Publications of the Academy of Finland 2/08

Research Programme for Future Electronics (TULE)

Evaluation Report 2003–2006

Members of the Evaluation Panel

Professor Kjell A. Ingebrigtsen (Chair)
Programme Manager Christiane Kaell
Professor Dan Ritter
Programme Director Wilfred G. van der Wiel
Doctor Hele Savin

Academy of Finland in Brief

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Photos: Optoelectronics Research Centre, Tampere University of Technology
Page layout: DTPage Oy
ISBN 978-951-715-691-2 (pdf)
Helsinki 2008

Contents

Description

Publisher	Academy of Finland	Date April 2008
Author(s)	Evaluation panel	
Title	Research Programme for Future Electronics (TULE). Evaluation Report 2003–2006	
Abstract	In response to a proposal by the Research Council for Natural Sciences and Engineering, the Board of the Academy of Finland decided on 13 November 2002 to launch a Research Programme for Future Electronics. The objective of the programme was to promote long-term and high-level basic research leading to new innovative applications and to support the ongoing research and development efforts within the Finnish electronics and electrical industry. The TULE research programme originally had a total funding of 6.75 million euros and it consisted of 13 research projects. The Programme Steering Committee decided, in two steps, to strengthen the programme with additional projects, and, in the end, there were 18 projects under the TULE umbrella with a total funding of 7.51 million euros. Programme cooperation at the national level was most active with the Miniaturizing Electronics Technology Programme (ELMO; 2002–2005) funded by Tekes , the Finnish Funding Agency for Technology and Innovation. International cooperation was targeted at the ERA-NET project MATERA, a European network project for organisations funding the field of material science and technology. An international evaluation panel was appointed to evaluate the TULE programme. The panel was asked to assess the programme as a whole and focus especially on the following issues: planning of the programme and its scientific quality, success of the implementation of the programme goals and objectives, contribution to researcher and expert training, collaboration and networking, applicability of research and import-ance to end-users as well as recommendations to the Academy for future programmes. This publication includes the report of the evaluation panel. The panel was impressed by the scientific results obtained in the time available. Projects obtained outstanding scientific results, some generated patent applications, and some even led to the start-up of companies. There was very active cooperation within some consortia with significant added value, and international collaboration was also considered impressive. The projects all generated PhDs, which will contribute to the dissemination of scientific knowledge in the electronics industry in Finland. However, the added value obtained by the TULE programme, compared to allocating the same budget to an open call, was considered very difficult to evaluate. It is recommended that this aspect be under constant evaluation also in the future.	
Key words	research programme, evaluation, research funding, electronics research, future electronics, material science	
Name and number of series	Publication of the Academy of Finland 2/08	
ISSN	0358-9153	
ISBN	Print	Pdf 978-951-715-691-2
Number of pages		
Distributed by	Academy of Finland, POB 99, FI-00501 Helsinki, viestinta@aka.fi	
Published by	Academy of Finland	
Place and date of printing	Helsinki 2008	
Other information	www.aka.fi/publications	

