GLOBAL REPORT ON THE EVALUATION OF THE RESEARCH UNITS ON MATHEMATICS

Panel Coordinator:

Irene Fonseca

Carnegie Mellon University, Pittsburgh, USA

Evaluation Panel:

Jean Pierre Bourguignon

CNRS, Institut des Hautes Etudes Scientifiques (IHES), Bures-sur-Yvette, France

Sir David Cox

Nuffield College, Oxford, UK

Roland Glowinski

University of Houston, USA

Gerard Huet

Institut National des Recherches en Informatique et en Automatique, France

Thomas Laffey

University College Dublin, Ireland

Jalal Shatah

Courant Institute, New York, USA

Carles Simo

University of Barcelona, Spain

Vera Sos

Hungarian Academy of Sciences, Hungary

Joel Spencer

Courant Institute, New York, USA

Tamas Terlaky

McMaster University, Canada

1. METHODOLOGY

I.1 The Site Visit

The 2002 evaluation covered 24 Centers and site visits took place from July 8 to July 16, 2002. Site visits were opened with a presentation by the Center Leader on the composition of the Unit and its research interests, followed by a brief description of the Center's research activities during the period 1999-02. Often a representative of each team in the Center gave a more detailed overview of the output, ongoing and future initiatives in the corresponding area. The visit terminated with a discussion between the Panel members and the members of the Center to better identify and clarify the Center's vision in terms of future directions of research, planned initiatives, and the difficulties encountered by the Center in pursuing their program.

Some Centers adopted a format of presentation whereby, after giving his or her overall presentation, The Center Leader would offer a "menu" of choices to the Panel to select those areas which the Panel wished to look into in more depth. This was very well received by the Panel, not only because it created a more lively and relaxed atmosphere, but also because it helped to keep the timing under control and it showed a great deal of confidence and thorough preparation.

The Panel coordinator met briefly with the President of the FCT, Professor Ramôa, who clarified the funding mechanisms of the FCT, the objectives of the Programmatic Funding, and addressed the mission of the panel.

I.2 Programmatic Funding

Programmatic Funding was awarded when perceived as having a potential impact on specific aspects of the research activity of the Center, or when pro-active and deliberated major efforts from the funding agency were in order so as to stimulate initiatives of national importance, such as

- to create a Center of Excellence in Numerical Analysis and Mathematical Computation, possibly with its headquarters in Coimbra;
- to support and encourage the development of the statistical work in biomathematics in Évora.

Other guidelines to allocate Programmatic Funding were:

- training of young researchers, both at the PhD and postdoctoral levels;
- funding for hosting senior researchers with the main purpose of mentoring young researchers in the Unit;
- funding for mobility;
- funding to organize summer schools and/or conferences and workshops;
- funding to update depleted libraries;
- funding for state-of-the-art computational equipment.

I.3 Recommendations

For future evaluations the Panel recommends that:

1. there should be at most 3 visits per day;
2. each visit should normally last 3 hours;
3. each visit should include at least 45 minutes for relatively informal conversation between Center members and relevant specialists in the visiting team;
4. Advisory Committee should submit reports to the FCT and the Panel should have access to these prior to the visit;

5. the list of Center members should indicate group membership (see the recommendation III.1.1.1);
6. in addition to the selected, more relevant publications for the Center, there should be 2 selected publications for each research group within the Center. These should be made available to the Panel in advance of the site visit;
7. the description of the proposed future research should consist of a few well organized and planned lines of investigation and not simply a list of subject topics;
8. the FCT should supply either electronically or on request by hard copy all relevant documents from the Centers at least six weeks in advance of the site visits.

1.4 Calendar Of Visits

II. QUALITY OF RESEARCH

With the system of evaluations in place since 1996, a first stage of development has been reached and time has come to reassess the validity of some of the recommendations made in the initial phase. In particular, it appears to the Panel that the emphasis put in the organization of events such as schools, conferences, symposia, has borne its fruits with the justified aim of putting Portugal on the international scientific map. The priority now should be shifted to freeing time for the best researchers, so that they can embark on substantial and long term projects. This must be addressed while keeping in mind that most mathematicians in Portugal are suffering from very high teaching related service loads. Major efforts should be made to address this problem which is paramount if one is serious about developing research at a high level in Portugal.

