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National Programme for Materials and Structure Research 1994-2000

EVALUATION REPORT

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Preface

The National Programme on Materials and Structure Research (MATRA), launched by the Academy of Finland in 1993 to promote re-industrialisation, has been special in many respects: the total funding of around FIM 184.2 million and several rounds of applications, the long duration of the programme (1994-2000), its interdisciplinarity and the large number of research projects involved (a total of 48 projects or consortia). In addition, the programme was pioneering cooperation between the Academy of Finland and the National Technology Agency, Tekes (the Academy allocated FIM 142.5 million and Tekes FIM 41.7 million). The goal of the programme was to promote research collaboration both within and between academia and industry in the rapidly developing areas in the field of material science. The research projects involved are listed in Appendix 1.

The progress reports of the projects were used to assess applications for further funding, and foreign experts were extensively used to review the applications. The whole programme was evaluated by a panel of experts. The external evaluation was conducted by Professor Jan-Otto Carlsson (University of Uppsala, Chair), Professor Anders Liljas (University of Lund), and Professor Etienne Schacht (University of Gent). The main emphasis of the assessment was to evaluate the programme as a whole, not individual research projects. On the behalf of the Academy of Finland I wish to thank the experts for their most valuable work.

The experts were asked to focus their evaluation on the following issues in particular:

- To what extent were the objectives of the research programme met?
- Evaluation of the research programme as a whole (e.g. relevance, effectiveness of the programme)
- Recommendations for future research programmes

I would like to see that the experience and knowledge achieved through this research programme would advance materials and structure research in the future.

Helsinki, December 22, 2001

Marja-Liisa Riekkola
Chair of the Programme Committee of the MATRA
Vice-Chair of the Research Council for Natural Sciences and Engineering

1 Introduction

Materials and structure research is a cornerstone in advanced science and technology today with numerous important applications. Characteristic of this research is its interdisciplinarity, which usually requires new initiatives. The National Programme on Materials and Structure Research (MATRA) is such an interdisciplinary programme, encouraging work across borders in areas of importance for future science and technology. The MATRA programme, initiated by the Natural Science Research Council, the Research Council for Technology and the Medical Research Council of the Academy of Finland, was in operation 1994-2000. The funding decisions were based on the scientific quality and significance of the research, the scientific synergy to be gained through co-operation, training of researchers in new fields and the significance of the research in terms of applications.

The programme had four application rounds. The number of applications was 51 in the first round and 27 in the last round with success rates 12% and 27%, respectively. The research has been evaluated during the course of the programme. The objective of this evaluation is different from the earlier one and is focused on

– whether the scientific and other goals of the programme were met,
– the contribution of the programme to society,
– the added value of the consortia,
– the strengths and weaknesses of the MATRA programme.

This evaluation is supposed to be used as a guide in organizing new research programmes in the future.

2 Evaluation Procedure

During the summer 2001, the evaluators received the following documents:

- Programme memorandum
- List of MATRA projects
- Forms for self-evaluation and final reports
- Progress reports for projects accepted in the first and second round of application
- Reports of projects accepted in the third and fourth round of application and projects funded by the National Technology Agency, Tekes
- Self-evaluation reports of all the projects
- List of external experts used in the evaluation of the applications
- Summary of some output data
- List of missing reports

On 4–5 October 2001, the evaluators visited the Academy of Finland in Helsinki and met members of the MATRA Programme Committee. Four representatives of the consortia were also interviewed.

3 Summary of Self-evaluation Reports Self-evaluations and Achievements within the MATRA Programme

General

The self-evaluation report was outlined in such a way that the reviewers could easily have a good perspective of the success of different projects as well as of the MATRA programme as a whole.

Both the self-evaluation reports and the project reports clearly indicate an overall positive effect of the programme on the level of the scientific work performed by the partners in the consortia.

The output is very high:

Articles in refereed scientific journals	1,247
Refereed conference papers	700
Other publications	73
PhDs	107
MScs	214
LicPhs	82

Also docentships and Academy research positions were obtained within the programme.

The goals and objectives of the projects were in general surprisingly well met for being basic research. In some cases, however, fundamental difficulties arose and the project had to be refocused. According to self-evaluation reports, factors hampering the progress included limited access to experimental facilities and the fact that co-workers left for industry during the project, and that additional competence that could not be foreseen from the beginning was required. However, in neither case these factors can be considered as seriously hampering the progress.