Kuvailulehti

Julkaisija	Suomen Akatemia	Päivämäärä Huhtikuu 2008
Tekijä(t)	Arviointipaneeli	
Julkaisun nimi	Research Programme for Future Electronics (TULE). Evaluation Report 2003–2006	
Tiivistelmä	Suomen Akatemian hallitus päätti 13.11.2002 luonnontieteiden ja tekniikan tutkimuksen toimikunnan esityksestä käynnistää Tulevaisuuden elektroniikka -tutkimusohjelman. Ohjelman tavoitteena oli edistää pitkäjänteistä ja korkeatasoista perustutkimusta, joka tukee suomalaisen elektroniikka-alan tutkimus- ja kehitystoimintaa ja jonka avulla voidaan innovoida uusia sovelluskohteita. TULE -tutkimusohjelman budjetti oli alun perin 6,75 miljoonaa euroa ja ohjelma koostui 13 tutkimushankkeesta. Ohjelmaryhmä päätti kahdessa eri vaiheessa vahvistaa ohjelmaa lisähankkeilla ja lopulta ohjelmaan kuului 18 hanketta, joiden kokonaisrahoitus oli 7,51 miljoonaa euroa. Kansallinen ohjelmayhteistyö oli aktiivisinta Tekesin Elektroniikan miniatyrisointi -teknologiaohjelman kanssa (ELMO; 2002–2005). Kansainvälinen yhteistyö keskittyi ERA-NET MATERA -hankkeeseen, joka on eurooppalaisten materiaalitekniikkaa rahoittavien organisaatioiden verkostohanke. TULE -ohjelmaa arvioimaan nimitettiin kansainvälinen arviointipaneeli. Paneelin tehtävänä oli arvioida ohjelma kokonaisuudessaan kiinnittäen erityistä huomiota seuraaviin seikkoihin: tutkimusohjelman valmistelu ja ohjelman tieteellinen laatu, ohjelman tavoitteiden saavuttaminen, panostus tutkijankoulutukseen, yhteistyö ja verkottuminen, tutkimustulosten merkittävyys ja sovellettavuus sekä suositukset Suomen Akatemialle tulevia ohjelmia varten. Tämä raportti sisältää arviointipaneelin työn tulokset. Paneeliin teki vaikutuksen määräaikaisessa ohjelmassa saavutetut tieteelliset tulokset. Hankkeissa saatiin erinomaisia tuloksia, eräät hankkeet tuottivat patenttihakemuksia ja eräät johtivat yritysten syntyyn. Yhteistyö joidenkin konsortioiden välillä oli hyvin aktiivista ja tuotti merkittävää lisäarvoa. Paneeli piti myös kansainvälistä yhteistyötä merkittävänä. Kaikissa hankkeissa suoritettiin tohtorintutkintoja, mikä edistää tieteellisen tiedon levittämistä Suomen elektroniikkateollisuudessa. Paneeli totesi kuitenkin, että oli hyvin vaikea arvioida TULE -ohjelman tuottamaa lisäarvoa verrattuna siihen, että sama rahoitus olisi ollut haettavana yleisessä haussa. Paneeli suositti tämän seikan jatkuvaa arvioimista myös tulevaisuudessa.	
Asiasanat	tutkimusohjelma, arviointi, tutkimusrahoitus, elektroniikkateollisuus, tulevaisuuden elektroniikka, materiaalitiede	
Julkaisusarjan nimi ja numero	Suomen Akatemian julkaisuja 2/08	
ISSN	0358-9153	
ISBN	Painetulle kirjalle annettu tunnus	Pdf-versiolle annettu tunnus 978-951-715-691-2
Sivumäärä		
Julkaisun jakaja	Suomen Akatemia, PL 99, 00501 Helsinki	
Julkaisun kustantaja	Suomen Akatemia	
Painopaikka ja -aika	Helsinki 2008	
Muut tiedot	www.aka.fi/julkaisut	

Preface

The importance of high-standard basic research in the field of electrical engineering was clearly recognised by the Academy of Finland as early as in 2000. At the same time, Tekes launched a programme called ELMO, aiming at supporting the applied electronics research. This provided an ample opportunity to complement that programme by subsidising basic research. The programme was called TULE (TULevaisuuden Elektroniikka = Future Electronics). The intention of the programme was described as follows:

- The objective of the programme is to promote long-term and high-level basic research leading to new innovative applications and to support the ongoing research and development effort within the Finnish electronics and electrical industry.
- At the same time, the programme supports the development of research environments within university units, which is crucial to improving researcher training opportunities.
- Finally, the programme hopes to encourage science students working in such fields as physics, chemistry and mathematics to turn their attentions increasingly to industrial applications.

The first call of TULE took place in January 2003 leading to the funding of thirteen projects that started in July 2003. Later, the programme was supplemented so that it eventually consisted of eighteen research projects, the funding of which totalled 7.51 million euros.

This report is an evaluation of the results of TULE, by the following evaluation committee: Prof. Kjell Arne Ingebrigtsen (Norwegian University of Science and Technology, Norway), Programme Manager Christiane Kaell (National Research Fund, Luxembourg), Prof. Dan Ritter (Technion, Israel), Programme Director Wilfred van der Wiel (University of Twente, The Netherlands) with Dr Hele Savin, Helsinki University of Technology, Finland, as the expert secretary. I herewith thank the members of the committee for the very profound work of which this report serves as an evidence.

Iiro Hartimo
Chairman of the TULE Programme Committee

1 Introduction

The evaluation panel would like to thank the Academy of Finland for having been given the opportunity to learn more about Finnish science policy, and specifically about Finnish research in electronics, through the evaluation of the TULE Research Programme for Future Electronics. We were impressed by TULE's ambitious goals, and by the quality of the projects, which clearly demonstrate an intention to finance long-term research into future electronics.

