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Mathematical
Society

Position Paper of the European Mathematical Society on the European Commission's Contributions to European Research

Executive Summary

The European Mathematical Society recommends that

1. Mathematics appears as an independent priority in the next Framework Programme. Support to broad-based research in Europe cannot neglect the science which provides the language, methods and instruments used in every scientific and technological activity.
2. The FP7 objectives under the categories *People* (Marie Curie Actions) and *Cooperation* be maintained and enhanced. World-wide mobility and cooperation, as well as cross-sector mobility between academia and industry must be boosted to promote research and innovation.
3. The successful ERC instruments of funding be strengthened and further developed, in order to support and stimulate breakthroughs and sound future development of basic research.
4. The commission supports the creation of a *European Institute of Mathematics for Innovation*, a platform for cooperation and cross-fertilization between academia and industry, in order to increase industrial innovation, participation in societal challenges, and to foster further development and applications of basic and new emerging areas in mathematics.
5. The commission properly acknowledges scientific electronic databases as a strategic resource for research, and proposes appropriate actions for its development, preservation and open access to the scientific community.
6. EU research and innovation instruments and procedures be simplified. This applies to all steps of the process from the description of the objectives of the calls to the submission forms, the contract negotiation, the due reports and the financial audits.
7. The Commission include mathematicians in its various advisory boards, like EURAB and ESFRI.



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Introduction

The European Mathematical Society (EMS) acknowledges the potential the EC has to make scientific research a crucial element for European development. It endorses enthusiastically the perspective of a European Research Area, and the central role it very appropriately gives to scientific research in the economic development of our continent. It sees the creation of the European Research Council as a turning point in the EU's scientific strategy.

EMS wants to stress that mathematical research is pursued at a very high level and on a very broad front in Europe, and that, in the competitive world we live in, this position needs to be maintained by appropriate actions. Needless to say, keeping a leading position is cheaper than starting from scratch, but by no means free. This implies that resolute actions have now to be taken in various directions.

The question of human capital is crucial, and a difficult one as Europe is facing a large number of retirements of scientists over a small number of years. Moreover, in the last years international competition to attract the best researchers has become fiercer than ever. Europe still produces world-class mathematicians, and suitable conditions must be met to keep them here. The United States, Brazil, China and India are currently investing heavily in research, notably in mathematics, and Europe seems in fact to be lagging behind by a lack of engagement.

Mathematics has a role to play in most domains critical for economic and scientific developments, and this can only be achieved through new fundamental mathematics and by encouraging mathematicians to interact with specialists of other sciences and industry.

The universality of mathematics is its intellectual strength. Mathematical methods are instrumental in virtually every area of human scientific and technological activity. It takes professional mathematicians to use them in a really efficient way in multidisciplinary projects. At the same time mathematical research per se has to be considered as an independent priority. Without this, one runs the risk of becoming mere users of critical new developments made elsewhere.

Together with theory and experimentation, a third pillar of scientific inquiry of complex systems has emerged in the form of a combination of modelling, simulation, optimization and visualisation. In most of the cases, complex phenomena cannot be replicated in the laboratory. Some mathematical tools make it possible to manage huge volumes of data rapidly and economically. This generates fresh, and sometimes surprising, knowledge that crosses traditional disciplinary boundaries and can provide European companies with an essential tool for the production of innovative new products and for transformation of business and engineering practices, thus giving them the necessary competitive edge in globalized markets.



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Through this document, EMS intends to set the basis for a fruitful cooperation with the EC suggesting measures that will be instrumental in helping mathematicians to fulfil their role in the construction of a European knowledge-based society.

1. Why mathematics?

Knowledge has become the main wealth of the advanced world: nations, companies and people. Hence investing in research, innovation and education is now the key-leverage for competitiveness and prosperity in Europe. At the heart and foundation of this challenge, mathematics plays a crucial role as it provides a universal language for science and indispensable tools for the analysis, simulation, optimization, and control of industrial processes.

