STARTPAGE

HUMAN RESOURCES AND MOBILITY (HRM)
ACTIVITY

MARIE CURIE ACTIONS
Research Training Networks (RTNs)

“Interdisciplinary and Intersectional”

Call: FP6-2004-Mobiliy-1

PART B

STAGE 1 – OUTLINE PROPOSAL

“ARTDECO”

B1 PARTNER LIST

Participant number	Participant Organization legal name and Department	Country
1	GEIE ERCIM	F
2	Council for the Central Laboratory of the Research Councils, Rutherford Appleton Laboratory Computational Science and Engineering Department	UK
3	Oxford University Computational Laboratory	UK
4	IMATI-CNR Pavia	I
5	University of Pavia Department of Mathematics and Department of Structural Mechanics	I
6	CERFACS Toulouse	F
7	INPT-IRIT Toulouse	F
8	INRIA Sophia-Antipolis	F
9	University of Namur Department of Mathematics	B
10	Academy of sciences of the Czech republic Institute of Computer Science	CZ

Table 1 List of Participants

"All the life that whirls about us, runs, and stops is not only dependent on mathematics for its comprehensibility, but has effectively come into being through it and depends on it for its existence, …" (Robert Musil, "The Mathematical Man", 1913.)

B2 OUTLINE PROPOSAL

B.1 Scientific quality of the project

B.1.1. Research topic

To compete in the new global market, European industry must take advantage of the competitive edge that would 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 academics and mathematicians with skills and knowledge relevant to their applications. Moreover, there is a shortage of mathematicians within European industry, particularly in the sectors of computational mathematics. Thus, 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 arenas.

In 2002, ERCIM (European Consortium for Informatics and Mathematics) comprising leading research institutes from eighteen European countries, created a Working Group on "Application of Numerical Mathematics in Science" so that a cross fertilisation of numerical techniques used in different areas, and by different teams, could take place.
This Working Group has decided to submit this proposal for the creation of a "Marie-Curie Research and Training Network" aiming to become an international leader and a reference point within Europe on this underpinning theme of computational mathematics.
A survey among the active researchers in the laboratories of the organisations that plan to participate in the Network indicates that the following major fields have strategic interest and strong interactions:

- Numerical Linear Algebra;
- Numerical Solution of Differential Equations;
- Continuous Optimization and Optimal Control;
- Large-scale Scientific Computing.

Each of these 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 on science and industry.

B.1.2. Objectives of the Network

The global aspiration of the network is to link together mathematicians working in National Laboratories, Universities, and R&D groups in Industry.
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, 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, finite-volume 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 and SQP methods for nonlinear programming and optimal control.
- **Large-scale Scientific Computing**. In this interdisciplinary field, the topics of interest include many of those cited in the previous fields. Parallel and grid computing, and mathematical software should be added to them.

Within these fields, we have identified 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. In particular, we have identified among all our research topics the following transverse research lines as scientifically relevant for our cross fertilization project:

1. **Saddle points** - The computation of saddle points is a key problem in many fields. Several participants in the existing Working Group 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, and interior-point and SQP algorithms for optimization. Parallel computing can be the only way to approach the solution of these problems where the number of parameters to determine is exceedingly large.
2. **Optimal design and shape optimization** - The design of new materials and the optimization of artefacts (airplane, electrical devices, cars) in engineering requires the combined efforts of optimization, approximation, and linear algebra experts in order to simulate and solve the complex phenomena under scrutiny.

B.1.3 Scientific originality

The scientific originality of the project is in the cross fertilization between several fields of research and in its clear impact on European industry. Under the large-scale scientific computing title, we often find problems that are solved with mathematical techniques that are not at the cutting edge. The time needed for the implementation of new successful ideas in industrial software is too long even without taking into account the necessity of a complete validation of the new release.
We believe that a possible cure for this defect is the training of a new generation of young applied mathematicians with a strong field of specialization, combined with an outstanding knowledge in several other fields of applied and computational mathematics. This can be achieved using our network of universities, research laboratories, and industrial research and development centres where the young researcher will be involved with the cutting edge research.
In particular, we hope to exploit new optimization techniques that allow us to solve problems with a very large number of degrees of freedom ($> 10^7$).
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, optimal design, mathematics for financial derivatives, finite-element modelling for medical simulation, and environmental modelling.