The TULE programme covers a variety of activities through eighteen separate projects. Within the projects, one finds research in basic material science, photonics, electronics system design, and portable radio technology. To ensure this diversity, the Academy has grouped the projects into three themes: *Circuits and systems, Materials, optics and optoelectronics,* and *Nanoelectronics*. Partly because of the diversity of the projects, partly on demand of the Academy, the panel has decided not to evaluate each individual project for its scientific merit but to carry out the evaluation on the programme level. We will comment on points where we believe things could have been handled differently in the programme, and points where we think that the Academy should keep up the good practice used in TULE. Whenever appropriate, we will mention specific projects to illustrate the comments made.

We are generally impressed with the scientific results obtained in the limited time available. Indeed, some projects have obtained outstanding scientific results, some have generated patent applications, and some have even led to the start-up of companies. The projects have all generated PhDs, which will indubitably contribute to the dissemination of scientific knowledge in the electronics industry in Finland.

The evaluation panel would like to congratulate the Academy for the results obtained with TULE. Both the management of the programme and the preparation work done for the evaluation panel have been handled very professionally.

2 Evaluation

2.1 Planning of the research programme

TULE consists of eighteen projects, with six in each thematic group. The projects were obtained through two separate calls. In the first call, thirteen projects were selected. Five additional projects were added later, two of which through a second call. In some of the projects, several partners have built large consortia.

The original themes of the call were defined by the Academy's Research Council for Natural Sciences and Engineering. A programme steering group was appointed to develop goals and objectives, and to supervise the execution of the programme. However, in this process, the original themes had to be adjusted subsequent to the selection of projects in the second call. This may also be the reason for the multiple-step selection process. The evaluation panel believes that this may have been avoided if the Research Council had interacted more closely with the research community in the definition phase of TULE, a procedure that is quite common today.

The selection process from originally eighty proposals to eighteen projects was fast and efficient, which impressed the evaluation panel. In the final project selection, four external experts had the opportunity to discuss forty projects. The panel doubts that four experts have adequate in-depth knowledge to give such a diverse collection of proposals a fair scientific evaluation.

The evaluation of the research proposals was based on scientific excellence, which is considered an excellent criterion. If other criteria are taken into consideration, they should not compromise the scientific excellence of the project. TULE is oriented towards basic as well as applied and industrial research. The panel supports this. However, with such a blend of different scopes, it is important that the selection criteria of proposals are made very clear in the calls. Perhaps this could have been done better in the TULE calls.

2.2 Scientific quality of TULE

The evaluation panel has judged the scientific quality of the projects within the TULE programme based on their overall scientific output and impact. The panel realises that the Academy funding in nearly all projects is supplemented by funding from other sources, such as universities, research institutes, other national and international funding agencies, or industry.

As mentioned in the introduction, the thematic areas in the TULE programme are rather diverse. Scientific output is presented, measured and appreciated in various ways, depending on the respective research area. In basic research, peer-reviewed journal articles are highly regarded, whereas in more applied research areas, other outputs such as patents and spin-off companies are considered important. The panel has made an effort to take those differences into account.

The final project report mentions that the scientific research in TULE has resulted in 61 PhD dissertations, over 430 refereed journal articles, and more than 250 conference papers. These are impressive figures, considering the size and duration of the projects. Of course, these results have to be seen in the light of the supplemental funding mentioned above. The panel has noticed a few discrepancies in the publication lists, in particular double counting of publications. Having said all this, the scientific output is without any doubt very good.

Some of the basic research is excellent. This is expressed by publications in high-ranked journals, sometimes in collaboration with top groups from outside Finland. Several spin-off companies have been founded and even commercial products have been developed within some of the projects.

The added scientific value of consortium research was very much apparent in some of the projects, but not in all. In the thematic area *Circuits and systems*, quite a lot of small projects were funded with a clear relevance to future electronics. We noticed a large variation in publication output in this thematic area. In the other thematic areas, the direct relevance to future electronics was not always obvious.

2.3 Success of the implementation of programme goals and objectives

According to the TULE programme memorandum the programme goal was “to promote the long term and high level basic research leading to innovative

applications, and to support the ongoing research and development effort within the Finnish electronics and electrical industry".

The first group of projects entitled *Circuits and systems* clearly supported the R&D effort in the Finnish electronics industry, as is made evident also by their complementary Tekes funding. We found it difficult to evaluate the specific impact of each individual project, but are confident that the Finnish electronics industry will provide an appropriate feedback. The PhD students trained by these projects are obviously very valuable to industry.

The two other groups of projects, *Materials, optics and optoelectronics* and *Nanoelectronics,* lay greater emphasis on basic research, necessary for the long-term success of the Finnish industry and economy. We were impressed by the formation of several spin-off companies as an outcome of some of these basic-research projects. We were also impressed by the large number and high quality of publications, and the substantial number of PhD students trained within these projects. Although we did not examine the original research proposals, we believe that most of the objectives set by the various groups were met, in spite of some budget cuts.

