattering, with applications to fibre optics;
- Modelling of the ocean surface, wave spectra and applications to SAR images.

E. Functional analysis (4 faculty, 1 PhD student, 2 post-docs)

A better heading for the group would be ”Operator algebras and noncommutative geometry”. Two permanent members of the group are doing very good research on crossed products, topological dynamical systems, quantum groups and deformations. There is much international activity in that field and the Trondheim group has as well established place in it. The research of the rest of the group, including the research on the post-doctoral positions is in more marginal fields.

The group has very good international connections. It has arranged the visit of a leading foreign scientist as an Adjunct Professor at Trondheim during several years. This initiative could have been even more successful had it been accompanied by additional activities involving for instance also the algebra group.

The average age of the permanent members of the group is very high. It is important to recruit a good young scientist to a permanent position in the near future. Because of a limited market for candidates the search should not be too limited. Ideally one might look for somebody who can also interact with the strong algebra and topology groups.

F. Geometry and Topology (5 faculty, 5 PhD students)

There are five permanent members, most of them in their fifties, with one strong recent and younger recruitment.

The group has diverse interests, centred around algebraic topology and manifold theory. It has seized the opportunity provided by the reorganization of the University to create a very active cross-cultural seminar, with participation of some of the algebraists.

This is a very good group, with some excellent individuals, and has significant impact at a high international level. However, their impact at that level is constrained by lack of resources, such as post-docs and opportunities for contact with younger foreign researchers interested in joint projects.

G. Numerical analysis (4 faculty, 1 professor II, 4 PhD students, 1 post-doc)

The group has four permanent members with a good age distribution. The current main emphasis is on geometric integration, and it has evolved around previous work on numerical solution methods on ODE, where the group has a very good record and an excellent scientific leadership. The recent broadening of the scope to the PDE area was a good move, that has already increased the interaction with other groups, both nationally and internationally.

In order to increase the impact of current work, it is recommended that the rather theoretical work on geometric integration be now extended and applied to solve real world problems. Furthermore, it is important to initiate a more intensive collaboration with the differential equation group next door in the Department.

H. Statistics (9 faculty, 1 professor II, 13 PhD students, 2 post-docs)

Statistics at NTNU has three groups at a very good level with components of excellence. The work of all three groups is closely connected to, and largely motivated by, important fields of application.

The spatial and computational statistics group was formed ten years ago when its senior member moved from the Norwegian Computing Center to Trondheim. It has three permanent positions, and two of its current members are still below the age of 40. Considering the relatively small size of the group, it has been very successful in the training of graduates, including five PhDs during the past five years. Particular areas of emphasis in the research have been petroleum reservoir evaluation, ocean wave estimation, and medical imaging. In its geostatistical work the Trondheim group is apparently one of the world leaders, with an excellent academic record and connections both to oil industry in Norway as well as to leading foreign academic institutions in this field. From a methodological perspective, the work is largely based on hierarchical Bayesian modelling and on an application of Markov

Chain Monte Carlo algorithms in the numerical work. Thus there is a very strong computational element in the work of this group.

The industrial statistics group carries on an older tradition in Trondheim, concentrating on reliability analysis and quality technology. This group has currently four permanent full time positions and one part time position, with one member having moved recently from within NTNU and another from Moscow. The group has been as successful in training graduates as the spatial and computational statistics group, and its activities are similarly motivated by important practical applications, notably reliability issues arising in offshore oil drilling. Their research has a somewhat more traditional flavour than that of the previous group. Currently the main areas of research activity are stochastic modelling and statistical analysis of repairable systems, analysis of random waves and oceanic systems, design of experiments in quality technology, and nonparametric statistics. The group is well respected, and it has very good contacts both to industry and to academic institutions.

The biomodelling group is very small, with only two permanent positions. Their research activity has been mainly in the area of statistics and stochastic modelling in conservation biology, and it builds largely on a long time successful collaboration with a senior biologist at NTNU. This group has an excellent academic record, and its research has been well funded, for example, by the Research Council. They deserve encouragement also in the future to develop their important work.

In summary we strongly recommend support for the continuation and development of all the statistical work at NTNU with the biomodelling group especially deserving expansion in size.

I. Recommendations

Because of the tradition of the former NTH, the common problems of Norwegian universities (shortage of students, and even more of qualified students) do not hit NTNU with the same intensity, which is a favourable factor for Department of Mathematical Sciences.