B.1.4. Research method

The main project objective is to integrate several new algorithms and numerical techniques in Scientific Computing, in order to characterize and increase the accuracy of the models and to extend their field of applicability. We intend to achieve the target of integrating the expertise of each team by using young scientists and by organizing meetings and schools, where each team can present in simple terms their problems or their algorithms. Currently, the ERCIM working group already organizes similar activities. Nevertheless, we feel the need for a more sustainable and institutional effort. The successes of integrated initiatives and the long standing record of cooperation between several of the teams, stimulates our proposal.
Moreover, we think that the area of Numerical Linear Algebra represents the natural "glue" that will maintain the cohesion between the teams. Its fundamental value is in its immediate applicability to several problems and in its closeness to the software. Therefore, we plan to use the expertise in Numerical Linear Algebra resident within the majority of the teams to ensure a thread-safe approach to the implementation of the research topics described in Section 1.2 of this proposal.

B.1.5. Work plan

The objectives described in Section 1.2 are subdivided in work packages and then into several tasks. We describe the contents of each task and, in Table-2 we relate the teams to the tasks. Moreover, we add an objective related to the dissemination and the management of the network.

WP1.Saddle point problems:

- **Task-1.1.Direct methods**: comparison between the existing direct solvers and reordering techniques for fill-in control, parallel computing and grid computing. On the basis of this evaluation, improvement of existing, and development of new techniques.
- **Task-1.2.Iterative solvers**: Evaluation and improvement of the existing saddle point preconditioning techniques in combination with the Krylov and Chebyshev methods. Study and evaluation of the combination of saddle point preconditioners with spectral preconditioning (deflation of the smallest eigenvalues in absolute value). Study and evaluation of hierarchical solvers such as multigrid and Domain Decomposition.
- **Task-1.3.Mixed approach**: the study of mixed direct and iterative approaches and their comparison on very large problems with direct and iterative solvers, Null and Range Space algorithms.
- **Task-1.4. Applications**: application and comparison of these methods, taking advantage of the structural properties of the discrete operators to the solution of mixed finite-element approximations. Applications could include Darcy's laws, Biharmonic problems, Computational Fluid Dynamics, and Navier-Stokes equations. Application of interior-point algorithms for large-scale problems in the numerical solution of PDEs.
- **Task-1.5.A-posteriori error estimator and stopping criteria:** study of suitable error formulae in self-adaptive discretization methods. Identification of stopping criteria suitable for iterative methods applied to PDEs. Study of stopping criteria with respect to the a-posteriori error estimation and the error control in relation to the underlying PDEs.

WP2.Optimal design and shape optimization

- **Task-2.1. Algorithms for elliptic control problems:** use of interior-point techniques for the solution. Study of the discretization of the differential operators.
- **Task-2.2. Multi-scale optimization:** the use of multigrid/multilevel techniques in the context of optimization problems arising from PDEs.

Task-2.3.Adaptation of optimization algorithms to optimal design: study and design of improved general software in constrained optimization to the case where the constraints are PDEs.

Task-2.4.Applications: identification of suitable models, their approximation and solution in electromagnetism, aerodynamics, and in shape-memory alloys simulation.

Task-2.5. Sensitivity analysis: evaluation by Automatic Differentiation and use of adjoint operators in the study of the stability and sensitivity of the solution to the design parameters and in the identification of the optimal conditions.

WP3.Dissemination and Management

Task-3.1.Internal Dissemination, providing collaborative tools, ensuring a coherent information flow within the network and supporting the organisation of summer schools, workshop and conferences.

Task-3.2.External dissemination, through dedicated support ranking from ARTDECO web site, to news letters, ERCIM news and publications, and the participation to international conferences. The objective is not only to advertise the network's activities but also to attract new candidates while promoting ARTDECO achievements on a global scale.

Task-3.3.Administrative coordination, to ensure the completion of the work plan, the production of reports and deliverables, to handle the administrative dimension of the training programme (student contracts), to act as an interface with the European Commission and manage arising issues.

Task-3.4.Financial coordination, to ensure funding redistribution among the network teams, performs the management of financial resources for and towards the students on fellowship.

For each scientific task, the major deliverable will be trained students, technical reports and scientific publications. We assume that some of the results will be incorporated before the end of the project in numerical software libraries. This will be consistent with the tradition of several teams in building and maintaining software libraries. The general activity reports and annual reports will be delivered through Task 3.