The programme activities organised by the Academy took place mainly during the planning and evaluation stages, and the two programme seminar sessions. The students we have interviewed said that they have benefited from these seminars, while the opinions of the principal investigators interviewed were not as uniform. Some were interested in the work of other groups in the programme, and some were not. A specific positive outcome of the photonic crystal project was that certain research groups moved to the Centre of Micro- and Nanosystems, Micronova, to work together with other groups.

The added value obtained by the TULE programme, compared to allocating the same budget to an open call, is very difficult to evaluate. In some cases the programme approach may have been counterproductive. For example, the very successful optics projects could have been excluded just because they did not comply with the original scope of the TULE programme. We therefore recommend that the ratio of open calls to programme budgets will be under constant examination and evaluation.

A specific goal of research programmes, as specified in the Academy of Finland's "Research Programme Strategy" document, is the enhancement of collaboration between national research teams. We have observed that in some consortia this collaboration was very successful, resulting in joint publications. In other consortia, no real collaboration took place. Significant inter- and multidisciplinary research was carried out by mainly two of the projects. However, some of the most successful projects were not interdisciplinary, indicating that small projects should always also be welcome. Big research consortia, without genuine collaboration, are not a desirable option.

The administrative coordination of the programme was flawless. Scientific coordination took place only during the planning and selection stages.

2.4 Contribution to research and researcher training

The programme has been very successful in contributing to the education of PhD students. Although this varied considerably among the different projects, the overall number of 61 dissertations is commendable. Obviously, these results have to be seen in the light of supplemental funding and the regular PhD programmes at universities,

since the duration of PhD studies extend beyond the programme lifetime. The actual contribution to PhD education from TULE may therefore well be higher than this number, since many PhD students who started during the programme have probably not yet finished their degrees.

Many postdocs were financed through TULE. It is important that programmes like TULE support researchers who aim for an academic career.

2.5 Collaboration and networking

The PhD students appreciated the interdisciplinary TULE seminars, as these provided them a broad view of current research in electronics in Finland. The seminars were regarded as a good opportunity to meet other scientists in the field and to establish new contacts. International collaboration in TULE is quite impressive. World-leading research groups actively participated in some of the projects. However, these collaborations were often enhanced through the existing networks of individual scientists and cannot – or can only partially – be credited to the TULE programme.

There was very good cooperation within some consortia, with significant added value. However, this varied a great deal from one project to another. One reason for this could be the fact that the project topics varied from basic to applied research. Direct collaboration with industrial end-users was rare, except for the several spin-offs that were formed during TULE. Some of the consortia will continue further research activities in follow-up projects. It should be interesting for the Academy to follow this over time.

2.6 Applicability of research and importance to end-users

All TULE projects are relevant to future electronics products and systems. The difference lies in the time before applications emerge. Some of the projects have generated results, which are already being implemented, whereas most of the research will give value only in future products. The panel has been impressed by the generation of several commercial spin-offs from TULE research. Also, innovations have resulted in patent applications, which may have future value. It is a compliment to the scientists participating in TULE that even basic research was considered for its potential commercial value.

Most of the results generated within TULE, however, are contributions to the scientific generation of knowledge. As such, they contribute to the international progress in the field, and the primary users of the results are other researchers. This helps to establish international collaboration and Finnish researchers to get access to knowledge and research results generated by others long before these are published. This ensures that the research is in the forefront. In the long run, this may be the most important result of programmes like TULE.

Through consortia established in TULE, researchers from separate groups have decided to continue cooperation within new programmes and projects. There are several examples of this in the TULE projects. This will be of high value for Finland, and the evaluation panel was impressed by these initiatives.

3 Recommendations for the future

3.1 Planning of the programme/call

The evaluation panel suggests that, in future calls for proposals, scientific quality should be clearly stated as the primary objective in basic as well as applied science, if this is the intention.

We also recommend that representatives of the scientific community participate in the definition of a programme. This will ensure that the selected themes correspond to the capability and interest of Finnish research, right from the start of the programme.

Thematic programmes do not always have an added value in comparison to open calls. If the programme definition is too narrow, some high-quality projects may not pass the selection process. We recommend that the ratio of open calls to programme budgets will be under constant examination and evaluation. Cooperation and creation of consortia are encouraged with the objective to enhance the scientific quality of the project. The added value should be pointed out in the project application, and it should be a parameter that is measured throughout the project. However, a smaller project of just one group should not be excluded, as appears to have been the case in the second phase of the TULE programme. Large projects, with no real, genuine collaboration, are counterproductive, and should therefore be discouraged.