The scientific significance and the innovativeness of the MATRA programme are overall judged to be very high. Without any doubt the programme has increased the fundamental knowledge in areas of greatest importance to society and produced new innovations as well. A few examples are given below:

- Novel structural data of important biological molecules have been generated.
- New methods for preparation of catalysts have been developed.
- Development of conducting polymers for controlled drug design.
- Development of methods to prepare and characterize conducting membranes.
- Development of new, bioactive bioabsorbable composite materials.

The MATRA programme has stimulated, via the formation of consortia, the interdisciplinarity of research. This has helped substantially the formation or further improvement of centres of excellence in the field of materials and structure research.

The administrative constraints were low. The partners had much freedom in the implementation of the tasks and in the spending of the allocated funds over project cost items. This was undoubtedly a good basis for the stimulation of creative science.

Most consortia specify in their reports that linking between different groups with complementary expertise in one consortium has led to a significant improvement of the scientific level of their research group and in a number of cases also opened new fields. The programme has allowed the strengthening of international collaborations and the exchange of co-workers. This opportunity was exploited by a number of partners.

In general, participation in the programme has given a large number of groups the opportunities to focus in a more effective way on interdisciplinary research objectives. It has helped to develop a coherent research profile and to improve the level of research. It also increased the networking within the country. Consequently, this programme has a beneficial long-term effect on the scientific level in the field the programme was focused on.

Thus the overall result of the MATRA programme is very satisfactory. Obviously not all consortia have been equally successful or satisfied, and a number of projects accepted into the programme in a first round were not renewed in the next phase. However, this has allowed new groups and new topics to enter the programme and to benefit from the available resources. The final result of multiple rounds of application is an improvement in the efficiency and the output of the programme.

Comments on specific areas

Contribution to postgraduate training

The MATRA programme shows very good success in completed PhD, Licentiate and Master's degrees. Some projects organized graduate courses, summer schools and winter seminars to promote postgraduate training.

Employment

A very large number of the researchers involved continued research and development at universities, in industrial companies, hospitals or in administration. Some researchers found positions abroad. University personnel were frequently becoming employed by industry. Some researchers have also started their own companies. Very few, if any, of the researchers of the MATRA programme are unemployed. A shortage of positions for post-docs and senior scientists made researchers disappear from the academic scene too rapidly.

Advancement of research

Most projects have been interdisciplinary, and the research could not have been carried out without the consortia supported by MATRA. Collaboration has been a necessity, and most consortia have been successful in having collaboration among researchers from the necessary fields.

Collaborations made new approaches and technologies available to many groups and have also generated very valuable exchange between universities and industry. Collaborations have provided broad selection of knowledge, instruments and analytical tools, and equipment was more efficiently used. Extension of international networks was also created through various collaborations of the national groups. The broad competence of the consortia allowed the researchers to concentrate on their own fundamental competence, but at the same time benefit from learning approaches from the others. In general, the research has been done more professionally. The consortia also promoted exchange of ideas and interpretation models and had, as the whole MATRA programme, a significant educational value. Some projects gave a very good overview as how the pieces of a large project come together. Some of the projects continue in new constellations or were awarded EU grants or centre of excellence status for the consortium achievements.

Benefits of the programme

The MATRA programme as a whole was very broad and diverse. Some consortia could not find means to improve collaboration, but for example one consortium experienced that a larger overlap between the different competences would have been beneficial. The diversity made it difficult to interact within the programme and between the different consortia. Not only was the definition of structures very broad including inorganic, polymeric and biological material, but also the focus on structure was very loose. This led to the difficulty that some groups did not realize that they would have been eligible for the programme, others were told that this was where their application would belong. A more clear definition may have attracted more groups to apply. Other consortia realized in the end that additional competence would have been very valuable. In some cases the industrial partners could have given more input and feedback. It was also felt that because of the difference in background it was difficult to communicate, and some suffered from the lack of understanding of the benefit gained from teamwork. Some also experienced difficulties in establishing real collaboration. More frequent meetings initially would have been beneficial in some cases. Daily interactions are invaluable if they can be established. In all, collaboration and interaction between the MATRA projects could have been increased.

More money would be needed in general to develop the infrastructure that is highly important to advanced research. Others complained that the funding was too limited in order to achieve the goals. Others again would have preferred longer funding periods. Continued funding would have permitted a permanent collaborative organization in some selected areas.