		Task													
		1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4
Team	1											x	x	x	x
	2	x	x	x	x	x	x	x	x	x	x	x	x		
	3		x	x	x	x	x		x	x	x	x	x		
	4		x	x	x					x		x	x		
	5			x	x							x	x		
	6	x	x	x	x	x		x	x	x		x	x		
	7	x	x	x	x		x		x	x		x	x		
	8		x			x		x	x	x	x	x	x		
	9		x	x			x	x	x			x	x		
	10	x	x	x	x	x	x		x			x	x		

Table 2 Team vs. task connection

B.1.6. Existing collaborations

The partners involved in this proposal already have a long history of collaboration among them and with several laboratories in Europe and in the USA. In order to prove our expertise in the tasks we described in Section 1.5, we give a list of selected publications where the existing collaborations are

highlighted (see Table-1 for the team number).

1. P. Amestoy, I.S. Duff, and C. Voemel, Task Scheduling in an asynchronous distributed multifrontal solver. To appear on SIAM Journal on Matrix Analysis and Applications, (2004). (Teams: 2, 6, 7)
2. M. Arioli and G Manzini, 2002.A Null Space Algorithm for Mixed Finite Element Approximation of Darcy's Equation. Commun. Numer. Meth. Engng. , 18 pp 645-657. (Teams: 2, 4)
3. M. Arioli, D. Loghin, and A. Wathen, Stopping criteria for iterations in finite-element methods. To appear on Numerische Mathematik. (Teams: 2, 3, 6)
4. F. Auricchio, P. Bisegna, and C. Lovadina, Finite element approximation of piezoelectric plates, Int. J. Numer. Methods Eng, 50, 2001, 1469-1499. (Teams: 4, 5)
5. F. Auricchio, L. Beirão da Veiga, C. Lovadina, and A. Reali, A Stability Study of some Mixed Finite Elements for Large Deformation Elasticity Problems. To appear in Comput. Methods Appl. Mech. Engrg. (Teams: 4, 5)
6. F. Brezzi and M. Fortin, Mixed and hybrid finite element methods, Springer Series in Computational Mathematics, 1991.
7. F. Brezzi, T. J. R. Hughes, D. Marini, A. Russo, and E. Süli. A priori error analysis of a finite element method with residual-free bubbles for advection dominated equations. SIAM Journal on Numerical Analysis. , 36 (1999) 6, 1933-1948. (Teams: 3, 4)
8. A. R. Conn, N. I. M. Gould, and Ph. L. Toint, ``Trust-region methods", SIAM/MPS Series on Optimization, SIAM, Philadelphia (2000), ISBN 0-89871-460-5. (Teams: 2, 9)
9. M. J. Daydé, J.-Y. L'Excellent, and N. I. M. Gould, ``Element-by-element preconditioners for large partially separable optimization problems", SIAM Journal on Scientific and Statistical Computing 18 (1997) 1767-1787. (Teams: 2, 7)
10. N. I. M. Gould, D. Orban, A. Sartenaer, and Ph. L. Toint, ``Superlinear convergence of primal-dual interior point algorithms for nonlinear programming". SIAM Journal on Optimization 11 (2001) 974-1002. (Teams: 2, 9)
11. M. Rozložník and V. Simoncini. Krylov subspace methods for saddle point problems with indefinite preconditioning , SIAM J. Matrix Anal. and Appl. (2002), Vol. 24, No. 2, pp. 368--391. (Teams: 4, 10)
12. L. Giraud, J. Langou, and M. Rozložník: On the loss of orthogonality in the Gram-Schmidt orthogonalization process, to appear in the special issue of Computers & Mathematics with Applications 2004. (Teams: 6, 10)
13. M. Arioli, V. Ptàk, and Z. Strakoš, 1998. Krylov sequences of maximal length and convergence of GMRES. BIT, 38, pp 1-9. (Teams: 2, 10)
14. M. Arioli, J. Maryška, M. Rozložník, and M. Tuma: Dual variable methods for mixed-hybrid finite element approximation of the potential fluid flow problem in porous media, Research report RAL-TR-2001-023, April 2001. (Teams: 2, 10)
15. B. Carpentieri, I. S. Duff, and L. Giraud. A class of spectral two-level preconditioners. SIAM Journal on Scientific Computing, vol. 25, n. 2, pp. 749-765, 2003. (Teams: 2, 6)
16. F. Courty, A. Dervieux, B. Koobus, and L. Hascoet. "Reverse automatic differentiation for optimum design: from adjoint state assembly to gradient computation", Optimization Methods and Software, 5, 18, 2003, p. 615-627.
17. M. Vazquez, B. Koobus, and A. Dervieux. "Multilevel optimisation of a supersonic aircraft". Finite Element in Analysis and Design, Vol.40, 2101-2124, 2004
18. E. Schall, D. Leservoisier, A. Dervieux, and B. Koobus. Mesh adaptation as a tool for

certified computational aerodynamics. I. J. Num. Meth. Fluids 2004; 45:179-196

19. M. Michieli de Vitturi, F. Beux, G. Lombardi, and A. Dervieux. Optimum shape design for turbulent viscous flows around complete configurations of 2D flying sails. Journal of Computational Methods in Sciences and Engineering, volume 4, numbers 1-2 , 43-55 2004