The role of mathematical sciences in civilization has been of central importance for centuries. The current trend towards a global economy and a knowledge society has placed information and innovation technologies, increasingly dependent on scientific research driven by mathematics, at the forefront. Moreover, besides its role in science and engineering, the domains of application of mathematics have by now grown to include other disciplines like social, environmental, medical and economic sciences. We refer the reader to www.ceremade.dauphine.fr/FLMI/FLMI-frames-index.html for an extensive sample of examples.

Mathematics provides the tools to understand and reduce the complexity of the mutual interdependencies and leads the way in predicting, optimizing and controlling the respective systems. It could never be too much stressed that the challenges of emerging technologies, the increasing needs of new algorithms for scientific computing, and the complexity of the systems to be studied, pose problems whose solutions are strongly dependent on progress made in fundamental research.

Development and progress in mathematics have always been driven both by internal forces (to cross the boundary) and by external forces (the need of solving problems arising outside the discipline). The so-called applied mathematics cannot be considered as a field disjoint or the counterpart of a the so-called pure mathematics, since on one hand it uses potentially all fields of mathematics and, on the other hand, it is a continuous source of challenges to the fundamental research on structures and methods of mathematics.

The unity of mathematics has always made itself felt with considerable force, and it is one of its strengths. At the dawn of this 21st century, the interplay of mathematical ideas between the different sub-domains has probably reached an all-time high in intensity. This fact sets mathematics apart from many other branches of science, which have split up into multiple specialties, each developing its specific culture and sociology.



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The distance between fundamental mathematics and applications has become in many instances very short and is getting shorter both in time and in contents. In many cases, mathematical topics developed for purely internal reasons, have suddenly led to concrete applications. By way of example, we can mention the use of stochastic processes in finance, or of number theory in cryptography, system security and data compression.

2. Mathematics in Europe: a S.W.O.T. analysis

Strengths

Mathematical research in Europe is recognised as one of the best in the world. Several indicators place it even as number one, ahead of that of North America and of Asia.

For example, 14 Fields Medals, one of the highest recognitions in mathematics awarded to scientists under the age of 40, were awarded to Europe-based researchers versus 11 USA-based ones in the period 1980-2010. As for the Abel Prize, the analogue to the Nobel Prize for mathematics, established in 2003 and funded by the Norwegian Government, there have been so far five recipients on each side of the Atlantic.

The European mathematical community has efficient research networks, integrating national and international centres of excellence. These networks have common or collaborative programmes of training, visits, workshops and publications in all branches of mathematics. This is a significant step forward in the creation of a European identity of our scientists.

Traditionally, European scientists in most disciplines have received a sound mathematical background in our high schools and universities. This places European trained scientists in an excellent position to excel in multidisciplinary teams. The function of mathematics as an enabling science is one of the pillars of the European tradition that has to be carefully nurtured and for that purpose supported.

Weaknesses

Fragmentation is one of the points of weakness that has to be considered, as well as the uneven situations in different countries with respect to research. In particular, the use of mathematics in applications and industry is much less developed in some countries compared with others, thus depriving the economy of these countries of a powerful instrument of innovation.

Another major problem is brain drain. Part of the problem comes from insufficient good opportunities and conditions for post-doctoral and tenure-track positions in Europe. The situation is particularly dramatic in Eastern European countries. There,



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a high mathematical level has been achieved at the training level, as part of a longstanding tradition that remained almost unaffected also when restricted access to expensive material caused many problems to other branches of science.

Economic problems affecting some countries nowadays induce a massive exodus and serious concern about the ability of attracting or keeping talented young people in the future. Such a trend would irreversibly damage a remarkable reservoir of talents, that Europe will need in the near future, at a time where innovation is the key to success.

Opportunities

The high level of mathematical training in Europe brings an important opportunity for building interdisciplinary teams to address basic problems in many scientific areas.

In its competition in world markets, European industry can take advantage of the competitive edge **that** may be gained by using European mathematical expertise.