Teamwork

Many projects were only possible as team efforts and were almost entirely collaborative. In other cases the results were partly of a joint nature and partly of separate. Many joint meetings were held and joint papers were produced. Sometimes the team effort resorted to pairwise interactions only. In some consortia, teamwork has benefited exchange on all levels, both between group leaders and among graduate

students. Cross-utilization of instruments and chemicals has been an advantage. In one case not only the geographic distance but also the difference in basic knowledge prevented extensive interactions by the whole group. Teamwork also positively affected projects that were not part of the collaborations.

Contribution to society

The MATRA programme was profiled towards areas of highest importance to society: human health and diseases, communication and energy. In addition, the programme included areas of special interest for Finland, such as flotation of industrial minerals and targeted wood protection. With such a programme profile the contribution to society is obvious. Many projects involved effective co-operation between industrial partners and university researchers, and several patens have also been filed. In some cases companies have also been started.

In a few cases the results of the research have been presented to the public. The Finnish television and radio as well as some magazines have been interested in the programme. In the future, we believe, it is essential to increase the popularisation activities of science and technology. It is very important to give young people a positive view of science.

Contribution to academic society

The programme has provided a large number of young researchers with advanced education and practical training in an interdisciplinary research project centred on a common theme.

The significant funding and the administrative flexibility granted to the partners created an attractive environment for young students with opportunities to broaden their skills and interests.

The programme provided Licentiate and PhD students with training in experimental scientific work, allowed them to present their results for a broader group (not only in Finnish but also in English) and educated them in the writing of reports and scientific articles. The value of the programme towards research training is well reflected by the large number of academic degrees that were accomplished during the programme (cf. above).

From a science educational point of view the interdisciplinarity aspect is perhaps the most valuable one for young researchers' future career. In general, young researchers and graduate students found it encouraging to work in a large consortium at a national level. The programme has exposed young scientists to foreign visitors, special lecture courses and workshops and allowed contacts with researchers working on similar problems.

In a number of consortia young scientists used the possibility to work in other laboratories outside their home institution, even abroad, and so gained additional valuable experience.

The MATRA programme has also stimulated the creation of national graduate schools and contributed largely to a further improvement of scientific education on an advanced level.

Contribution to industry

The MATRA programme has provided substantial resources for basic science that is the basis for applied research and future industrial developments. The programme has resulted in a large number of patent applications and contributed to the creation of spin-off initiatives.

For industry this programme has been important as it has provided important funding to stimulate application-driven research with clear short-term benefits for companies. In particular, Tekes has allocated a higher level of support than usual in industry-linked projects.

Again, the interdisciplinarity of the programme has improved the level of the students and researchers and offered industry the possibility to recruit new co-workers with a broader training. The reports clearly indicate that industry has taken benefit of that opportunity.

4 Strenghts and Weaknesses of the MATRA Programme

The strengths of the programme are undoubtedly:

- the stimulation of interdisciplinary research via consortia
- the inclusion of both basic research and applied research projects
- the perspectives for long-term research if successful in the first round of application
- significant improvement of scientific level of participating research groups
- increased knowledge in areas of greatest importance to society
- introduction of new approaches and technologies through collaboration with other groups
- more efficient use of equipment
- significant educational value and training in research
- wide exposure of new techniques, workshops, special courses and foreign scientists to young researchers
- co-operation between industrial partners and university researchers
- a substantial amount of funding with minimal cuts in the proposed budgets
- the control of administrative constraints to a reasonable scale
- the joint effort between the Academy of Finland and Tekes.

The weaknesses of the programme are:

- occasional lack of interaction within consortia and between different consortia due to the non-existence of a steering committee
- the lack of resources for larger equipment
- lack of stimuli to encourage integration into international networks
- the leadership within the consortia
- the diversity of the programme
- distribution of resources directly to the groups within the consortia

The weaknesses of the programme are further commented below. It is quite common that a programme like MATRA becomes very broad and diverse. Focusing of the programme would help promote co-operation between the various consortia. A steering committee for the whole MATRA programme, composed of scientists as well as representatives of both the Academy of Finland and Tekes, would also have promoted collaboration by taking initiatives to stimulate co-operations.

It turned out that in a number of cases it was difficult in the initial phase to refocus the activities of individual groups around common themes. It was recognized by several partners, retrospectively, that a better organized scheme of intra- and inter-consortia meetings and workshops could have improved that interaction.

The evaluators got the impression of a weak leadership within the consortia. The consortium leader did not have power to really affect the research directions of the consortium as a whole. The distribution of the research money directly to the involved

research groups instead of allocating the money to the consortium weakened the leadership even more. Research funding should be allocated to the consortium for further distribution to the research groups after a consortium board decision.

