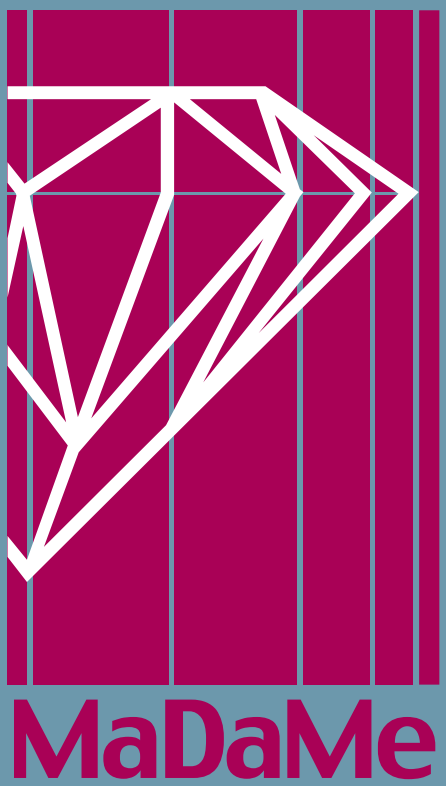
PUBLICATIONS OF THE ACADEMY OF FINLAND 15/03

Research Programme on Mathematical Methods and Modelling in the Sciences 2000-2003

EVALUATION REPORT



MaDaMe

ACADEMY OF FINLAND

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Research Programme on Mathematical Methods and Modelling in the Sciences 2000-2003 EVALUATION REPORT

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Preface

The Board of the Academy of Finland decided on 27 April 1999 to launch in 2000 a three-year Research Programme on Mathematical Methods and Modelling in the Sciences (MaDaMe). The budget of the programme financed by the Academy of Finland totalled about six million euros.

The projects funded through the programme represent in a balanced and diversified way a wide spectrum of the role that mathematics plays as a key method in the development of high technology, such as paper industry, forestry, geophysics and environmental sciences as well as important sectors of social value such as medicine and biology (e.g. physiology of the human body, cardiovascular system, genomics, tumor growth). A significant share of the investment has also been devoted to computational and statistical methods of data acquisition and analysis.

An international evaluation panel was appointed by the Academy of Finland to review the programme. Members of this panel were Prof. Stefan Arnborg, Numerical Analysis and Computing Science (NADA), Royal Institute of Technology (KTH), Stockholm, Sweden; Prof. Vincenzo Capasso, Milan Research Centre for Industrial and Applied Mathematics (MIRIAM), University of Milan, Italy (Chairman of the evaluation panel); Prof. Peter Jagers, Chalmers University of Technology, Gothenburg, Sweden; and Prof. Helmut Neunzert, Institute for Techno- and Economathematics, University of Kaiserslautern, Germany.

The evaluation panel was asked to address the following aspects:

1 Implementation of the research programme
  Coordination, management and functioning of the programme
2 Results and impacts
  Scientific quality, innovativeness, collaboration as well as scientific, social, economic and technological impacts
3 Recommendations for the future

This publication includes the report of the evaluation panel. Documentation of the programme and projects is available on the website of the programme at http// www.math.utu.fi/MaDaMe/.

Milan, November 1, 2003

Vincenzo Capasso, Professor

Chairman of the evaluation panel

1 MaDaMe programme

1.1 Background

Information intensive industries, such as telecommunications, electronics, and biosciences are among the fastest-growing sectors on the Finnish industry scene. To put the information in these fields to a more efficient use, it is essential to continue developing not only advanced information technology but also mathematical models with which the data are processed. The role of mathematical and statistical methods and modelling has continuously increased in other applied sciences as well. Mathematical models are crucial to understanding the mechanisms that lie behind natural and social processes and to interpreting large volumes of information.

The development of new mathematical, statistical and data processing methods needed in the analysis and implementation of models requires close collaboration between mathematicians and people working in the fields of applications. Finnish know-how in this field is of a very high standard, but further efforts are needed to create strong research centres and to facilitate cooperation between theoretical and practical fields.

Apart from mathematical modelling also data analysis has taken an increasing importance with the growth of data collection and data storage. The sheer size of empirical data sets and the inherent complexity of even smaller data sets often makes it extremely difficult to form a clear picture and to convey the essence of the information to end-users. To put the data collected to fruitful use, we need to have a knowledge not only of mathematical modelling and statistical methods, but also an in-depth understanding of the various phenomena lying behind the data.

The aim of the Academy of Finland Research Programme on Mathematical Methods and Modelling in the Sciences (MaDaMe) was to tackle the challenges outlined above. The programme had many points of contact with other Academy research programmes and indeed with international projects.

1.1.1 Objectives

The Research Programme on Mathematical Methods and Modelling in the Sciences had two main objectives: first, to develop and support methodology sciences whose results have practical applicability in various fields; and second, to help the fields of applications find the know-how they require in methodological studies.

To promote the development of mathematical modelling and applications-oriented methods, the programme encouraged the formation of multidisciplinary research teams. The aim was to increase collaboration among different fields of methodology sciences and to improve their interaction and exchange with the fields of applications. Ultimately the objective was to generate the information necessary for research purposes and for the development of the methods needed in different applications, and at the same time to provide training for researchers in Finland.