It is often claimed that computers have brought us in a modern technology era. In industrial innovation –that is essential in today’s globalized economy- computer power provides an essential tool. More and more companies recognise that mathematical/computer simulations and optimization may replace experiments in designing products to reduce costs and to improve flexibility. However, specific skills are required if they are to be used effectively. They involve problem identification, a correct mathematical formulation, and mathematical and numerical analysis to reduce the problem to its simplest form for affordable computation. Especially at the leading edge of innovation this implies addressing new fundamental mathematical problems; and the shortcut of using commercial software without the competence of evaluating critically its limitations leads often to a dead end. It is thus a consequence of increased computer power and computer usage that, if computers are to be used efficiently, more and deeper mathematical knowledge is required.

Threats

A fundamental threat that would undermine all the positive aspects mentioned above would be to devote too much effort to applications, and neglect basic scientific training and fundamental research. New problems require new ideas, new methods, new approaches, etc., and these are possible only if there is a continuous deepening and widening of knowledge at the most fundamental level. It is thus crucial to cope with these challenges and to make sufficient investment in the basic theoretical and methodological research areas that underpin this response.



Still confining to applications, another dangerous attitude would consist in thinking that, since mathematics is a common language in science and engineering, the presence of professional mathematicians in interdisciplinary teams is unnecessary, neglecting the fact that, if mathematics brings tools for a rigorous and exhaustive analysis of problems, in many situations the tools have to be tailored if not developed *ab initio* to tackle the problems at hand, in direct interaction with the users.

It would also be erroneous to think that simulation of natural phenomena and industrial/economic processes can just be done by using commercial packages, i.e. using computers as black boxes. In all kinds of interdisciplinary scientific research, the wealth of data that are nowadays available could be wasted (or at least not properly exploited) if there are not correctly managed and interpreted; indeed, modelling and data mining are to be correctly used to transform data into information.

There is an increasing trend towards a more superficial education in mathematics, and therefore, the quality of the mathematical background provided at most of the European education institutions might suffer from such a negative attitude in the very near future. This would seriously affect profitable exchanges between mathematicians and researchers in, and users of, science and engineering.

3. How best to include mathematics in the next *Framework for Future EU Research and Innovation Funding*?

In mathematics there is an extremely close relationship between teaching, training and research. In fact, most researchers in mathematics are also teachers, and European support for research has an immediate effect on the improvement of mathematical qualifications in the manpower of the future. It is the appropriate moment to point out that the need for people mastering an advanced mathematical training has broadened enormously. Europe needs a dynamic community of scientists and engineers well trained in mathematical methods if it is to compete in the global market of the future where innovation is the key to success.

Teaching and training

In this age of science and technology, it is obvious that the future of Europe will depend crucially on the level of its researchers and, more broadly, on the level of its whole workforce. We are convinced that the successful initiatives EU has undertaken to stimulate the multi-national training of a new generation of European scientists, starting from the University level (Erasmus), have to be praised and intensified. In particular, we stress the importance of the Marie Curie actions for mobility: the different types of grants and the Initial Training Networks. These actions should be at least kept if not boosted in the next framework programme. We think that a well-supported scheme allowing students from overseas to enter European PhD



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programmes in mathematics will result in a win-win game for Europe and the countries of origin. The "return phase" format for any type of postdoctoral fellowship, namely a grant allowing one to spend two years in another European country and then, one year in his or her country of origin, is strongly supported. This format should also allow for spending some time in an industrial research environment.

Postdoctoral positions play a crucial role in helping researchers to build an independent career. They should also facilitate establishing themselves permanently in Europe. Scientists in Europe are often better trained than their counterparts in the United States up to the doctoral level, and this applies in particular to mathematicians. Since such a considerable investment in education and advanced training has been made in our countries, Europe should make every possible effort to keep highly competent young scientists, and to offer good opportunities for a permanent job.

Research

First of all, EMS is glad to praise the success of ERC in supporting the formation and the consolidation of small research groups and in stimulating and supporting senior scientists in the implementation of groundbreaking research projects. We particularly appreciate the bottom-up philosophy that characterizes the activity of ERC as well as its scientists-driven strategy. We would very much welcome that ERC could be put in a position of extending its activity to support other forms of research, and in particular network research activities. ERC – a recognized success story – represents one of the most effective instruments European science has. EMS regards ERC's further development and strengthening as a *conditio sine qua non* for the future of European mathematics.