The committee was much impressed by the overall strength of the Department. There are several strong research groups, with international visibility, but the boundaries are permeable, and there is a lot of scientific exchange and cooperation across groups, so that the Department functions as a well-integrated entity. This is all the more remarkable since the research groups span all the way from very pure to very applied mathematics, and the present Department results from the fusion of the mathematics departments of two pre-existing institutions. This pleasant situation stems from a long-standing tradition of cooperation, and has been enhanced by generally charismatic leadership and by organisational changes giving more power and responsibility to the head of the Department (including the possibility to reallocate time between teaching and research). At the present time, because of this successful transition, morale is high and there is a general feeling of a department on the move. As the committee was sitting, the news came through of a National Center for Teacher Training being created at NTNU, and this was welcomed as an additional opportunity.

The research of the groups in algebra, topology and functional analysis is concerned with quite similar questions but the common expertise does not seem to be put to sufficient use. A much stronger interaction between these groups seems highly desirable and natural, and the committee recommends that they apply together for a SUP-grant.

The committee also recommends stronger interaction between the groups in complex analysis, PDEs and numerical analysis, on the one hand, and the engineering school on the other.

The main recommendation of the committee is that the size of the Department be increased. The number of excellent research groups is truly remarkable for a department of this size, with the consequence that the pressure of doing world-class research and teaching in a demanding institution are heavy on the individuals. Many research opportunities with the other departments of NTNU go unexplored because of lack of manpower. The committee feels that the Department would function even better and have broader impact if its size were significantly increased by hiring more permanent people.

XI. University of Oslo

Department of Mathematics

A. Overall description

The Department of Mathematics at the University of Oslo (UiO) consists of three divisions with a joint administrative and technical staff. The three divisions consist of Mathematics (Algebra, Analysis, Logic, Topology), Mechanics (Fluid Mechanics, Solid Mechanics) and Statistics.
There are 41 permanent faculty, 5 professors II, 12 PhD students, 7 post-docs.

The Department has made a great effort towards strengthening the public awareness of mathematics. It has been very active in the process that led to the creation of the Abel prize, on the occasion of the Abel bicentennial.

The Department has several CoE applications pending, a SUP on modelling of currents and waves for sea structures, and has a deep-ranging cooperation with the Department of informatics (the MoD project, applied mathematics and data).

B. Mathematics

1. Analysis (9 faculty, 2 professors II,1 post-doc, 3 PhD students)

The group working on operator algebras has two permanent members of international standing doing excellent research. They both have initiated important areas of research including a concept of noncommutative entropy, unbounded derivations and approximately finite-dimensional algebras. The latter especially has developed into a fundamental concept in operator algebras but also in quite a number of other fields. There is a lot of international activity in this area and the group has a prominent place in it. The research of the group has also close connections to mathematical physics. One strong researcher belonging to the group has a non-permanent position at a college at Oslo. The average age of the other members is very high. The group is one of the strong points of the Department. In order to maintain it, it is essential to recruit good young scientists to permanent positions in the near future.

The group on differential equations consists of one permanent member, who is part of the Norwegian school on hyperbolic PDEs, while most other members of that group are at NTNU (see the comments in section X. D). Research output is very good.

The group working on stochastic analysis consists of two permanent members, but currently only one is engaged in research. He has had a remarkable influence in teaching the subject, at UiO and NHH; he has directed six PhDs in the past five years, and written a textbook which is a world classic. He belongs to the Norwegian school on stochastic PDEs and white noise analysis (see the review of the Differential equations group at NTNU), which has been supported by a VISTA project, but his efforts are now concentrating on mathematical finance. The group clearly needs strengthening if the stated objective of attaining world-class status in mathematical finance is to be achieved. Current research is somewhat on the academic side, and would benefit from closer contacts with industrial problems.

There was little information on recent research output for the groups in harmonic analysis and several complex variables.

2. Algebraic Geometry (6 faculty, 1 post-doc, 3 PhD students; in addition, there are 5 members of the group with positions outside UiO)

The algebraic geometry group has six members, with a good age distribution.