The programme was aiming to support international networking. This was also true of nationally-based projects. The aim was to promote international cooperation and to establish international contacts and in this way to enable new funding options for further research.

1.1.2 Contents of the programme

In the natural sciences and engineering, mathematical methods and modelling constitute an integral part of research; however, their use has increased significantly in other fields as well, including medicine, economics, the social sciences and environmental research. Models are not only simulations of reality, but they can also help to shed light on the mechanisms lying behind the phenomenon concerned and even uncover important new aspects. There are many complex phenomena that cannot be studied at all without models. On the other hand, a mathematical or statistical model is often necessary for testing hypotheses as well.

The MaDaMe programme was based essentially on methodology sciences: mathematics, computer science and statistics. Research projects involved in the programme were expected to show a strong commitment to practical applications and to collaboration between methodology research and fields of applications. Mathematical methods and their applications in information technology are very much like precision weapons. In the same way, data processing problems in the fields of applications may trigger new methodological developments in mathematical modelling.

Key areas of study in the research programme included the following:
- dynamical systems and modelling of non-linear phenomena
- signal and image processing and mathematical methods for pattern recognition
- the processing of large data volumes, data retrieval and compressing as well as the visualisation and analysis of large and complex datasets.

1.2 Organization

The MaDaMe programme was run and managed by a steering group nominated by the Academy of Finland. The steering group was composed of members of all the Academy's four research councils and a representative from the National Technology Agency, Tekes. The steering group was chaired by Professor Mats Gyllenberg from the University of Turku. The composition of the steering group was partly changed after the end of the year 2000, when the Academy's new research councils were nominated.

The coordination of the MaDaMe programme was based on the contract between the Academy of Finland and the Department of Mathematics, University of Turku. The Programme Director was Dr Marjo Lipponen-Salhi and an administrative secretary worked within the coordination till the end of 2002.

A total of 107 individual and 39 consortia plans of intent were submitted to the Academy of Finland. Of these, 18 consortia and 14 individual research teams were

invited to file their full applications. This selection was done by a subcommittee consisting of members of the research councils of the Academy of Finland and nominated by the Academy Board. The full applications were evaluated and rated by an external international review panel. Within the programme, seven consortia and seven individual research team applications were funded.

2 Evaluation procedure

The evaluation took place during a three-day meeting in Helsinki on September 24-26, 2003. The first two days were dedicated to oral presentations by members of the consortia and individual projects of their achievements within the participation in the MaDaMe programme. Subsequent interviews with the Programme Director and the teams were carried out by the evaluation panel.

The panel based the evaluation on
- MaDaMe programme memorandum
- Reports and self-evaluations by all the consortia and individual projects
- Interviews

The Chairman of the evaluation panel also discussed the outcomes of the programme with the Chairman of the steering group.

3 General evaluation

3.1 Scientific quality, innovativeness, and transdisciplinarity

A many faceted scientific programme such as MaDaMe, involving a number of people representing different research traditions and ambitions, will necessarily exhibit a varied result, both in quality and direction. We are aware that the success in scientific quality of such a wide programme cannot be homogeneously reached so that it must primarily be judged by its best components, their quality and innovativeness. In the present context, transdisciplinarity, i.e. transgression of disciplinary boundaries, adds another important value.

As will be developed in the reports on individual projects and consortia, it is clear that MaDaMe has been successful in this sense. It has provided an impetus and platform for some excellent mathematics being channelled into important science. Some of the mathematical (we use this word in its broadest sense, including statistical and computing science) work is excellent by traditional mathematical criteria (like rigour, ingenuity or concept formation), and is further applied to solve fundamental problems in science and/or technology (medicine). MaDaMe is to be commended for having supported some such top contributions that might otherwise have been left in the cold.

Another good reason for commending the Academy is related to the fact that all are aware of the difficulties in fostering transdisciplinary research given the constraints of the current structure of educational and career incentives, as well as those of most funding agencies.

Other work is on the same high level scientifically, but lacks the specific bridging quality that should have been the raison d'être of inclusion into MaDaMe, and did not lead to any transdisciplinary collaboration within MaDaMe (nor with any outside groups). Finally, when so many groups with such a diverse background are supported, it cannot be avoided that scientific value varies. We shall return to the crucial matter of what kind of role the steering group and coordination should have in such a situation, in connection with the evaluation of the Programme Director.

3.2 Educational aspects

A great and diversified effort has been expressed by almost all the groups in dissemination and researcher training at various levels in the interest areas of the programme. A main problem, emerged from various self-evaluations and interviews, has been due to the intrinsic difficulty of a multidisciplinary education, and to the career structure that prefers specialization.

A large number (33) of doctoral theses, in various ways connected with the MaDaMe programme, have been completed during the period, together with seven Licentiate degrees and 47 MSc degrees.

Under the typical framework of specialized research, it was nevertheless agreed that the impact of the MaDaMe programme on the training of new professionals in the scientific-technological area has been an important capital for the Finnish scientific community.