5 Outlook and Recommendations

It is the understanding of the evaluators that a continuation of a diverse programme on materials and structure research is not to be anticipated. However, support to interdisciplinary projects focused on selected aspects of materials science, including basic research and applied research, should be continued. Interdisplinary projects linking established sciences with new emerging sciences deserve strong support by the Academy of Finland and by Tekes, without hampering the resources for innovative individual projects. New developments in materials science will most likely emerge at the interface between established disciplines and include new technologies as well as nanoscience and bioscience.

It is recommended that programmes combine research efforts with high-level permanent education initiatives on a national level. The formation and support of national networks and centres of excellence, focused on new developments and emerging technologies, are important in ensuring that Finland stays at an internationally competitive level. However, group-initiatives should leave sufficient resources for individual projects. For group-initiatives, bottom-up initiatives should be considered as positive elements in the selection procedures. Top-down initiatives should avoid the formation of consortia based on opportunistic reflections. Programmes should be structured in a way to leave room for creating dynamic research environments.

It is also recommended that the Academy of Finland and Tekes make a joint effort to provide centres of excellence with the resources needed to acquire essential major durable equipment. Group projects should have a management structure that is responsible for effective co-operation between the contributing partners and that should guarantee an optimal use of the available resources in a flexible manner.

In addition, opportunities should be provided for linking national research programmes with European networks in order to promote the Finnish presence on the international scene of frontier science and technology. Finally, initiatives like the MATRA programme helps in building-up and in cost-effective use of the advanced infrastructures and capital equipment.

6 Acknowledgements

The evaluators express their gratitude to the Academy of Finland for the invitation to participate in the evaluation of the MATRA programme and for the hospitality provided during their visit to Finland. The provision of concise project reports and self-evaluation reports has allowed us to carry out the evaluation more efficiently. The open discussions with representatives from the Academy, Tekes as well as with some principal investigators helped enormously in editing the final evaluation report. This evaluation exercise has been very interesting and informative for us.

Appendix 1

THE LIST OF RESEARCH PROJECTS OF THE MATRA PROGRAMME

Individual research consortia/projects are grouped by the funding organisation and listed in alphabetical order after the project leader.

RESEARCH PROJECTS FUNDED BY THE ACADEMY OF FINLAND

RESEARCH PROJECTS ACCEPTED IN THE FIRST ROUND OF APPLICATION 1994-1996

Advanced epitaxial materials for microelectronic applications (EPIMATTER)
Pekka Hautojärvi, Helsinki University of Technology

Structural requirements for ternary complex of heparan sulfate, tyrosine kinase glycoprotein and growth factor ligand
Markku Jalkanen, University of Turku

Novel materials for catalysis
Eeva-Liisa Lakomaa, University of Helsinki, at present Vaisala Oyj

Design of novel polymeric materials of next generation
Barbro Löfgren, Helsinki University of Technology

Synthesis and properties of high performance ceramic oxides with focus on porous structures: membranes, filters and bioceramics
Jarl B. Rosenholm, Åbo Akademi University

Studies on new sophisticated biodegradable surgical biomaterials and devices: bioactive implants, biohybrid tissues and bioreactors
Pertti Törmälä, Tampere University of Technology

Appendix 1

RESEARCH PROJECTS ACCEPTED IN THE SECOND ROUND OF APPLICATION 1995-1997

Increasing the lifetime of hip endoprosthesis by amorphous diamond coating. Evaluation of biological host response to new materials
Asko Anttila, University of Helsinki

Structure-function relationship of protein phosphatases and cyanobacterial toxins
Torbjörn Drakenberg, VTT Chemical Technology, at present University of Lund

Carbon condensation in metastable environments
Juha-Pekka Hirvonen, VTT Manufacturing Technology, at present European Commission and Rolf Hernberg, Tampere University of Technology

Materials for molecular electronics: conductive polymers with well-defined morphology
Jouko Kankare, University of Turku

Organic thin films with functional activity
Helge Lemmetyinen, Tampere University of Technology

Structure-function relationships of DNA- and bone-binding proteins as a basis of their biological activities and for design of new pharmaceutical compounds
Pekka Mäenpää, University of Kuopio

Polyelectrolytes and electrochemically active membranes: synthesis, characterisation and applications
Franciska Sundholm, University of Helsinki

Properties of fibrous compounds and disordered materials
Jussi Timonen, University of Jyväskylä