Likewise, participation by international researchers in consortia should be encouraged when constituting a net added value for the project. However, concerning the financing model, the Academy should cover the Finnish part of the project.

In the call for projects, the expected size of projects should be indicated. This will help researchers create the right dimension of projects, and it may improve the quality of a consortium. It will diminish the work on proposals that should apply for financial support from other sources.

If financing of postdocs is insufficient in Finland, as the panel was told in interviews, programmes like TULE could be used to emphasise postdoc research.

3.2 Selection of the projects

A programme like TULE should cover basic research as well as applied research. However, in order to make a fair selection of the best projects, it is important that the selection criteria are clear and that they are communicated to the applicants in the call.

We recommend that a project by a single applicant may well be accepted when the scientific quality alone merits support of the project. Also, other criteria than scientific excellence could be used for the evaluation of the research proposals. However, they should not compromise the scientific excellence of the project.

The selection of scientific reviewers is important for the ranking of proposals. We therefore emphasise the need to choose reviewers who have in-depth competence in the projects they are asked to review. This is the best way to ensure that the projects

are of the highest scientific quality. It may result in using more reviewers, each with fewer proposals to review. The selection of projects by a limited number of reviewers, who come together and are able to make a comparison between different projects, is, however, regarded as a very positive point. If a reviewer only assesses one project proposal, such a comparison is of course impossible. One or two reviewers on a more elevated level may take care of the balance between proposals from different specialities. The review panel emphasises the importance of keeping the selection time short, as has been the case for TULE.

Cooperation should be encouraged in cases where there are proposals from different applicants with clear commonalities.

Since the evaluation of the programme and the projects should be based on goal achievements, the goals must be clearly stated in the project plan. This was not always the case in the TULE projects.

The evaluation panel has observed that projects that were funded below their proposal had not been asked to modify their ambitions and goals in correspondence with the new funding scheme. We recommend that this is corrected in the future.

3.3 Programme evaluation

Although peer review of journal papers is the normal quality assurance of scientific work, the scientific evaluation of a project is also of high value to researchers. The evaluation panel suggests that, if possible, the Academy should engage the scientific panel, used in the initial project selection, as a scientific review panel of the final scientific outcome of the projects. The scientific review panel should participate in the final programme seminar. This also gives an extra motivation to the project researchers.

This scientific review should come in addition to a programme review panel, which in such case may be a national group.

We recommend that the Academy give clear instructions for the final project report. The most important scientific results should be emphasised with reference to publications. Joint publications between separate groups in consortia should be pointed out as a consortium added value. Impact factors for journal publications could be one way to rank and compare projects.

In the final programme seminar, project leaders could be asked to select the best project within the programme based upon the project reports and the presentations at the programme seminar. The Academy could create some way to reward the project with the highest vote. This will create more attention to the final report, to the seminar presentation, and to the final project seminar.

ANNEX 1A
The assignment

Assignment to the evaluation of the Future Electronics research programme (TULE)

The Academy of Finland has launched the evaluation process of the Future Electronics research programme. The evaluation of the programme will be carried out by an international evaluation panel. The chairman of the evaluation panel is professor Kjell A. Ingebrigtsen, Norwegian University of Science and Technology, Norway; and the members of the panel are programme manager Christiane Kaell from The National Research Fund, Luxemburg; professor Dan Ritter from Technion - Israel Institute of Technology; and programme director Wilfred G. van der Wiel from University of Twente, The Netherlands. Scientific secretary of the panel is Dr Hele Savin from Helsinki University of Technology, Finland. With this assignment we, on behalf of the Academy of Finland, confirm your membership in the evaluation panel of the Future Electronics research programme.

The objective of the evaluation is to estimate to which degree TULE research programme has succeeded in fulfilling the objectives originally set for it in the Programme Memorandum. Of specific interest are the programmatic approach, added value and programme impacts, exploitation of research results, networking and dissemination of results.