II.1. Impact, Areas of Strength, Areas of Weakness

Research in mathematics in Portugal continues to progress, and significant improvements since the evaluations of 1996 and 1999 may be observed in the re-alignment of research interests (e.g. the very successful investment in computational algebra in the Centro de Álgebra (Lisboa)), in the reduction of the hypertrophia from which some very narrow subjects suffered, in the creation, re-structuring or streamlining of certain Centers, and in the more aggressive search for funding both in Portugal and through European projects.

Worldwide impact of the research carried out in Portuguese institutions is confined to very specific areas, which is what is to be expected from a geographically small country with relatively limited research resources and strongly impaired by the teaching system, see Section III.

Areas of Strength: dynamical systems, differential equations, mathematical physics, stochastic analysis, symplectic geometry, algebra (semigroups), statistics. Within statistics there are large and important topics that seem to be unrepresented, sampling

theory and design of experiments for example, and an excessive specialization on others.

Areas of Weakness:

Computational mathematics, mathematical programming, stochastic control, applied stochastic processes including stochastic operations research, theory of probability, mathematical biology, and core mathematics including number theory, discrete mathematics, algebraic geometry, several complex variables.

Research directions do not seem to be drive knitted n by internationalization or by funding system, and often are closely knitted with those of former PhD advisors. Similarly, international contacts are nurtured mostly with former advisors and PhD granting institutions. Although these are clearly useful and important to preserve, it is highly advisable that researchers gain scientific autonomy, and create their own scientific niche working on problems of interest to the world scientific community. The funding system, with its inherent “safe-net” guarantee, does not present an incentive to go after risk taking ventures. Indeed, it is imperative that Portuguese researchers do not see securing external funding as a “burden”. This is probably one of the most successful avenues to strengthen international visibility, to enlarge international scientific contacts, and to help to think ahead by formulating future plans of research.

Mathematical modeling has developed to an unprecedented level worldwide in leading research institutions worldwide and having the experience of multidisciplinary work is becoming more and more fundamental in the training of students who may go into the industry at some point in their career. Bridging mathematics to other disciplines is not easy. It requires an enormous investment of time, visible impact is not immediately perceived, and often the resulting mathematics is perceived as being “shallow”. There seems to be a widespread lack of appreciation (not confined to Portugal) of the challenges and difficulties of deep involvement in specific applications. This affects especially a number of Centers whose titles suggest a nominally applied focus.

The interface with engineers, biologists, and with industry is almost nonexistent. In Portugal there is still little influence of external funded research in the mathematical

sciences, with the exception of some areas of statistics and operation research. As for the latter, the Panel finds it hard to assess at national level as several groups in operations research escape the evaluation of the mathematics panel and are evaluated exclusively by other panels (e.g. economics, engineering, etc) which do not include mathematical-programming-operations research experts capable of giving a fair assessment of their methodological foundation.

The creation of R&D in Portuguese industries and technologies will require a strong political involvement of the Portuguese government, and the participation of mathematicians can never succeed without a core of researchers trained to model and to analyze experimental industrial and technological phenomena.

II.2 Recommendations

1. The absence of critical mass at the forefront of **computational mathematics**, with strong links to wide-ranging applications, is a matter of great concern and national importance, as it must be dealt with promptly and swiftly. An aggressive investment of the FCT in this area is pivotal. The Panel identified Coimbra as being the Center which shows more potential to carry out this tremendously challenging initiative of creating, in dialog with researchers nationwide whose research profile fits the agenda, and hosting a Center of *Excellence in Numerical Analysis and Mathematical Computation*. If not addressed forcefully, this void will have devastating consequences in the progress (or lack of) o mathematics research in the country. This is not a new recommendation:

(from the 1999 report)

