



EXPRESSION OF INTEREST

Network of Excellence

Applications of Computational Mathematics and Statistics in Science and Technology

Submitted by **EEIG-ERCIM**,
European Research Consortium
for Informatics and Mathematics

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Annex 3

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EUROPEAN COMMISSION

*EXPRESSIONS OF INTEREST TO IDENTIFY
RESEARCH ACTIONS READY FOR SPECIFIC
PROGRAMME TOPICS AS A BASIS FOR THE
PREPARATION OF WORK PROGRAMMES FOR THE
6TH FRAMEWORK PROGRAMME FOR RESEARCH*

EoI n°:

(for Commission use only)

ADMINISTRATIVE INFORMATION					
<i>Name of organisation submitting the EoI</i>	<i>ERCIM (European Research Consortium for Informatics and Mathematics) and CLRC - Rutherford Appleton Laboratory</i>				
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<i>Title of the expression of interest (up to 10 words)</i>	<i>Applications of Computational Mathematics and Statistics in Science and Technology</i>				
<i>Acronym (up to 20 Characters)</i>	<i>NUMAS</i>				
<i>This EoI refers to an Integrated Project</i>	<input type="checkbox"/>	<i>This EoI refers to a Network of Excellence</i>	<input checked="" type="checkbox"/>		
<i>Sub-Thematic Priority¹ most relevant to your topic</i>	<i>1.1.2.i</i>				
<i>Other relevant Sub-Thematic Priorities²</i>	<i>1.1.4.i</i>	<i>1.1.6.3</i>			
<i>Abstract (max. 10 lines)</i>	The global aspiration of the network is to link together mathematicians working in the National Laboratories, the Universities, and the R&D groups in Industry. We want to fulfil this by developing the network around the following key objectives: integrated research projects that address the present fragmentation, a programme of training for young mathematicians (PhD students and postdoctoral researchers), human mobility, dissemination activities and visibility. The achievement of these objectives is expected to have a profound impact on the way numerical mathematics and statistics are perceived by the industry and by the public at large. Moreover, this network is expected to create an environment that will facilitate the transfer of technology between industry, national laboratories and academia by the use of the intellect and the knowledge of young scientists.				
<i>I request that the information given in this form is not published³</i>					
<i>This form must be accompanied by the short document (maximum 5 pages) referred to in Section 3 of the Guide for Submitters.</i>					

¹ Indicate only one sub-thematic priority number given in Annex 1, eg. 1.1.6.1.i or 1.1.1.ii.b or 2.3

² If appropriate, indicate one or more sub-thematic priority numbers given in Annex 1.

³ Unless you tick the YES box the information included in the Annex 3 form will be published by the Commission Services. The **5 Pages EoI short document will not be published.**

Managing Organisation

The management will be undertaken by EEIG-ERCIM, the European Consortium for Informatics and Mathematics founded in 1992. Through this unique structure, sixteen different national research organisations with strong activity in IT research and development, in as many European countries, are tooled to participate in joint projects, keeping the management simple and effective. ERCIM has its central Office located in France and acts as a front-end to access the scientific expertise of its members (e.g. ERCIM has acted as an evaluation agency for the “InfoDev” World Bank programme). The Office has set up strong internal and external channels for solicitation and dissemination. It also has considerable experience in managing EU-funded projects (more than 30). ERCIM has its own International Fellowship Programme and Internal Mobility scheme. It also organises prospective workshops (like the EU-NSF ones), seminars and conferences. The ERCIM Office has also a very valuable competence in results dissemination, as part of its assets rest with customised web design, set-up and assistance, and the edition of the ERCIM News magazine (over 8000 copies distributed worldwide). This, combined with the sixteen research organisations disseminated across Europe makes ERCIM a key player in European IT research and development, and a reliable foothold for international cooperation.

Rationale for proposing the action

To compete on in the new global market, European industry should take advantage of the competitive edge that could be gained from using European expertise in applied mathematics and scientific computing. Engineers, applied scientists and mathematicians working in industry can greatly benefit from close collaboration with applied mathematicians with skills and knowledge relevant to their applications.

Moreover, there is a shortage of industrial mathematicians within European industry, particularly in the sectors of numerical mathematics and statistics. Therefore, there is the need for a new action to bring industry up to date with the state-of-the-art mathematical ideas, methodologies, tools and techniques.

Academic resources in Mathematics for Industry are also scarce and fragmented across Europe, while industrial needs are widely spread. Exchange and interaction are necessary in training, research and industrial collaboration if there is to be an effective transfer of knowledge and skills.

We have recently had the opportunity to contact several colleagues working for institutions participating directly in ERCIM. The need to build up stronger links between the mathematicians within ERCIM and the Universities stimulated the creation of two Working Groups dedicated to the application of numerical mathematics in science and to mathematics and statistics, where a cross fertilisation among the numerical techniques used in different fields of scientific computing can take place.