B.2 Training and transfer of knowledge activities

B.2.1. Content and quality of the training and transfer of knowledge programme

It is widely acknowledged today that young scientists represent one of the most rapid and cost effective means of dissemination and diffusion of new knowledge, methodologies and concepts to the industrial world. The ARTDECO network will create an environment that will facilitate this process investing the majority of the funds in a fellowship programme and in summer schools. It will also provide the framework for early interaction between young PhDs, postdoctoral researchers and industry. This interaction will enlighten researchers to 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 the training and teaching programme will help academic researchers to select the key and difficult industrial problems requiring new techniques.

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 three-year fellowship in at least two academic institutions and another part in an R&D centre if his/her research studies are of interest to an industry associated or cooperating with a participant. A Steering Committee will evaluate and recommend the value of the applications.

The partners involved in this proposal already form a multi-disciplinary consortium where the existing teams can already bring their expertise to the training network and to the students. ERCIM will be the management structure ensuring the administrative and financial coordination of the network, while the other teams involved will focus scientific agenda and training.

The ARTDECO management organisation will rely on a coherent architecture organised around the work packages: WP1 and WP2 will address the joint research and training agenda, backed up by the Research and Training Coordination Board (RTCB); WP3 will be dedicated to the dissemination efforts to be conducted within and outside the network and to ensure the general management of the project, performing the administrative and financial coordination.
The RTCB is composed of the scientific coordinator, Dr Mario Arioli, who also chairs the ERCIM Working Group “Applications of Numerical Mathematics in Science”, and all the work package leaders. The scientific coordinator chairs the board and all decisions are taken by a majority vote. The RTCB will consider also the possibility of inviting an external member of international outstanding mathematical prestige and educational experience from outside the network and the EU as an advisor on international cooperation with non-European institutions.
RTCB will supervise and stimulate the overall research and training activities while fostering exchanges and interactions among the scientific workpackages. In particular, the RTCB will coordinate the activities of the PhD students with special attention to the legal and institutional aspects concerning the fulfilment of their duties vis-a-vis to the European University responsible for awarding the title of Doctor of Philosophy. Moreover, when legally possible, we will encourage the recognition of the PhD title by another European University participating in the Network and involved in the training of the candidate. The RTCB will define the students selection requirements for all partners and co-operate with the ERCIM office in charge of implementing the selection and

integration of young researchers. The RTCB is also to discuss the multidisciplinary scientific orientations and to assess the quality of the network's achievements as an internal peer review committee.

The project involves institutions with an established record in research and in education. Among them we have nine research centres and laboratories with a vast range of expertise and competence in numerical linear algebra (CCLRC-RAL, Academy of Sciences of the Czech Republic, CERFACS, INPT-IRIT), in numerical solution of partial differential equations (IMATI-CNR, INRIA, Oxford University), and in optimization (CCLRC-RAL, University of Namur, CERFACS, Academy of Sciences of the Czech Republic, INRIA, INPT-IRIT). They are some of the leading centres for research and education in Europe.
The fields of expertise of the University participants cover all the sectors indicated in Section 1.2. Moreover, all the Universities involved have both the administrative and the training skills required by the project.

Industry will be involved in establishing the lines of research and in the preparation of the calls for application. In particular, some of the partners (ERCIM-W3C, CERFACS, INRIA, and CCLRC-RAL) have a long standing co-operation with industries potentially interested in the outcome of the project. This co-operation will facilitate the task of transferring the results and the know-how. The allocation of some of the experienced researchers to industry will be decided in a later phase of the project when their training will reach a sound level.
The subdivision of the fellowships among the partners is based on the level of personal involvement declared by each of them. We divide the project into two phases:

1. In the first year we will recruit 6 experienced researchers to guarantee a sound start-up for the activities. The subdivision among the partners will reflect the resulting level of qualification of the researchers that the market will offer.
2. The recruitment of 10 early-stage researchers will start after the first year of the project. This delay will allow the academic institutions responsible for their PhD to fulfil the formalities required by the local University and by the national state legislation. The RTCB will take charge of the scientific coordination between the hosting institutions and the original one.