"... Good contacts with centers of excellence worldwide, and creation of critical mass are in order. Only a strategic initiative involving a few universities and centers at the national level may, if carefully planned and granted the necessary financial support, establish a program to develop in Portugal a new generation of high level experts in Computational Mathematics, including Numerical Modeling, Scientific Computing, Theory of Algorithms, Data Analysis and Approximation Theory. We are on the edge of major unpredictable scientific breakthroughs that will radically transform our lives, ranging from the emergence of nanotechnology to neuroscience. With new problems come new opportunities, and Mathematics as to be well positioned to embrace them. This will require strategic planning, support for

work with long-term objectives, breadth across disciplines, while maintaining and strengthening abstract or fundamental Mathematics..."

Technological and industrial advances in the developed countries point unequivocally in this direction. Furthermore, progress in pure theoretical mathematics can be guided by the interpretation of numerical and symbolic experimentation. The Panel strongly recommends direct engagement of the Portuguese politic of science makers, ranging from granting the necessary resources to appointing a panel of experts in mathematical computing that will advise the local researchers on how to launch such a project and how to establish the necessary links with the recognized institutions;

2. mathematical programming needs strengthening. Although there are groups doing an excellent job in applying operations research techniques to practical situations, developing methodologies for high level applied operations research work, and building industrial relationships, the methodological research in the country is weak. Optimization/mathematical-programming gives an excellent interface with engineering and industry (see item 3 below), thus rendering it is strategically important to mathematics research in Portugal;

3. the FCT must design mechanisms and incentives to foster networks of mathematicians and other scientists and engineers, and to create the proper environment for the development of the meaningful and successful experiences in this direction;

4. internationalization and the building of connections with the best researchers and more advanced research institutions in the world are pivotal to the advance of the discipline in Portugal. A system through which researchers would be encouraged to visit for extended periods (e.g. during part of their sabbatical year) some of these centers, maybe under the recommendation of the Advisory Panel, could help bring up to the speed the international visibility of Portuguese mathematicians. In particular, "inbreeding abroad" should cease to exist, a situation still common in Portugal where PhD students are sent to the same institutions where their local advisors, mentors, or otherwise senior faculty got their own doctoral degree and/or postdoctoral training;

5. calls for FCT proposals targeted to specific areas (e.g. nanostructures, bioscience, etc.) may provide an incentive for researchers to venture into new, "hot" contemporary areas of research.

III. STRUCTURE OF RESEARCH

III.1 The Organization of the Centers

Since the evaluation of 1999 there has been a remarkable re-structuring and internal dynamization of several Centers, almost all with very positive results. Although somewhat hard to explain, except maybe for historical and cultural reasons, it is still a fact that Portuguese researchers start from the premise that to do research one has to be integrated in a unit or center of some sort. Possible negative effects of this structure are twofold:

- Centers tend to identify with departments, and criteria for membership are vague at best;
- researchers tend not to seek their own funding through individual programs and aggressive networking, as the center's "safe-net" basic funding provides the essential.

Major centers have strong, updated libraries, smaller centers out in the country do not have the financial flexibility to attain a reasonably goo library which will meet their research needs. A good inter-library network, involving a centralization of library loans and classification, will resolve this lack of access to reference material (Évora has been leading an effort of this sort for the past couple of years).

III.1. Recommmendations

In the report of 1999 the Panel laid down a set of indicators of what is needed to be considered a member of a research unit. These still stand. In addition,

1. the Panel **insists** that members who have not published a paper in an international refereed journal or a research monograph published by a reputable international academic publishing house within the last three years be (temporarily) removed from the membership list. Doing otherwise will bring discredit to the Center and it will necessarily hurt its ranking;

2. the Panel strongly urges the Leader of the Center to go well beyond the day-to-day management duties to create new research opportunities, to alert for funding initiatives, to help networking with other Centers in the country and abroad, and to act as a scientific leader;
3. the membership role and constitution of Advisory Boards need thorough review. Advisory Boards members should be appointed from a pool of world experts, preferably not collaborators so as to ensure objectivity, and for a maximum of, say, six years not renewable. They should be expected to visit at least twice in that period and be given and supply annual reports to the FCT on the occasion of the 3-year Centers reviews, and the Panel should have access to these reports prior to he evaluation exercise;
4. Centers should be encouraged to seek partnership in library networks;
5. Centers should be directly linked to the housing institution's office in charge alerting to funding opportunities.