3.3 Cooperation inside and outside the MaDaMe research programme

One objective of the programme was to increase collaboration among different fields of methodology sciences and to 'improve their interaction and exchange with fields of applications'. This goal was achieved by the majority of the consortia, they succeeded in doing both: to trigger new and stronger cooperation between mathematicians, computer scientists, physicists, chemists, engineers, medical scientists, etc., and to get in close contact with e.g. biomedical and meteorological applications.

This confirms that the composition of the projects selected to the programme was in general correct. New collaboration was created when applying for funding from the MaDaMe programme and preparing the application.

The programme as a whole, however, developed very little collaboration. An excessive spirit of competition (possibly induced by the relative smallness of the Finnish scientific community) has unfortunately prevented a more extensive exploitation of potentially more fruitful synergies among groups. Only partly this situation might have been improved by more coordination by the central management. Possibly participation in similar interdisciplinary projects may help to open novel channels of communication.

There were some 'interconsortial' cooperations, but these were most often not created by the MaDaMe programme. In many cases the MaDaMe funding enabled the researchers to deepen and push some old collaboration, which otherwise would not have been possible. It also gave an opportunity to start a new direction of research.

The willingness of the scientists to accept MaDaMe as a common house for their research was too low as was the appeal or the pressure by the Academy. One can force cooperation between different groups only if they are willing to try. Some were not. The groups did not take the opportunity to learn what other consortia do or had done. At the two-day evaluation colloquium, the participation was mainly day-wise. The MaDaMe programme did not succeed in developing a corporate identity.

The cooperation with Finnish partners outside the programme existed here and there and was sometimes even approved, for example, when measurements from possible applicants were needed. But one must realise that Finland is a rather small country and therefore most of the people interested in a certain subject were already gathered in a consortium, or at least involved in the MaDaMe programme. It was therefore rather unlikely to discover a completely new cooperation partner outside tracks known before.

3.4 International networking

International networking, which the MaDaMe programme aimed to support as well, was very strong at the start of the programme and became even stronger in almost all projects. It is impressive and a pleasure to see how close and strong the cooperation is among these Finnish scientists and their colleagues in the United States, European Union countries, and Russia. Almost all projects have an impressive list of international visitors and visits abroad. In giving the consortia a longer-term support for inviting visitors and for travelling, MaDaMe has certainly promoted better international cooperation and established more international contacts. Some consortia already at this stage report joint publications with foreign scientists that have resulted from the projects, but the main harvest is expected in the near future.

This refers to one of the original objectives of the programme: to enable new funding options for further research. This is certainly the general goal of the science policy in each country, and the MaDaMe programme was a good and valuable building block in this construction.

3.5 Socio-economic impacts

The socio-economic impact of mathematical modelling comes from understanding quantitative phenomena in important processes of human activity, nature, and their interaction, and with the possibility to better use the economic, human and natural resources. In projects involved in a programme such as MaDaMe, the impact typically comes years after research results. One would expect long-term economic impacts of MaDaMe in medical engineering and health care, paper manufacturing, forestry, wildlife and fishery management, biochemical industry, sea transportation and education. The examined PhD theses, particularly those which concentrated on applied mathematical modelling and data analysis methodological issues, will be an asset for among others the information technology sector, although no project was intimately tied to an IT application. It would be premature to estimate the economic value of these impacts. Culturally, in the form of scientific knowledge, there are interesting results in theoretical ecology and evolution, economy, space physics, mathematics and theoretical computer science.

3.6 Shaping the Finnish Research Area

In Finland there are several scientific groups with a tradition of sophisticated mathematical modelling that is world-leading, whereas in many other areas such sophistication has not been attempted, because of lack of needs, interest or resources. It has emerged quite clearly in our work and is stated in several self-evaluations that there are barriers to communication and a spread of best practice which are cultural and built into the academic system. This means, for instance, that groups which outside the programme compete with each other cannot really be expected to cooperate within the programme either, unless rather concrete incentives are provided. The absence of such incentives probably meant that less than optimal integration was accomplished. However, there were several cases where an awareness

was created about the promises of a deeper approach to modelling than the current standard for the application area. The MaDaMe programme provided thus a useful way to accomplishing a movement in this direction. If the positive developments seen in a few cases can spread by themselves and by example, remains to be seen. A good example the mathematics community should consider is the prominent role played by physicists in leading successful mathematical modelling projects within the MaDaMe programme.

3.7 Functioning and coordination

As a general remark, the evaluation panel has got the impression that the management structure of the overall programme had not been accurately defined. Coordination at the level of top management has not been evident either. The steering group was well aware that collaboration in research activity cannot be imposed from the outside; under these constraints it was left to the Programme Director to find ways to create opportunities to meet and exchange ideas.

Unfortunately this message was not clearly conveyed to the Programme Director, who moreover lacked previous experience of such an ambitious and large project. She seems not to have had the necessary authority and/or support to channel the programme into more collaboration and coherence.

This raises the question of how to choose leadership for similar ventures, and how to steer them. The panel recommends the Academy to adopt the policy of open international calls for such directorships in the future, and also that the responsibilities of Programme Director and steering group respectively be clarified.