The training of the early-stage and experienced researchers will be based both on individual transfer of knowledge and on the participation in summer schools where all the partners in turn will contribute with their personal involvement.

During the 4 years of the project, we plan two summer schools that will cover, during a three to four weeks period, the research topics described in Section 1.5 and other topics that might arise in the future. Each team will have the opportunity to lecture on their research expertise.
The first summer school will serve as a bridge between the expertises on saddle-point computation in optimization, perturbation analysis, and the numerical solution of partial differential equations.
The second summer school will be organized around the use of advanced computational optimization, optimal design and their applications.
We will require the speakers and all the team members to produce lecture notes that will be used during the summer schools and that can become references in the scientific literature. These lecture notes and all the publications relative to the project produced by the participants to ARTDECO will be made available on the internet through the web home page of the project.
Furthermore, we will organise workshops 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, databases of test problems, and a newsletter are presented.

The Network will also provide the organizational support for the movement of the participating researchers between the institutions. Moreover, we will encourage all the early-stage and experienced researchers to present the results of their activities during the workshops organised by the project and we will support their participation in international conferences in their specific sector.

We anticipate that the use of the less traditional forms of communication (such as articles for non-specialists, web pages), as well as other types of activities, will enhance the appreciation of computational mathematics in general, and will render the role and the contribution of the proposed Network in science and technology transparent for the general public.
The ratio between individual and network-wide training is a delicate issue that involves careful identification of the individual psychological and scientific needs of the early-stage researchers. The English language will be the official language of the network and we must ensure that the early-stage researchers are fluent in it, taking into account that they are supposed to visit the other teams involved in their training. Thus, the balance between the individual training given by the institution legally responsible for the PhD and the period of individual training abroad must be decided by the tutors responsible for the early-stage researcher. The RTCB will arrange that all the early-stages and the experienced researchers have the possibility of participating in the common summer schools and in the common workshops.
Finally, the presence of national laboratories equipped with large computing facilities such as the HPCx at CCLRC will give the possibility for all the participants and especially for the early-stage and experienced researchers to be trained on the use of state-of-the-art parallel techniques and advanced numerical software.

B.2.2. Planned recruitment of early-stage and experienced researchers

From experience of earlier participation at European networks, we believe that there is a need for an important recruitment effort at the beginning of the project. A slow start to the recruitment can otherwise become a major difficulty. Experience shows that recruiting young researchers from western European countries is not an easy task. We are convinced however that extending our recruiting areas to the new member states will ensure that it is possible to recruit excellent candidates. We will start recruiting as soon as possible by advertising vacancies on the web (Cordis, ARTDECO webpage and our institutions WebPages), in journals and electronic newsletters. ARTDECO will also contact colleagues throughout Europe, including the new member states, and this is expected to lead to the main source of candidates.

Owing to the realistic difficulty of recruiting of early-stage researchers, we plan to proceed during the first year with the recruitment of 6 experienced researchers that will help the start-up process and will sustain the cross-fertilisation effort during the first 2 years. We will use all the electronic (Na-net the numerical analysis network and Opt-Net and SIAG-Opt the optimization networks) and classic channels of information for advertising the positions. The recruitment will also be sought via the extensive European Grid network. Many Grid applications involve numerical computing, and this will provide a useful recruitment and dissemination channel for a network of this kind.
The experience of ERCIM in running its fellowship programme will be crucial in this phase. During the first year, the university teams will proceed with the selection of suitable candidates with the necessary intellectual qualities and suitable background. The ERCIM consortium advertises postdoctoral fellowships throughout Europe twice a year. This campaign results in roughly 150 candidates in all areas of applied mathematics and computer science, including discrete mathematics, systems and control and computer science. This constitutes an excellent source of candidates for experienced researcher’s positions.
Particular care will be paid to ensure that all candidates get equal opportunities. Moreover, all

partners are well aware of the necessity to promote the gender issues during the recruitment procedure. It will be clearly indicated in the advertisement that particular attention will be given to encourage (and give opportunities to) young women researchers to pursue their career in the field.
We believe that the training programme will initiate a permanent flow of young European experts in the area of Computational Mathematics. This objective will be achieved by making the research area more visible in Europe, by the organisation of workshops and summer schools that will be open to the entire European research community, by the dissemination of our lecture notes to all network institutions, and by the close interactions between early stage and experienced researchers within the network. Thus, the total person-months request for experienced researchers is 216 months (6×36 months) and for early-stages researchers is 360 months (10×36 months).