III.2 Faculty Structure. Teaching and Research

All Portuguese research centers in mathematics are strongly associated with universities, and salaries of researchers (with the exception of postdoctoral fellows) depend exclusively on their teaching duties. These salaries are not differentiated in terms of productivity, but rather in terms of rank within the university system. This brings about several constraints to the advancement of research productivity in Portugal:

- the utter dissatisfaction of researchers who do not see their work recognized neither in terms of salary increase nor (often) in terms of promotion;
- the lack of incentives in pursuing new research initiatives;
- the impossibility to recruit in targeted research areas.

It is not education mission that is being challenged or questioned, but the lack of flexibility in the management of teaching duties and recruitment of researchers/teachers. This is a tremendous problem, and one that the Panel has been

concerned with since the first evaluation of 1996. Any (partial) remedy will require direct intervention of the Minister of Science and Higher Education.

Basic education in applied mathematics, both at the undergraduate and M.Sc. levels, given by most Portuguese universities is insufficient. There are good programs of studies in pure mathematics where students are exposed to mathematics almost exclusively from a theoretical point of view but where they do not gain much insight into bridging with other disciplines. Multidisciplinarity is the avenue of the future, where computational skills will become more and more imperative, and where researchers will be asked to tackle mathematical modeling of real world problems. A balance must be reached between theory and application. Students should be exposed to other disciplines during their undergraduate education. Curricula should be re-visited so that students are confronted with different ways of doing science and are required to take a certain number of credits in topics outside mathematics. As a word of caution, there are degrees in statistics and/or operations research that seems to put more emphasis in the applications but give a very weak and narrow knowledge of basic mathematical tools.

Many Centers have well developed outreach activities. The engagement of researchers in academic programs to challenge gifted children, and to sustain the awareness of K-12 teachers to the developments in their discipline, is pivotal. The design of attractive contemporary undergraduate courses, and the preparation of students to pursue research (vertical integration programs) and non academic high profile jobs (industrial internships), require the involvement of research active educators.

III.2.1 Recommendations

1. Evaluations of universities and Centers of research should not be disassociated. An articulation of the two exercises, for example by ensuring that the two panels share some members, is crucial so as to guarantee that the adopted criteria, standards and guidelines are compatible;
2. curricula in applied mathematics should be revised in light of new challenges in the health sciences, engineering, and technology;

3. for promotions and teaching buy out (with clear rules so as to avoid abuses) contact hours, research production, supervision of PhD students, mentoring of post-doctoral fellows, committee and other service work, leadership positions in the Center or in other university or professional organizations, should all be weighted in a reasonable way;
4. the introduction of a few rotating teaching-free positions to be occupied temporarily based solely on a merit of a research proposal;
5. new appointees (recent PhDs and postdoctoral fellows) should be spared service/committee work;
6. new PhD's or postdocs' teaching load should be light in the first year increasing over the next three years to the normal full load (normal load should include for everyone a mixture of service, undergraduate and graduate teaching);
7. the particularly challenging introductory courses (critical in attracting students to a field) should be taught by the most experienced teachers leaving the more specialized material (easier to teach perhaps) to the beginners. Faculty members that would be primarily assigned to teaching the lower class courses could be freed every so often from such heavy teaching load;
8. weekly contact hours should not exceed 6 for research active faculty members. The academic calendar year should concentrate all yearly teaching activities in semesters of no more than 17 or 18 weeks (15 week classes + 2 or 3 week exam period), freeing the researchers during a period of 3 to 4 months in the summer for their research.