Interaction between the Programme Director and steering group has been scarce if not absent, possibly due to the changes occurred in the steering group itself. This has left the Programme Director without sufficient power to actively monitor the scientific interactions among various groups participating to the initiative.

3.8 Conclusions

The final conclusion of the panel is that the overall scientific quality fulfils the criteria of high international standards, and the socio-economic impact of the outcomes of the programme will reveal the great added value of the programme. Additionally, the impact on the training of new professionals with a transdisciplinary attitude will reveal itself in the medium-long term, providing an important capital for the Finnish scientific community.

4 Statistics

The programme has involved a total of 108 researchers (32 professors, 42 senior researchers and 34 junior researchers) and 116 students (73 postgraduate and 43 undergraduate). It has produced a total of 619 publications (381 journal articles, 98 conference articles, 19 monographs, 121 preprints). It has also contributed to the researcher training of 87 students (33 PhD degrees, 7 Licentiate degrees, 47 MSc degrees).

5 Individual evaluations

PROGRAMME DIRECTOR

Marjo Lipponen-Sahli, University of Turku

The technical coordination of the programme has been carried out in a professional way, particularly in activities that aimed at the national and international visibility of the programme.

Documentation has been accurate, by means of a variety of posters and related graphical tools which have been presented in various occasions and exhibitions. Updated information has been made available via a dedicated web site. Articles and seminars, also communicated via updated media, have enhanced the national and international visibility of the programme. Minisymposia have been organized at various relevant international conferences under the flag of MaDaMe.

On the other hand, as reported by the Programme Director herself in the written report and evidenced in the interview, the main problem of the MaDaMe programme has been the lack of central coordination of the set of consortia and individual projects.

It seems that the Programme Director was not given the power, nor the responsibility, of active monitoring the outcomes of the scientific activities within the programme, even though in few cases the coordinating support of the Programme Director was appreciated, especially by the most active groups.

Coordination at the level of top management has not been evident either. Interaction between the Programme Director and the steering group has been scarce or even absent, possibly due to the changes occurred in the steering group itself.

EVALUATION OF THE RESEARCH PROJECTS

The following criteria have been used in the evaluation of the consortia and individual projects: scientific quality, interdisciplinarity, educational aspects, collaboration within the group, collaboration within the MaDaMe programme as well as national and international visibility.

CONSORTIA

Development of Bayesian Methods with Applications in Geophysical and Environmental Research

Heikki Haario, leader of the consortium, University of Helsinki
Erkki Kirola, Finnish Meteorological Institute
Petteri Taalas, Finnish Meteorological Institute
Pertti Vakkilainen, Helsinki University of Technology

Funding: 588,660 euros

"The aim of the project is to investigate and develop data processing and assimilation methods by using Bayesian approach."

Markov Chain Monte Carlo methods are computer intensive, broadly applicable tools for parameter estimation. This group has successfully developed and applied such approaches on satellite data (e.g. ozone measurements) and on limnological problems. The work meets high demands of interdisciplinary collaboration between mathematics/statistics, physics/meteorology, and biology/environmental science. On the algorithmic side, work has been very efficient, but on the modelling side rather conventional.

Within the project two theses (one PhD, one MSc) were completed and several internationally published papers were written. The collaboration within the consortium seemed excellent. The contacts with other MaDaMe groups have varied – contacts were good within the inverse problem community, whereas they could have been closer for instance with Elja Arjas's group.

Conclusions: There seems to be no doubt that the work will have an impact on estimation methods in the subject areas treated, and indeed it already has had some impact. It must be judged as a successful MaDaMe ingredient.

Theory of MHD Simulation and Its Application to the Magnetosphere

Hannu Koskinen, leader of the consortium, University of Helsinki
Tuija Pulkkinen, Finnish Meteorological Institute

Funding: 336,380 euros

"The aim [of the project] is to develop methods of magnetohydrodynamics (MHD) simulations of space plasmas."

The main MHD code already existed prior to the start of the programme, but the group developed a new 'hybrid code' in which the electrons are treated as fluid and the ions as particles. Moreover, a better post-processing of the MHD code was constructed. The scientific quality of the project and of the group are certainly very good; the mathematical aspect of the work during the project is not so strong, but the hybrid code contains interesting algorithmic ideas.

The project, however, was not interdisciplinary at all. It was in spirit, regarding the methodology and the participating scientists, a very good, pure physics project. This was clear from the beginning, and it is not the fault of the consortium to use the money for what they had promised to do. We are sure that contacts to mathematicians inside, or especially outside Finland, would have been rewarding but were never considered and not even wanted.

The project has a very good record in postgraduate training. One PhD thesis was completed and two others are expected. The money was mainly spent on young researchers.

The rather small consortium worked perfectly together, in spite of the fact that the two professors had rather little time to spend with the project. However, they did not get in close contact with other MaDaMe projects, and the research landscape was not really changed by this project.

The international visibility of the project was very high since, as mentioned above, the scientific level is very good in relation to international standards as well.

Conclusions: This was a scientifically strong project which, however, did not fit into the MaDaMe programme.