In the Evaluation Report, the panel is expected to assess the programme as a whole and reflect the following issues:

1. Planning of the research programme
   - Preparation of the programme and planning of the contents of the programme
   - Research projects funded and funding decisions in creating the necessarpreconditions for the programme
2. Scientific quality of TULE
   - Scientific quality and innovativeness of the research
   - Scientific competence of the consortia
3. Success of the implementation of the programme goals and objectives
   - Concordance with the objectives of the research programme
   - Functioning of the programme
   - Added value of the programme
   - Contribution to enhancing inter- and multidisciplinarity in research
   - Scientific and administrative co-ordination
4. Contribution to researcher and expert training
5. Collaboration and networking
   - Collaboration within the programme
   - Collaboration with other Finnish groups
   - International co-operation
   - Collaboration with the end users

6. Applicability of research and importance to the users
   - Contribution to promoting the applicability of research results
   - Relevance and importance to the users
   - National and international impact of the programme
7. Recommendations for the future (including the justification for the recommendations)

The time and place for the panel work have been decided to be 8-9 November in Helsinki at the Academy of Finland, Vilhonvuorenkatu 6. The preliminary schedule for the panel is as follows:

7th November	Arrival in Helsinki
7th November	Get-together supper at 8 pm
8-9 November	Panel meeting at the Academy of Finland (Panel dinner in evening of the 8th)
9th November	Departure from Helsinki – evening flights

The work will include examination of research reports, self-evaluation assessments, publications and other products of the programme; meeting with the Programme Steering Committee as well as discussion with researchers, and programme coordination. There will a period reserved for the panel's own discussion and drafting of the Evaluation Report. Technical assistance will be provided during the visit.

Further details of the meeting will be delivered later.

Paavo-Petri Ahonen
Programme Manager
Academy of Finland

ANNEX 1B
Material for the evaluation

Overall information of the Academy of Finland and TULE programme:
Brochures and links to web pages www.aka.fi/eng, www.aka.fi/tule

Overall Information of Research Programmes

Academy of Finland Research Programme Strategy

Assignment letter to the evaluation panel members

TULE Programme Memorandum i.e. Programme Call in January 2003
List of funded TULE research projects
List of TULE Steering Committee members

TULE programme events presented (on TULE web page):

- Final seminar on 12 December 2006
- Media relations seminar on 20 November 2006
- Mid-programme seminar on 15 March 2005
- PhD seminar on 25 March 2004
- Opening seminar on 30 September 2003

Project's final reports (December 2006)
Project's progress reports (March 2005, on TULE web page)
Self evaluation Report by Projects

TULE Presentations
TULE brochure (2003)

ANNEX 2
TULE EVALUATION PANEL

Chair

Professor Kjell A. Ingebrigtsen
Norwegian University of Science and Technology
Norway

Members

Programme Manager Christiane Kaell
National Research Fund
Luxembourg

Professor Dan Ritter
Technion – Israel Institute of Technology
Israel

Programme Director Wilfred G. van der Wiel
MESA+, University of Twente
The Netherlands

Scientific Secretary

Dr Hele Savin
Helsinki University of Technology
Finland

ANNEX 3
AGENDA FOR THE TULE EVALUATION PANEL MEETING

Date: 8-9 November 2007
Place: Academy of Finland, Helsinki, Vilhonvuorenkatu 6
Host: Dr Paavo-Petri Ahonen
Ms Sanna Vitikainen

Wednesday, 7th November

Arrivals to Helsinki
20:00 Get-together supper, Holiday Inn City Center lobby restaurant (Petri)

Thursday, 8th November

08:30	Meet in the hotel lobby, metro to the Academy together (Petri)
09:00	Kick-off of the panel meeting – Introductions of panel members and Academy staff – Presentation of the Academy (coordinator) – Presentation of the research programme evaluation (coordinator) – Organization of the panel work (Chair)
10:30-11:30	Interview of the programme coordinator
11:30-12:00	Interviews: Research Projects and Stakeholders
12:00-13:00	Lunch
13:00-16:00	Interviews: Research Projects and Stakeholders
16:00-17:00	Summary of day one, drafting of the Evaluation report

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19:00 - Panel dinner hosted by the Academy; Restaurant Teatteri

Friday, 9th November

09:00-10:00	Interview of the programme coordinator and discussion
10:00-11:30	Panel discussion, writing of the Evaluation report
12:30-13:30	Lunch
13:30-15:00	Panel discussion, writing of the Evaluation report
15:00-16:00	Summary of the panel and feedback to the Academy; agree on the delivery of the evaluation report

ANNEX 4
TULE Research projects

Constraint-driven platform-based SoC design (EUR 120 000)

Project leader: Jari Nurmi, Tampere University of Technology

The project focuses on developing methodologies for efficient modular design of future complex systems-on-chip based on a self-timed network-like communication platform. In this approach, the whole module interconnect network is viewed as an IP component. New methodologies will be developed to e.g. platform modelling, architecture model, and verification.