III.3 Recruitment of Young Scientists and Postdoctoral Fellows

Special attention should be paid to young researchers in making sure that strong enough incentives are in place to have them spend time abroad if they have received their doctoral training in Portugal, and to keep contacts with the institution at which they got their PhD if there were trained abroad. Creating a feeling that the young generation is at ease in the international mathematical village is very important for the future of the mathematical enterprise in Portugal. From this point of view a special effort should be made to have more Portuguese teams join European teams.

Presently all graduate from a given Portuguese university are automatically granted membership in one of the centers in that university, well before there is any evidence of research potential. Research needs have seldom anything to do with promotion and/or recruitment criteria.

The inbreeding is still existent and it has a few advantages: PhD students may go abroad to complete their degrees without worrying about subsequent job applications, and without having to teach so as to ensure their subsistence. The panel is of the opinion that the negative effects greatly outweigh positive ones:

- teaching abroad while preparing a PhD is an invaluable experience;
- exposure to other research programs and the possibility to interact with other scientists must be strongly encouraged.

III.3.1 Recommendations

1. New PhDs and postdoctoral fellows should have very limited teaching responsibilities, and the expectation that they will actively pursue their research interests;
2. strategic recruitment is imperative in order to achieve international recognition;
3. postdoctoral fellows who are broadening their expertise by moving away from the field of their doctoral studies will not be in disadvantage in the competition for these positions.

III.4 Structure of Graduate Education

A few centers are scientifically mature to justify the supervision of PhD students and the mentoring of post-docs. Other may be in position to co-advise trainees. A system with a second advisor for each student has many merits. However, and in order to ensure well-roundness of their training, young researchers should be encouraged at some stage in their training to go abroad for a relatively long period of time. By the same token, a steady stream of foreign visiting scholars should maintain the influx of new ideas, new blood, and could help with the training of graduate students. It appeared to the Panel that too often the weakest departments still keep their students to themselves, when a much more efficient training could be achieved elsewhere, including at more active places in Portugal.

III.4.1 Recommendations

1. Consider the possibility of putting pressure on departments to ensure that a sufficient percentage of their PhD students are getting their training outside;
2. when a doctoral student is supervised from another Center the student should have an additional advisor in his/her own Center.

IV. MAJOR RECOMMENDATIONS

Below some of the recommendations made throughout the report are highlighted.

1. To free time for the best researchers so that they can embark on substantial and long term projects;

2. Advisory Committees should submit reports to the FCT and the Panel should have access to these prior to the visit;

3. The absence of critical mass at the forefront of computational mathematics must be dealt with promptly and swiftly. An aggressive investment of the FCT in this area is pivotal in the creation of a *Center of Excellence in Numerical Analysis and Mathematical Computation*. The scientific objectives and methodology of such a center must meet the approval of a panel of (at least 75% foreign) experts in the subject;

4. Center members who have not published a paper in an international refereed journal or a research monograph published by a reputable international publishing house within the last three years must be (temporarily) removed from the membership list;

5. Evaluations of universities and Centers of research should not be dissociated. An articulation of the two exercises is crucial so as to guarantee that the criteria, standards and guidelines are compatibles;

6. Curricula in applied mathematics should be revised in light of new challenges in the health sciences, engineering and (nano)technology;

7. To introduce of a few rotating teaching-free positions to be occupied temporarily based solely on merit of a research proposal;
8. New appointees (recent PhDs and postdoctoral fellows) should be spared service/committee work. Their teaching load should be light in the first year increasing over the next three years to the normal full load (normal load should include for everyone a mixture of service, undergraduate and graduate teaching);
9. Weekly contact hours should not exceed 6 for research active faculty members. The academic calendar year should concentrate all yearly teaching activities in semesters of no more than 17 or 18 weeks (15 week classes + 2 or 3 week exam period), freeing the researchers during a period of 3 to 4 months in the summer for their research activity.

Acknowledgments

Our thanks go to the FCT staff, and in particular Dra. Maria José Camecelha de Abreu and to Ellen Barends, who worked tirelessly before and during the evaluation process to allow the panel to successfully complete its mission. Our thanks go also to the Portuguese mathematicians who received us with great enthusiasm.