DynAMo: Dynamic Adaptive Modelling of the Human Body

Jaakko Malmivuo, leader of the consortium, Tampere University of Technology
Jari Järvinen, CSC - Finnish IT Center for Science
Raimo Sepponen, Helsinki University of Technology

Funding: 470,930 euros

"The rationale of the project is to increase the accuracy and the viability of the mathematical modelling of physiological systems from the present theoretical and experimental level towards clinical applicability."

The goal of the project was the simulation of electrical fields in the human body created by the motion of the thorax and the simulation of the blood flow in the aorta. The field simulation is based on a rather simple quasistatic Poisson equation model for the thorax. The main problem is a proper geometric resolution and description of the thorax – the rest is done by classical FEM or FD models. The flow simulation couples weakly with the movement of the vessel and the motion of the blood. This was already done before the project started. During the project the Navier-Stokes code was improved and the comparison with 'real' data was extended. The data came mainly from foreign partners in Germany and in the US, since the third partner in the consortium, the Electronics Laboratory, did not participated at all. As a pure engineering project, it has some merit, but in the sense of improving methodologies, it is a bit meagre.

The meagre nature of improvements in methodology is due to lack of interdisciplinarity. The project would have profited from interaction with mathematics and with biomedical scientists. With respect to mathematicians, they were and are content with what they have. With respect to medical people, they did not meet the interest they would have earned.

Concerning the training of young researchers, three PhD students completed their studies during this period; however, one or two of them were certainly quite advanced

before the project started. The educational output of the project is therefore to be considered as normal.

The cooperation of Tampere and CSC was good, even if they worked on the different subjects – electrical fields and blood flow – at different places. It is not clear to us how the two subjects will merge in the future. Contacts with other MaDaMe projects did not exist. International cooperation, however, was strong, and one may say that international partners substituted for the missing support from Finnish institutions.

Conclusions: This was a respectable engineering project with little methodological progress and no interdisciplinary value – not appropriate for MaDaMe programme.

Stochastic Adaptive Dynamics of Complex Systems (STADYCS)

Pekka Orponen, leader of the consortium, Helsinki University of Technology
Tapio Ala-Nissilä, Helsinki University of Technology
Ilkka Hanski, University of Helsinki
Seppo Honkapohja, University of Helsinki
Kimmo Kaski, Helsinki University of Technology
Eva Kisdi, University of Turku
Antti Kupianen, University of Helsinki

Funding: 830,430 euros

"The consortium studies stochastic adaptive dynamics of complex systems and their modelling applications in physics, biology and economics. The emphasis is on the effects of stochasticity in such systems and the interaction of processes evolving at different time scales in their dynamics."

A major outcome of the programme has been a stronger, even though not diffused integration of classical deterministic methods and stochastics. The high quality of individual groups is well documented by the large number of publications in refereed international journals.

Different groups in the consortium have not much interacted among themselves. In particular, mathematicians have not been very actively involved in cross fertilization of methods and scientific topics which by their own are of great interest in various areas of social and economic value.

All participating subgroups have actively promoted seminars, schools and special courses for educating young researchers. (New educational programmes have been implemented.) During the project, six PhD degrees, one Licentiate degree and seven MSc degrees were completed.

The consortium involved high-profile research teams with common 'a priori' scientific interests and complementary expertise. It would have been advisable to create more cooperation between the different groups within the consortium. Members

of the consortium did not take much advantage of the presence in the MaDaMe programme of groups working on similar topics even though with different point of view and competence. In particular, collaboration with groups having a background in biology would have been advisable.

The consortium has been very active but at the level of individual subgroups. Internationally, each subgroup has been very visible in the niche of their specific interests, through intense participation in international events and exchange of visits with major research centres worldwide.

Conclusions: The scientific production has been very high both in quantity and in quality. Individual groups of recognised excellence have lost the opportunity to establish more cooperation among themselves and within the MaDaMe programme.

Anisotropic Inverse Problems with Biomedical Applications

Erkki Somersalo, leader of the consortium, Helsinki University of Technology
Risto Ilmoniemi, Helsinki University Hospital
Jari Kaipio, University of Kuopio
Matti Lassas, University of Helsinki
Jukka Nenonen, Helsinki University of Technology

Funding: 433,590 euros

"The goal of the research project is to do theoretical and applied research in the fields of mathematical inverse problems and their biomedical applications."

The scientific and mathematical standard of this project and of the consortium is excellent. This could be taken as a paradigm of how MaDaMe projects should work. The very nice theoretical work, dealing with the extremely complicated task of identifying anisotropics in media, which are penetrated by waves or diffusion, is based on using Riemannian geometry. It allows a judgement of the 'grade of non-uniqueness' of the problem and has a direct and important impact on the medical problems in impedance tomography and brain research.

The project is interdisciplinary as well; it includes pure and applied mathematics, applied physics, medicine, and engineering. The different methodologies work together and create synergetic effects. There are even contacts to commercial applications.

There are altogether six graduate students working on their theses; it seems none of them have finished yet, but will soon do so. This is an active postgraduate school with more quality than quantity.

The consortium works closely together, all parts are involved and none could be missed. There were contacts with other MaDaMe projects dealing with inverse problems. However, these contacts already existed before the start of the MaDaMe

programme. Contacts with further projects such as DynAMo would have been valuable to these projects.