To stimulate a synergy between mathematics and industrial innovation, companies should be offered the possibility of finding a "one stop shop" where information on competencies of different laboratories and groups would be made available (see below a suggestion for a practical implementation of this task). By the same token, European industrial mathematics would be given the possibility of reaching (virtually) the critical mass of expertise to meet the short-term demands of the private sector. This action will promote the vision of mathematics as enabling technology in the European industrial culture.

Concerning top-down programmes, we stress that mathematics should appear in the next Framework Programme as a quality indicator in most interdisciplinary projects (nanosciences, biomathematics, genomics, energy, environment, communications, etc.), but also as a priority in itself, with the possibility of funding networks of a reasonable size. In many instances, mathematics is instrumental not only in giving answers, but also in asking the right questions. Industrial and applied mathematics need to be underpinned by mathematics as a whole. The private sector will always



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excel in identifying promising technologies and exploiting them, and it will provide corresponding research support, much of it inevitably focused on the short term. Applied mathematicians thrive on the problems posed through contacts with industry and other scientific disciplines. An appropriate investment in the basic theoretical and methodological research areas that underpin their analysis is absolutely necessary for a truly successful response.

It is evident that public bodies bear the major responsibility for long-term investments in mathematical research. Indeed, long term cannot be on the agenda of most industrial companies. Therefore, it is important to develop a publicly funded European area of scientific freedom, where scientists are encouraged to take new initiatives and will create new science following their own approaches. In short, Europe has to give a real chance to the unexpected.

4. Some practical instruments

Research infrastructures

The ESF-EMS Forward Look project “Mathematics and Industry” was recently carried out aiming at identifying ways to establish an efficient synergy between mathematics and companies as well as a more strict involvement of mathematicians in the implementation of long-term projects in the knowledge-based society.

It issued a final report based on the discussions of three working groups, on the involvement of national mathematical communities, and on the results of an electronic survey that received several hundred of answers (see www.esf.org/publications/forward-looks.html). Its main conclusion is the recommendation to create a virtual research infrastructure (European Institute of Mathematics for Innovation, EIMI) that should have the following goals: (i) to design a European platform for the academia-industry cooperation, including the selection of best cases, the presentation of prototype software for modelling, simulation and optimization, databases on expertise and experiences of the various laboratories, (ii) to organize common training activities, exchange of researchers, study groups with companies, focussed modelling weeks, internships, lifelong training for high tech companies (iii) to suggest partnerships to tackle challenging problems and support networking research activities, (iv) to stimulate cross-fertilization between disciplines, (v) to provide a “one-stop-shop” for industries, public administrations, banks, insurances, and SMEs to contact when they need cooperation, (vi) to fund appropriate networks for industrial and applied mathematics, e.g., by grants matching industrial contributions, (vii) to provide a “direct line” to scientists from other disciplines to connect with the groups willing and capable of joining multidisciplinary projects. EIMI would also be a primary channel for interaction with EU structures and funding agencies and with non-European funding and research structures.



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The already existing mathematical research centres and institutes with a long and outstanding tradition should be financially supported to guarantee their activities and sustainability.

Electronic databases, journals and repositories

Access to electronic databases will be essential for the development of mathematics and its interactions with other disciplines and industry. Europe must be an essential partner in the world competition in this domain. There is already a comprehensive European database of mathematical literature, namely Zentralblatt-MATH, whose content is at par with the American-based one MathSciNet, a product of the American Mathematical Society. EMS is involved in its strategic development. This database is a good example of public-private cooperation, as Springer Verlag and the FachInformationzentrum, a German agency are involved in its maintenance and development. Support from a French-based unit for software development is also to be acknowledged. For these reasons, EMS presses the EC to make sure that Europe has properly identified scientific electronic databases as a strategic resource and proposes strong action to deal with this issue.

A second critical issue has to do with the future of scientific journals, a tool that is essential to scientific research. The system of scientific information is undergoing major transformations because of the new technological developments that go along with the generalisation of internet access. One of the consequences is a radical change in the economical model underpinning the commercialisation of journals. More may be coming with the new paradigm of "open access". Right now the new situation causes a number of university libraries to having difficulties to cope with the very substantial increases in prices that have been witnessed in the last twenty years. Many cannot acquire the basic necessary tools for their mathematics researchers. It should be noted that mathematics is a discipline in which the role of academic publishing houses is considerable and very complementary to that of commercial companies.