It is a very solid group, very good as a whole according to the terms of assessment; but it has outstanding members, whose work has international impact, both inside and outside the field of algebraic geometry proper (i.e. in string theory), who are clearly in the excellent range. One subgroup works in classical enumerative geometry, and there is an interesting subgroup in noncommutative geometry which might benefit from making its research more visible.

Given that string theory is not a very active subject in the Norwegian theoretical physics community, there might be an opportunity for workers in this group to build it up.

3. Topology (6 faculty, 2 PhD students)

The topology group has also six members, with somewhat bimodal age distribution, and it faces a transition with three impending retirements.

It is a good group as a whole, but it can boast of a really excellent new appointment, and the group’s future looks very good. The group’s work toward appointing women in the field should also be remarked, and praised. We see here an initial kernel with every reason to grow into a research group of world-class stature. Norwegian mathematics departments may not think of themselves as research institutions which attract younger people from abroad, but that is what is developing here, and the group deserves the resources it needs to deal with this situation.

4. Logic (2 faculty, 1 PhD student)

Starting from the existing situation, it seems to be very difficult to build up a group in logic within the Department of Mathematics.

C. Mechanics

1. Fluid mechanics (5 faculty, 3 professors II, 4 post-docs, 2 PhD students)

There are 3 permanent professors with post-docs and a relatively healthy supply of graduate students.

The group serves as an excellent bridge between mathematical sciences and applications to engineering and geophysics. It produces highly skilled researchers who afterwards can easily find employment. The group is well balanced in theory, computations and laboratory experiments, all of which are essential for a successful fluid mechanics group. It also very dynamic, as demonstrated by their SUP success. Efforts to organize international conferences should be commended. Its principal weakness is the small number of graduate students (although they have more than other groups).

It is a very good group with a potential to be excellent. Much of its activity concerns computational fluid mechanics, and since the numerical analysis group has left the Department of Mathematics, it is important that connections be kept up across departmental borders.

2. Solid mechanics (2 faculty, 4 professors II, 1 PhD student)

The group is small with only two permanent faculty members and one adjunct. The main strength of the group lies in the fact that its members both are experts of finite element computations, which enables them to collaborate easily.
Both members of the group have chosen a new focus for their research, namely composite materials. The mechanics of composite materials is of great industrial value and is also a natural area for research. One awaits the results of this new orientation; it will be quite a challenge to achieve world class level in this area.

D. Statistics (11 faculty, 4 professor II, 1 PhD student)

UiO has a large and very good statistics group with parts of real excellence. Taken with other statistical strength in Oslo (not reviewed here), it makes Oslo a substantial centre of statistical research covering a reasonably broad range of specialities, both theoretical and applied.

In terms of size and level of academic accomplishment, the statistics group at UiO has clear international status. Comparison with the group at NTNU shows some noticeable differences. While the NTNU group is clearly structured into three subgroups with different research profiles, the statisticians at UiO look more like a network of individuals with links of varying degrees between them. Research belonging to the domain of general statistical methodology has a more prominent role in Oslo than in Trondheim. Although applications (for example, to medical statistics, engineering reliability, insurance and actuarial mathematics, and to chemometrics) have played an important role in motivating such research, the links do not seem to be equally strong and explicitly visible in research funding. Important areas of recent methodological research are survival and event history analysis, hierarchical and/or nonparametric Bayesian models, statistical inference and the associated Markov chain, Monte Carlo algorithms, Monte Carlo filtering, Bayesian approaches to system reliability, the partial least squares (PLS) estimation, and quantum probability and statistics.

In view of the widely diverse nature of the applications of statistics, linked though they are by some underlying unity of concept, we regard both the organizationally clear structure at NTNU and the more diffuse system at UiO as entirely viable. Indeed it may be a considerable advantage for the future that Norway has two such strong groups organized so differently.

Although the group has been quite successful in its graduate training, with 12 PhD degrees completed during the past five years, the prospects into future cause some worry. The main reason seems to be a general shortage of qualified candidates applying for PhD student positions. It would be a great pity if the potential of the current statistics group at UiO, which constitutes an important national resource, cannot be fully used in graduate training.

We strongly recommend continuing support for the development of statistics at UiO. It is, however, highly desirable that they increase the number of doctoral students and we welcome their plans to do so in their proposals for future development.