Appendix 1

RESEARCH PROJECTS ACCEPTED IN THE THIRD ROUND OF APPLICATION 1997-1999

Structure, function and assembly of biological macromolecule complexes
Dennis Bamford, University of Helsinki

The ternary complex between heparan sulphate, fibroblast growth factor receptor and fibroplast growth factor: Structure and structure-based drug design
Adrian Goldman, University of Turku, at present University of Helsinki

Theory and simulation of materials solidification
Lauri Holappa, Helsinki University of Technology

Development of non-peptide agonists of somatostatin
Pekka Häyry, University of Helsinki

Physical properties and chemical reactions on metal surfaces of model catalytic systems*
Vilho Lantto, University of Oulu

Design of novel polymeric materials of next generation
Barbro Löfgren, Helsinki University of Technology

Biomaterials for information processing*
Jussi Parkkinen, University of Joensuu

Advanced epitaxial compound semiconductors for optoelectronics (EPI-2)
Markus Pessa, Tampere University of Technology

Synthesis and functionalisation of porous ceramic oxides
Jarl B. Rosenholm, Åbo Akademi University

Nano-optics and electronics*
Martti Salomaa, Helsinki University of Technology

Studies on bioabsorbable, bioactive polymeric composites
Pertti Törmälä, Tampere University of Technology

* Part of the Nanotechnology Research Programme 1997-1999 (NANO) funded by Tekes and the Academy of Finland.

Appendix 1

RESEARCH PROJECTS ACCEPTED IN THE FOURTH ROUND OF APPLICATION 1998-2000

Improving the wear and corrosion resistance and fixation of implants by amorphous diamond coating. Evaluation of biological host response to new materials
Asko Anttila, University of Helsinki

Cardiac Troponin C, Structure and Dynamics
Torbjörn Drakenberg, VTT Chemical Technology, at present University of Lund

Materials for molecular electronics: conducting polymers with well-defined morphology
Jouko Kankare, University of Turku

Organic thin films with functional activity: preparation, properties and applications (partly funded by Tekes)
Helge Lemmetyinen, Tampere University of Technology

Novel Photoactive materials
Tapani Pakkanen, University of Joensuu

Polyelectrolytes and electrochemically active membranes: synthesis, characterisation and applications
Franciska Sundholm, University of Helsinki

Properties of fibrous compounds and disordered materials
Jussi Timonen, University of Jyväskylä

Appendix 1

RESEARCH PROJECTS FUNDED BY TEKES

Nanomaterials and their manufacturing methods
1997-1999
Simo-Pekka Hannula, VTT Manufacturing Technology

Electroluminescence in Si/SiO_2 superlattices
1998-2000
Heikki Ihantola, University of Turku

Ultrasonic characterization of material properties of articular cartilage
1998-2000
Jukka S. Jurvelin, Kuopio University Hospital

Flotation of industrial minerals
1997-1999
Jaakko Leppinen, VTT Chemical Technology

Coordination compound catalysts
1997-1999
Markku Leskelä, University of Helsinki

Controlled gas phase routes to nano-structured oxide and metal thin films and powders
1998-2000
Markku Leskelä, University of Helsinki

Development of nickel-titanium coatings with good cavitation, erosion and erosion-corrosion resistivity
1997-1999
Veikko Lindroos, Helsinki University of Technology

Functional biomaterials surfaces (FUMA)
1998-2000
Risto Penttinen, University of Turku

Surface structure of wood microfibrils: location of cellulose, hemicelluloses and lignin in native and enzymatically treated samples (partly funded by the Academy of Finland)
1997-1999
Jaakko Pere, VTT Biotechnology

Appendix 1

Targeted wood protection: new inleachable wood presevatives
1997-1999
Anne-Christine Ritschkoff, VTT Building and Transport

New technology for structural studies of medicinally important proteins: the structure determination of testosterone binding fab fragments
1998-2000
Juha Rouvinen, University of Joensuu

Usage of DNA transposition complexes in gene technology
1997-1999
Harri Savilahti, University of Helsinki

Functional olefin copolymers
1997-1999
Jukka Seppälä, Helsinki University of Technology

Light emitting silicon based superlattices
1998-2000
Juha Sinkkonen, Helsinki University of Technology

New technology for structural studies of pharmaceutically important proteins
1998-2000
Kristiina Takkinen, VTT Biotechnology

Advances properties of copper alloys
1998-2000
Tuomo Tiainen, Tampere University of Technology