A special feature of mathematics is that documents have a much longer lifespan. Thus present day researchers, as well as practitioners coming from other fields, will effectively need access to the whole of the literature for his or her work. This makes the request for the transfer of data contained in journals on electronic support a urgent one. The question of their long term availability goes along with it. The EC has to get involved with digitalising efforts initiated on a large scale in the U.S., either by competing with them or, a likely better alternative, by partnering with them. In the latter case, a sufficiently strong position must be reached before hoping for a real partnership in the construction of mathematical repositories. For that



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purpose, the EC must consider providing financial support for accessing the infrastructure, for research related to its development, and its upgrading. This should lead to the establishment of an extensive European Mathematical Library –an on-going project strongly backed by EMS. Such a project should be one of the main milestones of the programme under definition, as far as the support to mathematics is concerned.

Summer schools

Summer schools and conferences are essential means of training and communication between scientists. In the case of mathematics, they usually cannot be funded by the regular budget of the research teams. In FP5, individual summer schools could be funded on a competitive basis. In FP6, series of conferences and summer schools could be funded, a more effective approach. Unfortunately, this possibility vanished in FP7. The EMS recommends to incorporate the funding of series of summer schools and conferences in the next Framework Programme.

Simplification of procedures

We welcome the rules adopted by ERC to simplify the submission of applications. However, in most other of EU calls, uniform rules do not allow for the maximal efficiency of the programmes. Sometimes, using the same format to cover many different situations leads to situations that are unbearable to scientists. Quite often, questions asked in the application form obstruct the communication between the proposer and the scientific panel. This is in part due to a very restrictive view of subsidiarity: instead of simply saying what research is planned for the panel to read, the proposer will have to answer a series of questions, distinguishing training, research, added European value, externalities, etc. It has gone so far, that some high level scientists do not apply anymore, whereas others hire the (paid) service of consulting agencies, which specialise in knowing how to transform a scientific project into a “viable” application, destroying most of the time the real content of the project, and making an informed understanding of what is really at stakes impossible.

An additional remark concerns the rule that foresees that part of the first applications for some calls must be anonymous. This procedure may give an impression of impartiality, but in fact to delete the information on the level of expertise of the researchers is to deprive the assessor of a major element of judgement. In a community like the mathematical community, whose level of fairness is acknowledged (partly because the practice of science makes it almost impossible to claim great results without proving them for good in a short interval of time), this becomes another element that puts away the best researchers,



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something that is totally unacceptable if the EU is really serious about contribution to science at the highest level.

Management procedures of any EC project are unanimously considered by the scientific community as extremely heavy, this perception encompasses every stage: the preliminary negotiations, contract signature, due reports and financial audits.

All this creates a terrible image for the (substantial) contribution the EC makes to the development of science, and a clear departure from this situation has to be announced and implemented. This state of affairs is reflected in the fact that, in several countries, the very best scientists do not consider any more applying for European funding as a viable option, something that is totally unacceptable if the EC is really serious about contributing to the development of science at the highest level in Europe.

Consulting and advisory boards

To best design and coordinate EU scientific policy and actions, it is absolutely necessary to include mathematicians with a strong background (both in basic mathematics and in potential applications) and with a broad scientific vision, in the various advisory boards the EC sets up. Very surprisingly, this has not been and is not the case for example in EURAB, ESFRI, and no mathematician is a member of the Governing Board of the European Institute for Technology. This ostracism has to stop as soon as possible for the benefit of science.

Meanwhile, EMS would be very happy to coordinate the participation of the European mathematical community in the process of developing the concepts for the next framework for future EU research and innovation funding. It could do that by sending representatives or suggesting participants to the corresponding committees. It could also be given the charge of coordinating the appropriate actions for the inclusion of up-to-date mathematical technologies in the research programmes of other disciplines, as well as to the transfer of know-how to European industries on all scales.