The national visibility of the project could be better, since the research is really exciting and of general interest. The international visibility is already very high.

Conclusions: This project could be the 'lighthouse project' for future programmes.

From Images to Fibre Networks (FibNet)

Jussi Timonen, leader of the consortium, University of Jyväskylä
Pasi Koikkalainen, University of Jyväskylä
Tommi Kärkkäinen, University of Jyväskylä
Antti Penttinen, University of Jyväskylä

Funding: 487,750 euros

"The goal of the project is to develop methods for the analysis of fibre networks through image analysis and thereby for modelling their structural properties."

The consortium has reached by far the expected outcomes; the average quality of the scientific production has been rather high. At the consortium level, the main objective of the programme, i.e. integration of different methods has been successfully achieved. Integration of different approaches to image analysis has been strengthened, in particular typical computer science methods in pattern recognition have been integrated with methods of stochastic geometry.

Education has been of major concern for the consortium. Training of students has been very active, both at the level of PhD and at the level of MSc. The group has actively participated in summer schools on topics driven by the consortium itself. MSc theses in direct collaboration with industry have enhanced the impact on professional training. During the project seven PhDs, two Licentiate degrees and 15 MSc degrees were completed.

Within the consortium cooperation between mathematics, physics, statistics, and information technology has been successfully implemented. Weekly contacts and joint seminars have favoured the integration. However, the collaboration within other groups of the MaDaMe programme was not so evident.

The group has disseminated its results and methods via national summer schools, seminars and workshops. A new Laboratory for Data Analysis has been established, with the contribution of different departments. Members of the consortium have delivered several conference presentations (invited, oral and poster contributions), and many invited seminars in various institutions abroad. Joint publications have appeared with scientists of various universities abroad. The intense programme of visits by international scientists has highly contributed to the international visibility.

Conclusions: The consortium has shown the effectiveness of the MaDaMe programme in stimulating cooperation among different scientific environments, both to the benefit of scientific advancement and dissemination via educational programmes. Better integration with other groups of the MaDaMe programme would have been advisable.

Integrated Computational Methods for Genomic, Proteomic and Metabolic Modelling

Esko Ukkonen, leader of the consortium, University of Helsinki
Juho Rousu, University of Helsinki

Funding: 252,280 euros

"The main goal of the project is to develop computational methods and computer software for integrated analysis and mathematical modelling of genomic, proteomic and metabolic data."

The consortium developed new experimental and computational methods for analysing metabolisms, as well as methods to analyse mass spectrometric and gas chromatography data obtained with these methods. The mathematical techniques are mostly linear although potentially high-dimensional. The quality of the work is good, a judgement based mostly on the clever design and serious evaluation, rather than on mathematics innovation.

The disciplines involved are mathematics, computer science and biotechnology. Collaboration lies in the definition and development of experimental procedures leading to analysable data.

Six PhD students have been working with the group. One PhD degree and three MSc theses are presently being finalized.

The collaboration in the consortium was obviously good and will apparently continue with different funding. However, there was no significant interaction with other consortia beyond socialising in programme events.

The scientific national visibility is good. The organisation of conference ECML/PKDD and Finnish NMR meeting gave a good national visibility, but there was less popular visibility. The consortium has also good publication records with several invited talks and conference presentations in good conferences and workshops, as well as visiting exchanges.

Conclusions: The consortium has achieved innovative interdisciplinary results, even if the consortium is small and has worked mainly on a single application question. New analysis methods in this area are needed and they have potentially an enormous value.

INDIVIDUAL PROJECTS

Mapping of Random Natural Structures: Genes, Trees and Ice

Elja Arjas, Rolf Nevanlinna Institute, University of Helsinki

Funding: 336,380 euros

"The project contains a spectrum of different substantive research problems, ranging from molecular level and population genetics to forest ecology and geophysics. From a mathematical modelling and data analytic perspective, however, a single paradigmatic approach is applied to all these fields of research, involving probabilistic modelling of the studied structure, Bayesian inferential methods in the estimation of the unobserved variables in these models, and algorithmic Markov Chain Monte Carlo methods for carrying out the numerical work."

From the title, this would seem a rather scattered project, and this impression was not completely removed by the material presented. But all three parts are on a high scientific level, and deal with important problem areas. Modelling is explicit and estimation methods are up-to-date. The topology of cooperation seemed somewhat star-shaped with the project leader in the star centre.

In its combination of mathematical expertise and conscious problem choice it reflects MaDaMe ideology well, less so in collaboration with other MaDaMe projects, where we feel that this group could have been more of a resource for others. We note, though, the seminar on modelling and data analysis, with participation by mathematicians.

One PhD and two lower degrees were finished during the project. The national visibility of the project is good, and the group is active on many Finnish arenas.

Conclusions: There is good reason to expect serious international impact from these activities.

Future Cancer Burden in a Population

Timo Hakulinen, Finnish Cancer Registry

Funding: 356,220 euros

"The project develops the statistical modelling on future incidence and prevalence of the mortality from various cancers and on survival of the patients."