E. Recommendations

There is a striking contrast between the general quality of the research in the Department and the relatively small number of PhD students: the ratio of PhD students to professors, at 12/41, is too low. The problem is particularly urgent, in view of the fact that the age distribution within the mathematics faculty is skewed towards senior faculty.

The Department is to be commended for addressing the problem at its roots, that is, the general lack of interest for mathematics in the public at large and the decrease in enrolment in mathematical programs at the University. There have been a number of very visible initiatives, such as the Abel bicentennial and the many activities around it, and less visible but as important ones, such as systematic visits of school classes by faculty members.

There has been a complaint that during the past 10 years, the number of university supported PhD students have been cut from 15 to 2. One possible answer would be to apply for Strategic University Programs. In view of the quality of research in Oslo, the committee recommends that more mathematicians apply for SUP-grants, as the fluid mechanics and statistics groups have done. A joint SUP-grant involving some of the strong research groups such as the ones in topology or operator algebras could be an important asset and provide funds for much-needed post-doc positions.

As this report was in its final stages, the news came that the Center of Excellence application ”Mathematics for Applications” had been successful. This proposal is a joint effort by people in the Departments of Mathematics, Informatics, Physics and Theoretical Astrophysics at UiO, and goes a long way towards meeting the committee’s concerns, by stretching across disciplinary barriers, by associating groups in pure and applied mathematics, and by setting specific targets for the number of PhD students. The committee sees it as a sign of vitality of the Department, and sets great hopes on the success of this Center.

XII. General recommendations

A. Facing the depletion problem

There is an urgent need to recruit young people into faculty even before their elders reach retirement age. This is the highest priority, and it comes at a time when Norway's European neighbours will face a similar renewal problem, and when the US and Canada are launching a major effort for the mathematical sciences, resulting in a high level of competition in a particularly small market. This basic need translates into several directions:

1. More resources should be put into the mathematical sciences, enabling universities to create new positions now, without waiting for the retirements to happen.

2. University and research positions in mathematics have to be made more attractive in terms of money and prestige, so as to enable Norwegian universities to compete on the world market. The creation of named chairs should be considered.

3. There should be a joint effort by the Research Council and the universities to create a clear path leading to academic careers, with quick decisions taken at the crucial transitions (from master's degree to PhD scholarships, from PhD to post-doctoral or temporary positions). Attention is drawn to the importance of free projects in that context.

4. There should be special provisions to encourage women to enter mathematical studies and academic careers.

B. Encouraging collaboration between mathematics and other sciences

1. The Research Council should encourage where appropriate the inclusion in research proposals of contributions for mathematical and statistical support, and the referees of research proposals should normally check that mathematical and statistical support is properly accounted for.

2. Where a research contract is awarded to a specified research institute under funding from a particular Ministry, collaboration with a local University for mathematical and statistical support shall be encouraged where appropriate, and in any case allocation of resources for mathematical and statistical support should be provided.

3. Arrangements for joint supervision of research students across departments should be encouraged and University rules should ensure that both departments involved receive proper credit for the work, especially in smaller institutions.

4. Local research interests, at the institution level, provide opportunities for collaboration: for instance, there is a need for statisticians in biology, and researchers in plasma physics or PDEs have knowledge which is useful to oceanography. Collaborations of this kind are to the great advantage of both parties, and should be encouraged, for instance by SUPs.

5. The groups in Operator Algebras and Algebraic Geometry should explore possibilities for interaction with theoretical physics, and even look for collaborations abroad if there is too little interest from Norwegian physicists in the subject.

C. Keeping up existing facilities and networks

1. The library system and the computer facilities are essential tools for research and education, and it is crucial for the future that they be kept up to date.

2. The collaborative system in place (summer schools for PhD students, theme semesters at SHS with teaching leave for professors, yearly meetings at Nordfjordeid for researchers in a given field) should be encouraged and supported, and possibly extended.

3. The existence of several strong specialized groups in statistics should not be allowed to inhibit the unity of the subject.

4. At NTNU, the numerical analysis group belongs to the Department of Mathematical Sciences, whereas at UiB and UiO it belongs to the Department of Informatics. These varying types of department affiliations occur in other countries as well, and are not a problem in themselves, provided, however, that one is aware of the particular relevance and importance of cooperation across departmental borders in such situations.