Controlling electrons and phonons in quantum devices, CODE (EUR 320 000)

Consortium leader: Jouni Ahopelto, Technical Research Centre of Finland
Other project leader: Jukka Pekola, Helsinki University of Technology

In this project the possibility to control electrons and phonons in nanoscale structures is investigated. New types of amplifiers, both for room temperature and low temperature applications, are investigated. Furthermore, thermal effects and phonon localization in porous silicon will be studied for utilization as a novel thermal insulator in many applications.

Dynamic parallel radio structures for cell array platforms (EUR 120 000)

Project leader: Jouni Isoaho, University of Turku

The target of the project is to develop radio structures and algorithms that are easily mappable to array structures, and support dynamic reconfiguration and error-tolerance. Integration of CDMA, space time coding (STC) and MIMO into reconfigurable radio architecture will be carried out.

Electronic properties of carbon nanotubes, ELENA (EUR 565 000)

Consortium leader: Kai Nordlund, University of Helsinki
Other project leaders: Pertti Hakonen, Helsinki University of Technology; Kimmo Kaski, Helsinki University of Technology; Esko Kauppinen, Helsinki University of Technology; Risto Nieminen, Helsinki University of Technology

The project consortium investigates carbon nanotubes: understanding the basic nature of electrical conductivity, manufacturing carbon nanotubes with suitable properties for electronic applications, understanding the role of defects and dopants to the conductivity, and developing ways to make nanotube-metal contacts with good transmission properties.

Integrated polymer microsystems for fluidics (EUR 160 000)

Project leader: Sami Franssila, Helsinki University of Technology

Liquid handling on a miniturized scale, utilizing channels, nozzles, mixers and other components, will be studied, and especially polymer/metal integration for power supply and electrical detection. Integration of capillary electrophoresis separation system with electrospray ionization is aimed at.

High-efficiency wideband transmitters, HeWiT (EUR 240 000)

Consortium leader: Timo Rahkonen, University of Oulu
Other project leader: Saska Lindfors, Helsinki University of Technology

This project aims at developing circuit and signal processing techniques needed in implementing a wideband (BW>10 MHz), linear and power-efficient radio transmitters for multicarrier and OFDM applications.

Low power biomorphic neural circuits based on floating gate MOS and S ET transistors, LOWNE (EUR 460 000)

Consortium leader: Jukka Tulkki, Helsinki University of Technology
Other project leaders: Kari Halonen, Helsinki University of Technology; Matti Weckström, University of Oulu; Markku Åberg, Technical Research Centre of Finland

The project goal is to develop a fast, power and area efficient multiple input floating gate transistor based neural circuit structures for signal processing. These transistors can perform combined operations - summing, multiplication - on a single transistor. The floating gate transistors can be realised either with MOS technology or nanotechnology devices.

Multi-antenna configurations and transceiver structures for mobile terminals, MACMOT (EUR 370 000)

Consortium leader: Visa Koivunen, Helsinki University of Technology
Other project leader: Erkki Salonen, University of Oulu

The goal of the project is to develop adaptive multiantenna systems for mobile terminals. Multiantenna systems both in base stations and mobile terminals will lead to so called Multiple-Input Multiple-output (MIMO) systems. This is the key technology in the future beyond the 3G and 4G wireless communications systems.

Novel electroacoustic solutions for micromechanical radios, MIRA (EUR 530 000)

Consortium leader: Antti Räisänen, Helsinki University of Technology
Other project leaders: Matti Kaivola, Helsinki University of Technology; Heikki Seppä, Technical Research Centre of Finland; Ilkka Tittonen, Helsinki University of Technology; Timo Veijola, Helsinki University of Technology

The goal of the project is to develop a novel, highly-integrated radio transceiver by using the MEMS technology. Implementation of such highly-integrated, single-chip radio-transceiver front ends based on MEMS has not so far been possible because of the required different fabrication processes. The very recent advances in using bulk acoustic waves in micromachined structures provide a promising approach.

Nanosensors, NASE (EUR 750 000)

Consortium leader: Päivi Törmä, University of Jyväskylä
Other project leaders: Jouko Korppi-Tommola, University of Jyväskylä; Markku Kulomaa, University of Jyväskylä; Ilari Maasilta, University of Jyväskylä; Matti Manninen, University of Jyväskylä; Kari Rissanen, University of Jyväskylä; Jorma Virtanen, University of Jyväskylä; Matti Vuento, University of Jyväskylä

In this project i) nanosensors for temperature and ii) nanosensors utilizing DNA and carbon nanotubes are investigated. Nanothermometers for individual living cells are

studied which is supported by basic research on thermal effects of nanostructures. Carbon nanotubes and DNA-molecules are studied as basic blocks for organic nanoelectronics: DNA detection sensors and optical properties of carbon nanotube rotaxanes are of interest.