This project studies cancer prediction from an epidemiological, methodological viewpoint. Attempts are made to model incidence change by time linear trends. Due attention is paid to risk factors, effects of screening programmes, age and sex distribution. This is obviously an important area, and of great usefulness to society, and it is natural that such a team has been included into the MaDaMe programme.

The group has a strong position in Finnish epidemiology and is also well connected internationally. This is a small group which seems to collaborate well under its leader. There was one PhD degree finished at the very beginning of the project and one at the end of the MaDaMe period.

Conclusions: The work of the project does not display extensive contacts with other disciplines, inside or outside the MaDaMe programme.

Structural Dynamics in a Hierarchical System: Mathematical and Computational Methods for Forest Growth Models

Annikki Mäkelä, University of Helsinki

Funding: 370,010 euros

"The objectives of the research is to develop and apply mathematical modelling techniques and computational methods for structural dynamics of forest stands."

The group seeks to build realistic models of forest growth for forest management. The essential difficulty is to model and combine systems with different time and space scales. They have a good qualitative understanding of the system and in many details quantitative models as well. Current work aims at putting pieces together and obtaining data for calibration. The use of this type of detailed modelling is new in Finnish forestry. Although in some cases one could ask why alternative or internationally known methods have not been used or studied, the group seems to be on the right track.

The work involves forest science, mathematics and theoretical computer science. It is quite clear that this important type of modelling effort would not have been started now without the moral and economic support given by the MaDaMe programme.

Several PhD students have worked within the project, but no one has yet completed the PhD degree.

In the collaboration within the group no serious problems could be seen. It seems as if some parts of the model family were rather independent from the rest, but integration goes on. Contacts in spatial statistics (Jyväskylä) were useful but have not yet led to joint papers. It seems as if the diversity of models and projects in the MaDaMe programme made it difficult to get an overview of possibilities and to assess the advantages of different approaches in the present application.

Popularisation of the tree-structured tree-modelling is an obviously promising area for national visibility and has been indeed exploited in high-school projects. More of this and simulators for environmentalists, both amateur and professional, can be expected. As yet small parts of the modelling results are used or considered for use in forest management.

Group members participated in and are arranging several meetings on forest growth modelling. International visibility is thus good, but as yet more in forestry than in modelling.

Conclusions: This project is a good example of how MaDaMe can raise ambitions in an applied area with modelling and simulation needs.

Computational Bioprocess Engineering

Markku Nihtilä, University of Kuopio

Funding: 134,550 euros

"The main research topic of the project is the flat systems and their control design applied to bioprocess engineering."

The goal of this project was to apply flatness-based control in a number of application areas. If a system is flatness-based, certain effective control strategies can be applied. The report does not give the impression that a satisfactory analysis has been achieved. On the other hand, it is mentioned that there is some commercial interest in an application in radiotherapy.

Control theory applied in an application discipline is by definition interdisciplinary, and the report claims that interaction between disciplines emerged. According to self-evaluation, the researcher training in the project was unsatisfactory. However, some doctoral students are working on radiotherapy planning.

The group is small and the internal collaboration worked well. However, there was not much collaboration with other consortia beyond attending common meetings.

The national visibility of the project seems to have been marginal. The project has had contacts with French and Russian groups, and a reasonable number of publications.

Conclusions: The project had too little funding for both doing research and participating in serious integration activity, and the latter was apparently not prioritised by the principle investigator. Without a student, integration is not easy. No supplementary funding was obtained.

Mathematical Modelling of Remote Sensing Measurements to Facilitate Inverse Solutions

Lassi Päivärinta, University of Oulu

Funding: 420,470 euros

"The objective of the project is to develop mathematical models capable of modelling the scattering process and radar measurement operation in various situations."

The scientific standard of the participating scientists is high, the problems are very challenging and both partners – the group consists mainly of Päivärinta and Lehtinen – are very eager to cooperate and solve these problems together. The aim is to identify stochastic objects from radar signals. Lehtinen has developed ad hoc theories, which are working well, but need justification and improvement. Päivärinta has very good and interesting results on the identification of stochastic objects, but not for radar measurements. While the project has moved the two towards each other, they have not yet reached each other; the gap is still quite large. Related to the same problem is a stochastic theory of measurements developed in a Licentiate thesis. This may be helpful, but the degree of innovation in this work may not be very high. The competence is higher in inverse problems and radar theory.

The project is interdisciplinary; rather distinct methodologies from applied physics and from pure mathematics try to come together and they do in fact come much nearer to each other.

Only one PhD thesis was clearly mentioned in the presentation and the interview. The predicted result of two PhD theses from the project is not overwhelming compared to the six young researchers and students employed in the project.

The rather small, two-person consortium worked closely together. They presumably would have worked together without MaDaMe, but the project enabled them to put more time and effort into this project. The cooperation with other MaDaMe projects was restricted to the consortium led by Erkki Somersalo and was again not a consequence of the programme, but rather the Inverse Problems Society in Finland.

The ten researchers involved in the project are not as visible as the two project leaders. This holds even for the training of young researchers. The international visibility was very high and international contacts increased through the project.

Conclusion: Two good scientists of different disciplines made strong efforts to come together in a field where cooperation will be beneficial. They earn support.