D. Remedying some weaknesses

1. There is too little mobility between Norwegian universities, between the university system and the research institutes, and between Norway and abroad. There is a variety of tools available to correct the situation (scholarships, sabbaticals, professor II positions), but they do not seem to be coordinated.

2. The field of insurance mathematics and insurance statistics needs review: it is split into two different places, has little connection with financial mathematics and research is disappointing.

E. Concluding remark

None of these recommendations addresses the major problem of mathematical education in high schools. In addition to the existing efforts by the Norwegian mathematical community, one might think of a national program, such as the VIGRE program in the US, which would coordinate these efforts and support them financially.

XIII. Appendices

A. Appendix 1: The members of the committee

Elja ARJAS
http://www.rni.helsinki.fi/~ela/

Elja Arjas was born in 1943. He received his Ph.D. in 1972 from the University of Helsinki. He has been Professor of Applied Mathematics and Statistics at the University of Oulu (1975-1997) and Research Professor/Academy Professor at the Academy of Finland (1992-1997). He is now Professor of Biometry (part time) at the University of Helsinki, and Research Professor (part time) at the Finnish National Public Health Institute (KTL). He was editor of the *Scandinavian Journal of Statistics* (1991-1994) and has been joint editor of the *International Statistical Review* since 1999. His current research interests are statistical genetics, statistical modelling and analysis of event histories and Bayesian statistics. He is a member of the Finnish Academy of Science and Letters, the International Statistical Institute, and a Fellow of the Institute of Mathematical Statistics.

David COX
http://www.stats.ox.ac.uk/people/cox

Sir David Cox was born in 1924. He read Mathematics at Cambridge. He then worked in the Department of Structural and Mechanical Engineering, at the Royal Aircraft Establishment and the Wool Industries Research Association. Subsequently he held academic positions at Cambridge, Birkbeck College, Imperial College, London, and Nuffield College Oxford. He has published papers and books on various aspects of the theory and application of statistics and applied probability. He is a Fellow of the Royal Society of London and a Foreign Associate of the US National Academy of Sciences.

Joachim CUNTZ
http://www.math.uni-muenster.de/inst/reine/inst/cuntz/cuntz.html

Joachim Cuntz was born 1948. He received his Ph.D. in 1975 from the University of Bielefeld and his habilitation in 1977 from the Technical University of Berlin. He held a research position from 1978 to 1981 at the University of Heidelberg. He has held academic positions at the Universities of Pennsylvania, Aix-Marseille II, and Heidelberg. He is currently a Professor at the University of Münster. He is currently a member of the board for the MPI of mathematics at Bonn and for the Oberwolfach Research Institute. He is also editor of the *Crelles Journal* and *Documenta Math*. His research interests are in operator algebras, K-theory, cyclic homology and noncommutative geometry. He has received the Max-Planck-research prize (1993), the Medal of the Collège de France (1997), the Leibniz Prize (1999), and an honorary doctor's degree from the University of Copenhagen (2001).

Ivar EKELAND
http://www.ceremade.dauphine.fr/~ekeland/

Ivar Ekeland has been a Professor of Mathematics at the University of Paris-Dauphine since 1971, and he was President of the university from 1989 to 1994. His work is in optimization theory, non-linear functional analysis, symplectic geometry, and in mathematical economics. He has published papers and books in these fields, and he has also written books on science for general audiences. He is a foreign member of the Norwegian Academy of Sciences, and holds honorary doctorates from the University of British Columbia and the University of Economics and Finance in Saint-Petersburg.

Bertil GUSTAFSSON
http://www.it.uu.se/katalog/person.php?alias=XX803&lang=en

Bertil Gustafsson was born in 1939. He got his Ph.D. at Uppsala University in 1971, where he became a Professor in Numerical Analysis in 1982. He is now also the Dean of the Division for Mathematics and Computer Science at the same university. His main research interest is the numerical solution of time-dependent PDE, in particular those with application in fluid mechanics. Together with Heinz-Otto Kreiss and Arne Sundstrom he took part in the development of the so-called GKS theory for difference approximations of initial-boundary value problems. He is a co-author of the book « *Gustafsson-Kreiss-Oliger : Time dependent problems and difference methods* » from 1995.