These Working Groups have decided to submit a joint proposal for the creation of a “Network of Excellence” aiming to become an international leader and a reference point in Europe on this underpinning theme of computational mathematics. Specifically, this Network will:

- Operate on a European scale,
- Promote the use of Computational Mathematics in Industry, and
- Educate industrial mathematicians to meet the growing demand for experts in Numerical Mathematics and Statistics.

This last point is especially relevant to our project: The education and training of a new generation of young scientists will have an impact on the European High Tech community that we expect will be more durable than new, but sometimes artificial, research projects. The early involvement of industry will greatly accelerate the speed with which new research ideas are exposed to “real world” conditions and become appreciated by industrial users. We hope to create an environment that will help Europe to match the American swiftness in integrating new generations of mathematicians into academic and industrial environments.

Objectives of the Network

The global aspiration of the network is to link together mathematicians working in the National Laboratories, the Universities, and the R&D groups in Industry.

We want to fulfil this aspiration by developing the Network of Excellence aiming at the following key objectives:

1. Integrated research projects that address the existing fragmentation. We will identify research projects around which we can propose an interdisciplinary programme of research that will integrate and focus the current activities.
 2. A programme of training for young mathematicians (PhD students and Post Doc researchers): We want to organise the training so that each fellowship will be shared between several laboratories and some R&D industrial centre. The successful experience with the ERCIM fellowships programme supports the validity of this
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idea.

3. **Human mobility:** We intend to extend the programme of exchange of personnel among the participants, to support medium and long-term visits and sabbatical leaves. Moreover, we will formulate a teaching programme with the Universities involved in the network where national laboratory and industrial members will actively participate as lecturers and postgraduate students would be able to use credits gained at several Universities towards the completion of the course requirements of their programme of study
4. **Dissemination activities and visibility:** Besides the channels of dissemination (scientific journals, workshops, web and electronic communications) normally used by the mathematical community, we intend to pursue less traditional forms such as articles written and targeted for non specialist publications that cater to multidisciplinary and heterogeneous audiences for the timely and wide dissemination of new research results. These would serve to inform scientists, engineers, technology managers and the public with advances in the field and would highlight the importance of computational mathematics and statistics for science and society.

The achievement of these objectives will hopefully have a deep effect on the way numerical mathematics and statistics are perceived by the industry and by the public at large. We must show the practical utility of our activity, the potential impact on everyday life, and the extent of their use in developing new technology. Moreover, by enhancing the mobility of young researchers between universities, research institutions and industry we will also facilitate the technology transfer process.

General approach foreseen to achieve the objectives

The network should be internally organised with a Steering Committee consisting of one expert from each field of interest and some experts from industry. The major role of the Steering Committee will be to identify, define and stimulate initiatives that span several areas, and to select common research activities

It is reasonable to assume that the actual members of the two aforementioned ERCIM Working Groups will form the core of the Network and that the industrial R&D centres will be associate partners. We estimate that more than 50 researchers from 28 organisations will participate in the Network.

Taking into account that we envisage to offer between one and two fellowships per organisation, we expect that the Network would support 40 young scientists. The estimated annual budget necessary to run the project would be around 2 million Euro (we assume that the project will run for a minimum period of 4 years for a total cost of 8-10 million Euro).

Integrated activities

We will organise workshops, schools and integrated teaching programmes involving industrial and national laboratory lecturers. We will take full advantage of electronic communication creating web pages where the scientific activities are presented, databases of test problems, and a newsletter. The Network will also provide the organizational support for the movement of the participating researchers across the institutions.

Research activities

A preliminary survey among the researchers, active in the laboratories of the Organisations that participate in the Network, indicates that the following major fields have strategic interest:

- **Numerical Linear Algebra;**
- **Numerical Solution of Differential Equations;**
- **Continuous Optimization and Optimal Control;**
- **Computational Statistics;**
- **Statistical Applications;**
- **Large Scale Scientific Computing.**

Each of the fields frequently uses techniques developed in one of the others. By creating a network of European researchers, the increased collaboration and communication between the fields will further strengthen this research and enhance its impact in science and industry. Removing any one of these fields would greatly dilute our intention to involve most of the laboratories in this Network.

We now briefly describe the specific topics of research in each field.

- **Numerical Linear Algebra**

The topics range from sparse matrix theory, direct and iterative solvers for large and sparse linear systems of equations, least squares and total least-squares problems, to the computation of eigenvalues, eigenvectors, singular values and singular vectors for large-scale and /or structured matrix problems, including the use of symbolic manipulation techniques for the solution of polynomial systems of equations.

- **Numerical Solution of Differential Equations**

The topics of major interest are finite-element methods, mesh generation, multigrid methods, wavelets, spectral methods, and time-stepping methods.