B.2.3. Impact of the training and/or transfer of knowledge programme

The use of computational mathematics plays a vital part in the USA technological leadership. The American NSF increased the budget for 2003 by 20% with respect to the previous year and a considerable part of the budget is targeted to education[1]. In Europe, applied mathematics expertise is scattered and fragmented and lacks the recognition awarded in the USA. By gathering together the disseminated expertise in Europe into a European training environment, we intend to ensure a future and lasting flow of young experts in the area. Because some regions actually suffer a lack of means and expertise, it is an important aspect of the proposed network to develop doctoral level courses not typically available in all European universities. ERCIM, among other organizations, takes charge of sponsoring the mathematical activities within the national laboratories. The ambition of our network is to start the seminal work of involving the national laboratories with European universities into a common educational project involving top quality research.
Furthermore, we also want to promote an interdisciplinary action within the field of computational mathematics. Besides a strong specialist training, we will stimulate all the players involved to have a sounder knowledge of all the research developed in the network. This will hopefully prepare a new generation of researchers inclined to exercise more lateral thinking in their work. Beyond this direct result, ARTDECO will also support the European scientific community through a number of underlying side effects.

Firstly, the added value of such a European training network is a real opportunity for the new and future member states. The European Research Area will directly benefit from this initiative as it will help new member States to adjust their expertise. Indeed, new member States have often a very strong mathematical tradition with excellent educational programmes with a high participation rate, but it appears that they often lack good programmes for training in applied mathematics and applied research. This situation not only explains why these countries will profit from the network activities, but also highlights the fact that ARTDECO will also benefit from the local expertise these countries have preserved and developed as a tradition.

Another side effect of ARTDECO will be to improve the strength of research and support the existence of a European-wide network. This will prove essential in our effort to keep the best researchers in Europe. A major part of the world leading researchers in the area is European, yet too often these researchers work in the USA. This project will contribute to the general effort to reduce or reverse this traditional brain–drain. It is the network's intention to capitalise on the existing European excellence in the field to further develop the expertise of this research community.
We will give the early-stage and experienced researchers the opportunity of an early involvement in

[1] see http://www.siam.org/siamnews/03-02/budg03.htm

an international multidisciplinary environment and of building a strong personal relationship with the European and international researchers at the cutting edge of mathematical research. We want to promote the image of mathematics beyond the borders of our project making available the material used for the training of our young researchers to a larger sector of the public by the creation of specialized web pages where the topics of our research are presented in simple but precise terms to all the non-specialist scientific community and to the interested public.

As mentioned previously, part of the impact of this training programme is to ensure a future and permanent flow of young experts in the field. This goal is also part of the rationale behind the proposed mix of early-stage and experienced researchers. By bringing together post-docs and early-stage researchers, we hope to enrich the community with shared expertise and create links among distinct generations of researchers, as a first spark towards future collaboration. The underlying idea is to get experienced researchers to assist early-stage researchers in the development of their future careers. This will act as an early transfer of knowledge on which the network believes researchers will rely to pass on knowledge and expertise.

The subdivision between early-stage and experienced researchers and their distribution among the teams has been motivated by additional technical and institutional reasons. Some national laboratories do not have the juridical authority to confer academic titles. Nevertheless, they are the repositories of extremely valuable specialist competence and of cutting edge computing equipment. These two qualities add values to the network giving the opportunity to the young researchers to become familiar with world class supercomputers and to be involved in the theoretical and practical design of advanced numerical software.
We anticipate that the impact of 16 new researchers in the fields of computational mathematics will improve the human resources of the teams involved. The successful achievement of the research objectives and the transfer of the relative know-how and of the skill in using the related numerical software will enhance further the reputation of teams involved and will promote and assist the future career of the early-stage and experienced researchers at the international level. In this respect, we plan to invite among the speakers at our workshops and the teachers at our summer schools selected international non-European specialists. This will give the additional opportunity to build additional personal relationships between our young researchers and the international scientific community.

Finally, ERCIM will take responsibility for advertising the results and the transfer of the know-how at the international, the European and the national level through its institutional channels.
With its European dimension and joint programme for post-docs and early-stage researchers, this multidisciplinary training network will promote excellence across the boundaries, between disciplines, educational systems and age generations.

ENDPAGE

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