Jean-Pierre KAHANE

Jean-Pierre Kahane was born in 1926. He was a student of the Ecole Normale Supérieure from 1946 to 1949. He held a position at the CNRS during the period 1949-1954. He began his teaching career at the University of Montpellier in 1954. He became Professor of mathematics at Orsay in 1961 till 1995. His research field is harmonic and complex analysis. He wrote papers and books on Fourier analysis and related matters, and also on education. He has been a member of the Academy of Science since 1998.

Chiang C. MEI
http://web.mit.edu/civenv/parsonslab/mei.htm

Chiang C. Mei is Donald & Martha Harleman Professor of Civil & Environmental Engineering at Massachusetts Institute of Technology. His fields of research in applied mathematics include wave hydrodynamics, fluid-structure interactions, dynamic poro-elasticity, elastic waves, seabed mechanics, earthquake engineering, mud flows, land subsidence, soil vapor extraction and air sparging. His publications include two books : *Applied Dynamics of Ocean Surface Waves*, and *Mathematical Analysis in Engineering*. He was the founding editor (1977-1980) of the *International Journal of Applied Ocean Research* is an associate editor of the *Journal of Fluid Mechanics*. He has received the Guggenheim Fellowship (1972-1973), the T. K. Hsieh Award (1984) by the British Institution of Civil Engineers, the Rosenstiel Award for Contributions to Applied Marine Physics from the

University of Miami (1987). He has been a member of the US National Academy of Engineering since 1986, and an Academician of Academia Sinica of the Republic of China in Taiwan.

Susan MONTGOMERY

Susan Montgomery is native of Lansing in Michigan (USA). She was born in 1943.
She received her Ph.D. in mathematics from the University of Chicago in 1969. She has been a Professor of Mathematics at the University of Southern California since 1982. She was a Guggenheim Fellow from 1984 to 1985. She was also a member of Board of Trustees of the American Math Society during 1986-1996 and she chaired it in 1989 and 1994. She chaired the USC Department of mathematics from 1996 to 1999. Her work has been in non-commutative algebra in particular on group actions, on rings and on Hopf algebras. She is an editor of the *Journal of Algebra*, *Advances in Math*, *Journal of Algebras and Representation Theory*. She was a CBMS lecturer in 1992 and published a book on Hopf algebras with the AMS in 1993.

Jack MORAVA

Jack Morava was born in 1944 in South Texas. He received his Ph.D. in mathematics in 1968 from Rice University. He has been Professor of Mathematics at Johns Hopkins University in Baltimore, Maryland since 1983. He was also appointed Professor of Physics and Astronomy in 1992, and since 2001 he has directed the Japan-US Mathematics Institute (JAMI) there. He has held research appointments at the Institute for Advanced Study (Princeton), the Isaac Newton Institute (Cambridge), the Steklov Institute (Moscow), and the Tata Institute (Bombay). His early work concerned connections between number theory and algebraic topology; more recently he has been involved in applications of topology in quantum field theory.

B. Appendix 2 : Mandate for the evaluation committee

I Introduction

The Division of Science and Technology at the Research Council of Norway has decided to evaluate basic research activities in mathematics in Norwegian universities and colleges. The report of the evaluation committee will form the basis for the future strategy of the Research Council.

The objective of this evaluation is to review the overall state of basic in mathematics in Norwegian universities and colleges.

Specifically, the evaluation process will:
1. Offer a critical review of the strengths and weaknesses of research in mathematics in Norway, both nationally and at the level of individual research groups and academic departments, and review the scientific quality of basic research in an international context.
2. Identify research groups which have achieved a high international level in their research, or which have the potential to reach such a level.
3. Identify areas of research that need to be strengthened in order to ensure that Norway in the future will possess necessary competence in areas of importance for the nation. And as one aspect of this, enable the Research Council of Norway to assess the impending situation regarding recruitment in important fields of mathematics.

The long-term purpose of the review
The evaluation will provide the institutions concerned with the knowledge they require to raise their own research standards. They will be provided with feedback regarding the scientific performance of individual research groups, as well as suggestions for improvements and priorities.

The evaluation will improve the knowledge base for strategic decision-making by the Research Council, function as a platform for future work on developing mathematics and represent a basis for determining future priorities, including funding priorities, within and between individual areas of research.

Finally, the evaluation will reinforce the role of the Research Council as advisor to the Norwegian Government and relevant ministries.