- **Continuous Optimization and Optimal Control**

The topics of interest are: interior point methods for large-scale linear, quadratic and nonlinear programming, SQP methods for non-linear programming and optimal control.

- **Computational Statistics**

The topics of interest are related to the following application fields: model selection, outliers detection, regression diagnostics, linear and nonlinear model estimation, error analysis and error propagation, error-in-variables modelling, correspondence analysis, principal components analysis, cross-validation, Bayesian inference, Markov chain, and Monte Carlo methods.

- **Statistical Applications**

The topics of interest overlap those of the previous section, but here we will focus on statistical signal processing, statistical communication, econometrics, quantitative finance, data mining, chemometric, and biomedical applications.

- **Large Scale Scientific Computing**

In this interdisciplinary field, the topics of interest include many of those cited in the previous sections. We want to add to them parallel and grid computing, and mathematical software.

We expect that several application areas will benefit from the results and the activities of the Network: We mention, for example, simulation of electromagnetic phenomena, electrical circuit theory, computational chemistry, computational biology, computational materials, CFD and structural engineering, mathematics for financial derivatives, finite-element modelling for medical simulation, environmental modelling, image and signal processing, econometrics, data filtering, information retrieval, statistical data mining, data compression and representation.

Within these fields, we plan to identify some integrated actions around which we can propose an interdisciplinary programme of research that will integrate the current activities focusing them on a common interest “kernel” target. An example of such a “kernel” target is the saddle point problem. Several participants in the existing Working Groups are already studying this problem in the context of different applications, thus building multiple perspectives for its handling and solution. These applications include mixed finite-element approximation of partial differential equations in elasticity and fluid-dynamics, optimisation and interior point algorithms, solution of weighted least squares problems, modelling statistical processes, and solution of indefinite sparse linear systems of equations. Another kernel is the eigenvalue problem, that we know is of great interest to a large cross section of the participants of the current Working Groups. Its solution involves the study of efficient numerical algorithms, and applies to areas ranging from stability studies for differential equations to singular value decomposition in computational statistics and information retrieval.

Training

Our ambition is to create a new model of fellowship where all the actors of the advanced technological world can participate at some stage. Based on the experience developed in the context of ERCIM, we propose a fellowship programme where a young mathematician will spend part of his/her biannual fellowship in some academic institution (at least 2) and, if his/her research studies are of immediate interest to an industrial associate partner, another part in an R&D centre. We propose the possibility of a renewal after the Steering Committee evaluates and recommends the value of the specific activities.

Dissemination

It is widely acknowledged today that one of the most rapid and cost effective means of dissemination and diffusion of new knowledge, methodologies and concepts to the industrial world is young scientists. The Network will create an environment that will facilitate this process. It will also provide the framework for early interaction between young PhDs, postdoctoral researchers and industry. This interaction will enlighten researchers with the workings of industry, and will put industry in contact with potential new staff recruits specializing in areas that are of its specific interest. Furthermore, the involvement of industrial lecturers in some training and teaching programme will help academic researchers to select the key and difficult industrial problems needing new techniques. We anticipate that the use of the less traditional forms of communication (such as the articles for non-specialists) mentioned earlier, as well as other types of activities, will enhance the appreciation of numerical mathematics and statistics in general, and will render the role and the contribution of the proposed Network in science and technology transparent for the general public and the tax payers. The public has the right to know how EU and the researchers involved in its programmes are using the money.

Need and Relevance

European mathematical research already enjoys an outstanding profile amongst the international scientific community. In particular, the activities in numerical mathematics and in statistics undertaken within each European country are of the highest quality. Organisations such as ECMI (European Consortium for Mathematics in Industry) and ERCIM contribute to the recognition that Mathematics, as the language of the sciences, plays an important role in technology, finance, biology, and environmental sciences. Nevertheless, in the words of the Exxon R&D president, Edward E. David still *"too few people recognize that the high technology so celebrated today is essentially a mathematical technology"*. As result of this situation, the visibility of numerical mathematics and computational statistics is still quite poor among the public. When new scientific discoveries or new technologies hit the front page of the news, the computational mathematics at the core of them is seldom highlighted. The lack of visibility is also quite serious vis-a-vis European industry which is increasingly becoming dependent on high technology with a growing need for mathematical expertise in both research and development.

The fragmentation of research among the European countries is a matter of fact, and no single European country is likely to have sufficient expertise of mathematical knowledge. The European Union also recognises this need for the exchange of skills and knowledge between member nations, and has strongly supported its COMETT, ERASMUS and HCM programmes. Moreover, co-operation between European Universities, National Laboratories, and institutes directly financed by each country is still sporadic, essentially undertaken at the national levels, or left to the goodwill of the individual mathematicians.

We strongly believe that the best way to build stronger links between European Universities, National Laboratories and Industry is to encourage young scientists to act as intermediaries.