New materials and structures for semiconductor gas sensors, NEWGAS (EUR 180 000)

Consortium leader: Pekka Kuivalainen, Helsinki University of Technology
Other project leader: Vilho Lantto, University of Oulu

The aim of the research project is to develop new advanced gas sensors with enhanced performance based on new materials such as epitaxial tin oxide and layered tungsten trioxide together with new micromechanical air bridge structures. Better stability and lower power consumption compared to the previous sensors is the goal.

Photonic crystal based integrated optics, PhC-OPTICS (EUR 445 000)

Consortium leader: Hanne Ludvigsen, Helsinki University of Technology
Other project leaders: Jouni Ahopelto, Technical Research Centre of Finland; Matti Kaivola, Helsinki University of Technology; Harri Lipsanen, Helsinki University of Technology; Ilkka Tittonen, Helsinki University of Technology

The goal of this project is to increase basic information and to develop infrastructure for fabrication of future optical devices. Photonic crystal structures and components based on them will be studied to ultimately enable full-scale integrated optics. Active devices (lasers, optical switches) and passive components (couplers, filters) will be developed.

Ultra-fast quantum-regime semiconductors, optoelectronics and sub-systems, QUEST (EUR 1 080 000)

Consortium leader: Markus Pessa, Tampere University of Technology
Other project leaders: Juhani Keinonen, University of Helsinki; Helge Lemmetyinen, Tampere University of Technology; Risto Nieminen, Helsinki University of Technology; Tapio Rantala, Tampere University of Technology; N.N., Helsinki University of Technology; Päivi Törmä, University of Jyväskylä; Mika Valden, Tampere University of Technology

The consortium is concerned with fundamental research of quantum-regime optical wavelength-scale semiconductors to improve the understanding of the physics of ultra-fast optical phenomena in matter and to demonstrate such phenomena in actual devices.

Structural and electrical properties of self-organizing molecular materials, SOMOMA (EUR 375 000)

Consortium leader: Ilkka Tittonen, Helsinki University of Technology
Other project leaders: Kimmo Kaski, Helsinki University of Technology; Paavo Kinnunen, University of Helsinki; Harri Lipsanen, Helsinki University of Technology; Adrian Sutton, Helsinki University of Technology

The aim of this project is to construct self-assembling electronic materials, by exploiting existing biomaterials and their derivatives. More specifically, a thoroughly characterized protein, cytochrome c, a well known component of the electron transfer

chain in the mitochondria of living cells, will be utilized. Fundamental electronic processes will be revealed and elementary storage devices will be designed and fabricated.

Room temperature spintronics, SPIN (EUR 595 000)

Consortium leader: Markku Sopanen, Helsinki University of Technology
Other project leaders: Jouni Ahopelto, Technical Research Centre of Finland; Pekka Kuivalainen, Helsinki University of Technology; N.N., Helsinki University of Technology

In this project GaMnN layers and layer structures are fabricated. Prototypes for different device structures will also be fabricated. The III-V semiconductors have a wide array of possible applications in spintronics (devices utilising electron spin): e.g. magnetic recording media, magnetic field sensors, magnetically driven devices, and spin transistors.

Ultra-fast microlaser module for optical communications (EUR 300 000)

Project leader: Harri Lipsanen, Helsinki University of Technology

In this project a novel glass waveguide 40-Gbit/s optical pulse generator will be studied. The GaInNAs/GaAs semiconductor material system will be investigated. These new materials will enable the fabrication of ultra-high repetition rate mode-locked lasers at 1.5 mm wavelength region.

Ultra low-power video compression system for mobile devices (EUR 120 000)

Project leader: Ari Paasio, University of Turku

Efforts are targeted towards design of low-power video compression system. The aim is to achieve a compression system where the key blocks are realized using analog circuits, thus resulting lower power consumption than digital realization.

Wireless physiological sensors for ambulatory and implantable applications, WIRELESS (EUR 780 000)

Consortium leader: Jukka Lekkala, Tampere University of Technology
Other project leaders: Jari Hyttinen, Tampere University of Technology; Minna Kellomäki, Tampere University of Technology; Markku Kivikoski, Tampere University of Technology; Jukka Vanhala, Tampere University of Technology

The aim of this project is to study and develop wireless sensor technology for ambulatory and implantable human psychophysiological applications. The wireless sensors will be demonstrated in certain soft and hard tissue implant applications such as implantable electrodes for detection of cardiac state and bone implant monitoring.