II Mandate

The committee is requested to make use of the departments' self-evaluations in its assessment of the overall state of mathematics and to draw up a report with a set of specific recommendations for the future development of this field. The committee is also requested to evaluate scientific activities with respect to their quality, relevance and international and national collaboration, bearing in mind the resources available. The committee is further requested to evaluate the way in which research in mathematics is organised and managed.
The conclusions of the committee should lead to a set of recommendations concerning the future development of research in mathematics in Norway.

Specific aspects to be considered:

1. General aspects

- Which fields of research have a strong scientific position in Norway and which have a weak position? Is Norwegian research being carried out in fields that are regarded as relevant by the international research community? Is Norwegian research in mathematics ahead of scientific developments internationally within specific areas?
- Is there a reasonable balance between the various fields of Norwegian research in mathematics, or is research absent or underrepresented in any particular field? On the other hand, are some fields overrepresented, in view of the quality or scientific relevance of the research that is being carried out?
- Is there a reasonable degree of co-operation and division of research activities at national level, or could these aspects be improved?
- Is the mathematics of today relevant t the needs of Norwegian industry and society? Do research groups maintain sufficient contact with industry and the public sector?

2. Academic departments

- Are the academic departments adequately organised?
- Is scientific leadership being exercised in an appropriate way?
- Do individual departments carry out research as part of an overall research strategy?
- Is there sufficient co-operation in the use of expensive equipment?

3. **Research groups**

- Have the research groups drawn up strategies with concrete plans for their research, and are such plans followed up?
- Is the size, organization and leadership of the research group reasonable?
- Are the results that are being obtained, e.g. number of fellowships awarded and articles published, reasonable in terms of the resources available?
- What roles do Norwegian research groups play in international co-operation in individual subfields of mathematics? Are there any significant differences between Norwegian research in mathematics and research being done in other countries?
- Do research groups take part in international programmes or use facilities abroad, or could utilisation be improved by introducing special measures?
- Is there sufficient contact and co-operation among research groups at national and international level?

4. Training and mobility

- Is recruitment to doctoral training programmes satisfactory, or should greater emphasis be put on recruitment in the future?
- Is there an adequate degree of national and international mobility?
- Are there sufficient educational and training opportunities for PhDs in industrial research?
- Where do graduates go after completion of higher degrees?

5. **Miscellaneous**

- Are there any other important aspects of Norwegian research in mathematics that ought to be given consideration?

III Parameters for the mathematics committee's work

The Science and Technology Division of the Research Council of Norway has conducted a number of subject-specific evaluations (physics, geo-sciences, chemistry, bio-sciences) in recent years. The following parameters for the mathematics committee's work are based on experience derived from these evaluations:

1. Hearings with the institutes/research groups:
   The Research Council has found that organizing hearings with the institutes has favourable effects, both professionally and administratively speaking, as an alternative to having the expert committee visit each individual institution (site visits). Accordingly, the mathematics evaluation will be based on conducting hearings; each individual research group will appear before the committee to present itself and be interviewed.

2. Evaluation at the researcher group level:
   Research groups will be the smallest units in the evaluation. This means the evaluation will not extend to the individual level. Further, the names of individual researchers are not to be mentioned in the evaluation report per se. Consequently, the research group's name must be topical and not based on the name of the group's chairperson.

3. Quality assurance of facts in the evaluation report – description of procedure:
   The Research Council wants to ensure that the final evaluation report does not contain factual errors about the institutes/research groups under evaluation. Factual errors are perceived in a very negative light by the groups involved. Accordingly, the Research Council requires that the facts the committee elects to include in its evaluations of each institute be subject to quality assurance by the institute in question before the report is submitted.

The following procedure will be instituted once the Research Council has received a draft evaluation report from the committee (spring/summer 2002):

- Each institute will receive a letter from the Research Council, accompanied by the chapter of the report that refers to that particular institute's research groups. The institute will be asked to point out any factual errors in the report.
- The institutes will provide feedback by mail about factual errors in the report.
- The committee will collect the feedback from the institutes.
- The committee will consider the feedback from the institutes/research groups, correct any factual errors and hold a separate meeting to consider the consequences of the feedback if any, for the final evaluation report.
- The mathematics committee's final report will be submitted to the Research Council and published (August 2002).

C. Appendix 3: The letter from the Research Council to the Norwegian universities (in Norwegian)