Our ambition is to create an environment where young scientists would be educated and trained using the skill and the experience of the Universities, the equipment and the expertise of the National Laboratories, on topics of interest for the Industrial R&D centres.

Excellence

The following countries and organisations will participate in the Network as the core group

1. Austria: Institute for Scientific Computing, University of Salzburg (ISCS)
2. Belgium: Department of Electrical Engineering, Katholieke Universiteit Leuven (ESAT/SCD)
3. Czech Republic¹: Institute of Computer Science, Academy of Sciences of the Czech Republic (ICS-AS CR)
4. Denmark: Technical University of Denmark (DTU), The Royal Veterinary and Agricultural University (RVA), National Environmental Research Institute Denmark (NERI)
5. France: INRIA/IRISA, CERFACS, INP Toulouse/IRIT (INPT/IRIT)
6. Germany: Weierstrass Institute for Applied Mathematics and Stochastics, Berlin (WIAS)
7. Greece: University of Patras (UPG), University of Thessaly Volos (UVG), FORTH
8. Italy: IMATI, IAC (CNR)
9. The Netherlands: CWI, Utrecht University (UU)
10. Norway: SINTEF, NTNU
11. Slovakia¹: Academy of Sciences of Slovakia (SAS)
12. Sweden: Linköping University (ULS)
13. Switzerland¹: ETH Zurich, University of Basel, Université de Neuchâtel (SARIT)
14. U.K: CLRC-RAL, University of Cardiff (UCW), Oxford University (OUUK), University of Manchester (UMUK),

In Table 1, we list the organisations that have agreed with this proposal with their field of interest and expertise. The number of researchers involved is around 50. Among them we count some of the best worldwide specialists in their sector. The multi-disciplinary skills and critical mass make the proposed Network of Excellence it one of the world leaders in the fields of numerical mathematics and statistics.

Some industrial partners have already agreed to participate (NAG UK, Hyprotech AEA-UK, Schlumberger ATC Abingdon UK, Hyperion Systems Engineering Ltd. Cyprus) and we are contacting other R&D centres with which we have had successful co-operations in the past (see Table 2).

¹ Third Countries/International Organizations

Integration and Structuring Effect

All European countries already have programmes in place for the integration of academic research with the industry around interdisciplinary projects. The European Commission has sponsored in the past several such projects and ECMI (in the future MACSI-net) plays a similar role between universities and industries in sectors that are complementary to ours.

We want to stress the novelty of our proposal that gathers the important components of the High Tech world, universities, national laboratories and industries around numerical mathematics and statistical topics of common interest, and teaching and training programmes.

Moreover, the existing system of grant application is beneficial for enhancing competition among well-established organizations, where the research infrastructure is well supported at the national level. However, this does not help in the establishment of new entities (specially among third countries organizations), nor does it build contacts between them and industry, or to design long term strategic plans. Being a part of the proposed Network will help to strengthen research groups and their interactions.

Finally, we wish to incorporate more organizations and, in particular, we will be always open to incorporate industrial partners in the future.

Organization	Numerical Linear Algebra	Numerical Solution of Diff. Eq.s	Continuous Optimization	Large Scale Scientific Computing	Computational Statistics	Statistical Applications
CERFACS	X	X		X		
CLRC-RAL	X	X	X	X	X	
CNR	X	X	X	X	X	X
CWI	X	X		X		
DTU	X		X	X	X	X
ESAT/SCD	X				X	X
IACM-FORTH	X	X			X	
ICS-AS CR	X		X	X	X	
INPT/IRIT	X		X	X	X	X
INRIA-IRISA	X	X		X	X	X
ISCS	X			X	X	
NERI	X	X		X	X	X
NTNU					X	X
OUUK	X	X	X	X		
RVA						X
SARIT	X	X	X	X	X	X
SAS	X			X	X	
SINTEF	X	X		X		
UCW				X		
ULS	X			X	X	X
UMUK	X	X		X	X	
UPG	X			X	X	
UU	X			X	X	
UVG	X				X	X
WIAMS	X	X				

Table 1. Core participant list and their interests.

Organization	Numerical Linear Algebra	Numer. Solution of Diff. Eq.s	Continuous Optimization	Large Scale Scientific Computing	Computational Statistics	Statistical Applications
Hyprotech (UK)	X	X	X	X		
NAG (UK) ^x	X		X	X	X	X
ISE Inc. (CH) ^x	X	X				
AutoForm Engineering Inc. (CH) ^x		X				
COMSOL (Sweden)	X			X	X	X
Hyperion Systems Engineering Ltd. Cyprus ^x			X	X		
Schlumberger ATC ^x , UK	X	X	X	X		
NEC Europe Research Lab	X			X		

Table 2. Associate participants (^x indicates that we have a confirmed agreement)