Merging Population and Evolutionary Ecology

Esa Ranta, University of Helsinki

Funding: 218,660 euros

"The research project aims at understanding evolutionary processes by studying them via population dynamics in spatially structured systems."

The group has produced a large amount of papers of recognized quality by leading journals of the relevant fields. Unfortunately, the main objective of the programme, e.g. integration of different methods for approaching common scientific and technological problems has not been successfully reached.

Education has been of a major concern for the group at various levels (five PhD degrees finished in Finland). Successful attention has been paid by the group in producing novel educational material.

The collaboration within the group has been very active, independent of geographic location of the investigators. The collaboration within the MaDaMe programme has been rather scarce, thus affecting the inflow of more adequate mathematical methods, and the stimulus to develop novel mathematical tools.

The group has regularly organised seminars and special courses on subjects related to the research programme. Various activities have been implemented for dissemination. International cooperation and visibility has been enhanced through exchange of visits from/towards different countries, often carrying complementary competences.

Conclusions: The group has confirmed international leadership in the fields of its own interest. Scarce impact of the inclusion in the MaDaMe framework.

Computationally Efficient Methods for Deep Computing

Henry Tirri, University of Helsinki

Funding: 302,740 euros

"Deep Computing' is a term for methods solving complex and large-scale modelling and analysis problems with emerging computer systems that combine ultrafast processing with sophisticated analytical software. "

Using terminology of artificial intelligence, the group has considered many methodological problems in modelling by graphical models for mainly discrete probability distributions. The standard methods to handle the basic directed graphical model family have been polished, and well so. As a first modelling step and for ill understood domains, these methods are obviously useful and currently underutilized in many application and science areas. The approach taken to produce an extremely easy-to-use web-service guiding newcomers around the most obvious pitfalls is good, since these users often give up after encountering a number of software handling errors.

The methods have been applied to many areas via the web service, which in general, however, does not lead to the type of interaction necessary in interdisciplinary work. But interdisciplinary studies have been made in Finland on education, social sciences and fishery management.

Several PhD students, scattered over the world, participated in the project but not all of them were funded by the MaDaMe programme. No one has completed a PhD yet, but two MSc theses have been produced.

The group consists of one professor with students and associated researchers. Interaction within the group seems to work quite well. There has been no serious

collaboration within the MaDaMe programme, although such collaboration would in some cases have been relevant. The principle investigator has though interacted nationally with groups in education and health care/biomedicine and the Finnish Game and Fisheries Research Institute.

Regarding national visibility, there were several partners in the projects (outside programme) as well as popular media coverage. Internationally, many first-class papers were published and good contacts exist with leading groups in the area.

Conclusions: The group is highly visible and has had considerable impact, particularly outside Finland. The principle investigator seems to spread himself and his group rather thin over the globe, which may easily prevent him from having a really serious impact locally.

6 General recommendations to the Academy of Finland

1. The panel acknowledges the significance of the Academy of Finland in influencing criteria of research evaluations and academic career incentives to promote and facilitate interdisciplinary research in the future.

2. Unfortunately, the society does not perceive mathematics as what it is today: a crucial ingredient for technological development, even a key technology. The panel recommends that the Academy of Finland takes a leading role in improving this perception, initiating more interdisciplinary programmes aimed to integrate mathematical modelling and mathematical methods within all scientific and technological areas of research, including medicine, finance, economics and social sciences.

3. The panel believes that the Academy of Finland may play an important and active role in supporting and developing transdisciplinary training and research in mathematics, including the establishment of a systems of rewards and credits for scientists participating in the process.

4. Several groups mentioned that the duration of the MaDaMe programme, i.e. three years, is way too short for starting new research collaboration with people from different backgrounds, especially in international collaboration. Indeed, finding a common language between people from different disciplines can be very time consuming, i.e. networking between multidisciplinary groups tends to be slow. A system of three years plus two additional years for the most successful projects (a midterm evaluation is recommended) is suggested as a possible solution to the above problems.

5. The Academy is recommended to give more thoughts to the coordinating structure especially of the interdisciplinary programmes, since this type is in much higher need of a good management than the classical monodisciplinary programmes. This will ensure that research projects interact with actors outside the immediate research environment and make certain that future programmes have an impact upon society, and industry at large.

6. Training of young researchers can surely help in disseminating the awareness of the role that mathematics indeed plays both as a fundamental method in scientific research, and as a common communication language in all areas of science and technology. The use of summer schools on multidisciplinary methods, and mathematical modelling seminars open to young graduates from all programmes implemented by the Academy may play a very important role in this respect. The Academy should strongly support graduate schools directed to education on transdisciplinary aspects of mathematics.

The projects funded through the three-year Research Programme on Mathematical Methods and Modelling in the Sciences (MaDaMe) represented a wide spectrum of the role that mathematics plays as a key method in the development of high technology, such as paper industry, geophysics and environmental sciences, as well as important sectors of social value such as medicine and biology.

The international evaluation panel states in this report that the overall scientific quality of the programme fulfils the criteria of high international standards, and that the socio-economic impact of the outcomes will reveal the great added value. The programme has also had an impact on the training of new professionals, and therefore it provides an important capital for the Finnish scientific community, although the duration of the programme was short.

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